The Ecological Transition in Bali.

by

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Declaration

Except where otherwise indicated this thesis is my own work.

Sean Foley

This thesis is dedicated to the people of

Banjar Taro

and

Banjar Penestanan

and

Banjar Tegal Tugu

Om Swastyiu Saraswati

Abstract

This thesis focuses on agricultural and socioeconomic transformations in three villages in Kabupaten Gianyar, southern Bali. The analyses of changes occurring in village rice agriculture and family economics are set within the perspective of Human Ecology, and examine broadscale shifts in the natural and social ecological balance of the traditional island economy.

Bali has a long-held reputation for its rice agriculture, social and religious organisation and artistic creativity. These features have been intensely affected by a range of externally initiated changes since the Dutch invasion at the turn of the century. Three main contemporary sources of change can be identified: government initiated development programmes, urbanisation and tourism. During the last 15 years the rate of modernising changes has accelerated.

The Green Revolution has been promoted throughout the Third World, including Indonesia, as a simultaneous solution to both increasing staple food production and material welfare. Two metrics, energy and money, were used to examine the probity of development strategies based on Green Revolution technology. In contrast, detailed changes in village socioeconomics were examined by an analysis of patterns of income and expenditure, both within and between each of the three villages.

The sustainability of Balinese agriculture has been transformed by the introduction of Green Revolution technology. This technology, at island-level, has led to substantial increases in total rice production, while radically decreasing the energy efficiency of production. This contrasts with increasing yield variability and dubious economic advantages for the individual farmer. In the socioeconomic sphere, modernisation of the island economy has led to increasing material inequality, even within relatively small village communities. Bali has moved from being a wholly self-provisioning, egalitarian and sustainable society, into one characterised by dependence on imports of essential goods and services, many of them non-renewable.

The results of the analysis suggest that there are several ways in which the government, people and farmers of Bali can, by complementary 'reversals'of policy and practice, move towards a less energy intensive, more profitable and more sustainable pattern of village agriculture and economics.

Preface

The impetus for this study arose from earlier research I undertook in Bali during 1979. This focussed exclusively on the comparative energetics of traditional and modernising rice cultivation, and formed the basis of a BSc Honours thesis submitted to Murdoch University, W.A. Growing familarity with the rapid changes occurring in Balinese rice agriculture also made me acutely aware of broader social, cultural and economic transformations underway throughout the island, due to modernisation. Moreover, it was also apparent that the speed of modernisation and its impact varied from area to area. For example, the locally-concentrated, low-cost tourist area in Kuta-Legian on the south coast has social and environmental repercussions differing in quality and quantity from those occurring in the high-cost tourist area 10 km away in Sanur. Both are radically different from the style of changes occurring in villages outside the tourist orbit or even the rapidly growing, non-tourist urban areas of Gianyar and Tabanan.

It was clear that any assessment of the general impact of changes brought about by modernisation had to account for these differences. This was particularly so, if general conclusions were to be drawn about the socioeconomic and ecological consequences of modernisation.

Having decided that Bali was to be the locus of research into the effects of modernisation on an ancient and flourishing society, the next task was to choose the region to be studied within this diverse environment. Previous fieldwork experiences suggested that southern, central Bali was the appropriate region to concentrate on. Because the core of traditional Balinese society lies in this region of the island, it is the most densely populated and intensively farmed part of the island, and has had the longest and most diverse experience of modernisation.

Initial analyses made prior to fieldwork indicated that within the central, southern region of the island (Kabupaten Tabanan, Badung and Gianyar) at least five different biogeographic and agroeconomic 'ranges' could be identified: coastal villages, relying to varying degrees on fishing; lowland villages, relying mainly on irrigated rice cultivation; mid-level villages, where terraced rice cultivation is complemented by varying amounts of dryland agriculture; upper-level villages, where irrigated rice cultivation and dryland agriculture are complementary; and, finally, upland villages, above the limit of irrigation, where reliance on dryland agriculture (annual, perennial and livestock) is total.

Entwined with these traditional biogeographical ranges are differing sources and durations of modernisation. Three are clearly identifiable: government initiated development programmes, particularly in irrigated rice cultivation and social and health projects occurring in nearly every village; urbanisation, generally centred around the administative capital of each Kabupaten, resulting in expansion of commercial activity and government employment; and, tourism, largely concentrated on the south coast, but also having a major impact on rural centres such as Ubud, and economically affecting many more remote villages which manufacture tourist artifacts. As in many other parts of the Third World, modernisation has generally made its earliest impacts close to urban centres, with more remote villages in thus Bali gaining later (and lower quality) access to government sponsored health and education programmes, for example, than periurban areas or tourist locales.. Within this region several factors made Kabupaten Gianyar the natural choice.

First, stretching from the southern coast to the centre of the island, Gianyar includes within its boundaries each of the biogeographical ranges noted above. Second, within Gianyar there are clearly identifiable examples of each of the types of modernisation: government initiated programmes, urbanisation and tourism. Although Kabupaten Badung and the island's capital Den Pasar have certainly been at the centre of modernisation, their very centrality makes them atypical examples of the range of changes underway across the island.

Conversely, Kabupaten Tabanan lacks the degree of tourist orientated modernisation common to Gianyar and Badung. Third, previous research in Gianyar had provided me with greater knowledge of environmental, socioeconomic and agricultural conditions in this region, and more extensive contacts with knowledgable individuals and government personnel.

At the outset of this project, I was well aware of the range of academic literature suggesting that the results of economic development in Indonesia were variable, benefiting some individuals and sectors of the society much more than others. Nevertheless, my initial ~~initial~~ investigations largely focused on technical questions dealing with the effects of modernisation on agriculture and energy use. Only during detailed analysis of the data collected during fieldwork did it become apparent that further exploration of the differential effects of modernisation within each of the villages was central to understanding (some of) the myriad changes taking place. This congerie of transformations are as much a social-political-economic phenomena as they are a transformation of peoples' technological and environmental relationships with the natural world - an *ecological transition*, . This realisation cast the data and writing of the thesis in a completly different light. Leading me to shift the emphasis from mainly technical issues (to do with energetics and agricultural technology), to essay a complementary analysis of socioeconomic changes in both rice cultivation and domestic economics.

It seemed, as the process of writing the thesis neared completion, that the only conclusions that could be drawn about the agricultural and socioeconomic effects of modernisation in Bali would be of the 'doom-and-gloom' variety: The unfortunate, inadvertant, undermining of a vital and sustainable society, due to the necessities of feeding a growing population and the imperatives of capitalist economic development. However, some further reading and reflection, and a re-examination of recent population and agricultural trends, made it clear to me that it was also possible to draw a more optimistic set of conclusions. These are embodied in a

set of suggestions for future agricultural development: a path hopefully having more potential for sustainability, providing some additional rural employment and improving the economic situation of farmers in Bali and, possibly by example, throughout much of Indonesia.

The are many people to thank and whose assistance over the last seven years requires acknowledgement. Foremost are the people of Banjar Taro Kaja and Banjar Taro Kelod, Banjar Penestanan Kaja, Banjar Pratha Mandala and Banjar Triwangsa. Without their patience and willingness to answer endless questions about the details of their personal, family and social lives, the research could not have been undetaken. My profound thanks to these people. Secondly, I wish to acknowledge the assistance of the elected heads of the these villages, for the time they gave in facilitating surveys in each village and the access they provided to village records and statistics. Thirdly, and no less importantly, to thank farmers from each of these villages, for their willingness to teach me some of the intricacies of rice cultivation and their co-operation in the detailed surveys of rice production.

The two years of fieldwork was undertaken jointly with Barbara Bower. Although our ways have now parted, I extend my sincere appreciation to her for the support, intellectual insights and laughter she provided under sometimes trying circumstances.

In undertaking the various surveys we were ably assisted by five Balinese, who worked alongside us during an extended period of fieldwork: I Made Rodja, I Wayan Sudra, I Nyoman Praya, I Wayan Kayun and I Wayan Arka. Their hard work, commitment to veracity when conducting interviews and measurements and general good humour cannot be praised too much. Without the help of our general factotum, I Made Jagri and family, our home and working life would have been much less comfortable and efficient than it was.

Recognition and thanks are due to the Government of the Republic of Indonesia which, via Lembarga Ilmu Pelelitian Indonesia (The Indonesian Institute of Sciences), gave permission for the research to be undertaken and provided vital administrative support when required. Sincere thanks are also due to the Dean and Staff of Fakultas Pertanian (Faculty of Agriculture) of Universitas Udayana, Den Pasar, for sponsoring my application to undertake research in Bali. In addition, I am most appreciative of the assistance offered by the Heads and Staff of many local government departments and agencies in facilitating access to statistical material; in particular, Kantor Dinas Pertanian in Den Pasar and Gianyar and Kantor Statistik in Renon and Gianyar.

Funding for the research project was jointly provided by the Centre for Resource and Environmental Studies (CRES), ANU and the Man and the Biosphere Programme (Project 11) of UNESCO. Their generosity and faith in the project will, I hope, be adequately fulfilled by this thesis and the reports and papers which will follow in due course.

The most onerous part of attempting a work such as this is organising one's approach to the material and the writing the draft(s). Without the personal and intellectual support of Doug Porter during this extended period this thesis may not have been completed or have achieved some degree of rational organisation. Many, many thanks Doug. To Stephen Boyden, who has acted as my supervisior, my gratitude for his initial support of the project and continuing encouragement over the past seven years. Rod Simpson, now of Griffith University, complemented Stephen Boyden's assistance and lent intellectual support during the process of analysis and writing. Many thanks Stephen and Rod. I am indebted to D.P. Chaudhri, now of Delhi University, for providing intellectual and editorial support when it was essential. Many thanks also to Charles Zammitt, an old friend now at San Deigo State University, Rob Wetselaar of CSIRO, and John Overton and Bryant Allen of ANU, for their editorial help in the final stages.

My partner, Melody Kemp, has provided a wealth of emotional and material support during the last two years - somehow enduring with good humour the seemingly endless days and weeks I have spent working at 'the computer' - thank you my love.

Throughout these seven years I have had the unstinting support of my family, particularly my mother, Pixie Foley, who has provided financial assistance at crucial moments and, more recently, carefully and critically re-read drafts, untangled logical flaws in presentation and undertaken the unenviable task of checking references.

My thanks to the staff of the Hancock, Menzies and Chifley Libraries at ANU who have, with expertise and good humour, often at short notice, managed to obtain obscure reference material from around the globe. My thanks also to the staff of the Computer Services Centre, particularly Kathy Handel, for assistance with the data analysis. During the statistical analysis I was often prevented from pursuing blind-alleys and faulty methods by the always willing assistance of Yvonne Pittelkow of Coomb's Computing Centre. At CRES the assistance of Tony Bayes and Mark Greenaway unravelled many of the intricacies of the UNIVAC's operating system for me at crucial moments.

Last, only by necessity of presentation, are many thanks to the staff of CRES, especially Eric Ward. Locally, on the third floor that is, a thank you to Fay Goddard for her secretarial assistance over the years. My thanks also to a succession of helpful people in the 'Main Office' of CRES, who over the years have somehow smoothed bureaucratic waters and provided all kinds of essential support.

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Chapter 1

Introduction.

1.1 Introduction.

During my stay in Bali a senior official expressed his concerns about the unintended effects of modernisation (*kemajuan*) on his island in the form of a simple metaphor. He said:

> Development is rather a like walking down a new path. When you start the journey if you take the wrong turning then you just back-track a little, take the correct turning, and continue. But, further on in your journey, if you find yourself on the wrong path and try to back-track to find the correct turning, it is as though someone has been coming along behind you and sweeping away your tracks, and the very path you have travelled. You then discover that you have lost both the record of your journey and any way of rediscovering the right path again. I think this is starting to happen in Bali.

The official is a modern, successful Indonesian serving the nation state. He does not mourn the departure of the 'good old days' - but, his metaphor is a deep expression of the need to maintain and make use of the traditional, while seeking the best ways to take advantage of what the modern world offers. He is fully aware from personal experience of the benefits and costs of modernisation. In plain language, his concern is that not only are valuable traditions and knowledge being overturned due to modernisation, but that the people holding this knowledge are aging and much of the knowledge built-up over hundreds of years will die with them.

This thesis deals with the experience of modernisation in Southern Bali, Indonesia. It focuses on two aspect of village life in which modernisation has made its deepest impressions: the transformations of rice cultivation and socioeconomic patterns. Recent changes bought about by modernisation in energy use, income and expenditure patterns, and information flows have resulted in an *ecological transition*, a fundamental transformation of the people's relations to the natural environment and one another - a change in *human ecology*.

The village communities in which the great majority of the Balinese population live, have been transformed from being self-provisioning, egalitarian and sustainable, into a society dependent on imported and/or processed natural resources to maintain their system of staple food production. Furthermore, modernisation is producing growing material and social inequalities within village communities and between rural and urban areas. As a result, the thousand year long sustainability of Balinese livelihood and culture is being seriously undermined within the span of one generation.

The central argument of this thesis is that modernisation without sufficient attention to sustainability may render the material benefits very short-lived, thus placing at risk the possibility of a 'good' quality of life for future generations. Natural systems will be damaged and essential resources will be exhausted, in particular, high-quality energy resources; and also soil fertility and species richness and diversity will be lessened. Further, without attention to equity issues (social justice), modernisation will lead to increasing social tensions and community fragmentation.

Particular historical, geographic and social features of Bali make it especially suitable for examining some of the impacts of modernisation.

1.2 The Historical Context.

Bali was one of the last places on the planet to experience the direct impact of colonialism. It was not until the beginning of this century that Southern Bali was occupied and brought within the Dutch administrative system, although the northern part of Bali came under direct Dutch rule in the middle of the 19th century.

In a broad sense, therefore, Bali was isolated from the social and economic changes evident in Java, for instance, for some decades. Moreover, Bali was incorporated into the Dutch colonial empire at a time when its economic rapacity was being constrained by public political pressures in Holland. Bali was not subjected to the type of economic exploitation prevalent in Java under the Culture System of forced crop deliveries (partially because the Dutch saw little of commercial advantage in Bali), while at the same time it became the recipient of positive social services, such as very basic public health and education services. In addition, the courage and persistence with which the Balinese resisted Dutch attempts at conquest, engendered in the Dutch a degree of respect for Balinese civilization - in a sense the Dutch treated Bali as if it were a living museum.

Although important political changes had been underway since the turn of the century, available evidence indicates no widespread or significant economic and technological changes at the village level prior to World War Two (hereafter WWII). WWII and the immediately following national revolution was a time of socioeconomic disruption and deprivation for the population of Bali. During the first part of this period the Japanese extracted as much food and taxation as possible from Bali - returning little if anything by way of infrastructure maintenance or new technology. After the war, four years of revolution kept Bali in economic and technological semi-isolation - only during the mid-1950s did the impact of the new, post-WWII praxis of economic development start to make itself felt in Bali. The final expulsion of the Dutch in 1957 and economic confusion and stagnation during much of the Sukarno era forestalled significant changes in the pattern of village life, until the initiation of the first national development plan (Repelita I[1]) in 1969.

Thus, the majority of rapid changes to traditional agricultural technology, and economic and sociocultural patterns have occurred since about 1969 (see Table 1.1). Simultaneously, more subtle, social changes in politics, demography, education and religion have also taken place since about 1969. In general, these changes have originated in the capital of Indonesia, Jakarta, making their impact on village life only after first being adopted by wealthier urban dwellers (e.g. access to motor transport, domestic electricity

1 The first of a series of five-year development plans (Rencana Pembangunan Lima Tahun or Repelita); and called Pelita after completion.

supplies, TV, senior secondary education). On the other hand, it is more likely that local (village) and individual (family) responses have been the stimulus for changes in other types of attitudes and behavior - e.g. birth control and education.

While it is certain the 'tendrils' of modernisation started to have some influence on the Balinese way of life from the turn of the century, it it also clear that not until the 1960s had the drive for modernisation effectively penetrated to villages all over Bali, and started to radically transform traditional lifestyles, social organisation and technology.

Table 1.1:
Bali: An Overview of Modern Technologies and Social Practices Introduced Since 1969.

1969-70	Introduction of High Yielding Varieties of rice.
1970-72	Introduction of mass primary education.
1972-on	Widespread use of kerosene as a domestic fuel.
1972-80	6-times expansion in number of motor vehicles.
1972-on	Broad availability of mass-produced consumer goods.
1974-on	Rapid expansion of 'Mass Tourism'.
1975-on	Rapid increase in tourist-type construction.
1976	Television introduced.
1977-on	Rapid expansion of non-urban electrification.
1981-on	Expansion and improvements in road network.
1982	Start of compulsory primary education.

Because Bali's material and social culture have survived, indeed flourished, for the past 1000 years or so, this island makes a suitable stage on which to examine the effects of externally promoted innovations in technology and social organisation on sustainability. Bali, until recently, has been almost wholly self-provisioning, without significant extra-local supplements; in fact, for a long period exporting substantial quantities of rice, copra and livestock. The intimate linkages between social organisation, religion and agricultural decision-making, exemplified by the Balinese *subak*, provide compelling evidence that traditional village-based socio-political relations were an essential part of this sustainability.

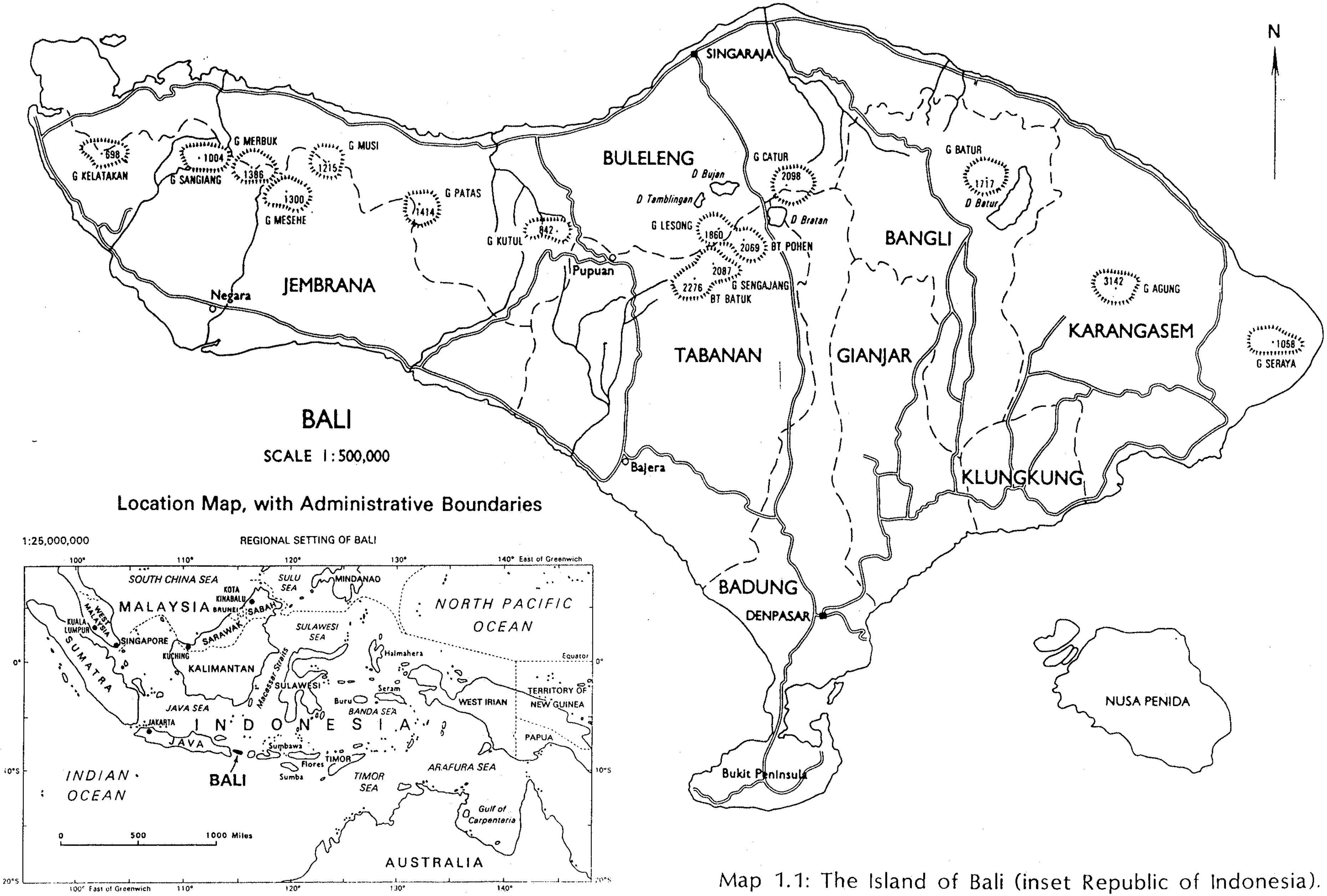
These three factors, late colonisation, recent modernisation and agricultural sustainability over historical time, make Bali a particularly suitable location for studying the direct impacts of state-initiated development. As has been made clear, transformation of many agricultural and socioeconomic relations, the real basis of modernisation in village communities, has been rapid during the last few decades.

1.3 The Geographical Context.

Bali is a relatively small island, 5,632 km^2 in area. Its size and population constitute only a minor fraction of the area or population of Indonesia (about 2%) (see Map 1.1). However, it is subject to many aspects of the land-food-people *problematic*, the problem of feeding a growing population from production on a fairly fixed extent of agricultural land, common to the densely settled parts of Indonesia, Java in particular. A range of government statistical information specific to Bali is readily available, because of its status as a separate province within Indonesia.[2] This administrative separation is enhanced by its geographical isolation as an island, simplifying accounting for major imports and exports, many of which are transported by sea.

The volcanic topography of Bali also provides a wide range of environmental conditions within a reasonably compact region. The steady altitudinal gradient from the southern coast up to the central east-west ridgeline creates an ecological gradient of terrain, soil, climate and water availability, in which a fairly clear zonation of traditional landuse has developed. In general, agricultural modernisation (e.g.adoption of High Yielding Varieties, hereafter HYVs), started from the lowlands close to new urban centres, and spread towards the remoter and higher parts of the island. In contrast, formal employment in the modern sector of the economy (e.g. offices, industry and hotels) and modern physical infrastructure (e.g. new roads, electricity, telephones) has tended to be concentrated in and near urban centres close to the coast, with isolated locales such as Ubud becoming urbanised as a result of tourism.

2 In addition, the research was confined to a single administrative region (Kabupaten Gianyar) within the island - further facilitating the collection of specific contextual data.



Map 1.1: The Island of Bali (inset Republic of Indonesia).

1.4 The Social Context.

The role of information is crucial in enabling individuals and communities to make decisions that take full advantage of new technologies and sources of income. Conversely, access to adequate, relevant sources of information helps individuals and communities avoid pitfalls in dealing with novel aspects of recent technology, and with changes in social and economic organisation.

The localised, participatory and democratic forms of decision-making common to traditional villages make a sharp contrast with the centralised, bureaucratic and authoritarian pattern common to modernisation in Indonesia. It is quite apparent that government agencies are taking increasing managerial control of traditional organisations, and using them as a conduit for the implementation centrally devised policies. This modern trend stands in clear contrast to traditional Balinese methods of manipulating access to information, particularly where it concerns community decision-making. Traditionally, each participant in a village meeting was aware of almost all of the factors and likely outcomes of decision-making, whereas today communities have, to a large extent, lost participation in and/or control over most major social, technical and economic decisions.

The history, geography and social organisation of Bali provide a valuable opportunity for investigating the transformation of fundamental agricultural and socioeconomic characteristics of traditional communities. The analysis of the ecological transition combines both aspects of both physical and social ecology and, therefore, is much broader than an examination of recent changes in physical ecological relationships.

1.5 Rationale and Organisation of the Thesis.

This research is very much in the mould of what Blaikie and Brookfield (1987) have recently called *regional political ecology*.[3] More broadly, it falls within the field of human

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3 They define/describe its scope as follows: "The adjective 'regional' is important because it is necessary to take account of environmental variability...The phrase 'political ecology' combines the concerns of ecology and a broadly defined political economy...the constantly shifting dialectic between society and land-based resources, and also within

ecology - that is, the study of human interactions with the natural and built environments and with one another. The research has used three case studies to examine the impact of modernisation on previously self-governing and sustainable traditional communities - with a view to drawing conclusions about the impacts of changes to-date and how these changes may affect the future viability of these, and other, village communities.

This thesis is divided into six substantive chapters. Chapter 2 introduces the land-food-people *problematic*, contrasting the FAO's policy strategies for agricultural intensification with the energy requirements and ecological consequences of energy-intensive agriculture. Bennett's (1976) concept of *ecological transition* is introduced; and attention is directed to the ideas of Schnaiberg (1980) in relation to economic growth alternatives, and to Douglass (1984b) for defining the meaning of the term *sustainable*. The later part of this section summarises the main criticisms of conventional agriculture (the FAO model) made by proponents of alternative agriculture. The techniques of energy analysis are introduced and different methods of analysis discussed. The literature relevant to the impacts of development strategies on agricultural modernisation, energy use and the agricultural environment are then reviewed from the perspective of sustainability.

Chapter 3 introduces the island of Bali through a summary description of its physical geography, population, employment and land use patterns. This chapter emphasises the rapid changes in staple crop agriculture that have been occurring during the last 15 years. In particular, it contrasts the resource, energy and organisational demands of HYV rice with the demands of traditional rice cultivation. The conclusion of this chapter summarises the broader changes in island-wide resource use arising from motorised transport, electrification and urbanisation.[4]

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classes and groups within society...also...a concern with the role of the state." (Blaikie and Brookfield 1987:17).

4 Examination of detailed appendices in Volume II of this thesis are an essential accompaniment to reading the text. The structure of the appendices mirrors the text. All appendix tables referred to in the text are prefaced with the letter 'A' (e.g. Table A3.4.2).

Chapter 4 describes the three villages selected for intensive study. These villages were selected for three reasons: first, to represent the range of biogeographical conditions found in the southern, rice-growing area of the island; second, as a surrogate for time-series data on the impact of modernisation on village communities; third, to illustrate differences in the impact of the three major sources of modernisation (urbanisation, tourism and government development programmes). A range of analytic techniques are used to demonstrate that there are significant agricultural and socioeconomic differences between the three villages. Having established these differences, the data is then used in the following chapters to support the contention that modernisation is having similar effects throughout the region: increasing the variability of rice yields and family incomes, and increasing dependency on extra-local material and information sources.

The results of field surveys of rice cultivation, covering three cropping seasons in the rice fields surrounding each of the three villages, are presented in Chapter 5. These results are set against the background of island-wide changes in rice cultivation, based on data from government publications. The analysis of contemporary rice cultivation in the three villages is undertaken in both energetic and economic units of analysis. Energy analysis shows that the adoption of HYVs has resulted in a fivefold decline in energetic efficiency. Moreover, despite increased yields, rice farming based on HYVs is of doubtful economic advantage to individual farmers. The analysis reveals weak linkages between inputs of labour and materials and output of HYV rice. Attention is then directed to within and between season variability in yields and incomes that farmers experience growing HYVs. The conclusion is that the transformation of the energetics and economics of rice cultivation, resulting from the adoption of HYVs, is a main feature of the ecological transition.

The socioeconomic transformation is the topic of Chapter 6. Differences in sources of family income and patterns of expenditure are analysed both within and between the three villages, and are set against changes in the sectorial composition of the island's economy. This analysis reveals significant differences in income sources and expenditure patterns between income groups in each of the villages. The high income group, the top 20% of the income range, gain much more of their income from non-agricultural/wage sources than does the low income group, the bottom 40% of the income range. This low income group is still largely dependent on income from 'traditional' agricultural sources. Increasing reliance on 'modern' extra-local, non-agricultural sources of income is characteristic of the periurban village and least evident in the remote village. In each of the villages the high income group also spend significantly more than the low income group on consumption of 'modern' as opposed to 'traditional' goods and services. This trend is also apparent going from the periurban to the remote village.

Chapter 7, the final chapter, places these very recent transformations in the historical context of the predominantly agricultural character of earlier ecological transitions. This chapter also contrasts traditional Balinese conceptions of relations between humans and the natural and spiritual worlds, with the ideology implicit in the national drive for modernisation and centralised, urban-based control. Finally, this chapter restates the central argument of the thesis and turns attention to policy questions relating to the future of agricultural intensification in Bali and elsewhere. The conclusion is that energy-intensive, *fertiliser driven monocultures*, typified by cultivation of HYVs, have reached close to their limits of productivity and are, probably, unsupportable energetically and ecologically in the medium-term. In recognition of this near-term impasse between the need to feed a growing population and continuation of current agricultural policies and practices several policy suggestions are offered.

Chapter 2

Energy, Agriculture and Sustainability.

> Ecology is concerned with the external limits which economic activity must respect so as to avoid producing effects contrary to its aims or incompatible with its continuation...Ecology has a different rationality: it makes us aware that the efficiency of economic activity is a limited one and rests on extra-economic conditions...the ecological perspective is incompatible with the rationality of capitalism. (Gorz 1980:15-8)

2.1 Introduction.

This thesis concerns an *ecological transition* taking place in Bali, Indonesia. Its focus is on the manner in which economic development (i.e. modernisation) is resulting in broadscale changes in the ecological status of traditional village communities. From semi-independent, self-provisioning and sustainable agroeconomies into communities dependent, in many important respects, on material, energetic and information imports from extra-local sources. It is argued that these recent changes, while bringing needed and appreciated improvements to many aspects of people's lives, are undermining longer-term ecological sustainability and social cohesiveness.

The first section of this chapter outlines the land-food-people *problematic* and a strategy, advocated by the Food and Agriculture Organisation (FAO) of the United Nations, for growing sufficient food to adequately feed a growing population. For brevity, this energy-intensive approach to raising agricultural output in the Third World is referred to as the 'FAO model'.[1] The FAO model is examined, in particular, from the perspective of the resource demands and constraints that reliance on non-renewable energy sources entails; specifically, how *sustainable* is this approach to agricultural intensification? The second section focuses on the broad changes in agricultural energetics resulting from the extension of Western, energy-intensive agricultural

1 The FAO in conjunction with other institutions, has prepared a series of assessments of global agricultural needs and prospects over the last 20 years or so.

techniques to the Third World, as part of an attempt to adequately feed an ever-growing population.

The third section defines the concept of the *ecological transition*, a concept central to this thesis. The ideas of Schnaiberg are then used to contrast different approaches to economic growth and development, and these linked to Douglass's analysis of different meanings of the concept of sustainability; the later part of this section summarises the main criticisms of conventional agriculture (the FAO model) made by proponents of alternative agriculture. Fourth, the techniques of energy analysis are introduced, as a preliminary to a review of post-WWII energy intensification of agriculture. The energy intensification of Western agriculture provides a background for discussion of the energetic relationships of traditional and modernising agriculture in the Third World, in particular, the energy intensification of rice agriculture in Southeast Asia.

2.2 The Land-Food-People *Problematic*.

To place this study of ecological changes in Bali in a broader context, an overview of food production in the Third World is first presented, in terms of projected population growth and food requirements to the year 2000. In the following discussion, particular attention is directed to SE Asia and Indonesia. Second, the introduction of HYVs to Asia in the mid-1960s (the Green Revolution), the development ethos which shaped it, its technical requirements, and successes and failures are summarised.[2]

The solution proposed by Higgins et al (1982) in 'Potential Population Supporting Capacities of Lands in the Developing Countries', for the land-food-people *problematic* is the rapid industrialisation (i.e. energy intensification) of agriculture throughout the Third World. The report provides an overview of the magnitude of the problematic, however, there are a number of fundamental problems with the strategies advocated. Specifically, the study pays scant attention to alternative

2 Only brief mention is made of other relevant and important issues affecting food production such as: environmental degradation, the need for land reform and the socioeconomic consequences of agricultural modernisation.

socio-political approaches (e.g. land reform) or to resource constraints (e.g. energy supplies). In essence, it proposes an acceleration of the methods common to the Green Revolution. A parallel FAO study, 'Agriculture: Towards 2000' (FAO 1981), advocates an identical approach (incorrectly termed 'sustainable growth') and, likewise, ignores alternatives and constraints.

2.2.1 Population and Food Production.

By the turn of the century the world's human population will have increased to more than 6 billion (UN 1979). To feed this population global agricultural output will have to increase by 50-60%; in the Third World it will have to double (FAO 1981).[3] Some 20 years ago a multidisciplinary team from the FAO began to lay the groundwork for assessing the potential population supporting capacity of the planet.[4] To achieve their goal they assembled national, regional and sub-regional data on the interactions of soils and climate, matching these with crop requirements to derive food production potentials.[5] Their objectives were:

> to ascertain...the potential population supporting capacities of lands in the Developing World with various levels of inputs...[secondly] to compare these estimates with data on present and projected populations in order to identify problem areas where land resources are insufficient to meet the food needs of populations at present (or projected to be) living on them...(Higgins et al 1982:5)

Two time periods were used in the study, 1975 and year 2000.[6] In essence, they determined the present and potential agricultural area, natural agricultural potential and current (1975) crop mix from 1:5 million scale agroclimatic maps and, based on this, then estimated production potentials for

3 It has been estimated that all but about one sixth of this increase in food needs will come from increases in population (De Bivot 1975).
4 In the Third World the extent of "critical areas" in the year 2000 would then be (millions ha) 2015 (low), 1244 (intermediate) and 404 (high). By comparison, in 1975 these areas were: 2453, 1702 and 1434 million hectares, respectively. In the year 2000 "excess population" in critical areas at the three input levels was estimated to be 503 million (low), 141 million (intermediate) and 48 million (high).
5 Five regions were defined in the study: Africa, South West Asia, South America, Central America and South East Asia - these regions constitute most of the 'developing' regions or the Third World. The methodology is detailed in Higgins et al (1982:9-28).
6 Population sizes and densities were based on the UN (1979) mid-variant for 2000. Average Third World population densities in the year 2000 were estimated to be twice those of 1975.

fifteen major food crops[7] and grazing land at three levels of manufactured and managerial inputs:

> **low** - using no fertilisers, pesticide or improved seeds and no long-term conservation measures - equivalent to subsistence farming.
>
> **intermediate** - with some fertilisers, pesticides and improved seeds, conservation measures and improved cropping patterns on half the land [fertiliser input: approx. 40 kg nutrients/ha.]
>
> **high** - with full use of all inputs, full conservation measures and the most productive mix of crops on all land - equivalent to Western European levels of farming [fertiliser input:approx 80 kg nutrients/ha.] (Higgins et al, 1982:10)

In a companion volume written five years later, summarising and updating the FAO study, Harrison (1984:15) observes that none of the five regions, on average, had reached intermediate levels of input by 1980/81, although SW and SE Asia had reached 42% and 47%, respectively, of intermediate levels - with most fertiliser being used on irrigated land. In estimating the availability of "potential agricultural land" in the Third World, about three times the area currently cultivated, no allowance was made for the preservation of forests or other natural vegetation on land with agricultural potential. It was explicitly recognised that ecologically and economically this was not a feasible expansion of agricultural land.[8]

In subsequent discussion attention is focused on Southeast Asia and Indonesia.[9] For 1975 it was estimated that of the total "excess population" in the Third World, 56% lived in SE Asia. For Southeast Asia, using all "potential agricultural land" and with a low level of inputs, it was estimated that

7 Millet, sorghum, maize, rice, wheat, barley, soybean, phaseolus bean, sweet potato, white potato, cassava, groundnut, plaintain/banana, sugar cane and oil palm .
8 The study took into account needs for land for non-agricultural use (averaged at 0.05 ha/person) and loss of land due to degradation, estimating that in SE Asia unchecked soil erosion would lead to about a 12.4% reduction in productivity. No allowance was made for the areal requirements of non-staple food crops or non-food cash crops, which currently occupy "in excess of one third of agricultural land." Nor was account taken of constraints on the availability of natural or manufactured resources to meet these levels of inputs in the medium or longer term. The impact of various patterns of inter-country and inter-regional food trade was not included in estimation procedures.
9 In both 1975 and 2000 the average population density in SE Asia, with a total land area of 898 million hectares, was the highest of the five regions: 1975, 1.25 persons/ha; year 2000, 2.16 persons/ha.

1.1 times the 1975 population of 1,118 million could be supported; at this level of inputs, about one third of the region (313 million ha) was "critical", with an excess population of 316 million - mainly in India, Pakistan, Bangladesh, Nepal, Bhutan, and Sri Lanka. Potential productivity, if inputs were raised to an intermediate level, could reduce critical areas to 62 million ha (with excess population of 56 million); at high input levels there would be only a marginal reduction in the critical area to 45 million ha (with excess population of 31 million).

In 1975 the study estimated that 92% of the suitable land in the SE Asian region was already under cultivation, the extent of this area was growing at about 0.46% a year and by the year 2000 100% would be under cultivation. However, in 1975 in Indonesia, Malaysia, Burma, Laos and Kampuchea, less than half of the potentially suitable land was under cultivation (Harrison 1984:42).

Against this apparent potential for doubling the area of land used for food production must be set a number of factors. Comprehensive though the study was, it did not attempt to estimate whether non-land natural resources, especially energy, would be sufficient to supply the necessary inputs; and, if they were, for how long they would be adequate. By omitting consideration of ecological and energetic constraints on the solutions proposed, the study represents an approach to economic development and analysis of social problems characterised by Smith (1979) as "sustainability as food sufficiency", Douglass (1984) as "food sufficiency" and Schnaiberg (1975,1980) as the "economic synthesis" (maximising economic growth and ignoring ecological disruption).

First, the study's definition of "potential for food production" included no allowance for areas currently used for non-staple food crops, non-food cash crops or forests for fuel, construction and environmental protection. Second, as population growth slows the proportion of adults increases and average per capita calorie requirements rise. Third, inequalities in food distribution require that minimum calorie supply needs to be about 3000 per day, rather than 2100 per day used in the study, if significant levels of malnutrition are to be prevented. Fourth, with rising incomes, calorie intake increases above minimum requirements and includes a higher proportion of animal protein.[10] The authors conclude, conservatively, that the estimate of potentially cultivable land needs to be reduced "by at least one third" to take account of these factors (Higgins et al 1982:57).[11]

Harrison, who takes into account factors reducing the population supporting capacity of the land and bases estimates on the potential of "actually cultivated land", gives an estimate of the population that the region could support at a realistic standard of living, given increasing levels of agricultural inputs. These estimates are presented in Table 2.1.

Table 2.1:
Southeast Asia: Population Supporting Potential Divided by Actual or Projected Population.

Year	1975	2000	2025
Input Level			
Low	0.7	0.85	1.35
Intermediate	1.85	1.50	1.55
High	3.1	2.20	1.95

Adapted from Harrison 1984:41. Notes see Footnote 12.

Given these assumptions, the estimates reveal that achievement of average agricultural production equivalent to "intermediate" input levels is essential if poverty and malnutrition are not to become endemic to the region. However, within the region there are large variations in land endowments and other natural and economic resources that might be used to increase food production. In these respects,

10 Each adjustment results in an increase in the area of land required to support the population and reduces the 'maximum' potential population carrying capacity.
11 In the South East Asian region by the year 2000 (ignoring the foregoing caveats), with low level inputs the critical area would be 89 million hectares (excess population 71 million) - an improvement over 1975 largely due to increased production in India; with an intermediate level of inputs, about 15 million hectares would be critical (excess population 8 million); at a high level of inputs about 0.1 million hectares (excess population 3 million).
12 The figures show the fraction of the actual and projected population that the region could support. Ratios below 1 are critical, and for years 2000 and 2025 are unadjusted for reductions in productivity resulting from cultivation of unsuitable land. The proportion of "low input level" land is decreasing over this 50 year period as a result of development already underway.

Indonesia is in a relatively favourable position in the medium term, compared to some other nations in the region.

For Indonesia (1975) with low input levels it was estimated that:

> the islands of Sumatra and Kalimantan are virtually free of critical zones, almost the whole island of Java, carrying two thirds of Indonesia's population, is critical, along with Madura, Lombok and Timor and large areas of Sumbawa and Sumba. (ibid p.43)

At higher input levels:

> With intermediate level of inputs...the potential population supporting capacity is still not equal to the 1975 population in zones over almost the whole of Java. High level inputs...greatly improve the situation, leaving critical zones largely confined to the area south of Bandung [West Java]. Large extents of zones with high potentials are apparent in Sumatra and Kalimantan. (ibid p.43)

In summary, these studies conclude that there is need for an acceleration of the existing pattern of energy intensive agricultural development. This is explicitly stated in a parallel FAO study (FAO 1981), which estimates that, on average, approximately a 1% increase in edible food output requires a 2.4% increase in energy inputs. In other words, these studies advocate a general intensification of the so-called Green Revolution strategy; this can be characterised as an energy intensive and technocentric approach to increasing food production.

2.2.2 Agricultural Intensification in Southeast Asia.

In the past 20 years the staple rice agriculture in this region, including Indonesia, has been transformed by the introduction of HYVs of rice, a complex political-social-technical process commonly known as the Green Revolution. These new varieties require the application of substantial amounts of nitrogenous fertiliser to achieve higher yields. In addition, their effective use requires improved irrigation control, use of biocides and, importantly, new methods of crop and economic management. Off-farm, major investments are necessary to ensure the timely supply of essential physical, financial and educational inputs. In contrast, dryland agriculture in this region has remained largely traditional in terms of crop varieties and agricultural technology.

Rice is increasingly the staple food of Indonesia and, therefore, changes in the technology and economics of rice production profoundly affect most of the population. Naturally, villages which depend most on the cultivation and sale of rice are the most affected. In the broader scheme, rice is the crop that has been the target of most agricultural development efforts during the last 20 years. The combination of these two factors means that the changes in rice production represent, arguably, the most important penetration of new technology into village life (Brown 1970:10).

The modernisation of staple rice cultivation has transformed the types, sources and magnitudes of energy used in this agricultural system. In essence, a traditional, semi-subsistence system, previously independent of extra-local inputs, has been changed into a semi-commercial system, profoundly dependent on extra-regional inputs, many of which are energy intensive. This thesis attempts to throw light on two issues related to these changes. First, how *variable* are the yield results obtained by this new technology, and what factors may help to account for the observed variability in rice yields? Second, given current knowledge of energy resources (in particular oil and natural gas), is this new, fossil fuel-dependent agriculture *sustainable* in the medium to long term (50-150 years)?

2.2.3 The Green Revolution and the Development Ethos.

The 'new agriculture' evolved in the West as a continuation of the pattern of agricultural development that had started in the 18th Century with the Agricultural Revolution (Grigg 1984). However, until the 1920s attempts at increasing agricultural productivity (land and labour) had not resulted in widespread mechanisation or the use of industrial fertilisers. After 1945 these two practices provided a basis for increasing productivity of labour (reducing labour costs) and land (increasing yields) (Leach 1976). As a result, Western agriculture rapidly became industrialised - that is, largely dependent on products from urban-based industry for vital inputs and on urban markets for sales. In many respects the Green Revolution in the Third World has followed the same paths.

Green Revolution is the name coined by W.S Gaud of the US Agency for International Development (Wade 1974) for the intensification of wheat and rice agriculture in the Third World. For rice, in broad terms, it involves use of specially bred seed that is: highly yield responsive to applications of nitrogenous fertiliser; resistant to common diseases and pests, although requiring the application of pesticides; more quickly maturing than traditional varieties (110-120 days vs 140-210 days); and non-photoperiod sensitive, allowing planting at any time of the year. Compared to traditional rice varieties, which required no purchased inputs, the new HYVs require the purchase of seed, fertiliser, pesticides and fungicides, more critical control of irrigation water and mechanical milling. All of these inputs are energy intensive compared to traditional inputs.

Technically, this was a strategy of "betting on the strong" (Oasa 1981), developing rice varieties for areas where the social and physical infrastructure would most favour a radical increase in yields with the new rice. These were the lowland rice areas in Asia, where (traditional) irrigation systems existed, ensuring the reliable water supplies essential for obtaining higher yields. Moreover, these were areas close to urban centres, with relatively good access to extension services and transportation for supplying new information and inputs. However, these areas made up only one third of the rice growing areas in Asia (IRRI 1975). So, from the outset (1965), and for the next 20 years, only farmers in these areas could make use of the new varieties.

The Green Revolution also has a political economic history that is important to an understanding of why this method of agricultural intensification was 'chosen', and of its social, economic and environmental effects in the rural areas where the 'new agriculture' has been adopted. Oasa (1981), in an analysis of the political and institutional history of the International Rice Research Institute (IRRI), clarifies the economic and scientific ideologies that led to the search for "the ideal plant type" - a fertiliser responsive rice variety that would increase food production in densely populated Asian nations and, thus, remove the threat of a "Red Revolution".

The development of the new seeds that formed the biological basis of the Green Revolution was carried out by Western-trained experts, in Western-funded and controlled agricultural experimental stations and laboratories at IRRI, Los Banos, Philippines (Oasa 1981; Cleaver 1972). The aim was to produce rice varieties that, by the use of industrial inputs, augmented land productivity and provided increments in staple food production to meet the needs of rapidly expanding populations in the humid tropics (IRRI 1985). The approach was archetypically reductionist, and little attention was paid to potential economic, social and environmental effects (Freedman 1978; Oasa 1981).

Given that the economic and social consequences of adopting the new technology were poorly understood at the time, and that urban populations required relatively cheap staple food if political upheavals were to be avoided, altruistic motives may well have had less influence than personal, economic and political advantage (Kitching 1982; Mears 1984). At the rural level the political and economic advantages that accrued to local political and economic elites from the adoption of the new technology have been well documented (IRRI 1975:5; Wharton 1969; Falcon 1970; Ladejinsky 1970; Palmer 1976, 1977).

The commitment of investment funds and agricultural expertise that the expansion of the new technology required overshadowed or eliminated other, less technocratic, approaches to increasing food production in the Third World (Chambers 1983:75-102 and 1985:117-28; Goldsmith 1981a, 1981b). Increases in land productivity (and prosperity) that the HYVs have brought have been largely restricted to regions of well-irrigated, lowland rice cultivation. The concentration of effort on these areas has resulted in the relative stagnation of efforts to improve dryland staple agriculture (Oasa 1981; FAO 1981; Richards 1985:19).

Earlier this century agricultural scientists discovered that the application of suitable green manures to ricefields could substantially increase yields (Moll 1941). More recently the yield improving capabilities of the symbiotic, nitrogen-fixing bacteria *Azolla* have been investigated (Wananabe et al 1977 & 1981). While these methods of increasing available nitrogen cannot provide the amounts of nitrogen 'easily' supplied by industrially produced urea, they have a number of other advantages. In particular, they are labour absorbing, reduce dependence for farmers on remote, industrial inputs and reduce the energy intensity of rice cultivation. Yet, except in China and Viet Nam (FAO 1977), neither of these approaches has received a fraction of the investment of capital and expertise applied to urea and pesticide dependent HYVs.

Dryland agricultural development, both experimental and applied, has also been neglected due to the concentration on the problems of lowland HYVs (Beets 1982:9-10,133).[13] This has resulted in piecemeal efforts to discover improved multi-species, multi-storied tree/arable crop agriculture (polycultures).[14] In general, efforts have been focused on cash crops (in Indonesia: coffee, rubber, tobacco, cloves, vanilla, etc), to the neglect of (semi-)subsistence tree and root crops (Mears 1984). In large part this reflects the general thrust of agricultural development in incorporating farming families in the cash economy; in part the much more demanding research tasks involved in developing more productive, environmentally balanced, multi-species cropping systems (Willey 1979); and in part the technical difficulty of analysing the economic costs and benefits of such diverse agroecosystems (Buttel 1980; Etherington & Karunanyak 1981; Altieri et al 1984).

13 Beets (1982) presents a succinct overview of the potentials, problems and research needing to be done to make, what he terms, multiple cropping more productive and widely adopted.
14 Sometime also called 'agroforestry' where the intention is "to get higher productivity, more economic returns, and better social benefits on a sustained basis, than are obtainable from monoculture on the same unit of land." (Nair 1979).

Thus, the Green Revolution was not the only possible approach to increasing food production to match increasing populations. We cannot be certain at present whether alternative approaches would be able to provide the increases in food production required. However, given the economic and energetic demands of HYVs, intensification of research and extension efforts for improving dryland cropping offers a plausible, long-term and energy efficient alternative to further energy-intensification of rice cultivation.

Grace Goodell, writing about the Green Revolution in the Philippines, pithily sums-up the consequences for millions of farmers of "betting on the strong":

> Above all, the HYVs extraordinary complexity calls for many new strategies for each farm family to buffer itself against the technology's *unstable yields and profits* (which may on the whole be higher, but suffer far more radical fluctuations). (Goodell 1984, emphasis added)

2.2.4 The Green Revolution in Indonesia.

The advent of the New Order in Indonesia (1965/66) coincided with the success of efforts by the scientists at IRRI to develop new fertiliser responsive rice varieties (IRRI 1985). These rice varieties, in combination with the urea fertiliser that could be produced from Indonesia's resources of natural gas, repair and extension of agricultural infrastructure and agricultural extension programmes, promised to rapidly increase rice production. The first of these new rice varieties (IR8 and IR5) were more susceptible to pests and diseases than the traditional or 'Nationally Improved' varieties (developed in Bogor during the late 1960s). Thus, while they could produce yields 3 to 5 times greater than the traditional varieties under ideal conditions (sufficient and timely water, fertiliser and pesticide), the 'real world' agricultural conditions in Java, where they were first introduced, were far from ideal (Collier et al 1974). In 1963 a new organisational framework, BIMAS (*Bimbingan Massal* or Mass Guidance), was introduced and, despite initial failures, resulted in rice production increasing at an annual rate of over 4% in the decade after 1967. Increasing rice production, price stabilisation and development of reserve stocks have been central elements of the three national five-year development programmes that have operated since 1969/70.

Bernstein et al (1982) have reviewed the diffusion of HYVs in Indonesia, which by 1979/80 were planted on over 60% of all the lowland rice area in Indonesia. In Bali by 1980/81 more than 75% of all ricefields were planted with one variety (IR36) and a serious outbreak of of tungro virus was only just prevented (ibid). Recently Mears (1984) has reviewed the general development of the Green Revolution in Indonesia and its role in achieving national food self-sufficiency. He documents earlier, largely unsuccessful, attempts to intensify rice production, the rising level of rice imports (1954-83) needed to meet domestic needs and the great emphasis placed on rice self-sufficiency.

The Indonesian definition of food self-sufficiency was broadened in 1974 to include food crops other than rice. However, little had been achieved in these areas by 1979, and Mears comments that "Food self-sufficiency programs, for crops other than rice, are only beginning to show results in the 1980s", and that the massive commitment to increasing rice production had resulted in only "a fragile self-sufficiency" in rice by 1981 and "delayed the appreciable impact of programs for secondary staple food-crop[s]" (ibid). This imbalance was associated with unequal distribution of benefits from the BIMAS programme (Collier et al 1974; Palmer 1976; Schiller 1980; Montgomery 1981), the susceptibility of rice production to unfavourable weather (e.g.1982/83) and pest and disease losses (the brown planthopper plagues of 1974-75). In addition, declining oil revenues and rapidly increasing domestic demand for petroleum-based products (Pauker 1982), point directly to the need to reduce the dominance of fertiliser-dependent (i.e. *fertiliser driven monocultures*) and heavily subsidised rice production (75% of the production cost of urea fertiliser), in favour of less fertiliser-dependent and more diversified dryland agriculture (i.e. *fertiliser catalysed polycultures*).

2.2.5 Successes and Failures.

The Green Revolution, as a technological package, represents *par excellence* the major features of the FAO model. In order to assess the relative successes and failures of the Green Revolution four questions require answers:

Has it increased rice production?
Has it improved social welfare for farm families?
Has it caused significant ecological damage or loss?
Is it sustainable in the medium and longer term?

Questions two and three bring to the fore the possible social and environmental 'costs' of increasing production using Green Revolution methods. The last question, which is central to this thesis, addresses the durability of the production gains, given the well-known input requirements.

With regard to the first question, there have been substantial increases in rice production throughout South, SE and SW Asia, where about 90% of the world's rice is grown and consumed (Flinn & Unnevehr 1985), since the early 1970s. Asian production of unmilled rice has risen from an annual average of 237 million tonnes in 1961-70 (pre-HYV) to 322 million tonnes between 1971-80 (Barker et al 1985:40). In Indonesia rice production has increased from an annual average of 12 million tonnes (1956-65) to 19 million tonnes (1966-75) and then to 26 million tonnes (1976-80) (Barker et al 1985:45). By 1983 Indonesian production had reached 32 million tonnes of unmilled rice (Mears 1984).

With regard to the second question, there is ample evidence to suggest that larger or wealthier farmers are better able to afford adequate quantities of the necessary inputs; tend to have more education to aid in coping with technical complexities; and may also be better able to profitably take up ancillary economic activities associated with HYVs.[15] Thus, the introduction of HYVs into traditional village economies has the potential for effecting widespread changes in the distribution of economic power, and these changes have tended to be detrimental to smaller, poorer farmers (Kikuchi et al

15 Marketing inputs, establishing rice mills, purchasing and selling 'surplus' rice, lending money for buying inputs.

1980; see also Oasa 1981:25-50, for a review of the literature.)

Third, the new rice has marked effects on the ecology of rice cultivation, as pesticides and fungicides (biocides) kill many more species than just rice pests. These species (birds, frogs, eels, fish, insects) are important supplementary sources of protein, particularly for poorer families; and play a theoretically important, though largely uninvestigated, role in maintaining the ecological balance of rice fields.[16] Inexperienced and/or indiscriminate use of broadcast or sprayed pesticides can also easily poison those applying them or bystanders. More subtle is the loss of irreplaceable genetic material contained in the traditional varieties that the HYVs displace, the passage of only a few years is required for the complete loss of micro-adapted varieties developed by farmers over hundreds of years (Bernstein et al 1982).

The introduction of HYVs, therefore, leads to two types of ecological simplification:

> **microscale** - in which the use of non-photoperiodic rice varieties permits planting regardless of the season (given sufficient water) and the use of biocides and fertilisers severely disrupts traditional, stable reproductive relationships between diverse species that co-exist in ricefields during parts of the cultivation cycle; and
>
> **macroscale** - the cultivation of vast areas using the one hybrid variety (currently IR36) which makes staple food production vulnerable to pest and disease epidemics for which chemical solutions are not known (e.g. *Helminthosporia oyzrae*) or situations where supplies of chemicals and application equipment are insufficient or too late to prevent widespread crop losses and consequent hunger.

As has been mentioned, ricefield ecology is poorly studied. Indeed the lack of this kind of research is one of the main failures of IRRI research programmes. From general principles it is known that the reduction of ecological complexity (i.e. species diversity and richness) destabilises ecosystems (Cox

16 The role of spiders and geliids in controlling infestations of brown plant hoppers (BPH) has been demonstrated by Kenmore et al (1984) and use of insecticides shown to lead to explosive population growth of BPH (density x800) due to reduced spider and geliid population densities.

and Atkins 1979). This danger is in addition to the continuing loss of genetic material through elimination of traditional, micro-adapted cultivars.

In summary, the Green Revolution has succeeded in increasing rice production, with an overall increment in production of about 50% between 1961 and 1980. In Indonesia a doubling of production was achieved between the 1960s and 1980. No final answer can be given to the second question, although, generally, the larger farmers appear to have gained more than small farmers. There is, however, fragmentary evidence that there has been a substantial increase in the interseasonal variability of yields (Goodell 1984), compared to interseasonal variability of traditional rice, which most severely affects the economic welfare of smaller farmers.

Loss of genetic material and and reduction in species diversity in ricefields supports a general conclusion of environmental damage although, due to lack of research, a definitive assessment cannot be made. Certainly, the Green Revolution has not resulted in an improvement of ricefield ecology. An attempt to answer the last question is a topic of this thesis. In Chapter 5 an attempt is made to assess the yield reliability and sustainability of the new fossil-fuel based rice agriculture in Bali.

2.3 The Ecological Transition.

Bennett used the term *ecological transition* as an organising principle in a book about cultural anthropology and human adaptation - which he saw as the central subject matter of human ecology. He defined it as: "the progressive incorporation of Nature into human frames of purpose and action" (1976:3) and operationally, as the study of:

> how and why humans use Nature, how they incorporate Nature into Society, and what they do to themselves, Nature and Society in the process...Ecologically speaking...[as] the breakdown of local self-sufficiency...the tendency to seek ever-larger quantities of energy in order to satisfy the demands of human existence, comfort and wealth. (1976:3-6)

Bennett advocated that *sustained yield*, that is sustainability, be employed as a yardstick to measure the effects of human impacts upon the environment; whereas, *survival at a reasonable level of security* was the basic criteria for human welfare (1976:3). He deliberately chose very general standards to emphasise both human dependence on the 'goods and services' provided by nature and to avoid cultural specificity.

Bennett located the onset of ecological transitions in the period of the "anthropocentric orientation towards the natural world that emerged during the Western Renaissance" (1976:5), a process which has continued with increasing intensity up to the present. However, Bennett's definition of ecological transition as the "progressive incorporation of Nature into human frames of purpose and action" fits equally well the broad pattern of human cultural evolution from the neolithic onwards. In fact, in a later part of the same work Bennett applies the concept to encompass the period from 10,000 years BP to the present, commenting that the evolutionary ecological history of humankind:

> is not a single transition, but a great many, involving both natural resources and social structure, the human species and all other species, the surface of the Earth and the settlement of humans. (Bennett 1976:123)

However, while Bennett acknowledges "a great many" transitions occurring in the past, he focuses particular attention on the post-Renaissance period. For it is in this period that Western society moved from being in equilibrium with the local resources available from nature, to disequilibrium, moving into:

> "free space," not bounded space...seek[ing] resources wherever they are to be found...such societies have a philosophy of social continuity, but it is expressed by growth and change - development, improvement, increasing satisfaction not tradition...(Bennett 1976:137-8)

These are characterised as those "progressing from low-energy societies to high-energy civilizations" (ibid:139). This transition is clearly linked with, and dependent upon, the exploitation of fossil fuels, new forms of technology and economic organisation. Bennett illustrates the idealised characteristics of these ecological types in a diagram. The dichotomy he employs so adequately illustrates the pattern of changes occurring in Balinese society that it is well worth reproducing here (see Table 2.2).

Table 2.2:
Ideal Types of Societies Based on Ecological Equilibrium.

Societal Characteristics	**Societies in Equilibrium with their Environment**	**Societies in Disequilibrium with their Environment**
Population Dynamics	Small, Controlled	Large, Expanding, Weakly Controlled
Contact with Environment	Direct Contact by Maximum Number of People	Direct Contact by Minimal Number of People
Range of Exploitation	Restricted to Local Resources	Resources from External Sources
Sustenance Needs	Close to Minimal; Defined largely by Physiological Needs	Maximal; Defined in Large part by Cultural Wants
Gratification Expectations	Low, Controlled	High; Promise of Continual Expansion
Technological Capacity	Low; Wholly Solar Dependent	High; Increasingly Fossil Dependent

Adapted from Bennett (1976:139).

To summarise, post-Renaissance ecological transitions, as envisaged by Bennett, encompass much more than a shift from equilibrium to disequilibrium in human exploitation of natural resources, although this is central to the concept.[17] Such a transition, or series of transitions, involves fundamental and heterogeneous changes in philosophy, social and economic organisation, technology and consequent, large-scale intervention in and modifications of ecological processes. Specifically, such transitions involve increasing reliance on extra-local resources, increasing social-stratification and

17 Singh (1976:15) makes the differences in expectations and practices between the pre- and post-industrial revolution periods (the second half of the 18th century) clear in the following way: "the Neolithic agricultural revolution, with which civilization began, merely established a fact which lasted for thousands of years; the scientific-industrial-technological revolution initiated a movement, which is still continuing" (emphasis original).

the release of consumption patterns from traditional social controls. He concludes his summarisation of what the modern ecological transition involves with the following comment:

> lower energy solutions to civilization practiced in Asian countries before the onset of "modernisation" may have been rooted in the greater emphasis in these civilizations on man-in-Nature ideals (1976:140)

This is the point of departure for this thesis, namely: The progressive transformation of Balinese society from a low-energy, equilibrium to an increasingly high-energy disequilibrium society - largely as the result of state-initiated economic development strategies.

2.3.1 Development of 'Middle Level' Hypotheses.

It may be that a somewhat more radical perspective of the relationship between development and sustainability, one linking economic structures and ecological relationships, offers a step towards the elaboration of 'middle-level' hypotheses. Schnaiberg's (1980) formulation brings these two facets into confrontation: an anthropocentric thesis and its biological antithesis - cultural/social desires vs the biological/ecological imperatives. This dialectic is more than merely abstract, it encapsulates the contemporary state of human successes, failures and neglects. At its most particular, the skewed distribution of wealth and welfare between individuals and communities, at its most general, the devastating imponderables of nuclear war.

Schnaiberg's thesis is that "economic expansion is a social desidaratum"; the antithesis is that "ecological disruption is a necessary consequence of economic expansion". Schnaiberg proposes that there are three alternative syntheses generated by this dialectic:

> an *economic synthesis*: which ignores ecological disruption and attempts always to maximise growth - this is the "unbridled" capitalist and state socialist synthesis.
>
> a *managed scarcity synthesis*: which aims to control the most pernicious forms of pollution and resource depletion - a regulatory approach to moderating the effects of "perpetual" growth.

> an *ecological synthesis*: resulting in substantial controls on production and consumption and aiming for a "sustained yield" - the pattern of production and consumption in traditional societies and a global necessity in the middle-term.

He argues that the synthesis adopted reflects historical and contemporary economic structures, and observation and analysis of the synthesis practised provides a way to understand social and economic responses to resource constraints. He contends that the *economic synthesis* reflects a regressive (inequality-magnifying) economic structure and the *ecological synthesis* reflects a progressive (equality-fostering) structure, one more open to seeking a dynamic balance (homeostasis) of social and biological necessities.[18]

These three syntheses define a region of outcomes - 'corners' of a multidimensional triangle. In contemporary locations one or more of these syntheses will be being acted upon, to some degree. For example: the corporate boardroom or the stockmarket exemplifies the economic synthesis; pollution control, selective education or urban renewal the managed scarcity synthesis; and locally-directed community development the ecological synthesis.

2.3.2 Development and Sustainability.

Schnaiberg's confrontation of the economic and ecological syntheses provides a powerful point of departure for distinguishing between the intended and unintended consequences of development, and constraints on availability of natural resources. Broadly, the intended effects are the improvements in human welfare: to be brought about by increasing the productivity of traditional peasant agriculture and integrating the village economy and society into regional, national, and hence, global economies. The unintended effects, broadly, are those which undermine the long term viability of food production systems and village local/civil society: making people's welfare dependent on urban-mediated

18 This contrast is similar in many ways to Riddell's (1981) contrast between the 'hard' and 'soft' approaches to development, the soft approach finds expression in the term ecodevelopment: "the concern for self-reliance...a 'best fit' attempt to optimise the balance between population numbers, locally available resources and culturally desired lifestyles." (p.5), which rests on two premises: "a recognition of the constraining influences of the law of entropy.. [and] a recognition of the consumptive power of cultural forces" (p.8).

goods and services from outside the village environment and removing from local people control over the aims and methods of community development (Gorz 1980; Illich 1974a & b).

The conflict between ecology and (neo-classical) economics has been one of the central themes in human ecology, and Young (1983) highlights Boulding's (1966) exploration of the similarities and differences between ecology and economics. Boulding accepted that economics is a 'subset' of ecology, one of the earliest attempts to reconcile these two syntheses.[19] The next forceful discussion of the economic and ecological syntheses had to await Georgescu-Roegen's paper of 1972, which pointed directly at the incommensurable nature of money and energy. He emphasised the fundamental dependence of human welfare and civilization on the availability of 'free energy'[20] and the inevitable exhaustion of resources (particularly minerals), even with a 'steady-state' economy. Odum (1967), in particular, attempted to explicitly link natural and social 'value' exchanges in an analytic model, and depicting money and energy as counter-rotating flows.

Throughout the development of human ecology, particularly in sociology, anthropology and geography, there has been an emphasis on the importance of processes, the location and scale of communities and human-environment interaction (Young 1983). The processes of interest have been both biological and social (those involving exchanges of matter, energy and ideas), frequently drawing on biological concepts of competition, succession and carrying-capacity to facilitate analysis. Community, variously defined, has generally been the 'natural' unit of study: villages and neighbourhoods. And, depending on the scholar and topic, more or less emphasis has been placed on socioeconomic or environmental aspects of human interactions.

19 The crucial differences between the units of measure/exchange of ecology and economics (energy vs money) were glossed over by Boulding, and the similarities noted were, necessarily, simplistic and, in one instance, distinctly forced.
20 Free energy is energy which is available to perform (useful) work. High quality or high density sources of energy, the quality of which is degraded in performance of the work, that is increases entropy.

A number of different academic disciplines have used the flows of energy through human communities to develop and test hypotheses concerning relationships between humans and their environments. The significance of energy for evolutionary fitness (in a neo-Darwinian sense) was first formally stated by Lotka:

> In the struggle for existence, the advantage must go to those organisms whose energy-capturing devices are most efficient in directing available energy into channels favourable to the preservation of the species. (1922:147)

More recently Howard Odum (1971, 1973) has argued that Darwinan fitness can be expressed in energetic terms:

> Lotka indicated that the maximisation of power (energy per unit time) for useful purposes was the criterion for natural selection. Darwin's evolutionary law thus developed into a general energy law. (1971:32)

Although some argument exists about the applicability of energetic efficiency as an indicator of human adaptation (e.g. Slobodkin 1972:294; Vadya and McCay 1975:296) it is widely accepted among biologists, human ecologists and anthropologists (Smith 1979).[21] Stanhill (1984a:1) lists an extensive array of natural and social sciences where the central theme is transformations and exchanges of energy. In anthropology energy flows have been used to describe and analyse the adaptation of hunter-gatherer, slash-and-burn and settled communities to their environment.[22]

In contrast to the approach commonly used in analysing energy flows, that is atemporal (instantaneous) energy efficiencies (output/input), Smith (1979) formally demonstrates that it is essential to take into account the duration over which energy is 'captured' and/or expended. What is important in assessing human (or animal) adaptation, in terms of evolutionary fitness, is maximising net energy flows per unit time, rather

21 Smith (1979) reviews and discusses the main arguments and applications of energetic approaches in anthropology as they bear on human adaptation.
22 For example, Lee's (1969) study of the !Kung Bushman; Rappaport's (1968) study of the Tsembaga Maring; Brooke-Thomas's (1973) study of energy flows in a settled agricultural community of the Nunoa Quechua of southern Peru in their high altitude environment.

than maximising instantaneous energy efficiency. He argues that:

> energy-limited organisms should increase their energetic efficiency in order to increase total net energy captured, while non-limited organisms should increase their energetic efficiency in order to minimise the time spent acquiring energy. (Smith 1979)

This challenges the assertion (Vadya and McCay 1975) that the attainment of energy efficiency necessarily conflicts with other adaptive goals, while agreeing that energetic efficiency has no "deductive priority over other factors" (Smith 1979).

From the perspective of sociology, Axinn and Axinn (1984) analysed the differential effects of development on subsistence and market-oriented farming families.[23] They proposed the use of a 'Recycling Ratio' (RR): expressing numerically the proportion of the total energy flows that are consumed within a family or community. They found that families with a high RR can be characterised as having a subsistence economy and those with a low RR a market-oriented economy. They suggested that the RR be used as an indicator of change, and that urbanisation leads to pressure on rural families to lower their RR, and so provide a 'surplus' for urban dwellers. They concluded that:

> One can infer...[that] there is a tendency for the quantity of energy conversion to be directly related to the level of social differentiation...[and that the] efficiency of energy conversion appears to be inversely related to the level of social differentiation. (Axinn and Axinn, 1984:138)

The results of some of this work have raised at least two serious questions central to human ecology. First, does ever increasing energy use result in ever increasing welfare (quality of life) or is there, for evolutionary reasons, an 'upper limit', beyond which more intensive energy use results in decreasing welfare (broadly defined)? Second, given the increasing dependence on non-renewable sources of energy (low entropy) for maintaining the 'smooth' functioning of society,

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23 They studied the effects of development on energy flows and social differentiation in Nepalese farming communities and the 'openness' or 'closure' of families and communities to new technology and information.

what are the consequences for human welfare of exhaustion or greatly increased difficulty (and hence much higher prices) in obtaining fossil fuels (e.g. Adams 1974; Newcombe 1976a; Chandra and De Boer 1978; Schnaiberg 1980; Axinn and Axinn 1984; and Smil 1984). This is the question of sustainability.[24]

Sustainability is a concept of particular interest in this thesis.[25] To reduce the concept of sustainability to refer only to the next human generation, or two, undermines its descriptive and analytic force. To accept that a suitable test of modernisation is that it succeeds, only, in providing adequate or increasing living standards for 25-50 years is to deny all notions of the existing population's responsibility for the welfare of its grandchildren (see Redclift 1984:23).

At least part of the confusion over what constitutes sustainable agriculture arises from the different orientations of those analysing the implications of current agricultural practices; and Schnaiberg's economic vs ecological syntheses bear directly on agricultural production. Independently, Douglass (1984b) identified three dominant meanings of agricultural sustainability, which he characterises as:

> sustainability as *food sufficiency;*
> sustainability as *stewardship;* and
> sustainability as *community*

These are characteristics that are effectively identical, respectively, with Schnaiberg's economic, managed-scarcity and ecological syntheses; in addition, each has a different time-scale, short, medium and long term.

The first of these (food sufficiency) is the definition generally adopted by mainstream economists and agriculturalists attempting to estimate future demands for food by taking into account, primarily, such factors as

24 Allied to this question, are issues to do with the distribution of benefits (equity) of technological progress, both within and between nations and regions.

25 In studying the effects of modernisation on a society which has persisted for at least 1000 years, Balinese society (Raka 1955), and supported a large population (approximately 700,000 plus) for at least the last 150 years (Crawfurd 1849:29), it is reasonable to argue that 'sustainable' agriculture (or other social activities) means practices that can maintain their productivity for a duration of a minimum of, say, 100-150 years (i.e. 4-6 human generations).

population growth, income elasticity of demand, international trade and possible government agricultural policies (Ruttan 1977; Freeman 1981; Larson 1984; Lockeretz 1984). This approach tends to ignore both resource availability (in particular energy) and the environmental consequences of agricultural practices. It relies upon the expectation of future technological advances to make-up for the depletion of resources and deterioration of the environment. It also ignores issues of distributional equity and the effects of continuing agricultural change on community structure and solidarity. This is the definition implicit in the FAO studies discussed previously.

The second definition (stewardship) takes as its point of departure the distinction between renewable and non-renewable resources. It emphasises the necessity of conserving renewable resources, whilst judiciously consuming non-renewable resources to augment the productivity of renewable resources (cropland, forests etc). At the same time it points to the need to avoid over-rapid use of non-renewable resources which might result in unsustainable production and consumption patterns, leading, in turn, to a collapse of the 'services' provided by natural systems (Gorz 1980; Jackson 1984b). This definition attempts to conceptualise sustainability in terms of long-term carrying capacity, and emphasises the need for restricting population growth and of conserving the resource-base necessary to support the population in the future.

The third definition (community) subscribes to most of the previous definition (stewardship), but places great emphasis on the need for promoting solidarity and co-operation between human members of a community and also between humans and the non-human natural world (Streeton 1976:3; Berry 1977; Sandbach 1980:23; Senanayake 1984).[26] This definition also explicitly includes the need for justice and participatory decision-making; in order to provide community members with the maximum opportunity to develop fully their individual talents (Cobb 1984). At root, it eschews human attempts to dominate and

26 For example, Streeton's axiom is that:"people cannot change the way they use resources without changing their relations with each other" (1976:23).

control nature and emphasises the need for farmers (and all people) to seek to act in concert with natural processes and to preferentially utilise renewable sources of energy and nutrients.

The appropriate definition of sustainability for this study is that of the *ecological synthesis* or *community*. This definition shares many common features with the political philosophy known as 'agrarian populism'.[27] This thesis focuses on the implications for sustainability of the growing dependence of agriculture and community life on extra-local, non-renewable resources, while accepting the central importance of the social goals of community justice (fairness) and decision making, in the context of traditional Balinese communities,

2.3.3 Alternative Agriculture and Sustainability.
Recently the long tradition of 'alternative' or 'organic' agriculture has received renewed attention. This approach to agriculture aims to minimise (over)use of industrial 'inorganic' inputs and, consequently, dependence on non-renewable resources. Further impetus for current work comes, in part, from recognition of the resource constraints that energy intensive agriculture faces in the medium-term, in part from concern about the environmental degradation generally accompanying energy intensive practices (particularly in the USA and Europe), and, not least, from awareness of the growing social and economic shortcomings of industrialised, monocrop agriculture (Logsdon 1984:3-18). By a natural extension, these criticisms and concerns apply to Western-initiated changes to traditional agricultural systems in the Third World, where increased staple food production is being pursued, almost exclusively, by industrialisation of agriculture (i.e. the FAO model) (Wright 1984:135-43).

These concerns focus on four aspects of the transfer of industrialised agriculture practices to the Third World: the

27 Redclift (1984) thoroughly explores the philosophical and political history of populism, with particular emphasis on Russia and Europe. Chambers (1983), implicitly, takes it as a starting point in his advocacy of a new professional perspective and commitment with regard to rural development in the Third World (Chs. 7 and 8). Richards (1985) employs this approach in exploring possibilities for increasing food production in Africa.

variability of the results achieved, its excessive resource demands (natural and capital), generally adverse ecological consequences, and the tendency to exacerbate existing socioeconomic inequalities (Redclift 1984:18). These can, for directness and simplicity, be characterised as concerns about agricultural sustainabiliy (Jackson 1984a:208-30).

The proponents of alternative agriculture challenge the tenents of industrialised agriculture on almost every front: technical, economic, energetic, ecological, social and philosophical. In essence they argue that - *if* we desire to create and maintain enduring, that is sustainable, agricultural systems and communities - 'reversals' of policy and practice are required on each of these fronts. Taking these points in order of descending generality: Philosophically they argue that, not only is the aim of domination of nature hubristic and de-humanising, but also fundamentally impractical - as humans rely totally on the 'free' public goods and services that the natural environment provides (Robertson 1984).[28] Socially they assert that viable, integrated agricultural communities are essential if sufficient labour is to be available (even to operate industrialised agribusiness farms); in the medium-term only viable communities can form the basis for handing-on vital information about the local agroeconomy to the next generation(s) of farmers, so specific and unique is each farming complex (Berry 1984; Worster 1984b).

The argument on ecological grounds is mounted from a number of points, many mutually butressing. Three of these points stand out. First, it is asserted that current agricultural practices are destroying the complex web-of-life in which farming is embedded (Cox 1984), that is (over)use of fertilisers and pesticides for short-term gain is undermining longer-term fertility (Jenny 1984), obviously this is strongly linked to the philiosophy about nature's 'free' services (Gorz 1980:20-3). Second, the rate of topsoil erosion is being accelerated beyond natural replacement levels (generally by

28 Robertson thoroughly reviews the philisophical and scientific history of of modern, industrial agriculture; see particularly Chapters 2 and 4.

several orders of magnitude) with current broad-acre farming practices: heavy machinery, multiple, bare-earth cultivations, minimal rotations and elimination of hedgerows and shelter-belts of trees (Brink et al 1975:625; Larson 1984:67). Third, is concern about the loss of genetic diversity, largely due to research aimed solely at maximising yield per unit area and time, and crop cultivar standardisation by seed manufacturers; both resulting in vulnerable, 'super-extensive' monocultures of cereal crops (wheat and maize in particular) and the loss of thousands of locally adapted cultivars (even those stored in 'seed banks') (Snyder 1984).

Pointed criticisms concerning the energetics of conventional agriculture are raised in the next section (see also Lovins et al 1984). From the alternative agriculturalists point of view, it is *because* conventional agriculture is mistreating the farming ecosystem that such massive inputs of energy intensive chemicals are required to make-up for the loss of inherent soil fertility (Cox 1984); quite satisfactory (profitable) net yields can be obtained using (modified) organic techniques for maintaining soil fertility (Beradi 1978; Craumer 1978; Bender 1984). The economic points of alternative agriculturalists link, quite naturally, with their social and ecological assertions (Strange 1984). In essence, they contend that long-term economic viability of agriculture depends on: a net surplus over costs in the long-term (net real capital accumulation); avoiding massive debt burdens, by being able to draw on community support in good and bad times (Lindorff 1985; Buttel 1984:102); and benefiting from the local economies of 'small-scale', with minimum transaction-type cash overheads and some buffering from urban-centred inflation (Gerard and Johnson 1984).

Technical points are raised by alternative agriculturalists challanging many of the tenets of conventional agriculture. Foremost is the general contention that agriculture production is *not* the same as industrial production, to organise it as if it were a factory is, thus, bound to reduce both biological efficiency and undermine its ecological basis (Bender 1984). In a more strictly technical sense, some biologists suggest that, for instance, the application of biocides actually increases the susceptibility of (some) plants to insect attacks, unwittingly altering their biochemistry so as to attract predators (Chaboussou 1980). Other critics point to off-farm pollution of watercourses by runoff of agrochemicals, and the poisioning (both acute and chronic) of farm workers and families (and workers in chemical plants) by biocides - both undesirable side-effects which could be aleivated by reducing (over)use of energy intensive chemicals (Worster 1980a).

In contrast to the forms of agriculture operating within the *economic synthesis* with *food sufficiency* as its production goal, alternative agricultural practices fall within the ambit of the *ecological synthesis* or agriculture as *community*. The guiding test being whether agricultural practices, when examined from social, ecological, economic perspectives, appears to have to potential for (achieving) sustainability. In terms of Bennett's equilibrium-disequilibrium dichotomy, the general aim of alternative agriculture is to achieve an enduring balance between human necessities and the natural world's ecological processes.

2.4 Energy Analysis and Agriculture.

Since the 1973 'oil crisis', probably the greatest use of energy, as a descriptive and analytic tool, has been in attempting to assess the relative energetic (technological) efficiency of various food systems and the effects of development (agricultural modernisation) upon them. However, before reviewing the results of some of these analyses, it is necessary to provide a brief introduction to the techniques used in energy analysis and the central role that extra-somatic (fossil fuel) energy plays in contemporary agriculture.

2.4.1 An Introduction to Methods.

Energy analysis is an application of the Laws of Thermodynamics to human affairs. Initially these laws were applied in chemistry and physics and provided vital insights into the nature of interactions in the non-living world.

Early in this century their application was extended to the biological sciences to analyse predatory (competitive) relationships between trophic levels in the natural world that make up 'the web of life' (Phillipson 1967). Newcombe (1976a:6-64) has provided a detailed historical review of the development of theories about energy and their application to the analysis of human society and human-environment interactions. He concludes:

> The theory and application of energetics has provided a valuable tool with which to decipher and integrate knowledge to enable a greater understanding of the man-environment interaction...It is paradoxical that only now, long after the theoretical foundations have been laid, when our dependence on extrasomatic energy is almost absolute, we should become serious about the study of energy-use in human communities.(Newcombe 1976a:63-4)

The objective of Energy Analysis is to measure in physical units the amount of energy required to provide goods and services. This includes both direct energy inputs to processes and indirect inputs that are 'embodied' in processed raw materials and equipment used to accomplish the process, tracing each input back to its original source.

In estimating the efficiency with which inputs of energy are used in a production process the usable physical output of the process, measured in energy units, is compared to the GER.[29] In the case of agriculture, the metabolisable food energy produced is divided by the GER to estimate a measure of energy efficiency called the Energy Ratio (ER). Because protein is such an important component of diet, the quantity of protein produced for a given input of energy is sometimes also calculated (kg protein/MJ) - providing an estimate of the qualitative efficiency of the food production system; and allowing comparison between plant and animal protein production processes. Additionally, the quantity of energy used per unit area per crop (energy flux density, W/m^2 or D) is frequently estimated and used for comparative purposes.

29 The total of these inputs is (often) termed the Gross Energy Requirement (GER), and is measured in multiples of Joules (usually MegaJoules or GigaJoules, MJ or GJ).

It is important at this point to distinguish between three complementary approaches to energy analysis: a) input-output analysis; b) statistical analysis; and c) process analysis. The first two approaches are typically used in estimating energy flows in national agricultural systems; the third in the detailed study of particular, well-defined agricultural and/or industrial production process. The input-output approach adapts the econometric matrix methods (Leontief 1966) to calculate exchanges between all sectors of an economy to estimate the relationship between monetary and energy units for each sector of a whole national economy (Herendeen 1969; Bullard and Herenden 1975). The statistical approach uses published statistics on the consumption of material and energy inputs to sectors of the economy to estimate the energetic and/or labour efficiency of production within a sector or sub-sector (Roberts 1978). The process method attempts to identify all the direct and indirect energy inputs to a particular production process and, in the case of agriculture, relate these to the particular products of the process (Pearson 1976).

A 'proper' application of the process method (i.e. one that observes the guidelines developed by the International Federation of Institutes of Advanced Study (IFIAS)) requires the collection of primary data to identify the boundaries of the process (system), delineate each step in the process, measure labour and material inputs to each step and quantify material outputs (IFIAS 1974, 1975). At a minimum, data on inputs and outputs should be drawn from a well-defined (agricultural) region and not be averages based on data from a variety of different regions and/or cropping systems.

It is sometimes difficult to make a strict dividing-line between the statistical and process approaches to energy analysis. While the analysis of a national agricultural system is clearly statistical, the analysis of the production of a particular crop or animal is somewhat more difficult to classify; most of the literature comprises analyses of this sort. In these cases the author(s) have made a (more or less) diligent attempt to identify each component of a production process (usually from published sources)_ and estimate the energy content of each of the inputs thus identified; estimating the energy content of the output(s) in the same way. The accuracy of the analysis depends wholly on the exactitude with which the boundaries of the production process(s) have been reported in the literature, the amount of (disguised) variance in aggregated data and the accuracy of the reported quantities of inputs and outputs.[30]

2.4.2 The Industrialisation of Agriculture.
In this section an overview is presented of the increasingly important role extrasomatic energy has come to play in agriculture - first in 'developed' nations and more recently in the Third World. Second, brief mention is made of the threat to agricultural productivity posed by energy shortages, absolute or relative, that are likely to emerge in the next 50 to 100 years. Finally, the need for field-studies of the effects of the energy intensification of agriculture is argued.

As agriculture has become more industrialised and population more urbanised the 'length' of the food-chain from farm to consumer has become longer, more complex and consumed more energy. In developed countries, particularly the USA, three to four times more energy is now consumed between the farm-gate and ultimate consumers than on the farm (Pimentel and Pimentel 1979). It is clear, therefore, that industrialised food-chains are highly dependent on non-renewable energy supplies.[31] For instance, the proportion of total national energy use devoted to food supply in an industrialised country, the UK, has been estimated as 16% (Leach 1976); a recalculation by Dovring (1984) for the USA indicates that the

30 In addition to these uncertainties, all analyses have to depend on the published sources for data on the energy content of material inputs and outputs. An example of the differences that these factors can make, in the case of maize production in the USA, is highlighted in Smil et al (1984). Another example is the differences in the published data on the energy and nutrient content of (staple) foods, for instance, between Platt (1962) and the Nutrition Almanac (1975).

31 Leach (1976:4) defines as pre-industrial agricultural systems requiring zero fossil fuel inputs; as semi-industrialised systems where 10-95% of total energy inputs are fossil derived; and as fully-indistrialised those systems where human and animal labour constitute less than 1% of all energy inputs. For example, agricultural workers in 1972 in the UK were backed by as much energy in the workplace as are workers in heavy industry (ibid:21).

proportion there is 4.5% of national energy use, rather than the 3% previously estimated (USDA).

In developing nations the length of the food chain is much shorter and less energy intensive - although its length, complexity and energy cost are increasing. Clearly these factors are associated with the prevalence of traditional agricultural systems, a largely rural population distribution, minimal consumption of processed/manufactured food, (generally) less elaborate food preparation and, not least, lower nutritional standards. The much lower proportion of animal protein in the diet of most people in developing countries, compared to the large and growing proportion in developed countries, reduces the energy cost of food supply and storage. As part of the process of modernisation governments - particularly in in Indonesia, the Philippines and Malaysia - are encouraging the expansion of the livestock sector, the aim being to improve general levels of nutrition. Naturally, this expansion has the effect of increasing the energy cost of food production; it also requires devoting scarce, high-quality agricultural land to the cultivation of grain or root crops for feeding or fattening battery-produced meat and poultry.[32]

Only a few studies have been made in developing countries of the energy cost of the food supply chain, and the patterns and quantities of energy use are in sharp contrast to patterns in the developed countries (Leach 1976; Newcombe 1976a; Pimentel and Pimentel 1979). From the perspective of this thesis the projected availability of Indonesian energy resources is crucial. At current and projected rates of extraction Indonesian oil reserves and proven resources will be exhausted in about 35 years; for natural gas the timespan is a little longer, about 60 years (Pertamina 1980; BP 1985). Based on these projections of resources (i.e. absolute shortages by the mid-2000s) and the growing reliance on oil and gas for intensifying agricultural production (and transporting inputs and outputs) the 'new' agriculture is likely to run short of

32 See Leach 1976:84-6 for an analysis of energy costs of livestock production in the UK.

essential inputs only 3-4 generations after its widespread adoption.

The energy and environmental political groundswell of the 1970s stimulated the production of a number of increasingly sophisticated global and regional energy-population-economic computer model scenarios. The earliest of these, 'The Limits to Growth' (Meadows and Meadows 1972), anticipated a global crisis of growing proportions starting to have an impact in the late-1980s. More sophisticated regional models were rapidly developed as more powerful computer technology was used to construct ever more complex and multi-dimensioned models. The results of the more sophisticated models 'pushed back' the onset of a crisis of depleted fossil fuel resources (for example Mesarovic and Pestel 1975). However, all these models failed to deal adequately with distributional and equity issues (Galtung 1973).

Despite the more optimistic outlook on fossil fuel resources, since the global recession (1979-82) and growing conservation efforts, these newer models still projected an absolute shortage of energy resources starting to occur in 50 to 70 years time (BP 1985). The primary shortages foreseen are those of oil and natural gas - the two most efficient and flexible fuel sources, particularly for transportation. The economic effects of depletion are certain to be apparent well before this time (i.e. 2030-50 AD) and, the global distribution of economic and military power being what it is, it will be the populous, developing countries that will be most vulnerable to increases in relative energy prices (Banks 1980; FAO 1981). These problems will also beset those nations that have substantial energy resources and large and growing populations, such as Indonesia. In Indonesia in 20-25 years estimated energy exports[33] and domestic energy consumption (increasing rapidly with continuing development), will not *both* be able to be met from the available resources (Pauker 1982).

33 Mainly to the USA, Japan and Australia, the income from which largely funds the nation's development programmes.

Examination of the linkages between energy use and food production has received most attention in relation to energy intensive agriculture in developed countries. The approach used has been to quantify changes in energy flows that underpin modern agriculture, make projections of future energy requirements and define opportunities for improving both energetic and economic efficiencies (conservation) (Altieri et al 1984). A much smaller number of studies has been undertaken in developing countries and many (if not most) have been based on aggregated, secondary data. The severe problems of data reliability and aggregation of data from disparate agroeconomic areas within one country makes many of the results suspect (Smil 1981).

While these studies have provided a 'sketched-in' impression of the effects on welfare and energy flows of agricultural modernisation (i.e. increasing energy dependency in agriculture) - subject to inevitable flaws and omissions resulting from poor quality and aggregated data - they lack any information on the degree of variability (Dovring 1985) or the sustainability of the results being achieved by the 'new agriculture'. This lack can best be remedied by detailed studies of the impact of energy intensive agriculture (e.g. the Green Revolution) on small areas or several communities, which collect extensive primary data on the inhabitants, their agriculture and welfare.

2.4.3 The Application of Energy Analysis to Agriculture.

The energetics of agricultural systems have been intensively investigated only during the last 20 years. Early attempts at equating biological inputs and outputs were those by Clark and Haswell (1971), who analysed the yields of a number of agricultural systems in terms of the human effort expended. Hanks (1972) used a similar approach in analysing and comparing traditional and modernising rice cultivation in Thailand.

It was not until Durnin and Passmore's (1967) studies of the energetics of specific work tasks in industry that detailed data on human energy expenditure for specific agricultural tasks allowed inputs of labour and other materials and outputs of food to be expressed in common units (Joules or Kilocalories). Black (1971) presented an overview of the energetic efficiency of a wide range of agricultural systems, using energy inputs and outputs as the basis of comparison. These efforts allowed assessments to be made of agricultural practices in units that were not anthropocentric, thus allowing a comparison between the biological and economic aspects of agriculture.

Howard Odum's (1967) comparative analysis of six food production systems represents a landmark, analysing for the first time the role that fossil energy plays in increasing the productivity of agricultural systems. Pimentel et al's (1973) analysis of the energetics of maize production in the USA since 1945 showed that over 25 years the yield of maize had doubled but that energetic efficiency had decreased by about 25%. The accuracy of this decline in energetic efficiency was challenged by Smil et al (1984) but, after a recalculation of indirect energy inputs to fertiliser production[34], Dovring (1985) concluded that:

> the data re-establish the conclusion which Pimentel et al [1973] had reached for the wrong reasons: energy productivity in corn production appears indeed to have been declining.

The decline in the energy ratio (efficiency) was, however, greater than that calculated by Pimentel et al, falling 36% between 1945 and 1974 (from 5.2 to 3.3).

In 1976 Gerald Leach presented a detailed analysis of the energetics of some 50 component sub-systems of the UK food system - covering production, processing and distribution - highlighting the transformation of the energetics of the food system since 1945 caused by the widespread adoption of chemical fertilisers and mechanisation. In particular, he showed that the radical increases in the production of animal products in the UK (which consumed about 80% of all the grain

34 Which were 1.637 times greater than those used by Smil et al 1984.

grown and imported) further decreased the energetic efficiency of food production.[35]

Using Leach's data Stanhill (1984b) estimated that up to a 'non-solar' energy input level of about 1.0 GJ/ha/yr the yield of food energy increases approximately linearly; above this level there are declining returns to additional energy inputs until, at about 10 GJ/ha/yr, there is no additional increase in yield. This type of comparison emphasises the diminishing returns resulting from increasing energy intensity. However, it should be noted that, while the energetic efficiency of an agricultural process may be low, the energetics of the process often bear little relationship to its economic efficiency or profitability (Newcombe 1976b).

In the last 15 years a large number of *statistical analyses* of food production systems have been published, almost all analysing the industrialised agricultural systems of developed nations.[36] While these studies provide a useful overview of agricultural systems, their accuracy is limited by aggregation of data from many different scales and types of crop and animal production systems that co-exist within any national agricultural economy. For instance, Buttel and Larson (1979) show that for grain production in the USA from 1950-70, farm size and energy intensity per hectare were positively linked; Leach (1976), Stanhill (1974) and Delage et al (1979) have shown the effects of the scale of livestock production on agricultural energy efficiency; and Stanhill (1980) used protected (enclosed) tomato production, the world's largest protected crop, to illustrate the wide range of energy efficiencies obtained in a specific agricultural process.

The main aims of these analyses have been to trace the increasing energy intensity of agriculture, resulting from the substitution of mechanical power for human labour and the

35 Leach also calculated the energetic efficiencies of 85 food production systems - ranging from the shifting cultivation of the Tsembaga Maring of New Guinea to the industrial production of protein from petroleum and methanol feedstocks.

36 Only a few input-output analyses of agricultural systems have been published. Hirst (1974) used this method to estimate the changes in the energy requirements of the US food system from 1960 to 1970. Heerenden and Bullard's (1974 & 1982) studies of the energy costs of goods and services in the USA included agriculture. More recently, James (1980) and James et al's (1982) studied energy use in the Australian economy for 1968/69 and 1974/75, respectively.

increasing use of chemical fertilisers to augment or maintain soil fertility; and to compare these changes with increases in land and labour productivity. Stanhill (1984b) presents a comprehensive overview of this process of substitution, concluding that there was a steady increase in substitutions from 1900 until the mid-1960s, a rapid upsurge until 1973 and a slight decline thereafter.[37]

Wide variations in energy input-output relationships, arising from aggregation of data from within national or regional systems and biogeographical differences between regions, prevent anything but the most generalised conclusions about the relationship between agricultural productivity and energy flows. However, it is clear that industrialised agricultural systems are much more fossil fuel intensive than pre- or semi-industrialised systems; and, globally, variations in energy flows in agricultural systems span two orders of magnitude for labour intensity and three orders of magnitude for fossil energy use and food productivity.

The *process method* of energy analysis provides a means for making more accurate comparisons of the changes in agricultural systems over time; and provides a superior means for identifying potentials for energy conservation in specific cropping systems. The disadvantage of this approach is that the results provide only a limited basis for generalisations and this research approach, if carefully undertaken, is time consuming to conduct. Some researchers have used this method to compare alternative agricultural production systems. Lockeretz et al (1981) compared conventional and organic maize production in the US 'Corn belt' - concluding that the organic methods resulted in similar economic results, one third less soil loss and an ER higher by a factor of about 2.4. Berardi

37 Delage et al (1979), using the example of French agriculture, for which the longest data-series is available, showed that the augmentation of human labour and natural fertility rose from a turn-of-the-century level of about 22 GJ/yr/worker (1892) to 115 GJ/yr/worker (1965), jumping to 333 GJ/yr/worker by 1975. A similar pattern was evident in British and US agriculture during the post-WW II period, reaching 426 GJ/yr/worker in the UK (1972) and 264 GJ/yr/worker in the US (1970). During these 70-odd years the energy content of food production per worker also rose significantly: in France from 28 to 243 GJ/yr (1945-75) and in the UK from 142 to 347 GJ/yr (1952-72); comparable data is not available for the USA (Stanhill, 1984b).

(1978) reached similar conclusions in comparing conventional and organic wheat production in New York State.[38]

Pimentel et al (1973), in this and other articles (Pimentel et al, 1975; Pimentel and Pimentel, 1977), used the energy intensive example of US maize production to demonstrate that conventional US agricultural methods, whatever their other advantages, could not be adopted, even as a medium-term solution to increasing agricultural productivity in the Third World; and that the energy demands of this type of agriculture made it unsustainable in the longer term.[39] Such a conclusion strikes directly at the applicability of the strategy of agricultural intensification proposed in the FAO model.

2.4.4 Energy Analysis and Third World Agriculture.

This section presents a review of research into agricultural energy flows in Third World agricultural systems. It begins with examination of energy flows in settled agricultural systems in which introduction of HYVs of wheat, rice and maize have raised crop yields, made agriculture more dependent on extra-local sources of technology, energy and information and lowered the energy efficiency of staple crop agriculture. In general, human and animal labour inputs per crop have remained similar to pre-HYV levels, although new extra-farm processes have been mechanised (e.g. milling and transport). Increases in crop yields have mainly come from use of HYVs, improved irrigation and industrially produced, energy-dense fertiliser, each of which has augmented land productivity.

In the Third World, where data collection is sketchy, the data collected often of doubtful reliability and the majority of farmers not literate record keepers, the problems of

38 The method has also been applied to livestock production. Craumer (1978) concluded that Amish dairy farming, whilst using about 1.5 times more labour than 'modern' dairies, used 62% less energy, less land and gained higher returns per hectare. Dawson (1978), in a study of upland New Zealand sheep and beef production, showed that energy intensity increased with stocking rates, and that energy conservation was only possible by reducing fertiliser and transport use. Phipps et al (1976), in a comparison of stock-feed production in the UK, showed that 'recycling' of manure could provide substantial energy savings, without extensive modification of existing farming systems. All these studies relied on data collected from the farmers (thus conforming to the IFIAS guidelines) to assess alternative agricultural technologies.

39 Leach (1976:31) estimated that in 1972 if all the countries in the world (industrial and non-industrial) had attempted to feed themselves using industrial agricultural practices common to Europe and the USA it would have required 40% of global fuel consumption.

conducting any type of agricultural research are considerably greater than in developed nations. To date most studies of energy flow in agriculture have been based on aggregated secondary data at national or regional levels (e.g. Stanhill 1974, 1979 and 1981; Smil 1984). In addition to serious problems concerning reliability (see Smil 1981; Dazhong and Pimentel 1984a, 1984b), there are further problems due to the incompleteness of coverage of data from nations where much of agricultural production is for subsistence and there are great variations in productivity due to natural and technological constraints.

Thus, one of the most quoted publications (Makhijani and Poole 1975), on the supply and use of energy in six Third World agricultural communities was, perforce, based upon partial and hypothetical data concerning levels of agricultural activity, land and livestock ownership, labour resources and cropping inputs and outputs. Only very tentative estimations could be made of the likely effects of modernisation on energy flows or aspects of village development impeded by shortages of energy.

To the author's knowledge no input-output type of energy analysis of Third World agriculture has been undertaken. What follows is an overview of the statistical and process method analyses of energy flows in Third World agriculture, particularly rice cultivation. Some articles document energy flows in traditional systems of agriculture (e.g. Dazhong and Pimentel 1984b); some contrast traditional and transitional (modernising) systems (e.g. Freedman 1978); and others contrast traditional and modernised systems (e.g. Newcombe 1976). Overall these studies focus on four aspects of agricultural production: labour inputs to cultivation (human and animal); direct and indirect fossil fuel inputs; food output; and nutrient flows. These factors are widely used in comparative studies between modern agricultural systems, particularly that of the US, and Third World agriculture (e.g. Pimentel and Pimentel 1979).

Newcombe's (1976a) study of energy flows in the colony of Hong Kong was a major attempt to examine energy and nutrient flows and the effects of modernisation and industrialisation upon them. However, because Hong Kong produces only a small proportion of the food it consumes[40] the investigation was largely restricted to quantifying agricultural energy and nutrient flows in intensive vegetable cultivation. The modernisation of horticulture in Hong Kong resulted in ERs falling from 24.4 to 0.3 - the consequence of a 585% increase in energetic inputs to vegetable production (Brassica spp.) and only an 8% increase in yields (Newcombe 1976b).[41]

Stanhill (1981) used historical data and a statistical approach to determine the productive efficiency of irrigated Egyptian agriculture in 1800.[42] Labour inputs per hectare (20 MJ) were comparable to many pre-industrial agricultural systems. In an earlier article on contemporary Egyptian agriculture (Stanhill 1979) he concluded that the system was more efficient in its use of solar and fossil inputs than contemporary industrialised systems in Europe and the US. Most importantly, he concluded that energy-intensive, irrigated systems of Israel and California show "no evidence that they would produce more food [per ha]".

Dazhong and Pimentel (1984a) analysed the energetics of contemporary production of rice, wheat, sorghum, soybean and millet in NE China. ERs for maize production were similar to those in the NE US, although labour inputs were 100 times greater and fossil fuel inputs about one third less. They concluded benefits could be gained by selective mechanisation of compost transport, weeding and planting, that additional fossil inputs would be about the same as the human energy saved and that additional land would be released for food production, rather than used for grazing draught horses.[43] In a second article, Dazhong and Pimentel (1984b) analysed the

40 In 1973 it produced only, 3% of the grain, 26% of the vegetables and 10% of animal protein consumed in the colony.

41 Analysis of the flow of nutrients in the system showed that organic 'wastes' (1257100 tonnes/year), now pumped into the sea and watercourses, could supply nutrients for 21830 hectares of land (at 400 Kg N/ha) (Newcombe & Nichols 1979), and that recycling human and animal 'wastes' could significantly reduce pollution, waterborne diseases, energy requirements and economic costs.

42 Which he found to be more efficient than English agriculture of that time and to have higher wheat yields than a number of contemporary systems.

43 See also Jin,Y et al (1983) andHan,C-R et al (1985) for other statistical analyses of modernising agriculture in China.

traditional organic system (1952-54) and determined that it was self-sustaining, except for small nutrient losses; and was energetically comparable to traditional systems in Mexico, Guatemala, India and Nigeria. They conclude that production efficiencies achieved by the traditional system warrant further investigation for the contribution its methods might make to contemporary agriculture.

Freedman (1978, 1980 and 1982) reported on a comparative analysis of the energetics of alternative rice production systems in the Philippines. He compared traditional, transitional (labour intensive), Green Revolution (capital intensive) and experimental (management intensive) production systems. The study was an elaborate application of the statistical method to one crop.[44] Setting aside methodological shortcomings, he determined that the traditional method was most energy efficient (ER 13.8) and the Green Revolution method least efficient (ER 2.9) - although yields for the latter method were about 3.5 times those of traditional practices. He concluded that modifications of Green Revolution practices could offer high yields, while somewhat reducing the need for energy-intensive inputs.

Another study of alternative rice producing systems by two IRRI staff members (Kuether and Duff 1981) falls prey to the same kind of methodological flaws as that by Freedman (1978). In addition, it wrongly classifies as 'traditional' rice cultivation systems using fertiliser, biocides and machinery and, unrealistically, assumes that yields from each system are identical (3.5 Tm/Ha unmilled). The comparison they make is, therefore, between three modernised rice production systems using different amounts of mechanisation. Energy ratios (incorrectly calculated) were 6.57 for the (incorrectly specified) traditional system, 6.26 for the semi-mechanised system and 4.95 for the mechanised system. They failed to allow for milling losses (about 35%), thus the ERs for each alternative are overstated by about this amount and should be

44 Although he claimed to have used a process analysis methodology, the data used were from secondary sources and based on average inputs and yields obtained for traditional and HYVs from various, incompletely specified, locations and years (Freedman 1978:211-12).

4.27, 4.07 and 3.22, respectively. In each of the alternative systems fertiliser and biocides account for approximately half of total energy inputs. Unsurprisingly, they concluded that increasing dependence on commercial energy sources make the system more vulnerable to increases in energy prices.[45]

In a unique study, Briscoe (1979) used energy analysis to examine the effects on social structure of agricultural modernisation in a Bangladesh village. His emphasis was on who controls energy resources, not the energetic efficiency of agriculture. In this village, in which religion is the main basis of economic class differences (the Hindu minority are poorest) and crop residues provide over 70% of fuel needs, traditional open access to these resources is now denied to Hindus by Muslims. Additionally, cultivation of short-stemmed HYVs of rice in place of traditional long-stemmed varieties has severely reduced the absolute availability of crop residues. Because of population pressure and Muslims entry into fishing, competition for fishing resources has also become an arena of conflict, which the Hindus are losing. Briscoe concludes that:

> a modernising agriculture in Bangladesh is both essential and, given the social and economic structure, disastrous, for the majority of the population.

Research conducted in Sri Lanka by Bialy (1982) provides detailed descriptions of the pattern and magnitude of energy flows and their links with major economic transactions in a dry-zone agricultural community with a population of about 200 people.[46] Although most of the population live near subsistence levels, about half the food consumed in the village was imported, in addition to fertilisers and some fossil fuels. He concluded:

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45 Because of incorrect specification of the 'traditional' system, they wrongly conclude that "human energy represents a relatively small portion of the total input energy" (Kuether and Duff 1981).

46 He showed that the appropriate measure of the energy contained in biological matter was the heat of combustion and developed a modified form of Odum's energy flow diagrams to represent energy and economic flows.

> In a community where the flow of resources is not mapped to any significant extent by a flow of money, it is clear that a [energy and economic] flow diagram...gives a more complete description of the economy than would be possible with a conventional economic analysis...[it] effectively combines the ecological and economic interpretations of the use of resources. (Bialy 1982:236)

2.5 Conclusions.

It is abundantly clear that agriculture in the Third World is being intensified by, generally, the same methods that have been practiced in the now industrial, developed nations (i.e. the FAO model). All of the studies mentioned have drawn attention to the resource and economic demands that this process requires and the reduced energy efficiencies that result. Schahczenski (1984) in a review of Third World agricultural energetics, emphasised the relevance of energy analysis in technological policy formulation. However, because the majority of studies to date have relied upon secondary, aggregated data almost no information is available on the variability of the results achieved by the Green Revolution or the likely consequences of fossil fuel shortages on the sustainability of energy-intensive food production. Indeed, a survey of the literature reveals that no process energy analysis of the modernisation of traditional irrigated rice cultivation has yet been undertaken.

The concept of an ecological transition provides a useful descriptive tool in this study, directing attention to changes wrought by modernisation in both environmental and social (human-nature and human-human) relationships. Moreover, the use by Bennett of the 'sustained yield' yardstick fits well with the *ecological synthesis* and *community* typologies of development-modernisation proposed by Schnaiberg and Douglass. It also facilitates the assigning of the 'FAO model' of agricultural intensification to the *economic synthesis/food sufficiency* category, primarily for its failure to give adequate priority to issues related to resource and environmental sustainability. Conversely, the approach to agricultural intensification which aims to minimise dependency on non-renewable resources, make use of traditional/community resources and skills, by encouraging the preferential development of polycultures-agroforestry, reflects what Riddell (1981) (and others) have termed *ecodevelopment*.

One focus of this thesis is on the problems of agricultural variability and sustainability associated with the modernisation of rice cultivation in Bali. The thesis both describes and analyses the changes in energy and economic flows in rice agriculture arising from the broad effects of modernisation, and attempts to throw light on the consequences of these processes for agricultural sustainability. The second focus is the broadscale effects of modernisation on families' sources of income and patterns of domestic expenditure. The analysis is directed to the emerging differences within and between the three villages studied in the relative importance of wage-paying, non-agricultural income sources for low, medium and high income groups; and the significantly greater access of the high income group to new economic resources and information, partially via better education. The data for the analyses were collected in surveys of farmers and other inhabitants of three villages in Southern Bali during 1982-83; background information was obtained from village and government statistical sources.

Chapter 3

Balinese Human Ecology.

3.1 Introduction.

Bali has oft been the subject of romantic description, learned scholarship and, more recently, tourist brochures. However, little has been written by scholars on the natural history of Bali, the non-ritual aspects of how the Balinese make use of their natural resources or the changes that modernisation, in its many forms, is having on the relationship between the Balinese and their island environment.

This chapter first presents a description of the physical environment. Second, the increase in the size of the island's population over the last century is discussed and related to changes in employment; and, third, related to current land use and settlement patterns. Particular attention is directed to Kabupaten Gianyar, the focus of this research. Section 3.5 is devoted to a discussion of agricultural changes, especially the impact of new rice varieties (HYVs) during the last 15 years. In the later part of this section the relationships between increasing staple food production, population and agricultural energetics are analysed for the 1939-84 period. The next section discusses the marked increase in energy imports during the last 10 years, and overviews the role they have played in transforming the Balinese economy and society.

The major changes that are occurring in Bali are described from the perspective of an 'ecological transition' in the relationships between the island's human population, the natural environment and new resources. To make the nature of the transition clear, it is essential to take an historical perspective, although paucity of 'factual' information restricts the description that can be given.[1] The perspective concentrates on Southern Bali - the region that the Balinese

1 The discussion is accompanied by copious appendices, for which there are two compelling reasons. First, for readability the statistical nature and breadth of the discussion dictates that textual tables be kept to a minimum. Second, it is hoped that other scholars of Bali will be able to make good use of the hard-to-find data contained therein.

regard as *pusat kebudayaan Bali*, the centre of Balinese culture.

Before embarking on this description it is useful to present some information on the administrative divisions of the island. For administrative purposes Bali is divided into 8 *Kabupaten* (Regencies), whose boundaries generally conform to the pre-colonial kingdoms (see Map 1.1).[2] Each of the Kabupaten are subdivided into *Kecamatan* (Mayoralties); Kabupaten Gianyar, for instance, has 7 Kecamatan. The Kecamatan are further subdivided into *Kelurahan* (previously *Desa*), this being the lowest level of civil administration at which the government maintains permanent offices and full-time staff. Each Kelurahan is composed of a number of villages (*Banjar*), each of which has an 'elected' part-time official (*Kelian Dinas*), who is responsible for maintaining a census of the population and who also compiles village statistics. For this work he is paid a monthly stipend of about Rp 30,000 (1982) by the government.[3]

The description that follows is divided into sections, dealing with, Physical Environment, Population, Land Use and Settlement Patterns, Agriculture, and Energy Imports and Use. A final section draws together these observations and links them to the specific aims of the thesis.

3.2 Physical Environment.

3.2.1 Location and General Topography.

Bali, located immediately to the east of Java, is the westernmost of the Lesser Sunda Islands (see inset Map 1.1). To the east of Bali, separated by the Lombok Straits, lies the island of Lombok and from here eastwards there is a gradual transition in flora and fauna, first noted by Alfred Russell Wallace in 1869.[4] The island of Bali is volcanic, being dominated by Gunung Agung (Great Mountain) which rises to about 3,142 metres at the eastern end of the island; and

2 Except for Kabupaten Badung, Jembrana and Karangasem, the name of each regional capital and Kabupaten are the same.

3 In passing, it is worth mentioning that the reliability of the bulk of government statistical data on inter-censal population, land use, crops and livestock depends upon how diligently the Kelian Dinas collects and records the required information.

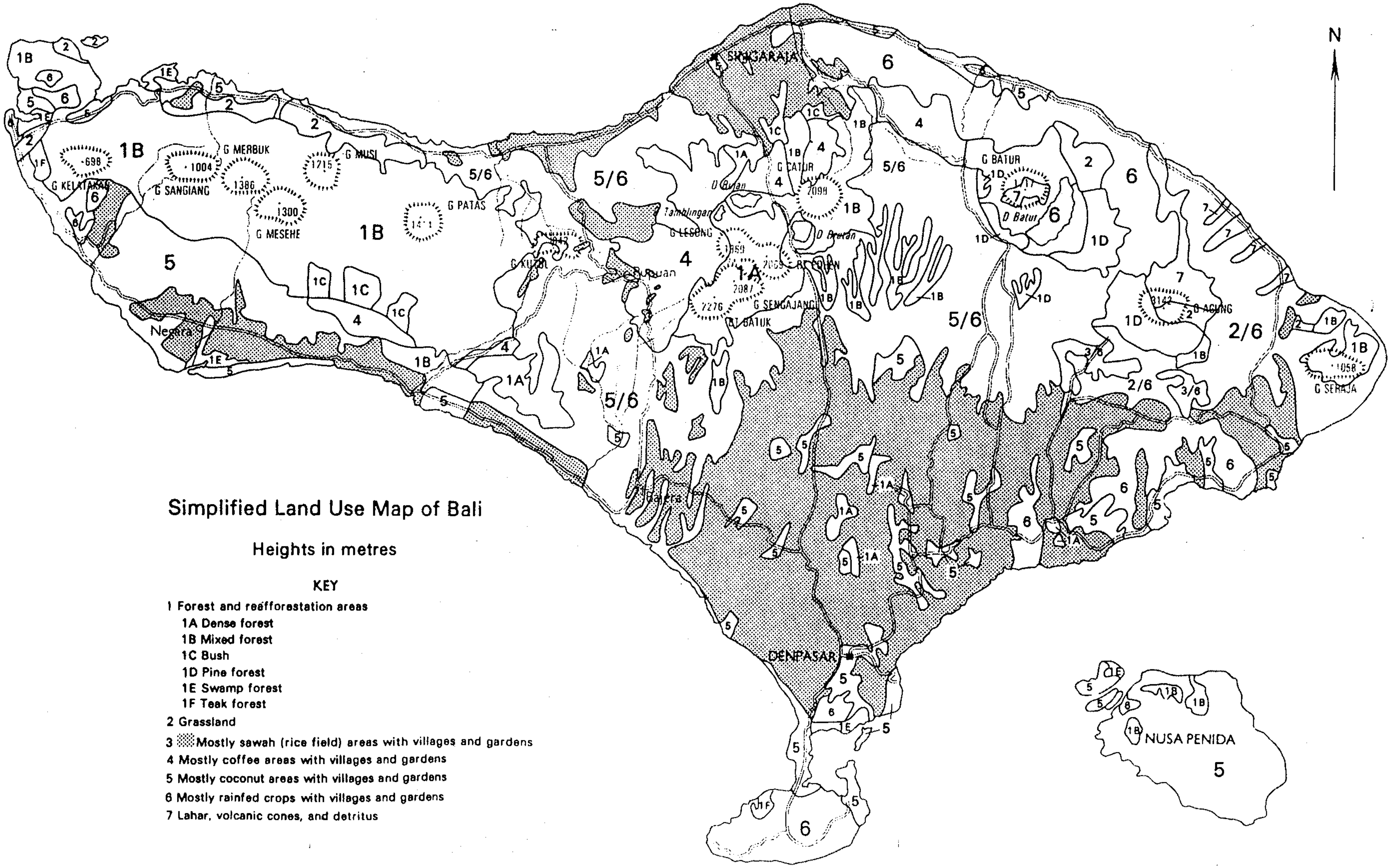
4 This division between Meleasia and Australasia is commonly called the 'Wallace Line'.

divided east-west by a chain of extinct(?) volcanoes. The highest of these Batu Karu (Broken Coconut) rising to 2,276 metres. On this small island there are 18 peaks over 1,000 metres and 7 peaks over 2,000 metres. In the centre of the island, nestled between these peaks are four caldera lakes, the largest being Danau Batur (Lake Batur) with an area of about 16 Km^2.

The island is approximately 5,600 km^2 in area, about 140 km long east to west and 90 km wide north to south. In appearance it has been compared to a fighting-cock, with the limestone plateau of Bukit at the south of the island forming the feet. To the north of the central ridge the land falls very steeply to sea-level (1400-0 metres over about 20 km); the northern coastline is formed by a narrow (about 3-10 km wide) coastal strip facing the Java Sea. The western part of the island is very mountainous, thickly forested and thinly populated; the northeastern part of the island is very rugged, dry and requires irrigation, even for successful dryland agriculture.

The area to the south of the central ridgeline is formed by the intersection of two volcanic fans, the eastern part formed by material from Gunung Agung, the western part by material from the western group of volcanoes. These fans slope down from an altitude of about 1400 metres to sea level over a distance of about 50 km, ending on a narrow coastal plain facing the Indian Ocean. Gradients in this region range from about 15% at the upper edge of the fans, to about 2% close to the coast (see Table A3.1.1). This is the most fertile and well-watered part of the island and the region most subject to centuries-old human modification. On these slopes live the majority of the population; in this region most of the island's rice cultivation takes place, and it is the area best known to visitors (see Map 3.1).

The volcanic fans are deeply incised by many relatively short, fast-flowing rivers. On the ridges between these valleys are located the rice terraces and villages that support and house the bulk of the population; deep, narrow valleys formed by



Map 3.1: Bali Lanuse (circa 197(

these rivers make east-west travel difficult. All of these rivers are utilised for irrigation, to such an extent that during the dry season little water reaches the ocean. The central area of the southern volcanic fan is drained by some 20 named rivers and their tributaries, the longest being Tukad Yeh Oos (River Oos) of 44 km; the river system with the largest catchment area is Tukad Yeh Ayung (River Ayung), 34 km in length (both of these rivers drain parts of Kabupaten Gianyar).[5]

All the traditional regional capitals, with the exception of Bangli, are situated on the coastal plain. Driving from the west eastwords along the main southern highway one encounters Negara (capital of Jembrana), Tabanan, Den Pasar (capital of Badung), Gianyar, Klungkung and, at the eastern tip of the island, Amlapura (previously Karangasem).

3.2.2 Climate.

A visitor's impressions of Bali's climate can be completely at odds, depending on time of year. Strong winds and rain from the northwest announce the onset of the wet season. Yet, during the wet monsoon the early morning is often clear, clouds then build up through the morning, resulting in heavy downpours through the middle of the day; evenings are frequently rain free, and the day closed by spectacular sunsets, often with more heavy rain during the night. At other times, low cloud cover obscures volcanoes and mountains for weeks at a time. The weather during the dry season is more predictable - warm dry days and cool nights with a steady afternoon sea-breeze from the southeast.[6] This dry trade wind is so constant during August-September that large kites made by communities near the south coast and tethered on cords about 100 metres long, stay aloft for days at a time.

Bali's climate is tropical monsoonal, with a distinct wet-season from about October to March and a dry-season for the

5 All these rivers carry a heavy load of sand and silt, much of which, via the irrigation systems, is redeposited on ricefields, and a portion of which is now dredged by hand for use in the construction industry.
6 During this time of the year the atmosphere is often made hazy by the smoke from burning rice straw trapped against the central ridge and, near the southern coast, by pollution from motor vehicles.

remainder of the year. During the wet monsoon winds and rain are mainly from the northwest; during the dry monsoon the cooler, dry winds are from the southeast. Because of the topography, rainfall within the region is quite variable over short distances. Generally, rainfalls in the higher, cooler reaches of the island are the heaviest.[7] Average rainfall for 1977-83 at Den Pasar was 1588 mm, although in 1982 the total was only 893 mm (56% of average), while in 1983 the total was 1804 mm (114% of average) (see Table3 A3.2.1-5).

Average monthly temperatures near the coast vary within a narrow range of 1-3^{o}C. Island-wide the annual average maximum is about 31^{o}C, and annual average minimum about 23^{o}C. Temperature falls with altitude and at higher altitudes the climate is more temperate than on the coast. Humidity is highest during the wet season (about 80-85%) and declines slightly during the dry season (about 70-75%).

3.2.3 Soils.

The volcanic soils of Bali have long been famed for their fertility (Raffles 1817:ccxxxiii; Crawfurd 1849:29; Earl 1850:537) which, in combination with skillful agricultural organisation, traditionally resulted in high yields of food crops, particularly rice. Despite their inherent fertility, the nutrient supply of ricefield soil, supplemented by mineral-bearing irrigation flows, had to be maintained by seasonal applications of green and animal manures; dryland (rainfed) soils also depended for their continuing fertility on cattle manure and mulching. Anecdotal evidence collected by the author indicates that recent abandonment of traditional manuring practices and near exclusive reliance on nitrogenous fertiliser for cultivating HYVs, may be undermining soil fertility accumulated over hundreds of years.[8]

7 The local variations in climate, the small number of recording stations, and dubious recording reliability, means that climatic data can only be considered as generally representative of conditions at specific locations.

8 Two points may serve to illustrate this contention. First, the accumulated fertility is such that farmers making the transition from traditional varieties to HYVs need apply no fertiliser for the first season (or two) and still obtain satisfactory yields; farmers who wish to revert to growing traditional varieties must first rebuild soil fertility before a successful crop can be obtained. Second, a higher price per unit area is charged by labourers for hoeing land that has had artificial fertiliser applied (even for a few seasons) than for traditionally treated land - they comment that the soil has become "too gluey" to work easily, this would appear to be an indication that there has been a deterioration in soil structure.

The most recent soil survey was carried out in 1957 and revised and published in 1970 by the Soil Research Institute, Bogor (Dai and Rosman 1970). The survey identified 5 major soil-types and 17 sub-types in Bali, based on the Indonesian system of soil classification.[9] Young regosols are the dominant soil type on the eastern side of the southern volcanic fan; while the western side of the fan is dominated by latosols (see Table A3.3.1). These two soil types are formed from ash and lahar deposited by geologically recent volcanic eruptions. Older volcanic soils (early Quaternary and Middle Tertiary) are the chief parent material of the other soils found on the island (LRDC 1980:14).[10]

There are five sub-groups of regosol found in Bali, two of these, humic regosol and yellowish-brown regosol, constitute the main types of the eastern volcanic fan. These soils show no horizontal differentiation, as they are sandy and built-up from unconsolidated rock and slightly weathered volcanic products. A hardpan, formed from iron/manganese oxides, commonly forms in irrigated ricefields as a result of ploughing.

Humic regosol soils occur at altitudes from 600-1300 metres and extend over about 56,000 ha, covering most of the higher reaches of Kabupaten Badung, Gianyar and Bangli.[11] Yellowish-brown regosol covers 53,000 ha, from about 600 metres to the coast, and is the main soil in the rice growing areas of Kabupaten Badung, Gianyar and Klungkung.[12] Latosols are represented by three sub-groups, one of these, yellowish-brown latosol, dominates the western side of the volcanic fan and constitutes the main soil type in Kabupaten Tabanan and Kabupaten Badung. This soil type extends over about 58,000 ha, from an altitude of about 1400 metres to the coast.[13]

9 According to the FAO/UNESCO classification there are 6 main types: Regosols, Luvisols, Cambisols, Andosols, Fluvisols and Lithosols.

10 Land Resources Development Centre, UK.

11 These have a slightly acid topsoil (pH H2O 5.29), with medium levels of phosphorus (82 mg/100 g) and potassium (50 mg/100 g), and are high in organic matter (8.45%) and nitrogen (0.25%); at higher altitudes they are rich in accumulated humus.

12 These topsoils have a grey, clay loam containing fine gravel and iron-mottles, neutral in reaction (pH H2O 6.60), with medium levels of phosphorus (56 mg/100 g) and potassium (94 mg/100 g), a low content of organic matter (2.1%) and negligible Nitrogen content (0.1%) (Dai and Rosman 1970 passim).

13 These soils have a deep profile with no clearly distinguishable horizons, a friable consistency and good drainage. The parent material is volcanic ash and tuff of intermediate

3.3 Population.

Two particular aspects of population size are important from the point of view of this thesis. First, the size of the population in relation to available natural resources. In a predominantly agricultural economy this means various types of agricultural population density. For instance, persons/ha of ricefield, persons/ha of dryland and persons/ha of agricultural land. Second, the size of the current and future population in relation to availability of useful work, broadly defined.

At the beginning of this century the Balinese were already feeling the pressure of population upon the available, fixed supply of land, particularly ricefields (Hanna 1972:96). Since the 1970s rapid growth of population, particularly people born since the 1950s, has far outstripped the available supply of jobs in all sectors of the local economy - agricultural, industrial and service (BPS Bali 1983a:20-44). Population growth is , therefore, placing increasing strain on both the natural and social environment.

The earliest estimate of the island's population appears in a manuscript dated circa 1000 AD, and gives a figure of 62,500 (Inscription Marakata, Lovric pers. comm.). During the mid-16th century unwilling visitors to Bali - shipwrecked sailors - recorded estimates of the total population as approximately 300,000 people (Hanna 1976:9). Estimates by others, some 150 years later, report a total population of some 700,000 (Crawfurd 1820, Medhurst 1830).[14] However, in 1900 a Dutch tourist to Bali reported on the population of Gianyar in 1880, as estimated by Schwartz, the first Dutch resident of Gianyar, as 160,400, after some 20 years of military strife (Hanna 1976:88). The earliest official estimate of total population came in 1912: for Bali 803,466 people and for Gianyar 119,223 (Alenhuyzen 1914:95); the second estimate, that of the Dutch census of 1920, was 947,233 people (see Table A3.4.1).

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to basic composition. Topsoil is greyish brown to dark brown clay loam, neutral in reaction (pH H2O 6.20) with high levels of phosphorus (143 mg/100 g) and potassium (78 mg/100 g), it has a high content of organic matter (16.0%) and nitrogen (0.7%) (ibid).

14 Distributed as follows: Jembrana and Buleleng 60-80,000, Gianyar 10,000, Badung 100,000, Bangli 30,000, Mengwi 150,000 (now part of Badung and Tabanan), Tabanan 200,000, and Klungkung and Karangasem together (by inference) some 150,000 (Medhurst 1830:85-6).

The first comprehensive population census[15] was undertaken under Dutch authority in 1930 and estimated total island population as 1.1 million (CKS, Volkstelling 1930, Deel V), and the population growth rate for 1920-30 as 2.78% p.a (see Table A3.4.2). Swellengrebel (1960:10) gives a figure of 1.48 million for 1950, based on unspecified post-WWII Dutch sources. Since then there have been three national censuses: 1961, 1971 and 1980 (see Table A3.5.1 for 1912 to 1990 population estimates). In 1980 the national census estimated Bali's population to be 2.47 million (see Figure 3.1).

In the 1961-71 decade Bali's population was increasing at 1.77% per annum, a much lower figure than that of the 1920s. In the 1970s the population growth rate fell to 1.69% as a result, in part, of an active family planning programme (*Keluarga Berencana*) instituted in the early 1970s by the national government.[16] However, the current (1980) population growth rates in each of the Kabupaten in Bali vary considerably. Kabupaten Gianyar, until recently the most densely populated, having the second lowest growth rate (0.72%); and Kabupaten Badung, the main administrative, commercial, tourist and urban region, having the highest rate (2.57%), in part a result of in-migration by people from other regions of the island and Indonesia seeking work and/or education. (see Table A3.6.1).

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15 This census, which covered all of the then Netherlands East Indies, collected data from the population on: age, sex, marital status, education, occupation, religion, ethnic origin, migration and so on.

16 The size of the population, and growth rates, has been limited to a minor degree by out-migration (Transmigrasi) to other less populous parts of Indonesia (Sumatra, Kalimantan and, more recently, Irian Jaya). As of 1984, total subsidised and private transmigration since before 1969 amounted to 146,285 persons of all ages; the annual rate of migration has been declining over 1981-84 (Bappeda 1980:129 (for pre-1969 to 1980); BPS Bali 1984b:45 (for 1981-84)). This is equal to about 3 times the annual natural increase in population (about 45,000 in 1984) over a period in excess of 20 years - thus making only a slight contribution to slowing the island's population growth. Set against this there are significant numbers of 'failed' transmigrants that return to the island, and substantial numbers of 'illegal' migrants to the island from (East) Java and other islands, many of whom have settled in West Bali or urban areas.

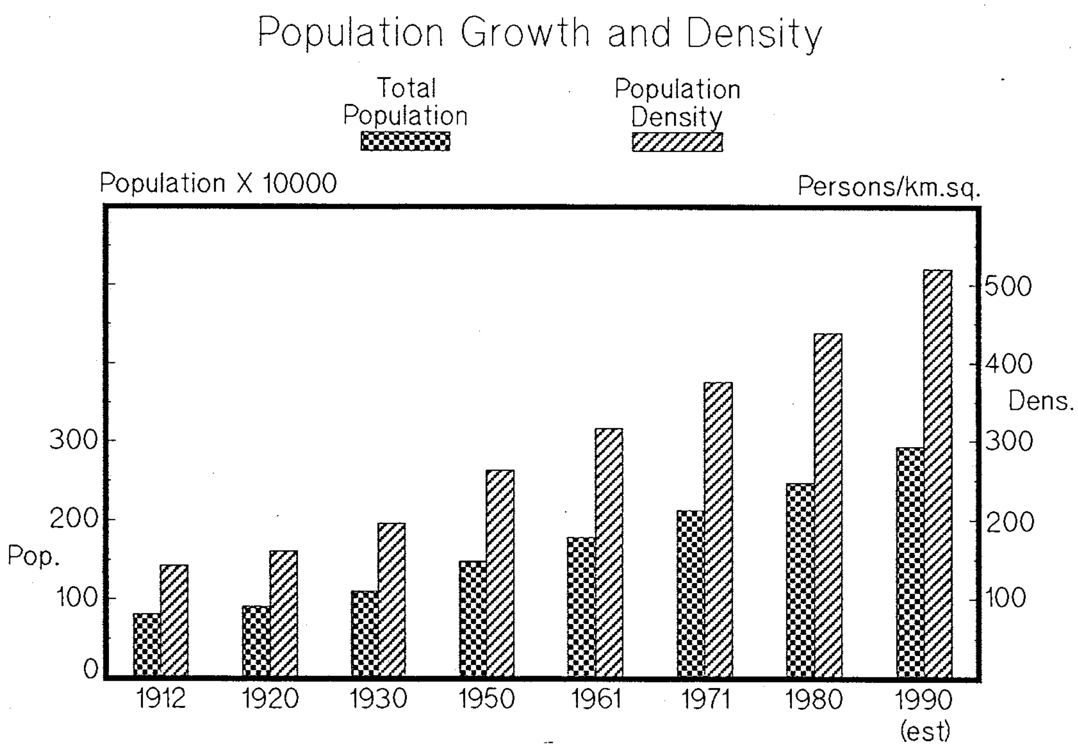

Figure 3.1: Bali Population and Population Density (1912–90).

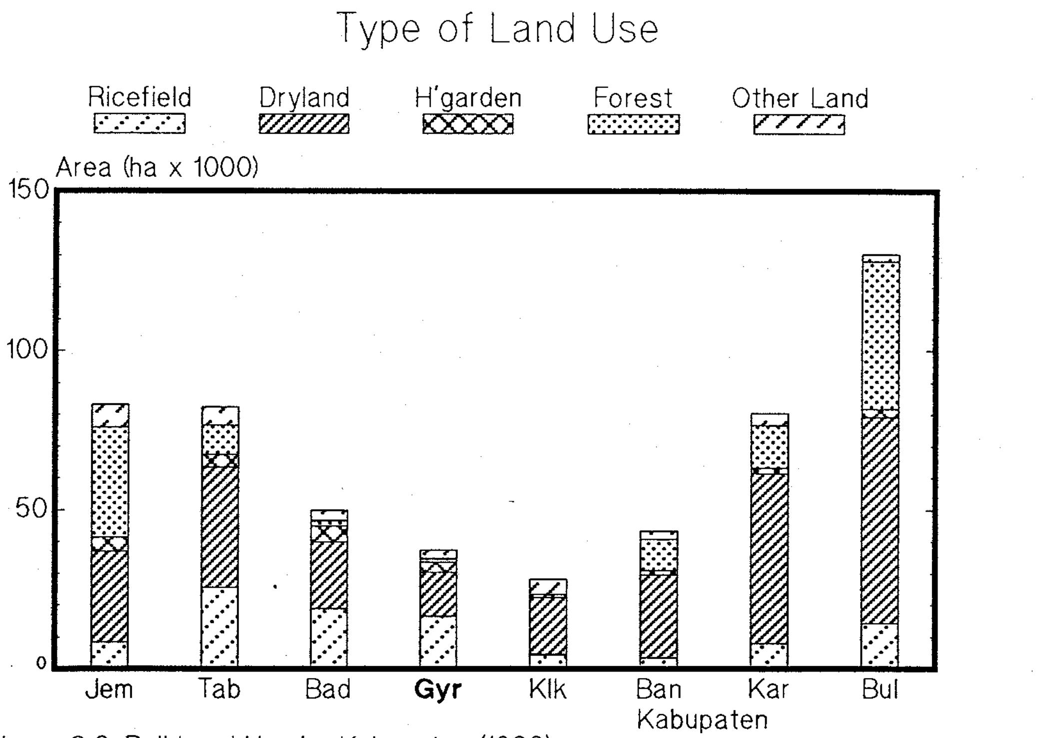

Figure 3.2: Bali Land Use by Kabupaten (1980).

3.3.1 Population Density.

Since the 1930s gross population density for the island has grown from about 196 persons/km^2 (see Tables A3.4.1-2) to about 439 persons/km^2 (1980), an increase of about 220%. In Gianyar, where the population density was already more than twice the average for the island in 1930 (and higher than the 1980 island average), the relative increase has been somewhat lower, about 186%, from 447 persons/km^2 in 1930 to 832 persons/km^2 in 1980. Thus, in the 60 years from 1930 to 1990 Gianyar's population density will have approximately doubled (see Figure 3.5). It is estimated that in 1990 the island's total population will be about 2.8 million; and Gianyar's population will have increased to about 350,000. This further increase in population will raise Bali's gross population density to about 520 persons/km^2 (up by 19%); and Gianyar's to about 950 persons/km^2 (up by 14%).

3.3.2 Population Density and Environment.

Gross population density is only a rough indicator of population stress upon resources. In a predominantly rural, agricultural environment, such as Bali, such a measure merely indicates the lower bound of a range of environmental stresses. Any further (destructive) modifications of the natural environment such as soil erosion or land degradation, pollution and urbanisation, simply increases stresses on the regenerative capacities of the environment. Its inherent productivity is reduced if nutrient and energy supplements are not used to make up for losses, and opportunities of gainful work for an expanding population, consequently, are made narrower.

A brief survey of some of the more direct effects of the 'pressure of people on resources' would have to include:

> the long-term decline in forested area, particularly on higher, dryer land (McTaggart 1983);
>
> major coral reef destruction and coastal erosion as a result of coral mining, banned but continuing (eastern coastline);

concentrations of human domestic and market refuse blocking natural and artificial watercourses (all low lying urban and tourist areas);

overloading the natural purifying/oxidising capacity of southern, inland river systems with village effluvium, commonly resulting in skin diseases;

not least, an observable and marked reduction in 'common' small mammal, bird and insect varieties, largely as a result of loss of habitat to agriculture, use of airguns and excessive applications of agrochemicals.

3.3.3 Population and Employment.

In 1980 some 40% of the total population of Bali was aged less than 15 years, with only slight variations in age structure between rural and urban dwellers; the pattern was similar in Kabupaten Gianyar (see Tables A3.7.1-6).[17] In Bali the size of the 'working age' segment of the population grew absolutely between 1971 and 1980 by some 370,000 people, to approximately 947,000 (596,000 men, 351,000 women); of whom in 1980, 51% worked in agriculture, 16% in industry, 18% in government, banking and services, and 15% in trade/commerce and hotels (see Figure 3.3 and Table A3.8.1 for 1971-80 details). However, of this total some 358,000 (38%) worked less than 35 hours per week; and of the total active workforce some 183,000 (20%) were seeking more work, although 66% of those seeking more work already worked 35 hours/week or more (BPS Bali 1983a:30-41). As of 1980 about 15% (363,000) of the total population live in urban areas and some 13% (123,000) have occupations in urban areas; the remainder of the population live and work in rural areas.

Labour force projections to 1990 indicate the total active labour force will have increased to about 1.3 million: 39% in agriculture, 22% in the secondary sector and 40% in the tertiary sector (see Table A3.8.2). Thus, by 1990 some 340,000 new workplaces will need to be established. Most of these, according to government plans, in the secondary and

17 In Indonesia people in the 'working age' group of the population are those over 10 years of age who have worked at least two days in the last week and are working or seeking more work (BPS Bali 1983a).

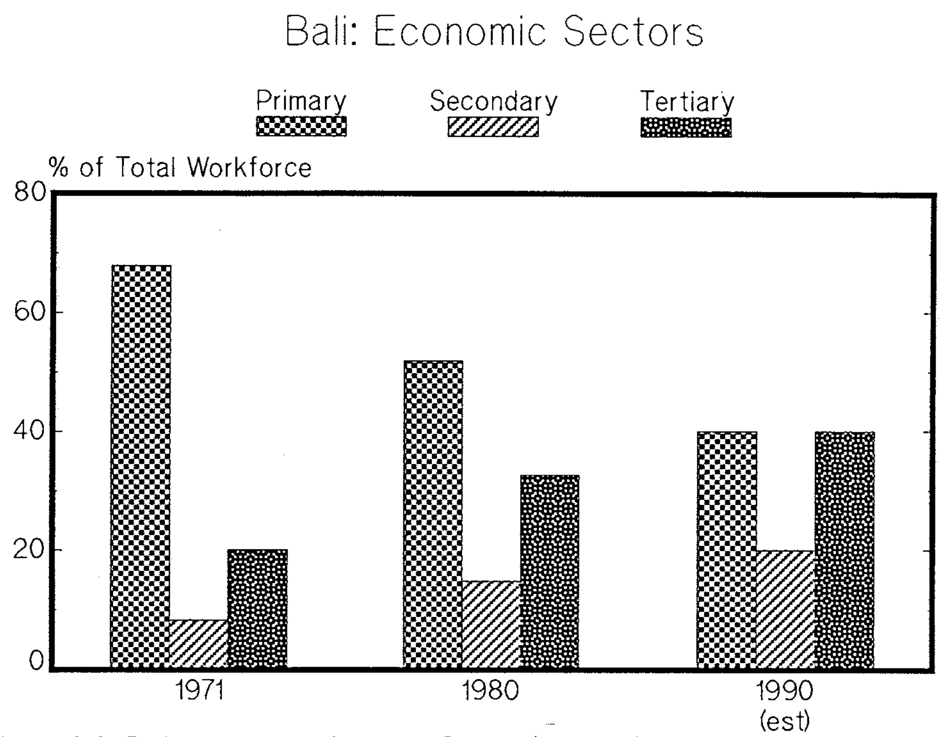

Figure 3.3: Bali Active Workforce by Sector (1971–90).

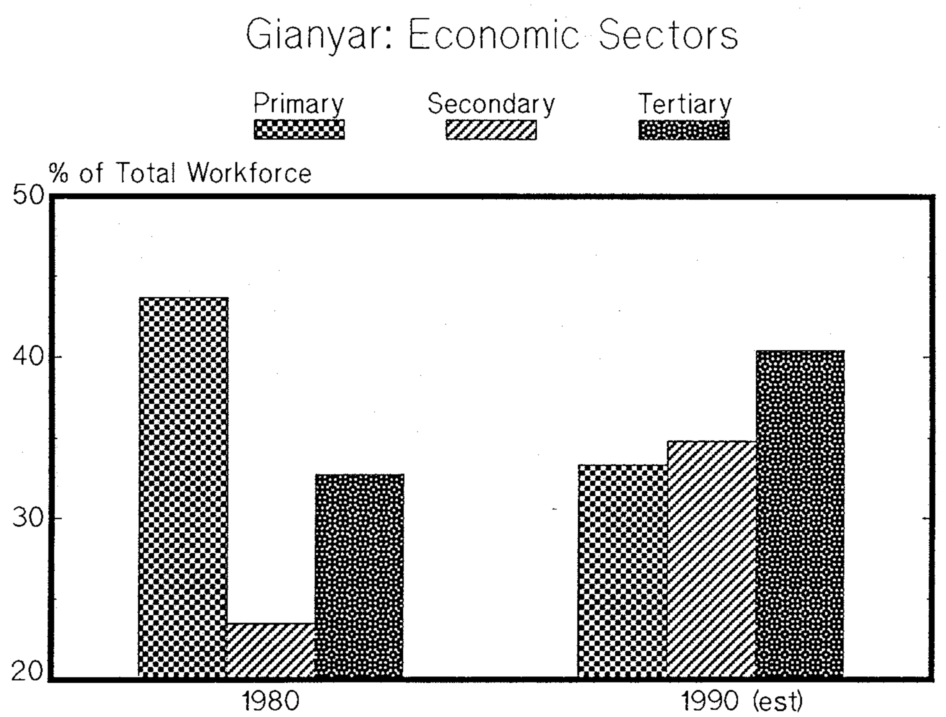

Figure 3.4: Gianyar Active Workforce by Sector (1980–90).

tertiary sectors where, based on projections by BPS Bali[18] (1983), the proportion of the total workforce will increase to 22% and 40%, respectively.[19] Roughly, the increase in the working population needing jobs, resulting from long-term growth in the population as a whole, will average about 3,000 people seeking new jobs each month until 1990. By then the proportion of the population in the workforce will have increased to about 41%. By 1990 the projected proportion of urban population and workforce will have increased to about 21% (1.2 and 0.5 million, respectively) of the island total.

Finding work for one third of a million new workers in secondary and primary industry will require much more investment per workplace than is necessary in agriculture where, despite massive investments in irrigation, extension and input subsidies (aimed at increasing staple food production), the workforce only grew by about 30,000 (7%) between 1971 and 1980. In Gianyar the growth in the total workforce is estimated to be about 36% over 1980-90, but only 4% of this growth will be in agriculture (see Table A3.8.1). The secondary sector in Gianyar is projected to increase in size by about 50%, and the tertiary sector by about 25% (see Figure 3.4 and Table A3.8.3).

3.4 Land Use and Settlement Patterns.

Despite its reputation for skilled and productive rice cultivation, most of the agricultural land in Bali is not irrigated, it is farmed for dryland arable and tree crops. Little has changed over the period from 1930 (when the first land use statistics are available) to 1980, in terms of the division between wet and dry agriculture (see Map 3.1). The area of ricefield has increased slightly to about 99,000 ha.[20] In dryland agriculture tree crops have become much more important during the last 50 years, the relative position vis-

18 Biro Pusat Statistik (BPS); BPS Bali for publications from the Bali office, and BPS Jakarta for publications fro Jakarta.
19 Few of these would be in agriculture, where un- and underemployment is already a problem (16,000 or 5% of the extra jobs projected).
20 It is now, however, double and triple cropped with rice, rather than single cropped as it was in the 1930s.

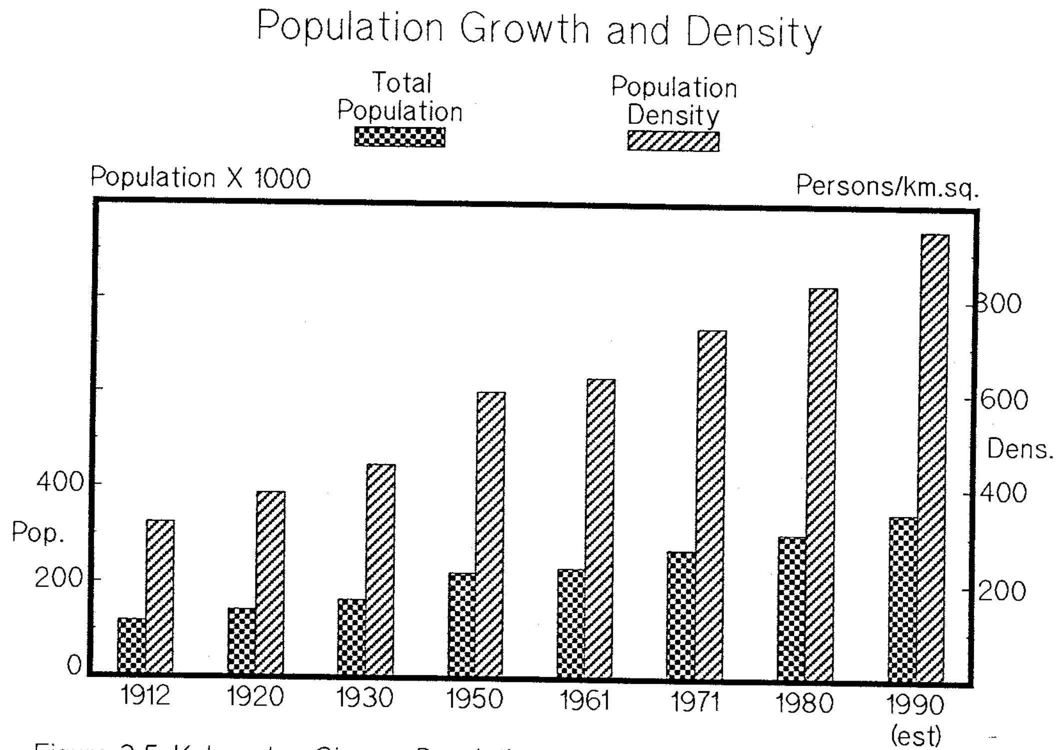

Figure 3.5: Kabupaten Gianyar Population and Population Density (1912–90).

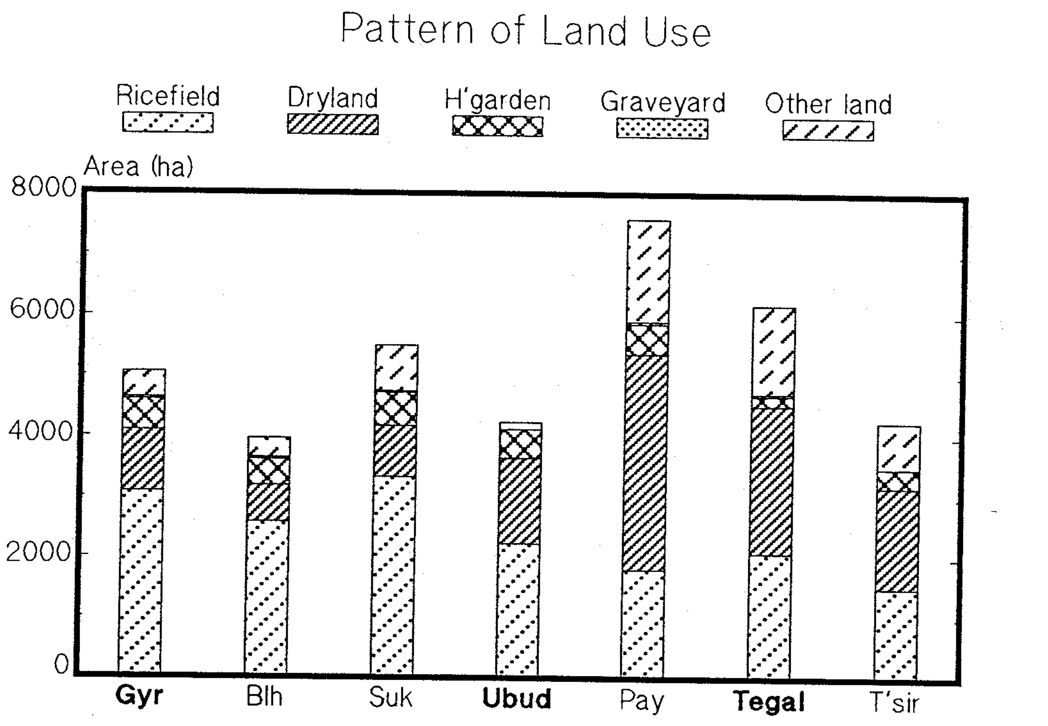

Figure 3.6: Kabupaten Gianyar Land Use by Kecamatan (1981–83).

a-vis arable crops having been reversed; tree crops now occupy some 150,000 ha, compared to about 90,000 ha in 1948 and 81,000 ha in 1930.[21]

Overall forested area has declined from about 132,000 ha in the 1930s to 125,000 ha in the late-1970s, a decline of about 6%.[22] There are two main causes for this change. First, increases in population have led to greater demand for building materials, particularly in the last 15 years. Quicklime, bricks and tiles all require woodfuel for their manufacture and the increased fuel demand has all been met by legal and illegal cutting of forest timber. Second, the eruptions of Gunung Agung and Gunung Batur in 1963 destroyed all vegetation on the upper slopes of these mountains, and considerable areas of vegetation lower down were inundated by *lahar* (mud flows).[23]

A comparison of land use patterns in Kabupaten Gianyar for 1948 and 1980 (Figure 3.6, for details see Tables A3.10.1-2) shows that, overall, the present pattern is very similar to that immediately after WWII. Kabupaten Gianyar, like the rest of Bali, has experienced increases in population density in rural villages and continuing urbanisation around the regional capital, Gianyar.[24]

The location of settlements throughout Bali has been primarily determined by topography, and only recently have landforms been substantially modified to facilitate construction. Villages (*banjar/desa*) in Southern Bali are set on ridgelines, as tree-shaded islands among the ricefields. In the midrange

21 Figure 3.2 presents the pattern of land use for 1980 (Tables A3.9.1-4 give details for 1930-80).

22 Currently, forests cover about 21% of Bali, although their quality varies markedly, the bulk of the high quality forest is in the central and western areas of the island. Forest reserves were first demarcated by the Dutch administration in 1927 to protect watersheds, replanting programmes began at that time and have continued intermittently; currently a conservationist policy of replanting (inside and outside designated reserves) and protection is being followed. Forest cover is least in the heavily populated south central area. See McTaggart (1983) for a review of forestry policy in Bali.

23 In both instances the government, recognising the dangers posed by soil erosion and lost agricultural productivity, has been attempting to rehabilitate and revegetate steeply sloping land throughout the island.

24 The combined impacts of the main east-west highway and tourism have, however, radically changed land use along the highway (as in other areas adjacent to main roads) and northwards along the narrow roads leading to the adjacent tourist centres of Ubud, Beduhulu and Tampaksiring. Along all these routes a ribbon of ricefields and dryfields have been built-over, despite government prohibitions, to erect shops and restaurants selling handicrafts and food to passing tourists.

(150-300m), where Penestanan is located, the ridges are narrow and the villages bounded east and west by deep ravines - villages commonly have a long, narrow plan a few hundred metres wide and several hundred metres long north to south. Closer to the coast and at the upper limit of irrigation, the locations of Tegal Tugu and Taro respectively, ridges are broader and the villages more compact and squarish or triangular in overall plan

There are two aspects to changes in settlement patterns resulting from the impact of population growth in Bali. The first is that the geographical extent of agrarian communities has not increased in area during the last 70 years or so. The second is that during this same period there has been a rapid increase in proportion of the population living in urbanised locations, on an island where previously no urban centres existed. An additional facet of the 'urban influence' is construction of social facilities (schools, dispensaries, storage facilities and government offices) on land that was previously communally owned. Traditionally this land was used as a common resource for 'paying' (usufruct) village domestic, agricultural and religious officials (*kelian adat, pekaseh subak and pemangku pura*).[25]

For villages that have remained agrarian, particularly those in rice growing areas, additional domestic living space has been provided for an increasing population by building new compounds/houses on land within the confines of the village previously covered with vegetation, cultivated or not. Second, within most of the compounds in each village more new sleeping accommodation and kitchens have have been built in the compound proper (*karang*) and/or housegarden (*tebe*). A comparison of the current number and layout of compounds within village boundaries with 1:5000 scale Dutch tax maps (surveying completed 1948), particularly the three villages

25 This process of alienation and new building has largely been beyond the control of members of rural communities (Banjar, Subak and Desa Adat).

under study, clearly shows that this 'filling-in' of compounds and housegardens has been underway for sometime.[26]

The consequence of this first pattern is that domestic population densities in 1980 have, on the whole, increased by about four times since the turn of the century; about doubled since the 1930s; and will be about three times 1930 levels by the 1990s. The advantage of this strategy, enforced by traditional precepts, is that there has been minimal loss of usable agricultural land - particularly ricefields and excepting housegardens to a varying degree - to residential area in rural communities. The alienation of communal land, on the other hand, started by the Dutch early this century, means that village officials are now dependent upon the government, rather than the community, for rewards for their services on behalf of the village, and an unknown area of potential agricultural land within villages (possibly 15%) has been built-over as a result of this process.

The growth of urban centres followed in the wake of Dutch colonial expansion, as colonial administrative centres were 'appended' to the villages in which royal and noble courts existed.[27] The building of government offices, establishment of permanent markets and the orientation of the transport network have all helped to convert traditionally 'largish' court centres into expanding urban areas (see Table A3.11.1).[28] Additionally, previously rural communities have been engulfed by the ever expanding (sub)urban boundary; particularly around Den Pasar and the newer tourist areas on the southern coastline at Sanur and Kuta-Legian (see Table A3.11.2-4). Currently, the size of the urban population is increasing at more than three times the rate (about 4%) of average

26 A comparison of dozens of current village boundaries with those given on 1:5000 scale Dutch maps (surveyed over 1911-17) indicated that very few rural villages exceed their historical boundaries.
27 Especially in court centres which are now regional administrative capitals (Den Pasar (Badung), Gianyar, Tabanan, etc).
28 Originally land confiscated from the royal families of Buleleng, Badung and Karangasem was used for building government offices etc; more recently the government has been resuming privately owned land on the periphery of regional capitals for office space and housing complexes for government military and civilian employees.

population growth (about 1.3%) - implying that the urban population (and probably area) will double by year 2000.[29]

In summary, three changes in land use and settlement patterns have emerged during this century. First, and most importantly, land of all types in all locations has become more densely populated and agricultural land more intensively worked. Second, traditional administrative and market centres have become the nuclei of rapid urbanisation, by virtue of administrative and commercial concentration. Third, modern transportation and communication has made the island administratively centralise; and integrated economically with the larger nation state for the first time in its history.

3.5 Agriculture.

While this thesis is not directly concerned with the historical development of agriculture in Bali, some comments on its origins and evolution are necessary. As far as it is possible to tell Bali (like Java) was once covered by lowland and mid-altitude tropical forests. The human occupation of the island and transition to settled agriculture probably occurred some 2000 years ago, following a sequence from hunting-and-gathering to slash-and-burn agriculture, culminating in settled agriculture with (wet) rice as the staple crop (Bennett 1976:130-2). Fragmentary evidence indicates that sophisticated wet-rice cultivation, using tunnels to redirect water, was in operation by the 9th century. However, all of the currently important dryland crops[30] became available, at the earliest, only after the arrival of the Portuguese in the 17th century. Thus, while we know that rice has been an important staple for about 2000 years, we have little knowledge of what other plants, except palm species, were pre-historically important food sources.

Environmental modifications necessary to develop and maintain rice cultivation dominate the environment of Southern Bali.

29 Aside from reducing the amount of agricultural land available for food production, these urban areas also represent concentrations of material and energy consumption and, hence, of many (new) forms of pollution that are impairing quality of life - e.g. emissions from large numbers of motor vehicles; domestic, market and street refuse buildup; and inadequate sewage and wastewater disposal systems.

30 Cassava, sweet potato, maize, peanuts and soybeans - all originating from South and Central America.

The most obvious features being: the flattening and terracing of ridges to form ricefields; building diversion weirs, contour-following canals and tunnels to supply irrigation water; the creation by erosion of minor ravines to carry away runoff; and village communities set as 'islands' of human settlement and dryland agriculture amid the ricefields. The evolution of this land use and agricultural pattern over centuries represents an example of the positive feedback processes between the ecosystem (nature) and the sociosystem (human) - called *coevolution* by Norgaard (1984). In Bali this process led to the development of a unique, village-independent social institution, the irrigation association (*subak*); solely responsible for maintaining and controlling the irrigation network essential for rice cultivation.[31] By the time of the Dutch invasions at the beginning of this century, rice cultivation and accompanying environmental modifications and social organisations had been extended, using traditional technology, to almost its present area.

The available data on historical and contemporary land use, island-wide division of areas between wet (irrigated, *sawah*) and dry (dryfield, *tegal*) agriculture, indicate that it has changed little this century. Since the 1920s the area of ricefields has increased by about 7,000 ha (8%) and dryfields (including housegardens) by about 23,000 ha (9%). Comparing 1948 to 1980 there has been little absolute or relative change in agricultural areas; the same holds true, as far as it is possible to tell, for Kabupaten Gianyar. Generally, it is clear that there remains little or no suitable land available for areal expansion of cultivation; indeed much of the expansion in dryland agriculture to-date has led to severe soil erosion and loss of forest cover (Bappeda 1980:104). Given the limited area available, efforts in the past 15 years have focused on intensification of irrigated rice, and only recently on arable dryland crops. To date it has been rice

31 See Liefrinck (1934, reprint 1969) for a detailed description of traditional subak organisation in northern Bali prior to the 20th century; Grader (1939, 1960 reprint) for a description of traditional subak in western Bali, immediately prior to modernisation by the Dutch; Birkelbach (1972) for a review of the subak history organisation, responsibilities (secular and religious) and social responsibilities immediately prior to the widespread adoption of HYVs; and Hobart (1979:171-88) for a more recent analysis of their economic and social role.

agriculture that has received the great bulk of development funds and subsidies and, consequently, altered most.

3.5.1 Employment in Agriculture.

While the proportion of total population employed in agriculture declined by some 16% between 1971 and 1980 (Table A3.8.1), it still remained the main occupation for about half the working population of the island; although in Gianyar it had become less important (43% of workers).[32] Even in what are classified as urban areas about a quarter of the households still depended to some extent on agriculture for their livelihood (see Tables A3.12.1-4).

The great majority of these households, (76% overall and rural, 65% urban) depended on cereal crop agriculture (rice, maize, cassava, sweet potato); however, many, if not most, of these households also cultivate fruit and vegetables, perennial crops (coconuts, coffee, cloves, vanilla) and raise livestock (cattle, pigs, poultry) (see Tables A3.13.1-3) In Gianyar as altitude increases (from Kecamatan Gianyar to Ubud to Tegallalang) the pattern is similar, but with a greater emphasis on food crops than for the island as a whole (see Table A3.13.4).

3.5.2 Distribution of Access to Agricultural Land.

A central consideration governing the welfare of farming families is the amount of land to which they have access, either by ownership or rental. The general opinion among Balinese farmers is that at least a quarter hectare (25 Are) of ricefield (growing 2-3 crops per year of rice) is required to provide an adequate subsistence supply of milled rice (*beras*) for an average sized family (5-6 people). Thus, an average family with access to less than this area of ricefield would always have to buy additional rice in the market;[33] farmers working dryland would require about twice the area of (irrigated) rice farmers to meet subsistence cereal needs.

32 In 1983, 69% of rural households island-wide and 74% of households in Gianyar, still had at least one member working in agriculture.

33 Farmers who rented their ricefield would need about 2-3 times the area of an owner-operator to meet subsistence needs, after paying rental (generally, 50-75% of the crop in kind).

In 1983 among rural households, who constituted the vast majority of farming families on the island (95%), almost three quarters (72%) had access (owned and/or rented) to less than one hectare of land (irrigated and dryfield); and almost half (45%) had access to less than half a hectare (Table A3.14.1). About one fifth of rural families (22%) had access to less than a quarter of a hectare. In the same year in Gianyar, with higher than average gross and agricultural population densities, over three quarters of rural farm families (80%) had access to less than one hectare; some 65% of families to less than half a hectare; and nearly one third (28%) to less than one quarter hectare (see Table A3.14.2). In Kabupaten Gianyar there is a general pattern of the area of land controlled becoming larger with an increase in altitude - as dryland farm area becomes more important.[34]

The pattern of ownership, renting-in and renting-out of land at the local level is extremely complex, with many farmers both owning land and renting-in/out - depending on family, social and economic situations. Superficially at least, most farmland (85%) in Bali is owner-operated; about one quarter of the land (27%) falls under some kind of rental agreement; while about one sixth of the land is (presumably) additional land rented-in by owner-operators (27% minus 12%, Table A3.15.1). In Kabupaten Gianyar the overall pattern is similar (see Table A3.15.2).[35]

Despite the increase in population between the 1973 and 1983 Agricultural Censuses, there has apparently been little change in the relative distribution of access to land used for cultivation of staple food crops.[36] Indeed, the 1983 Census reports a slight drop in the number of households involved in staple crop cultivation (from 305,154 in 1973 to 292,974 in 1983) and in the area under cultivation (from 266,605 ha in 1973 to 257,653 ha in 1983 - see Tables A3.16.1-2). In broad terms, in both years, about 40% of farm households had access

34 This partially compensates for the lower productivity of unirrigated, upland farming and facilitates cultivation of perennial tree crops and raising livestock, mentioned previously.
35 In the higher altitude areas where dryland agriculture predominates (Kecamatan Tegallalang, Tampaksiring and Payangan) a higher proportion of land is owner-operated than in lower lying areas.
36 See the footnotes to Table A3.19 for caveats about the accuracy of this data.

to less than 50 Are (0.5 ha), summing to some 13% of total farmland and an average holding of about 36 Are; a middle group of some 30% of farm households had access to between 50 and 99 Are, controlling about 21% of farmland, with an average holding of about 67 Are; those controlling more than 100 Are (1 ha) made up about 30% of farm households and operated some 65% of farmland, with an average holding of about 192 Are.

Some caution is required in interpreting what is on the surface a very inequitable distribution of access to farmland, as the data were compiled by combining control (access) to ricefields and dryfields. First, it is extremely uncommon for any family to have access to more than about 0.75 ha of ricefield; second, dryfields are often greater than 0.75 ha in size - thus two, disjoint, distributions have been conflated in this particular Census tabulation. Third, because of differences between the Kabupaten in the relative proportion of rice and dry lands (see Table A3.9.3), average access to ricefields in Southern Bali (Tabanan, Badung and Gianyar) is distorted (understated) by inter-regional differences. If the separate data collected by the Census on rice and dryfield access (see Tables A3.17.1-2) are reworked, as in Table 3.1, to reflect more effectively the likely divisions in size distribution based on the average area owned in each size group, a (somewhat) more plausible pattern emerges.

A majority of farm families today have access to less land than the Balinese themselves consider adequate for meeting subsistence staple food needs. Inequality of land holdings is more severe for dryland agriculture, where about 19% of families control 60% of the land, than for ricefields, where the great majority of the land (about 76%) is controlled by a majority of families (57%).

Table 3.1:
Bali: Grouped Distribution of Rice and Dry Fields (Owned and Rented).

Census Class Average Area (ha)	Households Number	%	Land Controlled Area (ha)	%	Size
Ricefields					
0 - 0.49	76,726	44.8	17,119	22.7	23
0.5 - 0.99	54,128	31.6	25,763	34.1	48
>1.0	40,320	23.6	32,738	43.3	81
Overall	171,174	100.0	75,530	100.0	44
Dryfields					
0 - 0.49	124,493	41.0	16,161	8.8	13
0.5- 1.24	120,955	39.8	57,393	31.4	47
>1.25	58,339	19.2	109,089	59.7	54
Overall	303,787	100.0	182,643	100.0	60

Notes see Footnote 37.

3.5.3 Staple Crop Agricultural Production - 1939 to 1984.

Attention here is focused on the production of staple food crops (rice, maize, cassava, sweet potato, groundnuts and soybeans), and especially rice production.[38] To simplify the discussion, data for the whole period on harvested area, production and yields are indexed to 1969, the first year of post-Sukarno development plans.

First, changes in the harvested areas of staple crops, production and yields for the period 1939-84 for all Bali are surveyed; second, a survey of the changes in these factors is undertaken for Kabupaten Gianyar for the period 1969-84. Third, the data for Bali are used to estimate per capita food-energy and protein availability from staple crops for 1939, 1953, 1969 and 1984. Last, imports of fertilisers, pesticides and other subsidiary goods used to achieve increases in rice production are analysed, particularly with respect to their energy content.

37 The caveats expressed in the footnotes to Table A3.17.1 are relevant to this table. As can be seen, even after re-grouping the size groups used in the Census tabulation it is difficult to obtain average areas for each group that fall within the re-grouped ranges. Source: Tables A3.17.1-2.

38 The data on which this discussion is based are drawn from a range of contemporary and Dutch colonial sources (presented in Tables A3.18.1-9).

Bali: Harvested Areas, Production and Yields 1929-84. Compared to 1939, annual harvested area for all crops, except rainfed (dryland) rice and maize, had increased by between 126% (sweet potato) and 200% (cassava) by 1969. By 1984 rainfed rice area had declined to about 20% and sweet potato to 52% of their colonial levels. By 1969 the area of irrigated rice harvested had increased by about 142% over 1939, and by 1984 by about 175%. The total area of staple crops harvested in 1939 was about 202,000 ha per annum; by 1969 this had risen to about 257,000 ha and by 1984 to 271,000 ha (see Tables A3.18.1-9).

These increases in harvested area represent an increase in cropping intensity (area harvested/area of arable farmland) from about 60% (1939) to 102% in 1969 and to 105% in 1984. The pattern of increases in the (separate) cropping intensity for irrigated rice cultivation differs from other staples - in 1939 it was already about 102%, by 1969 145% and by 1984 167%. The differences between overall cropping intensity (all staple crops) and that for irrigated rice provides a clear indication of the development effort focused on rice in recent years.

Annual production, except irrigated rice, followed much the same pattern of changes as harvested area, until 1969. However, by 1984 annual production of irrigated rice, cassava, ground nuts and soybeans had increased significantly over colonial levels. The greatest increases in output occurring in irrigated rice production - since 1969 output has increased by some 175% (see Figure 3.7). An examination of the general trend, however, tends to indicate that rice production may have reached close to a maximum.

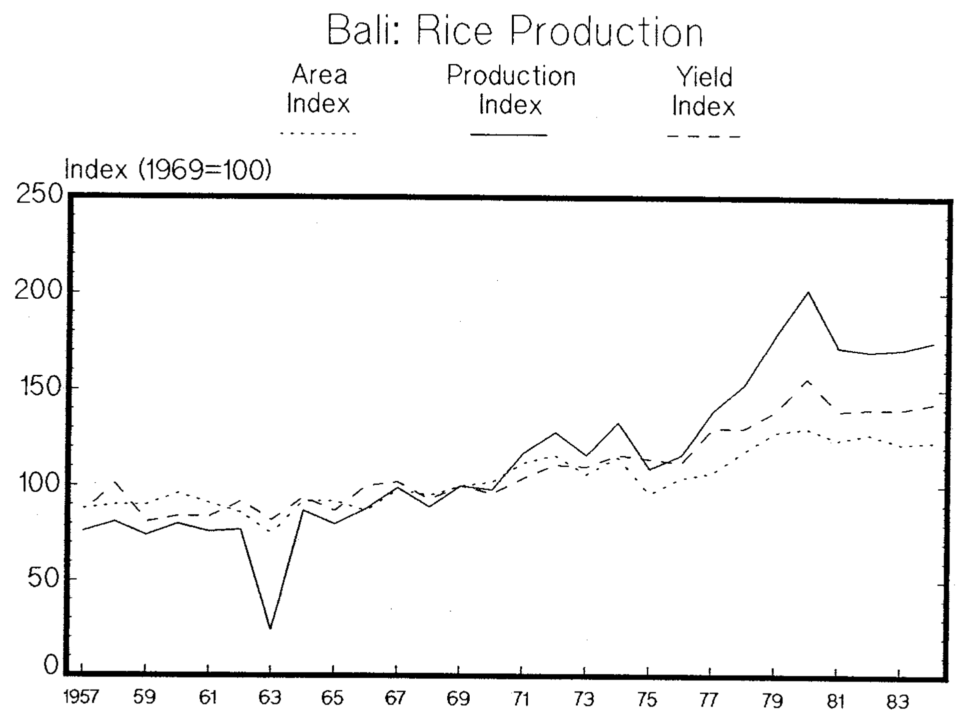

Figure 3.7: Bali Rice Production Indicies (1957-84).

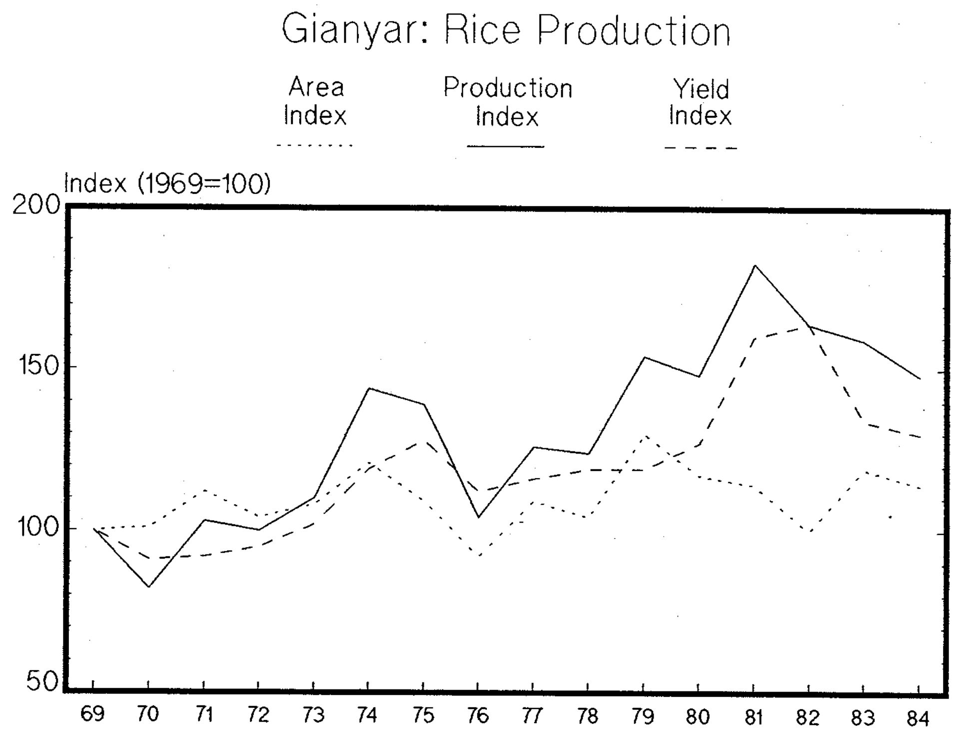

Figure 3.8 Gianyar Rice Production Indicies (1969-84).

Environmental (ecological) and irrigation constraints have since 1984 forced a change in official policy: instead of continuous cropping of rice (2.5 to 3.5 crops/year with no fallow or drying-out of the soil) farmers in most areas are now required to plant one non-irrigated (*palawija*, secondary) crop for every two crops of rice. This change has the general effect of reducing the output of rice, while increasing output of secondary crops grown on unflooded ricefields, such as maize, sweet potatoes, groundnuts and soybeans.

Of interest is the small change in average yields of staple crops that occurred between 1939 and 1969. Of these six staple crops, only the yields of irrigated rice and ground nuts had increased significantly over colonial levels by 1969; and yields of maize, cassava, sweet potato and soybeans had all fallen significantly during this 30 year period. By 1984, only yields of cassava and sweet potato were still below their 1939 levels.

In 1969 the yield of irrigated rice was only 12% above its colonial level, but by 1984 it had increased to about 160% over colonial levels, and some 146% over the average 1969 level. This increase was almost totally due to the widespread adoption of one particular fertiliser-responsive HYV (IR36) and parallel improvements in irrigation. The economic and energetic costs of this increase in rice yields are ongoing requirements for importation, distribution and use of increasingly large quantities of energy-intensive nitrogen fertiliser.

It appears that the fall in average yields prior to the mid-1970s was partly due to decreases in soil fertility, caused by the extension of dryland cultivation into more marginal areas; Second, to reductions in soil fertility resulting from reduced tree cover and increased erosion of topsoil. Increased yield of staples, except cassava and sweet potato, by 1984 may be attributed to introduction of improved cultivars; and, as most of the maize, groundnuts and soybeans are grown in unflooded ricefields during the dry season, to increases in residual soil moisture and nitrogen from the previous irrigated and fertilised rice crop.

Gianyar: Harvested Areas, Production and Yields 1969-84. In the post-1969 period the total annual harvested area of staple crops has decreased slightly - from about 36,300 ha in 1969 to about 35,000 ha in 1984 (see Tables A3.19.2-8). Most of this decline was the result of a reduction in area of non-irrigated staple crops, down from 11,200 ha in 1969 to 3,800 ha in 1984. During this period there were particularly steep declines in the harvested areas of rainfed rice (1000%), maize (366%) and sweet potato (575%); in contrast, by 1984 the harvested areas of cassava, groundnuts and soybeans had increased by 146%, 368% and 433%, respectively. The cropping intensity (and harvested area) of irrigated rice increased fairly steadily during this period, from 159% in 1969 to 176% in 1984 (see Figure 3.8).

Only for irrigated rice, cassava, groundnuts and soybeans have there been increases in annual production between 1969 and 1984 in Gianyar; the most significant of these being for rice, output of which increased by 129%, somewhat lower than for Bali as a whole during the same period (143%). Average yields of other staple crops, except maize and soybeans (yield increases of 115% and 126% respectively), changed less; while the yield of sweet potato declined by about 50% (see Tables 3.19.1-8).

3.5.4 Availability of Staple Crop Food Energy and Protein. The increases in annual rice production have allowed the government to buy-up increasingly large amounts of 'surplus' rice for export to other, rice short, parts of Indonesia.[39] Purchases by the government food procurement and distribution agency, Depot Logistik (DOLOG), rose to about 18% of total rice production in 1981, falling, however, in 1982 to 6% of production. In 1974 exports of rice amounted to about 1.6% of total production; in the late 1970s and early 1980s exports had increased to approximately 16% of local production,

39 Grain is sold by farmers to local government-run co-operatives (BUD-KUUD), which mill it and transport it to godowns run by the government food procurement and marketing agency (DOLOG, Depot Logistik) prior to shipment.

declining to about 4% by 1983/84 (Table A3.20.1). Although it is not entirely clear from the available data, it would seem that since about 1980 private traders, in competition with DOLOG for 'surplus' rice, have been playing an increasingly important (and profitable) role in exporting rice.

The need to supply food to international and domestic tourists places additional demands on the available food supply. Although there are no data on the eating habits of tourists, a lower limit for their requirements can be estimated by assuming (very conservatively) that they consume no more food per capita per day than do native Balinese. In 1982 Bali played host to some 151,000 international tourists, their average length of stay was 12.6 days (Santyo 1986); in addition, about 850,000 domestic tourists/travellers arrived by air and road from Java, it is assumed here that their average length of stay was two days (see Tables A3.22.1-2 for details of aircraft passengers). These arrivals are equivalent 1.903 million (international) plus 1.700 million (domestic) person-days, or about an additional 10,000 people for a full year.[40]

During the whole period under review the population of the island has been steadily rising - from 1.36 million in 1939 to 2.57 million in 1984. How have increased staple crop production and increased population interacted in terms of *average* per capita food energy and protein availability during this period? The results of an attempt to answer this question are presented in Table A3.21.1. Bearing in mind questions about the accuracy of the data and the fact that many other agricultural products (coconuts, fruits and vegetables, meat and eggs) are part of the common diet, it seems that little has changed in the last 45 years! In 1939 average daily per capita food energy was 11.6 MJ/day and protein 55 gm/day; in 1984 average available food energy was 10.7 MJ/day and protein 52 gm/day.[41]

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40 This figure very probably seriously underestimates the food demands of international tourists who, observably, eat much better than the average Balinese; second, it probably underestimates the number of domestic tourists/travellers and their duration of stay.
41 Other estimates made at intermediate points in this period (1953 and 1969) also exhibit insignificant differences in staple food availability compared to 1939 and 1984.

If family income distribution in 1984 is approximately the same as it was in 1939 then the lot of the average peasant family in relation to staple food availability would have changed little. If the income distribution has become more inequitable then the average situation would have deteriorated, and vise versa.[42] Landlessness in 1939 was undoubtedly much lower than in 1984, thus the proportion of the population with access to self-grown subsistence staples is now much lower. In 1939 there was not a large and growing urban population to be fed from available staple production, and in 1939 food did not need to be provided for domestic and international tourists (at a considerably higher level than the local 'average' level). Set against this, there are now substantial annual imports of wheat flour and sugar (in 1983 7,000 and 11,500 tonnes respectively), which helped to supplement local staple food production.

This comparison leads directly to the conclusion that if any improvement or deterioration in per capita staple food availability has occurred during the last 45 years this must be due to increases or decreases in the average availability of fruit and vegetables, and/or meat and eggs. Given the focus of attention on arable staple crops, space and lack of reliable data do not permit further discussion of the relative changes that these factors have had on diet.[43]

The next point to consider is the imports of agricultural chemicals that have made possible the increases in staple food production during the last 15 years.

3.5.5 Agricultural Transformation - Improved Irrigation, New Seeds, Fertilisers and Pesticides.

As has been shown above, in the 30 year period between 1939 and 1969 there was little significant change in staple food production. Total output of staple food energy increased by

42 Data on income distribution for the island as a whole shows that it has become more skewed during the last decade or so; see Chapter 6 for more details.
43 If the observably improved state of health and increased physical stature of the current generation of adolescents (in comparison with adults of their parents generation) can be taken as a guide, several (non-staple) food and health factors have resulted in a marked increase in both health and stature. In contrast, it must be added that their parents grew up and survived during a long period when food supplies were severely and frequently disrupted by economic depression, war and national revolution

about 128% and protein by about 127%, i.e. at less than 1% p.a. (Table A3.21.1). In the period between 1969 and 1984 this pattern was radically altered, and output of these two food components increased by 140% and 146%, respectively. Two main factors are responsible for this change in food production: a new seed-fertiliser-pesticide technology and an accompanying improvement in an already sophisticated irrigation system.

Improvements in Irrigation.

The traditional means of obtaining irrigation water was by diversion of river water into canals or tunnels, by construction at appropriate locations of semi-permanent weirs made of coconut logs and rocks enclosed in baskets. These were frequently washed away by floods during the rainy season. During the 1930s the Dutch colonial authorities used local corvee labour and materials to replace many of the more important dams with permanent concrete structures and upgrade primary distribution canals. The next major effort at improving irrigation occurred during the 1970s as part of programmes for increasing rice production.[44] In Southern Bali these improvements served mainly to improve security of water supply in existing irrigation areas; in the North and West of Bali (Kabupaten Buleleng and Jembrana) these improvements increased irrigated area and facilitated more widespread double-cropping of rice.

During the last 15 years the increased penetration of centralised irrigation control in Southern Bali has reduced both the scope of action and control by traditional irrigation organisations (the subak); and reduced the demand for local labour needed for replacing/maintaining major structures. By 1982 control of all except the lowest, most local levels of irrigation had effectively passed over to government officials. This shift in control now allows agricultural officials to determine the annual pattern of water supply and, hence, cropping patterns for irrigated rice. In general, this

44 Government employed contractors replaced remaining traditional weirs, rehabilitated existing concrete weirs and primary canals, and improved many primary, secondary and tertiary distribution canals.

centralisation has led to a more assured water supply, when there are no breakdowns in infrastructure (weirs, tunnels, aqueducts and canals). Conversely, central control has meant that damage to the system is slow to be repaired - depending as it does on urban-based officials and contractors to take action.

Increasing Use of Fertilisers.
The Department of Agriculture was experimenting with applications of green manures and manufactured fertilisers Diammonium Sulphate (DS) and Zinc (ZA) prior to the availability of the first of the Nationally Improved Varieties (hereafter NIVs) of rice in the mid-1960s. This work was re-initiated at several locations in the late 1940s after WWII, as a continuation of work in the 1920s and 1930s by the Dutch.

During the period 1950-61 the highest average yields (2,540 kg/ha milled) for local rice varieties in farm-based experimental trials were obtained in Kabupaten Gianyar (Sukawati) - using of a combination of green manure (350 kg/ha) and fertilisers (100 kg/ha of ZA and DS) (Dinas Pertanian, Bali 1963:48).[45] Prior to the 1970s green, duck and cow manure were all that 'average' farmers had available for maintaining or increasing soil fertility (Raka 1955:31).[46]

Figure 3.9 shows the spread of the area of ricefields cultivated with introduced varieties of rice (NIVs and HYVs) and the decline in area planted with Traditional Local Varieties (hereafter TLVs) over 1969-84. After 1977/78 the number of different varieties (Pelita through to IR5-IR32) planted declined, and IR36 has become the dominant variety; in 1983 it was used in about 90% of irrigated ricefields. The increased adoption of HYVs has resulted in a parallel rise in the amount of fertiliser (predominantly urea) imported and used in rice cultivation (Figure 3.10) - rising from about 16,000 tonnes in 1974 to 64,000 tonnes in 1982.[47]

45 Using green manure alone (about 300 Kg/ha) yielded 2,440 kg/ha; yields with inorganic fertiliser alone were 2,310 kg/ha.
46 Data from the 1983 Agricultural Census shows that green manure (separately or in combination with inorganic fertiliser) is now only used by about 30% of farmers in the main rice growing areas (BPS Jakarta 1986:115-6).
47 Imports and use of Triple Super Phosphate (TSP) have been much lower, and slower, to increase.

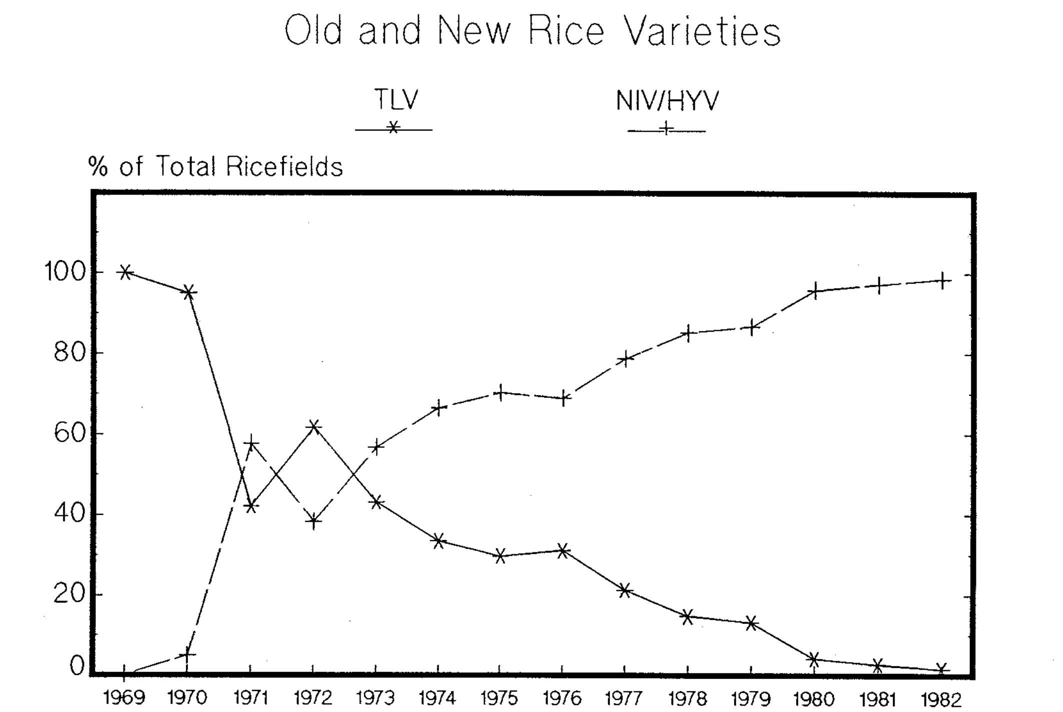

Figure 3.9: Harvested Area of TLVs and NIVs/HYVs (1969–82).

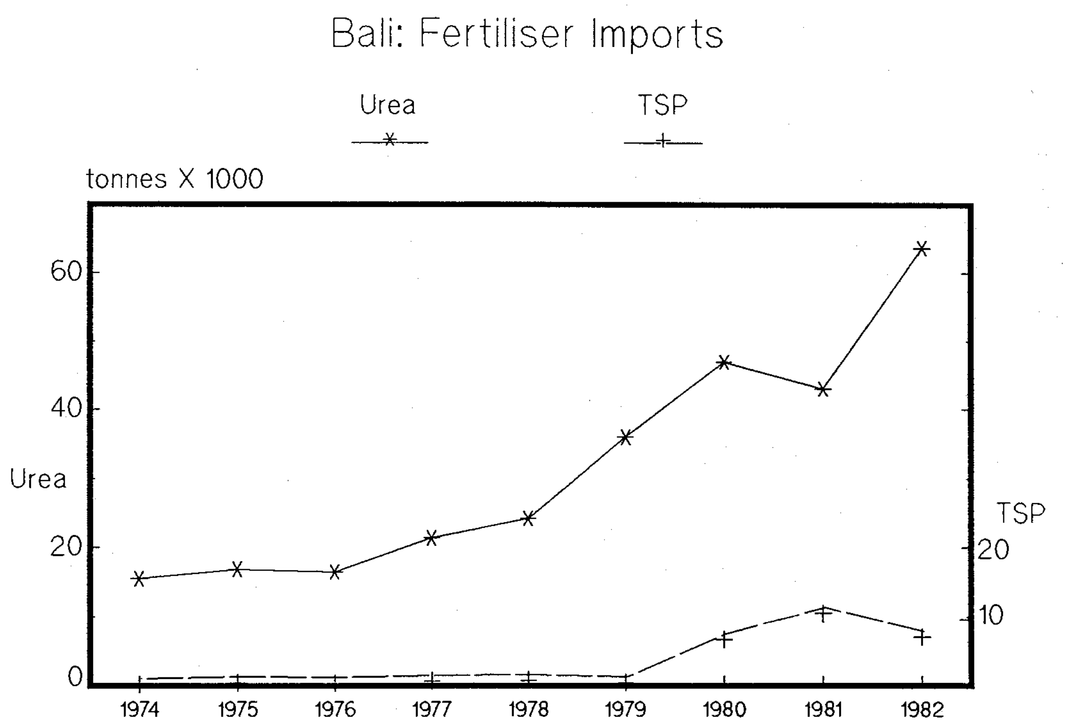

Figure 3.10: Bali Fertiliser Imports, Urea and TSP (1974–82)

Increasing Use of Pesticides.

Pesticides are an essential component of the technological 'package' associated with HYVs and, like fertilisers, they have been heavily subsidised. Their use is regarded by many experts as 'essential' for maximising yields (IRRI 1985:201, Barker et al 1985:89-92). Commonly, farmers have been encouraged by extension officials to apply them as a matter of course, whether or not pest infestation is evident. Damage to 'non-target' organisms by pesticides has already been mentioned. In addition, there are a significant, but officially uncounted, number of farmers and farm labourers poisoned and permanently injured by unwitting misuse of these dangerous substances.

As with fertilisers the data for pesticide imports spans a short time - 1975 to 1982. However, despite its brevity and the year-to-year fluctuations in imports, it is clear that the quantity has increased markedly since the mid-1970s. Though these are more energy-dense chemicals (133.7 GJ/tonne) than urea (53.1 GJ/tonne), their most important ecological characteristic is their (anti-) biological activity, affecting 'target' organisms and others alike. The majority (about 80%) of the pesticides imported are used in rice cultivation: principally Diazinon, Sevin and Furadan, which make up the bulk of imports (Table A3.23.2).

Despite the greatly increased use of pesticides in the last 15 years, crop losses to insects and diseases have continued to rise. For purposes of comparison, crop losses in the 'traditional' period 1929-39 (long before the use of HYVs, fertiliser or pesticides) are presented in Table A3.24.1. During this 11 year period annual losses averaged 2.4% (range 0.6% to 5.7%). In the period 1969-82, based on the published annual agricultural reports, losses averaged 2.0% (range 0.1% to 10.8%).[48] On the basis of these data, and despite the widespread use of pesticides, the proportion of the annual crop lost to pests and diseases has not declined significantly during the last 45 years.

48 The caveats regarding these data are discussed in the notes to Table A3.24.2.

However, if the alternative data presented in Table A3.24.3 are compared to the data on losses for the 1929-39 (and 1969-82) period, then it seems clear that the 'real' losses to pests and diseases have increased markedly in the last 15 years - averaging 6.8% (range 0.4% to 31.2%). It is also clear that the proportion of the crop affected each year by pests/diseases seems to have stabilised at about 15-20% during the period 1977-82, and the proportion of this area (crop) lost has also stabilised at about 42%. It is also evident that each year sees additions to the list of pest and disease species affecting rice, while previously epidemic diseases (*Walang Sangit*, *Wereng coklat*, *Tungro*) do not disappear, but only decline (temporarily) in severity (Table A3.24.4).

One very serious indication is that systemic soil disease for which there is no known 'treatment', e.g. *Helminthosporium oryzea* (a nematode), may increase in frequency and severity as a result of cultural practices associated with HYVs. Recent work in France and India strongly suggests that pesticides, rather than just disrupting predator-prey relationships, act to inhibit protein synthesis, and increase production of soluble sugars and amino acids which provide food for bacteria, fungi and other predators; the use of inorganic (manufactured and/or single-element) nitrogen fertilisers exacerbates these effects (Chaboussou 1986). Conversely, adequate and balanced supplies of macro- and micro-nutrients, particularly the ratios of potassium:copper:boron and maintenance of correct carbon:nitrogen ratios, promotes plant health and resistance to attack (ibid). The correct balance of these elements is undermined by (near) exclusive dependence on inorganic fertilisers, a generally common practice in cultivation of HYVs.

To summarise, while the total production of rice and staple crops has increased significantly during the last 15 years, average per capita staple food supply has not improved. It is apparent that there are two causes for this stagnation. First, a significant proportion of the rice produced is being exported (averaging 9.6%, 1975-84) to other 'rice deficit' parts of Indonesia; second, a larger proportion of potential rice yield (averaging 6.8% over 1970-82), has been lost to pests and diseases. Broadly, if these exports and losses had not occurred, per capita staple food availability could have increased by some 10-15% (1970-84).

The increment in total staple food production has been bought at the cost of marked increases in the importation and use of fertilisers and pesticides. Specifically, for irrigated rice cultivation, these changes have made farmers dependent on extra-local technical expertise, inputs and markets. At the same time, because of new rice pests and diseases, it has made yields less stable from season-to-season. From an ecological viewpoint 'modernisation' of staple food production and an almost total adoption of HYVs (in particular IR36), has resulted in a massive loss of the irreplaceable genetic material contained in the, now almost extinct, local, microadapted rice cultivars. Furthermore, it has resulted in destabilisation of a traditionally 'well-balanced' ricefield ecology - by inadvertently degrading soil quality and the wholesale introduction and multiplication of new pests and diseases.

3.5.6 Energy Use in Rice Cultivation.

The increase in production of milled rice has already been reviewed. The question here is what, in very broad terms, is the energetic relationship between increased rice production and the energy (and nutrient) supplement provided by fertilisers and pesticides. To simplify the discussion, human and animal energy inputs used for cultivation are ignored, as is energy required for milling rice and transporting fertiliser to farmers' fields and rice to urban areas etc.

In 1969 total production of irrigated rice in Bali was some 279,000 tonnes, with an energy equivalent of 4,428 TJ. In 1982 total production of irrigated rice had risen to 473,322 tonnes (milled), with an energy equivalent of 6,972 TJ (calculated on the same basis as Table A3.22.1). Thus, in this period (1969-82) the energy equivalent of rice production had risen by some 2,544 TJ.

Imports of fertiliser in 1969 were some 5,000 tonnes (assumed), with an energy content of about 265 TJ (ignoring minor amounts of TSP and pesticides). In 1982 the energy value of fertiliser and pesticide imports to Bali was 3,387 TJ (urea), 86 TJ (TSP) and 83 TJ (all pesticides), a total of some 3,553 TJ (Table A3.23.3). This is approximately a thirteen-fold increase over 1969. As it is estimated (conservatively) that about 80% of the imported fertiliser and pesticide were used for irrigated rice, this resulted in energy supplements to rice production of about 212 TJ in 1969 and 2,842 TJ in 1982.

In 1969 some 212 TJ of energy was used to facilitate production of some 4,428 TJ of rice food energy; in 1982, 2,842 TJ of energy was used to produce about 6,972 TJ of rice food energy. Thus, an increment of about 2,544 TJ of rice food energy (1982 minus 1969) required an increment of 2,756 TJ (1982 minus 1969) in energy inputs. Hence, there was an almost one-for-one exchange (2,756:2,544) between energy supplements, in the form of fertilisers and pesticides, and additional food energy, in the form of rice, despite an overall 140% increase in yields between 1969 and 1982. Put another way, in 1969 the energy content of supplementary inputs amounted to some 5% of the energy content of the rice produced, in 1982 it amounted to about 40%.

In its starkest terms, non-renewable fossil fuel energy (LNG) is being converted almost directly into food energy, without any additional increment by way of photosynthesis. This represents a radical decline in the energetic efficiency of rice production in Bali. A decline in energy efficiency that would be even more extreme if the energy costs for equipment and operations required for rice milling and transport, and storage of fertiliser, pesticide and rice were taken into account.

3.6 Liquid Fuel Imports and Use.

Historically, Bali was a 'walking society'. People walked island-wide as occasion demanded, occasionally goods were carried on pack horses, and well-established communication routes were well suited to this mode of transport. After the Dutch colonial invasion of 1906-08, motorable roads were quickly established (by *corvee* labor), some 500 Km by 1928. This road network, with minor additions, today (1982) forms the basis of the road system. Prior to the 1970s, consumption of fossil fuel for uses other than transport was restricted to relatively small quantities of kerosene used for domestic lighting and cooking.

The available data on the importation and use of energy are even slimmer than for most other sectors of the economy (see Figure 3.11). All the fossil fuels used in Bali are supplied by Pertamina,[49] and transported to Bali by sea from Indonesian refining plants. Distribution within the island is effected by Pertamina (to conventional service stations) and by private contractors to major consumers, wholesalers and roadside stalls (*kios bensin*). The main fuel imports are diesel (*solar*), kerosene (*minyak tanah*) and petrol (*bensin*). More recently, bottled LPG has started to be imported - to meet a rising demand by businesses, tourists and wealthier families for cooking and water heating.

Liquid fuels have four main end uses: motor transport, generation of electricity, industry, and domestic cooking and lighting. Overall consumption for each of these uses has increased greatly during the past 15 years (see Figure 3.11) - spurred on by significant government subsidisation (which has decreased or ceased since 1981). In addition to fuel for local use, Bali imports significant quantities of aviation fuel (Avtur), whose consumption has increased with the growth of tourist and domestic air travel.

Since the 1970s there has been a rapid increase in the number of motor vehicles and major expansions of the generating capacity of the Benoa power station, to supply electricity to rural communities and meeting urban commercial and domestic demand[50]; increased use of kerosene for domestic lighting and cooking, particularly in urban areas where woodfuel is not

49 The national oil and gas refining and distribution monopoly.
50 Only in 1971 was a major new electric power station constructed near the harbour at Benoa.

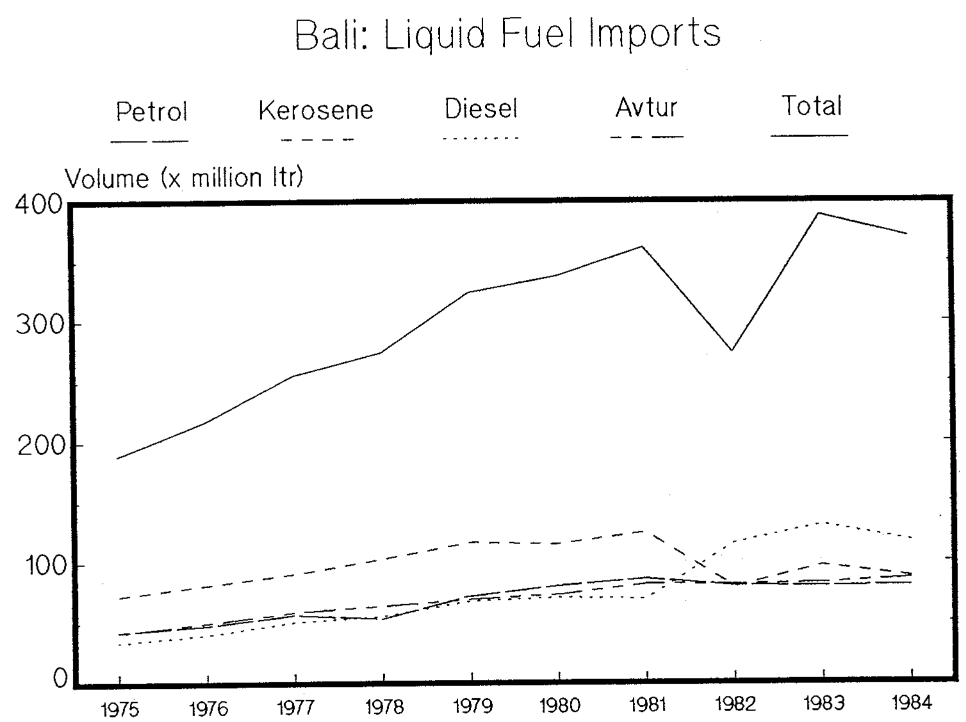

Figure 3.11: Bali Liquid Fuel Imports (1975-84).

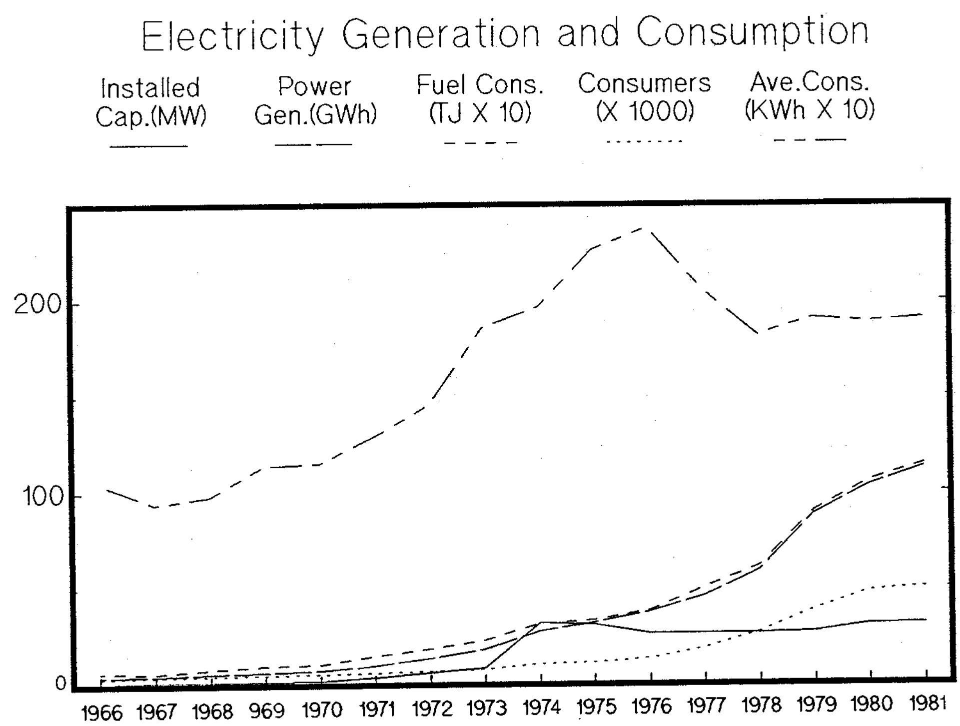

Figure 3.12: Bali Electricity Generation and Consumption (1966-81).

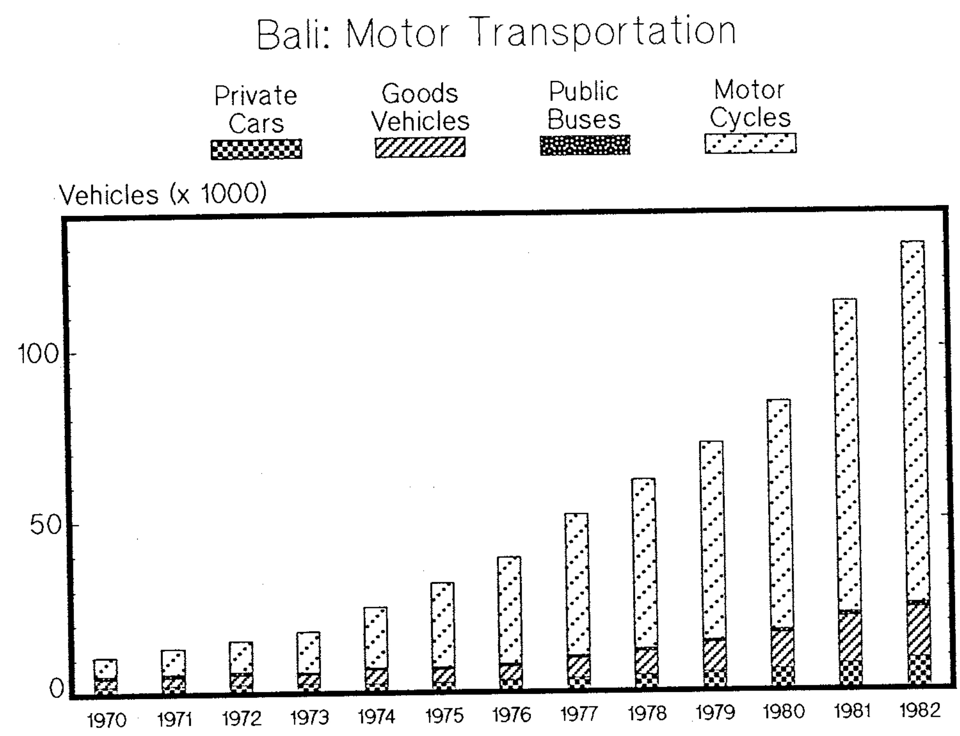

Figure 3.13: Bali Registered Motor Vehicles (1970–82).

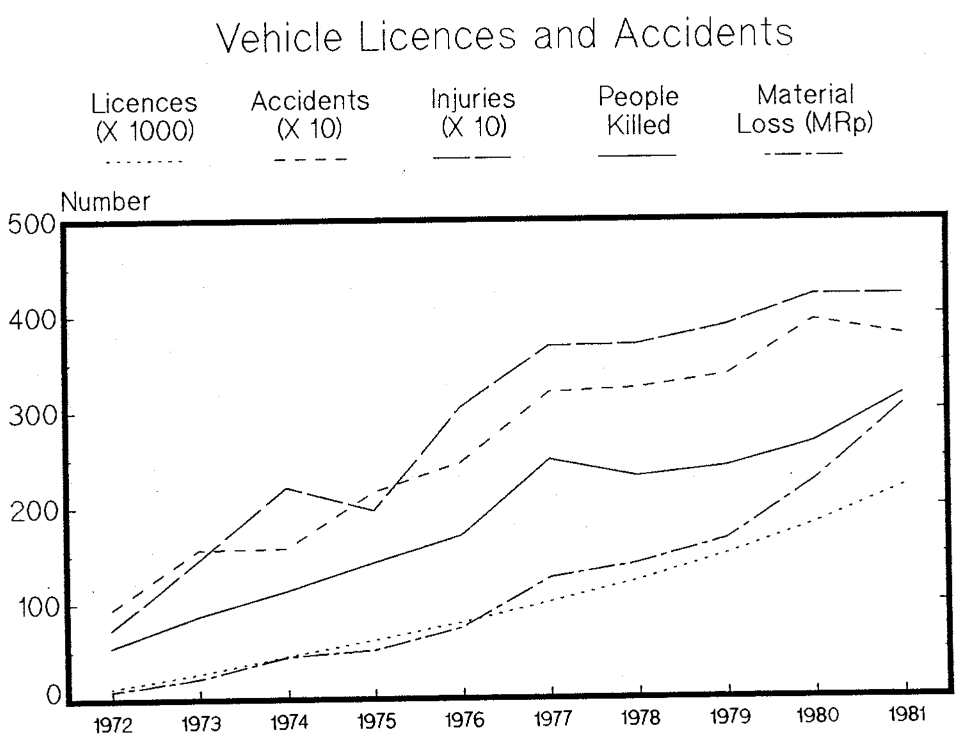

Figure 3.14: Bali Motor Vehicle Licences and Accidents (1972–81).

available; and, as an essential ancillary to the widespread adoption of HYVs, the establishment of hundreds of diesel-powered rice mills in villages throughout the island.

3.6.1 Road Transportation.

Until the 1970s Bali had comparatively few four wheeled motor vehicles and the majority of these were used for public transport of people and goods (see Figure 3.13). Until 1972 the total number of driving licenses in Bali was only 12,500; reported motor vehicle accidents were less than 1,000, serious injuries 736 and deaths 55 (see Figure 3.14). By 1982 nearly a quarter of a million people had driving licenses; the number of motor cycles, the most accessible form of private transport, was 105,000 (of a total vehicle stock of 130,000); annually, reported accidents had risen to over 2,000, serious injuries to 2,071 and deaths to 223. Private cars, motor cycles and public transport *bemos*[51] can be safely assumed to have consumed almost all of the 80 million litres of petrol imported in 1984 (see Table A3.28.1. Thus, while the Balinese have become much more mobile in the last 15 years, they are also paying a high price in terms of injuries and deaths; and in meeting the costs of importing vehicles, spare parts, fuel, and road construction/improvement and maintenance.

3.6.2 Electricity Generation and Distribution.

Buring the last 15 years the amount of centrally generated and distributed electricity has substantially increased, reaching 31 MW by 1980/81 (see Figure 3.12).[52] Since 1974 electricity generated has risen by about 400%, from about 27.6 GWh/year to 112.5 GWh/year. Since 1974 the number of consumers has risen by about 466%, to about 50,000 in 1982 (see Table A3.26.2); of these slightly over half are rural consumers (see Table A3.26.3). Until the start of rural electrification schemes in mid-1970s (*Listrik Pedesaan*) most consumers in Southern Bali were in urban areas, primarily Den Pasar. Average consumption (per consumer) in 1982 was 1,902 kWh/yr; however, average rural consumption was much lower (570 kWh). The significantly

51 Covered 1 tonne, four cylinder, utilities converted for passenger and goods transport.
52 The time-series data for electricity generation and consumption are one of the longest data-sets available for Bali.

lower per consumer use of electricity in rural areas in 1982 is indicative of a continuing bias in favour of urban consumers.[53] Region-wide, per capita consumption has approximately tripled since 1976 (from 15.5 to 47.0 kWh/year).

3.6.3 Industrial Energy Consumption.

Bali has relatively few secondary industries.[54] However, in the period 1975-82 industrial consumption of fuel and electricity by large and medium manufacturing establishments grew by about 250%, from 121.8 to 305.2 TJ/year. The majority of the fuel (about 87% in 1982) is diesel fuel, used mainly for self-generation of electricity (see Table A3.27.1). Total energy consumption by the sector in 1980 was 173.4 GJ (see Table A3.27.2). Assuming a relatively even availability of energy per workplace, each worker had available some 1.14 GJ/year, this is only about one third of the metabolic energy consumed per annum by each worker (about 3.65 GJ/year). Thus, such industry as there is in Bali is not technologically advanced, most work is undertaken without substantial mechanical assistance and, thus, without fossil fuel supplementation.[55]

3.6.4 Domestic Energy Consumption.

The domestic consumption of liquid fuels is confined to use of kerosene for cooking and lighting. It is probable that, except for the small volume consumed by industry (246 KLr in 1983), almost all the kerosene imported (96,267 KLr in 1983) is used either domestically or by commercial restaurants and street-side food stalls (*warung*) for cooking. Until 1982 kerosene was heavily subsidised by the government;[56] beginning in 1982 the subsidy was reduced and further reduced at the beginning of 1983, markedly slowing growth of consumption in Bali. In addition, some reduction in demand for kerosene as a lighting fuel has resulted from the rapid extension of rural electrification since 1980.

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53 Rural users, about half of all users, consumed only 17% of the electricity sold.
54 In 1980 only about 16% of the workforce (152,000 persons approximately, see Table A3.8.2) was employed in the secondary sector.
55 In small industries not covered by the source of this data it is certain that energy available per worker would have been even lower.
56 In a nationwide effort to reduce woodfuel use and hence environmental damage caused by (uncontrolled) wood gathering.

In 1982 the energy content of all liquid fuels imported to Bali and used on the island was 9,959 TJ (see Table A3.28.2). Of this 28% was petrol, 29% kerosene and 43% diesel.[57] From this total, some 1,143 TJ of diesel fuel (11%) was used for generating electricity (figures in parentheses are percentages of total use); about 305 TJ of various fuels was consumed by industry (3%); it is assumed that all of the 2,740 TJ of petrol was used for road transport (28%); and all of the 2,876 TJ of kerosene for cooking and/or lighting, domestic and commercial (29%). However, of the diesel fuel not used for electricity generation some was used by secondary industry, some for mechanical rice milling, and the remainder for road transport fuel. Assuming that industry and rice milling used similar amounts (265 TJ each, total 6%), some 2,670 TJ of diesel fuel was used for transport (27%), in addition to petrol.

In summary, of total liquid fuel imports of 9,959 TJ (273 million litres) in 1982: 11% was used for electricity generation, about 3% each by secondary industry and rice milling, some 29% for cooking and lighting, and an estimated 55% (5,477 TJ) for road transport.

In 1975 the energy content of liquid fuel imports was 5,379 TJ, population 2.2 million, and average per capita consumption 2.5 GJ/year. By 1982 total liquid fuel imports had risen to 9,959 TJ, population to 2.5 million, and average per capita fossil fuel to 3.9 GJ/year, an increase of 162%. Between 1982 and 1984 there was no increase in per capita consumption. Thus, in 1984 average per capita consumption of liquid fuels was approximately equal to average human metabolic energy consumption (3.65 GJ/year).[58]

As a consequence of these changes the economy of the island has become dependant upon fossil fuels for basic social, economic and technical functioning This includes, the intra-island transport of goods, especially agricultural inputs and

57 In addition, 2,951 TJ of Avtur was imported as bunker fuel, it is omitted from the following calculations.
58 By way of comparison, per capita consumption of commercial energy (fossil fuel) in Australia in 1983 was 216 GJ - 59 times metabolic energy consumption; per capita commercial energy consumption in Indonesia in 1983 was 9.2 GJ (World Bank 1985:189).

produce; processing rice; and the transportation to and from the island each year of some 150,000 international and 850,000 domestic tourists. These changes in energy use are main factors in an ecological transition. They provide the basis for distribution of new goods and services, transportation for daily or weekly commuting by thousands of workers, and the physical communication and information control essential for the integration of Bali into the nation state and, more peripherally, the international economy.

3.7 Conclusions.

The rapid growth in population, the national drive towards modernisation and expansion of the capitalist economy are at the base of the ecological transition in Bali, and Indonesia generally. In Bali, despite a tripling of population since the turn of the century, land use patterns, with the obvious exception of urbanisation, have remained almost unaltered. However, until a stable population is achieved sometime in the late 21st century, food production, useful employment and energy use per capita will have to continue to increase, if living standards are to be maintained.

Because almost all potential agricultural land has already been brought into production, future increases in food production will have to come from further intensification of cultivation. However, despite a great intensification of staple crop agriculture during the last 45 years, particularly the last 15 years, average per capita staple food availability has not increased.

It seems probable that rice production has reached close to a maximum level. Opportunities do, however, exist for increasing yields of other staple crops, mainly by use of improved cultivars and increased, but selective, application of natural and manufactured (inorganic) fertilisers. The other major possibility for increasing food production lies in making dryland agriculture, both annual and perennial, more productive. Progress in this area no longer awaits more international research, but is consequent upon the government putting into action effective extension and marketing schemes

The provision of adequate employment for the growing population is unlikely, it would seem, to come from significant additional employment in rice agriculture. To date there seems to be little initiative on the part of the government to actively encourage establishment of labour-intensive rural (agro)industries. Neither does there appear to be much potential for rapidly increasing employment in secondary industries, given slow growth to date and the large amount of capital required per workplace. A rapid expansion in the tertiary sector appears overly optimistic, based, as it is, almost entirely on continuing expansion of tourism and government employment. It is clear that a relative decrease in socially useful employment in the future would waste the 'human capital' resulting from recent expansions of education and health services. Is also a potentially disruptive social and political issue, given the heightened expectations of young people imbued by education and modernisation.

In summary, an essential component of the intensification of agriculture, provision of electrification, urbanisation, and articulation by motor transport has been the rapid increase in imports of direct and indirect fossil fuel energy. Indirect energy inputs to agriculture via fertilisers and pesticides in 1982 amounted to approximately half the energy value of the food produced (a quarter of the energy content of liquid fuel imports), making average fossil fuel energy subsidies per annum equal to about 5.1 GJ/capita in total.

There is no doubt a continuation of the current development strategy requires increasing energy use (and hence imports), if agricultural and other types of production and employment are to keep pace with population growth. Yet, as Indonesian resources of oil are expected to be depleted in about 30-35 years and natural gas in about 60 years, dependency on them can only be short-lived (two human generations) and increasingly expensive. Moreover, the current strategy of development pays little attention to various forms of environmental degradation resulting from modernisation, in particular; in addition to other social shortcomings, such as growing economic inequality.

This overview of the changes to Balinese society during the last 50 years, in particular, is the background against which the the three village case studies are set. The aim of the research design, which is described in the next chapter, was to select and investigate villages typical of the patterns of modernisation prevalent today in Bali: government development programmes, tourism and urbanisation.

Chapter 4

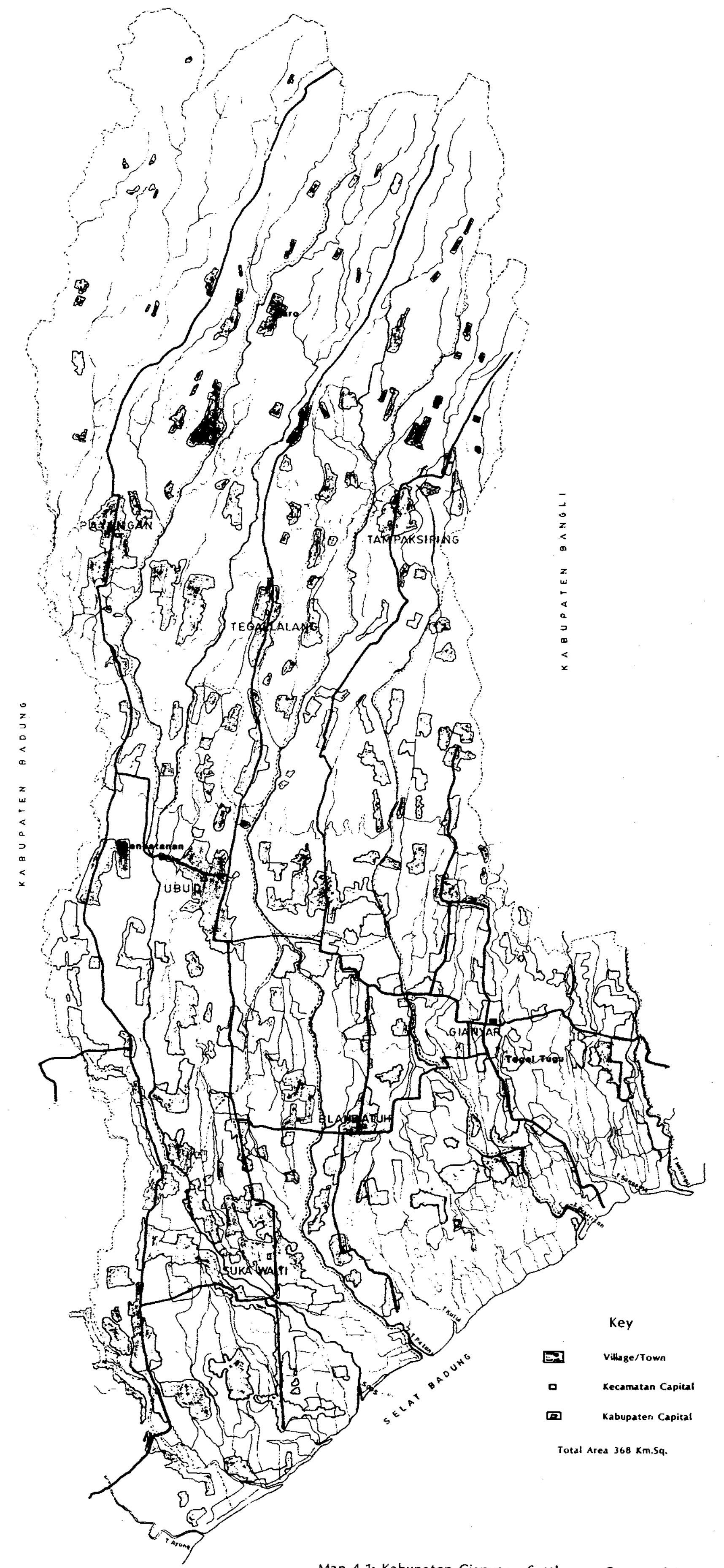
The Villages and Research Methodology.

4.1 Introduction

Three villages (*banjar*) in Southern Bali were selected for investigating the effects of modernisation on agricultural practices and village socioeconomic life: Taro Kaja/Kelod, Penestanan Kaja and Tegal Tugu.[1] Taro is located at the upper limit of the irrigated region in Kecamatan Tegallalang, Penestanan is situated in the 'middle' of the irrigated region in Kecamatan Ubud, and Tegal Tugu on the coastal plain in Kecamatan Gianyar, adjacent to the regional capital Kota Gianyar (see Map 4.1). The object in selecting these three villages was to study the effects of modernising changes (transformations) on communities typical of the range of ecological, agricultural and socioeconomic contexts in which the majority of the population in the region live.

This chapter lays the groundwork for the analyses that follow in in Chapters 5 and 6, in addition to presenting background information on the three villages in which detailed fieldwork was undertaken. The chapter has three primary purposes. First, to provide brief descriptions of each of the three villages - this incorporates the locations and land-use feature, significant demographic characteristics, and then, reflecting the focus of later analysis, the key features of rice agriculture and socioeconomic life. Some aspects of this overview are given more attention, for instance, the morphology and production cycles of the three groups of rice, TLVs, NIVs and HYVs. Other features are simply introduced in order to complete the overview, for instance, sources of family income and patterns of expenditure - since they are subject to detailed analysis in Chapter 6.

1 Each of these three villages is located in a different administrative subdivision within Kabupaten Gianyar: Taro in Kecamatan Tegallalang, Penestanan in Kecamatan Ubud and Tegal Tugu in Kecamatan Gianyar.



Map 4.1: Kabupaten Gianyar - Settlement Pattern (circa 1976).

Second, it is argued that these three villages are typical of the range of ecological, agricultural and socioeconomic contexts in which the majority of the population in Southern Bali live; they each reflect different aspects of transformation and influences of modernisation; and that these differences are analytically significant in a statistical sense - such that later assertions about the impact of modernisation can be addressed with some confidence. The third purpose of this chapter is to present the methods and techniques employed during fieldwork and subsequent analysis. This presentation is threaded through the following structure.

The analysis in this chapter is organised around five propositions or 'working hypotheses' - and three sections. The second section is concerned with demographic characteristics of the three villages, ranging from the household, village and inter-village levels of comparison. The primary propositions which guide the discussion are that:

> There are substantial differences between the three villages in agricultural and domestic population densities.
>
> There are substantial differences between the three villages in their age-structure and familial characteristics.

The third section reviews and compares village land-use and agriculture. This includes background information on the morphology of the three rice groups and the practice of rice cultivation. The proposition addressed here is that:

> There are significant differences between the three groups of rice varieties cultivated, in terms of labour and material inputs.

The last section, in less detail that the previous two, looks at two propositions about the labour and material inputs to rice cultivation, and different sources of family income and patterns of expenditure. These are fundamental dimensions of social and economic life in each of the villages. The reference points of this discussion of village society and economy are provided by two propositions, that:

> There are significant differences between the three villages in the way that farmers cultivate rice, in terms of labour and material inputs.
>
> There are significant differences between the three villages in the relative importance of different sources of family income and in patterns of expenditures.

First, this chapter provides an overview of the agroecology of Balinese village communities, emphasising their traditional self-provisioning and sustainable characteristics. Second, it presents the rationale used for selecting particular villages for study. Third, information on the geographical setting, land use and population densities in each village are presented. Fourth, an overview of population age structure and family size is given. Fifth, data from surveys of rice cultivation and socioeconomic conditions are used to show that each village is significantly different, with respect to the manner in which its inhabitants cultivate rice, obtain their incomes and spend their money. The chapter does not present the detailed data upon which these analyses are founded, rather it uses the data to demonstrate that the villages are significantly different.[2]

4.1.1 Balinese Village Agroecosystems.

The village in Bali is an identifiable ecosystem, having as its components the human population, domesticated animals, the built environment, surrounding cultivated land (wet and dry), natural vegetation and watercourses. Any given village interacts with other villages in the locality - exchanging energy, materials and information (cf Soemarwoto and Soemarwoto 1984:254-5). On the basis of village population's perceptions, the village and surrounding land (agroecosystem) form an identifiable system, similar to but distinct from other villages. The nature of local perceptions of villagers about their environment (cultural and natural), and conclusions drawn from direct observation by the author of interactions between villagers and their environment, makes it clear that the physical and cultural definitions of a village are conterminous - the village proper and its agroecosystem

2 In Chapter 5 the data is used to analyse the energetics and economics of rice cultivation, in Chapter 6 changes in family income sources and patterns of expenditure.

are structurally and functionally a whole, an identifiable ecosystem. The physical and cultural village is 'embedded' in its surrounding and inter-penetrating agroecosystem, making this system boundary non-arbitrary in character.[3]

Somewhat simplified, two main types of agriculture were used by traditional Balinese society: wet (irrigated rice cultivation) and dry (dryland cultivation of annuals and perennials).[4] The varieties of rice planted, although originating outside Bali, had been evolving in Bali by natural and farmer selection for hundreds of years. The technology of irrigation (weirs, tunnels, water dividers) and social organisation (irrigation associations, *subak*) had been in operation for hundreds of years, and drew only on local resources. The arrival of many dryland crops important by the turn of the century (e.g. coffee, sweet potato, cassava, maize, groundnuts) must post-date the arrival of the Portuguese in the 16th century, and some may be more recently introduced. Nevertheless, by the 1930s all these crops had been integrated into traditional farming systems. The tools currently used in farming and the processing methods used for the harvested food etc were all in evidence well before this century (cf Crawfurd 1820; Helms 1882).

In addition to agricultural systems there are also flows of energy within village communities to be considered. The small amount of historical data available suggests that the only fossil fuel available (kerosene) was not commonly used in the 1930s (Bakker 1935), indicating that villagers depended entirely on vegetable products (timber and palm oil) for cooking and lighting. As far as can be discovered, the Balinese never widely used wheeled transport, most loads being carried by humans, with some cross-island transport of

3 Conway (1984) discusses the problems associated with differences between definitions of natural and social systems, in particular whether or not to include human activities as part of or distinct from the agroecosystem (cf Spedding 1979 for an anthropocentric definition and Rambo 1984:2-7 for a definition that separates the village and agroecosystem); he points out that the distinction is of theoretical rather than empirical significance. Here, human activities are considered to be a component of the overall village agroecosystem - simply because without human activities there would be no agroecosystem.

4 Dryland farming includes cultivation of annuals and perennials in fields remote from the house compound in tegal(an) (outside the built limits of the village) and housegardens (tebe/pekarangan) within the family compound. Both types employ multilayered polycultures of trees, shrubs, arable and root crops (see Soemarwoto and Soemarwoto 1984:261-78 and Christanty et al 1986:132-58 for descriptions).

luxuries (e.g.salt) by horses (Helms 1882:26). The materials used for constructing houses, compounds and temples were all of local origin and, except for roofing-tiles and bricks, required only human labour for their acquisition and processing. Tiles and bricks were fired in simple earthen kilns fueled with timber. Thus, traditionally, the whole range of processes essential to village life, from food production to the construction of temples, were carried on using only the renewable materials and energy resources available within village agroecosystems.

While it is true there were some exports of agricultural products (rice, pigs, cattle) from villages (and Bali) and some imports (gold, silver, iron, opium), the scale of these transactions can be taken to have had a diminishingly small effect on the general proposition that traditional Balinese agroecology was at that time fundamently self-provisioning and sustainable.[5] Moreover, if the term 'sustainable' is to have any force, the fact that Balinese society flourished for over 1000 years with no reliance on outside inputs crucial to its functioning (the demands of a decadent aristocracy aside) means, quite simply, that it was ecologically sustainable.

Until this century and the arrival of the Dutch, almost all the needs of the mass of the people had to be met from resources available within an orbit of a few kilometers. The average person was, therefore, an expert in the resources available and the manner in which they could be transformed into socially useful foods or artifacts. Thus, when family or community decisions had to be made about how to maintain or expand the use of resources, each person (usually males at the community level) could make suggestions or 'vote' on alternative approaches - with a relatively complete knowledge of the likely social and economic costs and benefits to themselves, their family and/or the community. Hence, the system of information flows 'linked-up', and both positive and negative feedback loops were incorporated in social planning

5 From Dutch colonial records it is clear that Bali, shortly after colonisation, exchanged a very limited range and quantity of goods with the outside world (CKS, Indisch Verslag 1927-39). From earlier records it is fairly clear that this pattern had persisted for some time (200 plus years?) (Raffles 1817, Crawfurd 1820).

and action. That is, social or environmental actions detrimental to well-being fairly quickly rebounded on the perpetrators - likewise, the extractions of the nobility aside, benefits flowed relatively directly to those who suited their actions to the social and natural environmental possibilities.

4.2 Village Selection.

The research design ensured that villages selected characterised the patterns of agriculture and socioeconomic modernisation found in the region.[6] Bearing the above agroecological characteristics in mind, the four selection criteria or 'axes of variation' were that the villages chosen for intensive study:

> Be representative of the balance of agricultural systems (dryland vs wetland) found in Southern Bali - between the coastal plain and the upper limit of irrigation.
>
> Be typical of the range of ease or difficulty of access for people, goods and new information about agriculture, education and health.
>
> Evidence the differing effects of government development initiatives, urbanisation and tourism.
>
> Reflect the regional pattern of agricultural and general population distribution - densest near the coast and less dense as altitude increased.

6 In the initial period of fieldwork the criteria provided a referent when examining government statistical data, making exploratory tours throughout the region and conversing with local people.

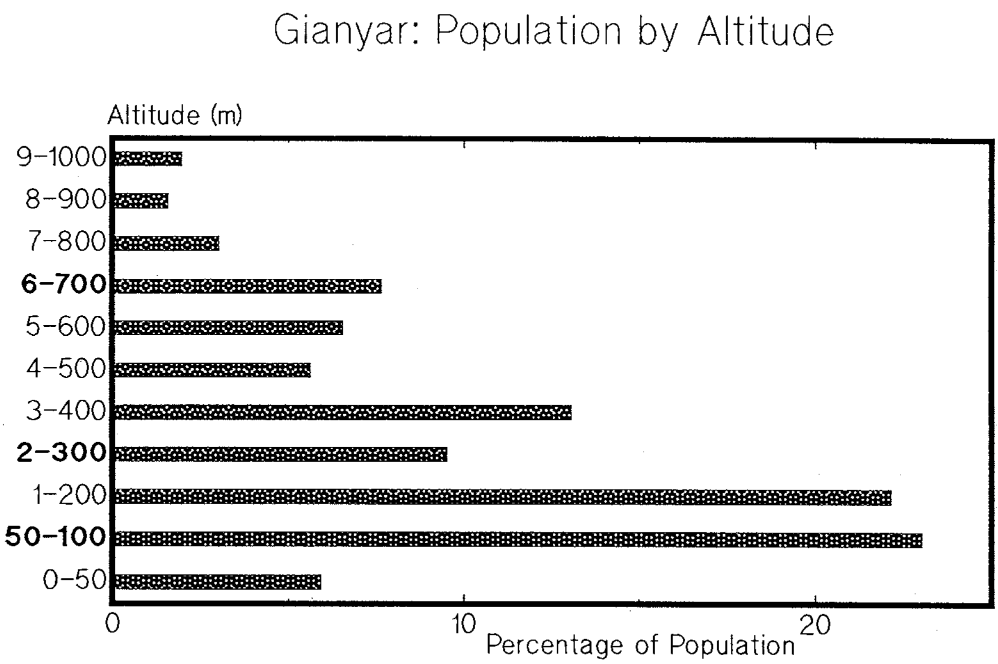


Figure 4.1: Kabupaten Gianyar: Population by Altitude (1980).

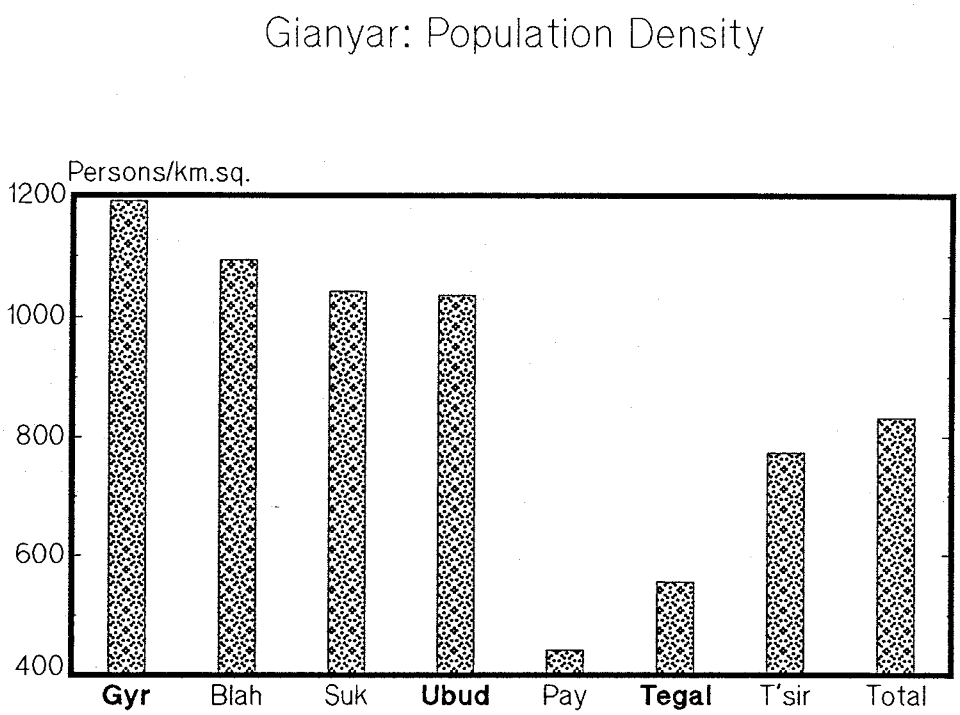


Figure 4.2: Kabupaten Gianyar: Population Density by Kecamatan (1981).

The three villages selected as a result of the application of these four criteria had the following general characteristics:

> **Taro:** A remote village, in which government programmes are the predominant agent for initiating modernising changes; at the upper boundary of irrigation (altitude 650m), with a balance of rice and dryland agriculture; somewhat lower population density than the regional average.
>
> **Penestanan:** A more accessible village in which tourism is an important element in fostering socioeconomic changes; agriculture dominated by rice cultivation, some dryland agriculture (altitude 220 m); in the medium range of regional population densities.
>
> **Tegal Tugu:** An easily accessible, periurban village in which urban factors, without tourism, are strongly influencing the pattern of modernisation; domination of rice cultivation (altitude 80 m); at the high end of population density range.

About 88% of the total population (1980) of Kabupaten Gianyar live between 50 and 700 metres altitude (see Figures 4.1 and 4.2 and Table A4.1.5).[7] Although it would have been interesting for comparative purposes to include the coastal and highland zones (fishing villages and dryland farming villages respectively), making the study relevant to the situation of the majority of the population dictated that they be excluded.

4.3 Village Descriptions and Demographics.

Before proceeding with the analysis of inter-village demographic differences, the broad geographic, administrative and land-use features of each of the three villages are described.

4.3.1 Banjar Taro, Penestanan and Tegal Tugu.

Banjar Taro Kaja and Taro Kelod (Taro).

Taro is the most remote from centres of modernisation of the three villages, located at traditional upper limit of irrigated ricefields.[8] Above Taro on this ridge mainly

7 An analysis of the 1980 census for data on population distribution indicates that only a small percentage (5.9%) of the population live in villages below 50 metres in altitude, adjacent to the coast. A similarly small proportion (6.6%) of the population live in the dryland region above about 700 metres in altitude.

8 Taro Kaja and Kelod, both of which have relatively large areas of ricefields and drylands, straddle the boundary between wet and dry agriculture. Had there not been new ricefields created to the north of Taro in 1975-76 (116 Ha, including 15 Ha in Taro Kaja), then these 10

dryfield agriculture is practiced, the ridge leading finally to the rim of the caldera that encloses Gunung Batur and Danau Batur (Mount Batur and Lake Batur). On the ridge below Taro is an alternating series of ricefields and villages, all of which draw their irrigation water from the River Oos (*Tukad Yeh Oos*) and its tributaries. This ridge terminates 14 km south at Campuan on the western side of the court (and now tourist) town of Ubud, at the confluence of the eastern and western branches of the Oos.[9]

The village referred to as Taro is in fact two traditional villages: Taro Kaja (Taro North) and Taro Kelod (Taro South). The village of Taro Kelod has two parts: the northern part is encircled by the lower (southern) part of Taro Kaja; and a southern part, called Delod Sema, located about 1 km to the southeast of the main village complex (see Map 4.2[10]). The religious congregations and traditional civil administration of the two villages are distinct at the village level, although they, together with other villages, are part of a unified civil administration, Desa (*Pebekalan*) Taro, at the next level of civil administration.

northern villages would have been even more distinct from those to the south i.e. reliant wholly upon dryland agriculture. These new ricefields added about 70% to the total area of ricefields in the Desa (see Table A4.1.2). If population in this village has doubled during the last 50 years (and responses from older local people suggest that it has probably more than doubled), then in earlier times ricefield population density would probably have approximated the current density for dryfields. In addition, if the new ricefields to the north of Taro had not been developed in the mid-1970s, ricefield population density in Taro Kaja would now be similar to that for Taro Kelod (33 persons/ha).

9 A fuller description of Taro, Penestanan and Tegal Tugu their built and natural environment, access and the differences between each village and the other villages within each administrative sub-division (Desa) can be found in Appendix 4.1.

10 These colour codings apply to Maps 4.1, 4.2 and 4.3 (the colours used are as 'natural as possible). Ricefields = Light Green; Dryfields = Dark Green; Blue = Rivers and Irrigation Canals; Yellow = Villages and Environs; Tan/Orange = Public Temples; Black lines = Asphalt Roads; Grey lines = Gravel Roads; and Brown lines = Earthern Roads. Technical difficulties prevented providing an 'on-map' coding of land use classes for each village.

Map 4.2: Banjar Taro Kaja/Kelod Landuse and Environs.

Desa Taro includes 14 villages, with a total population of 7028 at the 1980 Census (see Table A4.1.1). The 10 villages in the Desa to the north of Taro, located in the dryfields, each have much smaller populations than Taro Kaja and Kelod or the villages to the south, Tatag and Ked. The villages to the north have populations ranging from 174 to 395 (in 1981) with 64 to 86 families, and an average size of 330 persons. In the four southern villages (Taro Kaja and Kelod, Tatag and Ked) village population ranges from 580 to 1404 persons, with 130 to 304 families, and average village population is 929 persons. Over half the population of the Desa live in these four villages (3717 persons, 53%). Population density within Taro is moderate by local standards (12,500 persons/km^2) (see Table A4.1.2). Importantly, even in Taro, a village with access to relative large areas of dryfields, total population density (667/km^2) is still high compared to the average for Bali as a whole (439/km^2), though below the average density for Kabupaten Gianyar (832/km^2).

The surveys drew samples from all of Taro Kaja and the northern, encircled, part of Taro Kelod. This village complex is an environmental and ecological whole, distinct from the separated southern sub-village of Delod Sema.

Banjar Penestanan Kaja.

Penestanan Kaja is located approximately midway between the coast and the upper boundary of irrigation. It is the northern of two villages that share the name Penestanan (Kaja and Kelod), they are separated by what was, until mid-1983, a small, forested valley (see Map 4.3). The ricefields farmed by families from Penestanan are located mainly north and east of the village, and irrigated by water from the River Ayung (*Tukad Yeh Ayung*), the largest river in Bali which flows in deep valley about 1 km west of the village. Most of the dryfields owned by people from Penestanan are some distance south of the village. Only a minority of families in the village own or rent dryfields and, owing to lack of water in the dry season and distance from the village, dryland agriculture is not important as a source of food or income.

Map 4.3: Banjar Penestanan Kaja Land Use and Environs.

In the last 10 years there has been a rapid expansion of tourism in the village complex of Ubud, this influx of tourists has resulted in an increasing area of agricultural land in and around Ubud being built on to provide tourist rental accommodation (*losmen*), shops and restaurants. This tourist boom has also affected Penestanan, and some ricefields with good views have had tourist accommodation built on them. A significant proportion of the villages have found employment, full or part-time, in tourist related service activities; others, particularly young males, in 'mass-producing' naive paintings for sale to tourists or mass export for hotel decoration in Europe and South America.

Penestanan Kaja, one of 14 Banjar in Desa Kedewatan, is located at the central eastern edge of the desa. At the end of 1982 the total population of the desa was 9889 persons (see Table A4.1.3). Although the agricultural population density in Penestanan is considerably higher than in Taro (7 vs 10 persons/ha), families in Penestanan have considerably more ricefield per capita than in Taro (29 vs 11 persons/ha). Compared to the average for the Desa, Penestanan has a favourable ratio of people to ricefield, although compared to the Desa (and Taro) intra-village population density is very high (14,400/km^2). Total population density is about 50% higher than Taro, almost double the average for Bali, and well above the average for Kabupaten Gianyar.

The socioeconomic surveys included every household in the Penestanan Kaja.

Banjar Tegal Tugu.

The village complex of Tegal Tugu is located in the low altitude coastal ricelands, just southeast of the regional capital, Kota Gianyar (see Map 4.4). The land to the south of the village slopes gently downhill to a small coastal 'escarpment', the ridges are broad and the landscape is not, relatively, deeply incised by river valleys. The ricefields farmed by the families from the village lie mainly to the south and southeast and are irrigated by water from the River

Sangsang (*Tukad Yeh Sangsang*).[11] There is no forest vegetation in the area around Tegal Tugu, and almost all unbuilt-on land is used for cultivation. At the southern boundary of the village the ricefields start and on the north the village blends into the outskirts of the Gianyar urban area.

Tegal Tugu is composed of three intermingled banjar. In the northeast is Banjar Kajanan, whose residents are for the most part descendants of retainers of the Raja of Gianyar, this banjar has the smallest population of the three.[12] In the centre of the village, astride the main street, is Banjar Triwangsa whose members all belong to the *Kasatryia* and *Wesia* castes - hence the Banjar's name *Triwangsa*.[13] To the south, east and west of the centre of the village is Banjar Pratha Mandala, whose members are all of the *Sudra* caste; this banjar has four internal subdivisions (*tempek*). The three banjar that make up Tegal Tugu have a mixture of separate and joint arrangements with regard to civil and religious responsibilities.

These banjar are part of Desa Samprangan, the most easterly of administrative divisions in Kabupaten Gianyar, which is composed of 6 Banjar (see Table A4.1.4). There is a distinction between Pratha Mandala and Triwangsa in terms of per capita access to agricultural land, the latter having about twice the average area per capita. However, Tegal Tugu as a whole has a per capita access to agricultural land very similar to that for Desa Samprangan. In comparison to the other two villages, average per capita area of ricefields is somewhat higher than Penestanan and over twice that of Taro; access to dryfields is half that of Taro and many times that of Penestanan. Domestic population density in Tegal Tugu (20,907/km^2) is about 25% higher than for the whole Desa and Penestanan and almost twice that of Taro.

11 During the dry season there is not enough water to irrigate all the ricefields in the area, and water is allocated according to a schedule determined by the Agricultural Service (Dinas Pertanian).

12 Banjar Kajanan was excluded from the surveys carried out in Tegal Tugu, due to its relative isolation and differing history.

13 Roughly translated Triwangsa means 'the three races', the Brahmana (the priestly caste), Kasatriya (the ruling/military caste) and the Wesia (the trading caste), these groups all trace their ancestry to the Majapahit evacuation of Java in the 16th century. The bulk of the population are 'outside' this 'caste' system, they are generally called Sudra or Orang Jaba (literally 'outside people') i.e. outside the caste system.

Map 4.4: Banjar Tegal Tugu Land Use and Environs.

The socioeconomic surveys drew their sample from Banjar Pratha Mandala and Banjar Triwangsa, and excluded Banjar Kajanan.

A summary of recent population and land use statistics for each of the three villages is presented in Figures 4.3 and 4.4. These show a variable pattern of population densities for living areas (house gardens) and agricultural land. Domestic population densities are highest in Tegal Tugu, while agricultural population densities are highest in Penestanan. However, these 'unrefined' population densities disguise important differences in the intensity of land use in each village environment. For example, although there are less people per hectare of ricefield in Tegal Tugu than in Penestanan, farmers in Tegal Tugu harvest only two rice crops every 14-15 months, whereas the farmers in Penestanan generally harvest three crops during the same period.

Even from these summary statistics, and the brief description of each village's setting, access to transport and landuse patterns, it is clear that they differ substantially from one another in important ways.

4.3.2 Village Demographic Characteristics.

Age-Structure.

One of the most striking features of Balinese villages today is the large groups of children to be seen going to and from local schools each day. Currently, about a quarter of the population is of official school age (7 to 12 years) and almost half of the population is under the age of 20, having been born since the advent of the *Order Baru* (New Order) in 1965/66[14].

14 These proportions, and the ones that follow on adoption of modern forms of birth control, are in good agreement with official statistics on population structure/education and family planning for the region (BPS Bali 1982e:21-22), though for family planning markedly higher than for the whole of Bali (Statistik Bali 1982a:79).

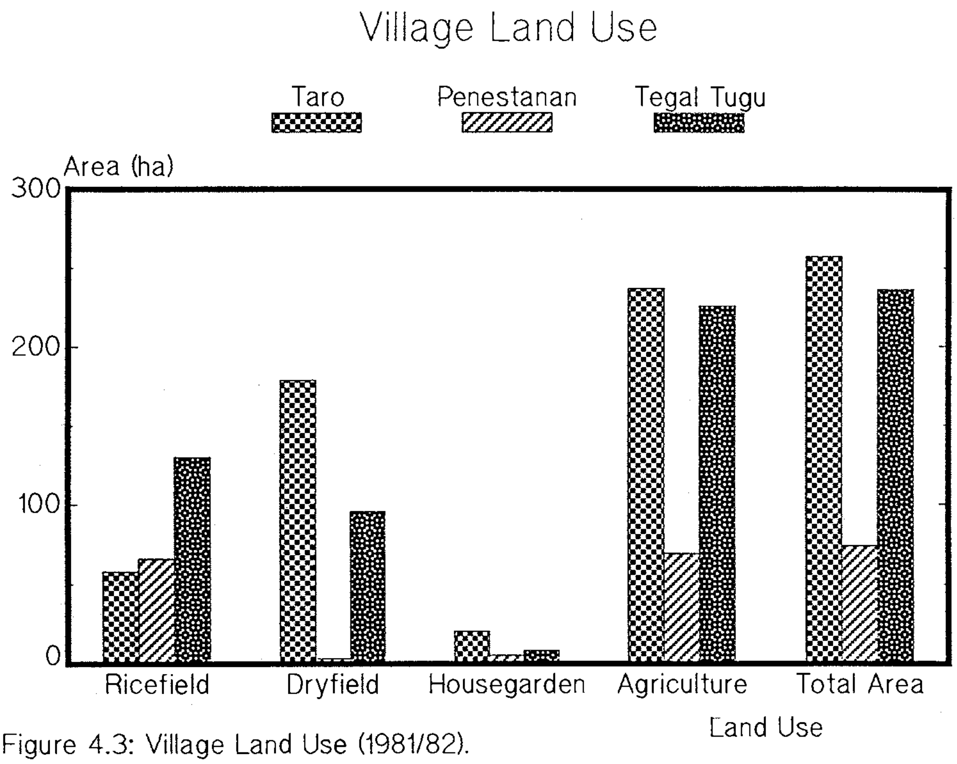


Figure 4.3: Village Land Use (1981/82).

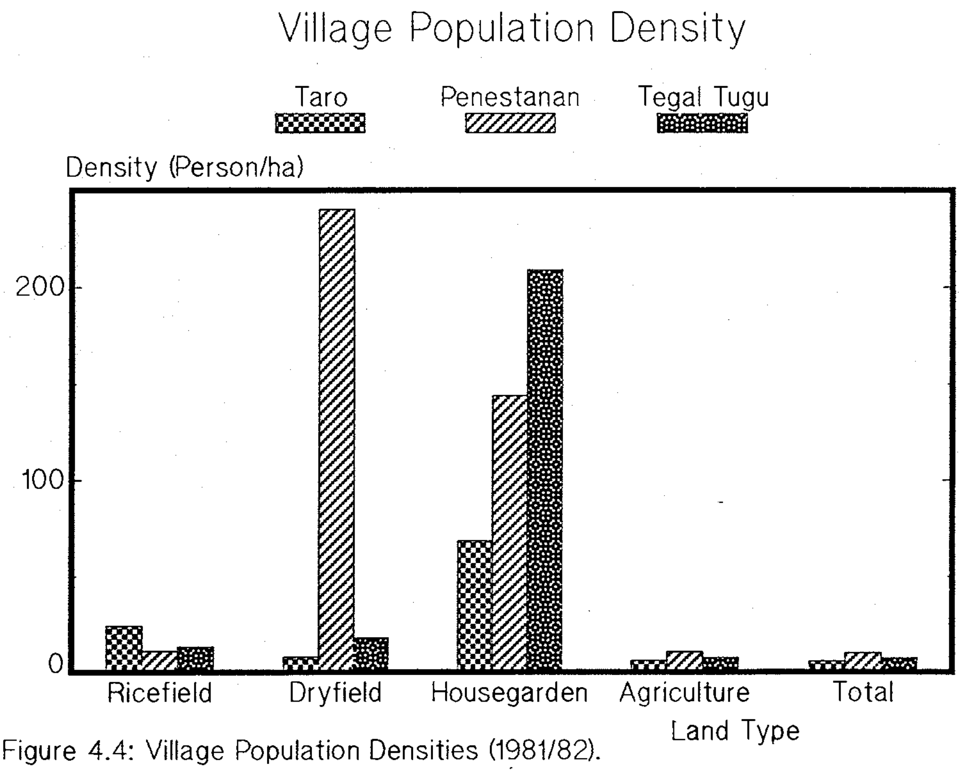


Figure 4.4: Village Population Densities (1981/82).

In the longer term, the rapid growth in population during the last 50 years has caused the average and median age of the population to decline. This growth is placing increasing demands on the natural and social resources of all communities, and on the government for providing the broader infrastructure necessary to maintain and/or improve the general standard of living. To reduce the medium and long term effects of increasing population a vigorous birth control programme has been in operation since the early 1970s.[15] The effect of this programme during the last 5-10 years can be seen (in crude form) by comparing the number of people in the 0-4 year age group with numbers in the 5-9 and 10-14 year age groups (see Figure 4.5 and Tables A3.7.1-6). Of the three villages Penestanan shows the most striking reduction in the 0-4 age group, over halving it (and presumably the birth rate) during the last five years, in Tegal Tugu and Taro the decline in birth rate has been slower and taken effect over a shorter period - these are strong indications that birth control is being widely adopted in these villages (see below).[16]

These patterns are also reflected in differences between the villages in terms of mean and median ages. In Tegal Tugu and Penestanan the mean age of the population is similar, while in Taro the mean age is some 25% lower - indicating later adoption of fertility control. Because of the rapid adoption of family planning (*Keluaraga Berencana* or KB) in Penestanan, the median age of the population is almost twice that of Taro, and markedly higher than that of Tegal Tugu. These changes are a significant indication of the effect of modern information and technology on population dynamics.[17]

15 See Streatfield 1986:43-55 for a review of this programme and the reasons for its success in an area immediately to the east of Tegal Tugu.
16 Details of the age-sex composition of the villages are presented in Appendix 4.2.
17 Despite the availability and cheapness of modern contraceptive methods it appears that the decline in the younger cohorts predates the widespread adoption of modern methods. Traditional forms of massage and herbal preparations may well have been used to control fertility before adopting modern means, in addition, a pattern of later marriage has been common for some time (Streatfield 1986:20-22).

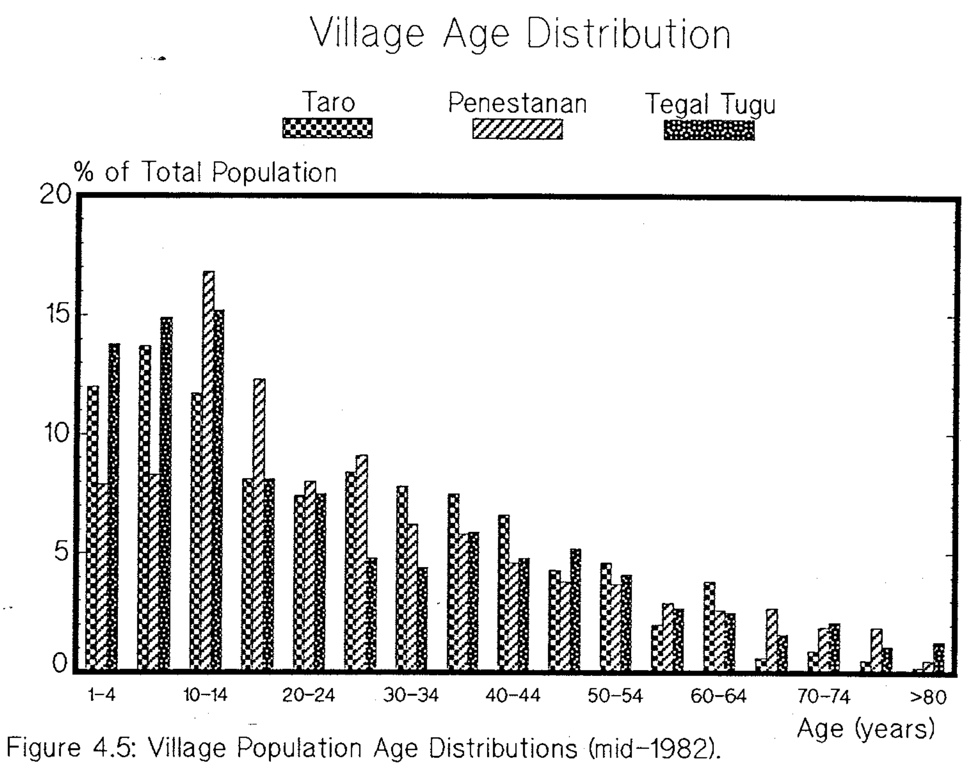


Figure 4.5: Village Population Age Distributions (mid-1982).

Figure 4.6: Village Family Size Distributions (mid-1982).

Birth Control and Family Size.

Overall, over half the couples surveyed were employing one of the three commonly available modern methods of birth control. But, as Table A4.2.6 shows, it has taken about 5 to 10 years for birth control to be adopted by two thirds of married couples in Penestanan; the median duration of adoption is about 6 years. In Taro just half the married couples are using birth control and in Tegal Tugu only a quarter of the married couples employ birth control; the median duration of adoption in these two villages is slightly less than 2 years.[18] By far the most common modern method of birth control adopted by women in each of the three villages is the Inter-Uterine Device (IUD) (see Tables A4.2.7-8).

The size of the family has an important bearing on the labour available for earning income, whether form agriculture or wage-paying employment; and on the scale of food, clothing, health and education outlays. The basic social unit in Bali is the extended family, whose members share dwellings and facilities within a compound (*karang*) and its associated housegarden (*tebe*). However, the basic economic unit is the nuclear family, and it is the family unit that bears the traditional and modern costs of child rearing.[19] Increasing population, and hence family size, has meant that additional sleeping and cooking facilities have been built within most compounds - tending to make many compounds crowded. Most families have between 4 and 5 members, except in Tegal Tugu where half the families have 6 or more members (see Figure 4.6). In addition, family size has grown - increasing the number of dependents per family - again the number of dependents is highest in Tegal Tugu (see Table A4.3.2). On average, each family has 1.4 males and 1.5 females of working age (14 to 60 years), though in Tegal Tugu the number of women of working age is slightly higher (see Table A4.3.3).

18 The reason for the markedly lower rate of adoption in Tegal Tugu, despite its periurban location and ready access to health care and KB personnel, is probably the much smaller proportion of the population in the prime child-bearing cohorts (25 to 35 years) in comparison to the two other villages.

19 As will be shown below, the costs for each family of paying for modern education and health care consume a significant, but variable, proportion of most families' expenditure.

In summary, the age structure of the population means that, despite family planning, the size of the population will continue to increase for decades to come.[20] By the turn of the century the population of the island will be about 3 million (see Table A3.5.1) and still increasing. Pressure of people on agricultural land will also continue to grow, within village precincts increasing population will lead to further crowding and greater competition for local resources of food, employment and fuel.

The differences in age-structure bears out the second proposition that there are substantial demographic differences between the three villages. Likewise, it is clear that there is a generally decreasing population density gradient from the lowland (Tegal Tugu) to the highland (Taro), although the pattern of land-use specific, population densities is quite complex.

4.4 Recent Changes in Rice Cultivation.

It is probable that, until the last 50 years, the technology of irrigated rice cultivation in Bali had changed little in the previous 1000 years. In the 9th century the Balinese were already constructing tunnels to improve the irrigation of rice fields (*sawah*)[21] and the tools that were in use probably differed little from those used at the turn of the century; except that iron and steel shod ploughs and other metal implements had replaced wooden-faced tools (Medhurst 1830). The timing of agricultural operations was then, as now, determined to a large extent by the monsoonal climate, with a wet season from about October to March and a dry season for the remainder of the year. Until the 1950s most farmers planted only one crop a calendar year (Raka 1955:31), since then cropping intensity has increased, with some farmers now trying to harvest four rice crops a year.

20 The problems this poses in terms of providing gainful and meaningful employment for a newly educated population of young people has already been mentioned (Chapter 3).
21 Swellengrebel (1960:11) cites Goris (1954) for a royal inscription referring to kesuwakan (modern Balinese subak) dating from 1022 AD. He also mentions another inscription dating from 896 AD referring to the craft of tunnel building (pengarungan), and comments "If there were already tunnel-builders in 896 it may be assumed that wet-rice farming in Bali is considerably older than that." (ibid).

Radical changes to Balinese rice farming have occurred during the last 15 years. For most rice farmers these changes have transformed the types and sources of physical inputs used (seed, fertiliser and pesticide), but not the sequence of operations or technology of human and draught labour inputs (land preparation and crop maintenance).[22] The new technology required for HYVs has necessitated major modifications in traditional practices. In particular:

- most farmers now plant three crops every 14-15 months;
- farmers now purchase their seed each season or two;
- all farmers using fertilisers and pesticides must make cash outlays for these inputs;
- a small minority of farmers now hire two-wheeled hand-tractors for land preparation (replacing ploughing and most hoeing);
- minor inputs of additional labour are required to apply fertilisers and pesticides (requiring back-pack sprayers);
- variable amounts of additional time are now needed to more closely manage irrigation water;
- the sickle has replaced the hand-knife (*ani-ani*) in harvesting and the crop is now threshed in the field;
- mechanical rice mills have almost completely displaced hand-pounding by women for husking and polishing rice.

The broader range of changes necessary to supply new inputs and distribute the local 'surplus' of rice to new urban centres and/or export are dealt with elsewhere (Chapter 3). It is important to bear in mind that these operations are carried out by each farmer on what, by Western standards, are very small parcels of land - typically about a quarter of a hectare (25 Are). After describing the differences between the three groups of rice varieties, these operations are briefly described; a fuller description is presented in Appendix 4.4.

4.4.1 Rice Morphology.

The morphology and cultivation requirements of the range of rice varieties grown today in Bali differ substantially. During the period when surveys of rice cultivation were being undertaken (1982-83) some 19 different varieties of rice were being grown in the ricefields adjacent to the three villages.

22 Despite these changes and more intensive cropping, the sequence of operations for the 'average' farmer remains quite similar to traditional practices (described in Dutch colonial literature, Liefrinck 1887-7:1-67).

Four varieties have been grown locally for some tens of decades, referred to as TLVs; thirteen of the varieties are the product of research carried out in Indonesia, referred to as NIVs; two varieties (IR36 and IR50) are HYVs, the products of work by IRRI in the Philippines. These groups of varieties are now described.

The traditional varieties grown in Bali have an unknown origin. Two main groups exist: *Padi Del* (loosely translated as 'slow/long' rice) with a growing period of 210 days, and *Padi Cicih* ('fast/short' rice) with a growing period of 140 days. Within each of these groups there are both non-glutinous (*beras*) and glutinous ('sticky', *ketan*) variants; within these sub-groups many different locally adapted varieties used to be grown; all the TLVs encountered in the surveys are members of the *Padi Cicih* group. These varieties are tall (1.5 metres) with drooping leaves and panicles, have thin stems, are responsive to nitrogen, but often lodge at application rates in excess of about 25Kg N/ha, and are high in resistance to traditional pests and diseases but low in resistance to *new* pests and diseases. Yields with traditional cultivation techniques (no fertiliser etc.) are about 2.5-3 tonnes/ha (unmilled), the use of nitrogen fertiliser can increase yields to about 3-4 tonnes/ha (unmilled). Excessive application of nitrogen fertiliser often results in lodging (falling over) of grain-laden plants in windy and/or rainy weather.

The NIVs are intermediate in stature (1.1 to 1.3 metres) between the HYVs and TLVs, have thicker stems than traditional varieties, are responsive to nitrogen applications, have intermediate levels of resistance to old and new pests and diseases, are less vulnerable to water stress and less reliant on accurately timed applications of fertilisers than HYVs, and have growing periods of 120 to 140 days. In comparison to the HYVs, yields are, generally, lower and excessive application of nitrogen fertiliser often results in lodging. Under ideal condition these varieties can yield up to 1.5-2 times (3-5 tonnes/ha unmilled) as much as traditional varieties.

The HYVs are short (about 85 cm, 'semi-dwarf'), stiff-stemed with erect leaves and 'highly' responsive to applications of nitrogen fertiliser, fairly resistant to low level attacks by many common diseases and pests, with growing periods of 105 to 110 days. Their drawbacks are that they are more sensitive to water stress, and they require application of pesticides and accurate timing of fertiliser applications for maximum yield; palatability is markedly inferior to traditional varieties. Under ideal conditions HYVs can yield up to 3-4 times (5-6 tonnes/ha unmilled) as much grain per crop as traditional varieties. IR36 is the most popular and widely adopted variety ever developed by IRRI; IR50 is a more recently developed variety, with a morphology similar to IR36, supposedly more suitable for planting at higher altitudes. Since the late-1970s IR36 has been the most widely grown rice in Bali and Java (Barker et al 1985:65), displacing previous HYVs, NIVs and TLVs alike.

4.4.2 Rice Cultivation Practices.

For the purpose of description, the tasks of rice cultivation can be grouped under four headings: Preparation, Maintenance, Harvesting and Post-Harvest. The tasks included under Preparation include those from the start of land preparation up to the transplanting of the rice seedlings. Maintenance tasks are those, such as weeding, that occur between transplanting and harvesting. There are few significant differences, in terms of labour requirements, in terms of Preparation and Maintenance between TLVs, NIVs and HYVs. Harvesting is a single, relatively rapid operation; and Post-Harvest operations are concerned with grain drying, storage and processing.

Rice Cultivation: A Brief Description.

Land Preparation.

The tasks included in **preparation** involve the following: seedbed preparation, straw burning/composting, ploughing, hoeing, harrowing, flattening, irrigation and transplanting.[23]

23 In the 'long form' survey the number of workers and the time taken for each of these activities was separately recorded; in the 'short form' survey only the number of workers and the times taken for ploughing, hoeing and transplanting were recorded. The short form, therefore, under-enumerates the total number of person-hours required for land preparation;

Crop Maintenance.

The tasks included under **crop maintenance** can be summarised as follows: fertiliser application(s), pesticide application(s), weeding and water control.[24] The 'maintenance' work to be performed by farmers after transplanting the rice seedlings is spread over about two months until harvesting - in contrast to the intense labour required for preparation. The most laborious task is weeding and the most frequent water control.

Harvesting.

The operations making up harvesting include the cutting, threshing, winnowing, bagging and transport of a farmers rice crop to the village.[25]

Traditional varieties of rice are harvested using a small hand-knife (*ani-ani*) to crop individual heads of rice, by cutting the stem about 30 cm below the base of the grain. These are gathered together in small bunches (*seping*) and a number of small bunches bound together with split bamboo to make a large bundle (*ikat*, each weighing about 25 to 30 Kg), these are then carried back to the village for drying and storage. The HYVs are harvested using a sickle, wielded by men. The stem of a bunch plants plants is cut about 5-10 cm above ground level, other workers then carry the rice to a threshing trestle set-up in the field on a large sheet of canvas, where the stalks are threshed to release the grains from the stem. The unhusked grains (*gabah*) are then winnowed to remove extraneous plant matter and dirt, before being bagged in hessian or polypropylene bags for transport to the farmers house (or rice mill) for drying, storage or milling.

Post-Harvest Operations.

After harvest the grain is carried to the village and, as quickly as the weather permits, dried prior to storage or milling. Traditionally, rice was stored in the

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where necessary the 'short form' data is supplemented with data collected using the 'long form' survey.

24 In the 'long form' survey labour inputs to each of these activities was separately recorded; in the 'short form' survey only data on the labour required for weeding was collected. As with land preparation information, 'long form' data are used to supplement 'short form' data where necessary.

25 These five, simultaneous, operations are treated as one in the 'long form' survey; they are omitted from the 'short form' survey.

family/compound rice barn after drying and the sheaves of rice hand-pounded to release the grains prior to cooking; almost all rice, including TLVs, is now mechanically milled. The labour requirements for post-harvest processing were not directly surveyed during fieldwork. Data on the labour required for hand pounding rice was available from earlier fieldwork (Foley 1979).[26] These figures are not included in economic and energetic calculations of costs and returns for individual farmers' operations.

4.4.3 Inter-Village Differences and Methods of Assessment.
The initial research design aimed, in part, to study the effects of the Green Revolution in Southern Bali. As a result of previous fieldwork experience it was hypothesised that there might well be significant differences between coastal, midlevel and highland villages in the practice of rice cultivation; and differences in cultivation practices between the rice varieties being grown. These differences result from physical factors (biogeography and morphology) and social factors, particularly the impact of modernisation on agriculture.

This working hypothesis was based on previous research experience (Foley 1979) - rather than the anthropological literature concerning rice cultivation in Bali, which tends to treat Balinese cultural practices (social, technical and religious) as homogeneous, particularly in Southern Bali (cf Mead and Bateson 1957). Farmers have adapted cultivation practices (levels of labour and material inputs) to suit the needs of each group of rice varieties, because of underlying morphological differences between TLVs, NIVs and HYVs,.

Methods.
The data required for testing the third and fourth propositions consists of quantitative information on unit area use of labour and physical inputs to cultivation and yields of rice. The amount of human and draught labour expended performing the operations detailed in Land Preparation, Crop

26 Data on the diesel fuel and lubricating oil requirements per tonne of rice mechanically processed were obtained from several mills located in or adjacent to the three villages surveyed.

Maintenance and Harvesting (listed in Table 4.1, below) were collected by interviewing farmers. This data, in combination with experienced farmers' assessments of the laboriousness of specific tasks and data on task-specific energy consumption available from Edmundson (1976) was sufficient to allow computation of human and draught labour energy inputs. Measuring the area under cultivation (using a 30-metre tape measure) provided a basis for calculating unit area inputs and outputs.

To obtain an estimate of the total output, a sample of five bags of rice from each sample farmer's harvest was weighed (using a 50 kg beam balance); determining the total number of bags of rice harvested, allowed computation of the output of rice per unit area. The raw data from weighings was corrected to a standard moisture content (14% w/w) by measuring the moisture content of a sample from each bag weighed. The energy content of output per unit area was calculated using data on the energy content of rice per kilogramme. Calculation of the energetic relations of labour used in production was then fairly straightforward.

Information on whether land was rented (and, if so, the financial details), the costs of hired labour and physical inputs, and the share of the harvest paid to the harvest team were all obtained from harvest-time interviews. Similarly, data on farmers use of physical inputs of seed, fertilisers and pesticide use were be obtained during the harvest. In total, these data permitted estimation of the energetics and economics of the whole production process prior to milling.

Because of the negative effects on the yield of HYVs of poor timing of fertiliser and pesticide applications, and HYVs susceptibility to water stress, data on the timing of these operations was also necessary, as was a estimate of irrigation adequacy. As not every farmer was covered by the SocioEconomic Surveys, it was also necessary to collect information on the farmer's age, education and family size. All this information was collected from farmers at harvest time.

A minimum set of data for investigating inter-seasonal variability is the above range of information for each of three consecutive seasons. Academic and other requirements dictated that fieldwork be completed by mid-1983, thus the three seasons prior to this time are those for which data were collected: dry season 1982, wet season 1982/83 and dry season 1983.

Data Collection.

Farmers were interviewed at harvest time to obtain data on task- specific inputs of human and draught labour; the duration and costs of tasks for which hired labour was used; inputs of seed, fertiliser and pesticide; and details of cultivation practices employed for water control, fertiliser and pesticide applications (see Appendix 4.7 for details of data collection methods). Although data on specific tasks were collected, data on labour inputs are aggregated into three groups: inputs up to and including transplanting (Land Preparation); crop maintenance activities from transplanting to crop maturity (Crop Maintenance); and harvest labour (Harvest Labour).

Two types of survey form were used in gathering data on cultivation practices. The more comprehensive form (long form) sought information from farmers on each of the separate tasks required for raising a crop of rice (see Appendix 4.5). The less comprehensive form aimed to 'streamline' data collection by gathering data only on what were judged to be the major tasks of cultivation (short form) (see Appendix 4.6). Unfortunately, this attempt at simplification did not result in substantial reductions in the time necessary to collect data from each farmer, and somewhat reduced information on human and draught labour inputs to cultivation (see Table 4.1 for a listing of tasks included).

Table 4.1:
Human Labour for Rice Cultivation:'Long' and 'Short' Forms.

		Long Form Items	Short Form Items
1	Burning/Flooding Straw	*	
2	Preparation of Seed	*	
3	Ploughing Sawah (x2)	*	*
4	Hoeing Sawah (x3)	*	*
5	Seedbed Preparation	*	
6	Harrowing Sawah	*	
7	Flattening Sawah	*	
8	Cleaning/Repairing Bunds	*	
9	Transplanting Seedlings	*	*
10	Draining Sawah (x3)	*	
11	Applying Fertiliser (x2)	*	
12	Weeding Sawah (x2)	*	*
13	Spraying Pesticide	*	
14	Bird Scaring	*	
15	Harvesting Rice	*	

Notes see Footnote 27.

In the comparisons that follow, analyses are based on data equivalent to the 'short form' used in the surveys of rice cultivation. Where important differences exist between data obtained by the 'long' and 'short' forms attention is drawn to them.[28] Essentially, comparisons are made between labour and physical inputs prior to harvesting.

Throughout this and following descriptions the ISO unit 'Are' is the metric unit of area used. The use of this unit of area is common throughout Indonesia: one hundred Are equal 1 hectare. As farmers' plots are typically about one quarter of a hectare in extent, the Are provides a more convenient unit than the hectare. All durations for labour inputs, quantities of physical inputs and outputs have been calculated on this basis.[29]

27 * Indicates data on task (number of workers, duration of work and cost of hired labour) collected by questionnaire. (xN) indicates number of times a task is usually performed. In order to make the data collected on human and draught labour inputs for both the 'long' and 'short' form surveys comparable, data collected in the 'long form' has been modified to conform to the categories used in the 'short form'. Although some detail on labour inputs in the 'long form' is forfeited in the overall analysis, the relevant categories of inputs for both forms are identical. For physical inputs (seed, urea and TSP fertiliser and pesticide) data collected with both the 'long' and 'short' forms is identical.

28 These differences relate, particularly, to the reduced subdivision of data on pre-harvest tasks (seedbed preparation, ricefield maintenance, ploughing and labour for fertiliser and pesticide applications), and lack of data on harvest labour.

29 To convert Kg/Are to Qunitals/ha, for example, a direct reading suffices; to convert to Kg/ha, Hours/ha or MJ/ha, simply 'move' the decimal point two places to the right; to convert

4.4.4 The Statistical Basis for Grouping Varieties.

In relation to rice varieties, the proposition is that:

> There are significant differences between the three groups of rice varieties cultivated, in terms of labour and material inputs.

The aim of this analysis is to determine if the cultivation practices used for each group of varieties (TLVs, NIVs and HYVs) reveal statistically significant similarities within each group. To demonstrate within-group similarities (i.e. the absence of significant differences) in cultivation practices Analysis of Variance (ANOVA) is used for TLVs and NIVs and the Student t-test for data on HYVs.

Only four different TLVs were encountered during the three seasons, giving some idea of the widespread adoption of HYVs during the last decade. Most were found in Taro, where HYVs had first been generally adopted in 1980. Although the majority of cases are from the sub-group of non-glutinous varieties, the sample includes a few cases of glutinous rice (*Ketan*).

Despite suspected differences in inter-seasonal cultivation inputs, the small number of cases available for analysis necessitates pooling data from TLVs for all three seasons. Even then, sufficient cases are only available in Taro and Penestanan (see Table A4.13.1). Except for the use of urea in Taro ($p=0.004$)[30], none of the probabilities of non-random differences for any of the variables exceeded 0.182, in either Taro or Penestanan. Additionally, pooling of data from different seasons has the effect of increasing F-ratios (and decreasing p values) over those separately calculated (hypothetically) for each season, thus exaggerating any statistical differences. Given the degree of similarity between varieties, and despite possible seasonal variations and inclusion of a glutinous variety, it seems reasonable to treat these varieties as one group.

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to Tonnes/ha 'move' the decimal point one place to the left. The word Are is capitalised to avoid confusion with the participle 'are'.

30 Values in parentheses are upper or lower, limiting values from the various analyses - they are given for illustrative purposes.

A total of 13 different NIVs were encountered during fieldwork, and four make up the majority of the sample of these varieties.[31] Only from Taro is sufficient data available to allow an analysis for each of the three seasons; for Penestanan data is only available for the third season; and for Tegal Tugu only for the second season (sample size is only 8 cases).

In Taro there are non-significant differences in labour and physical inputs (Table A4.13.2) for each of the surveys, except for seed and urea use in the 1983 season, no probability of non-random difference exceeds 0.106 (1982 season, draught labour). In Penestanan, 1982/83 season, none of the probabilities exceed 0.310 (draught labour); and in Tegal Tugu, 1983 season, none exceed 0.204 (draught labour). Given these similarities, the data on cultivation inputs for each of the varieties grouped as NIVs is pooled for purposes of analysis and discussion.

Because only one farmer growing IR50 was encountered in the third survey (dry season 1983) t-tests could only be applied to data from the first and second seasons. The results of the t-tests (Table A4.13.3) reveals there are no statistically significant differences in human and draught labour inputs and/or physical inputs between IR36 and IR50, in either the first (1982) or second (1982/83) seasons. Probabilities of non-significant differences for t-values in the first season (for individual villages) for labour inputs are all greater than 0.263 (Taro, land preparation, t=1.31, df=99), and for physical inputs greater than 0.066 (Taro, pesticide, t=1.29, df=20). In the second season, probabilities of t-values (for individual villages) for labour inputs are all greater than 0.353 (Tegal Tugu, draught labour, t=0.94, df=50), and for physical inputs greater than 0.140 (Penestanan, pesticide, t=1.54, df=20). Thus, given the similarities in cultivation practices, data on inputs for growing these two varieties are pooled in subsequent analyses and discussions.

31 Mansur: 45, 38 and 5 cases; Gembira: 5, 23 and 2 cases; Jelela: 1, 3 and 17 cases; and Semru: 0, 0, and 29 cases: 1st, 2nd and 3rd surveys respectively.

The justification for grouping the 19 varieties of rice into three groups is apparent from morphological characteristics; in addition, differences in cultivation practices provides a statistical basis for the groupings. There are, however, undoubtedly overlaps between the varieties in the pattern of cultivation practices used by farmers. Nevertheless, it appears reasonable accept the third proposition and to proceed on the basis that HYVs are cultivated using practices significantly different from those for TLVs and NIVs.[32]

4.5 Differences in Rice Cultivation and Village Economies.
This is the most crucial section in laying the groundwork for the detailed analyses that follow. Attention is now directed to differences between each of the villages in relation to rice cultivation practices and income and expenditure patterns. Having established that there are substantial differences between the villages in landuse and demographics, and in rice cultivation practices, hence input requirements, between TLVs and HYVs.

4.5.1 Differences in Rice Cultivation Practices.
To establish the fourth proposition that there are significant differences between the three villages in the way that farmers cultivate rice, in terms of labour and material inputs, three methods were used: Discriminant Analysis, Analysis of Variance (ANOVA) and Multiple Analysis of Variance (MANOVA). These methods were applied to combinations of data on inter-seasonal and inter-variety pre-harvest use of human and draught labour, and physical inputs of seed, fertiliser and pesticide.[33]

Discriminant Analysis.
Here, the analysis is applied to three groupings of input variables for each variety of rice and each season (survey),

32 An exploration of the variations in yield within each village for HYVs is dealt with in Chapter 5.
33 In Discriminant Analysis a linear combination of variables is used to establish a decision 'rule' for discriminating between groups (of cases); the rule is reapplied to the original data set to test its effectiveness in allocating cases to their original (true) group. ANOVA is used to decompose sources of variation for individual variables in a dataset; whether or not the datasets are significantly different statistically depends on the magnitude of the F-ratio, which is used to establish if the probability of a nonrandom difference between the grouped datasets is greater than a selected value (usually 5%). MANOVA is an extension of ANOVA to examples where multiple dependent variables are analysed for their combined effects upon an independent variable - in this case, village-specific cultivation practices.

and combinations of varieties and seasons.[34] The first group of variables includes human and draught labour inputs for land preparation, crop maintenance, total pre-harvest labour, draught labour (all measured in hours/Are) and water management (number of visits); the second group are physical inputs of seed, fertiliser, and pesticide (all measured in kg/Are); the third group combines groups one and two. The detailed results of the analysis are presented in Appendix 4.10.

Using only labour inputs, the method correctly classifies between 49% and 75% of cases, using data from three seasons surveys: between 66% and 98% for the first survey; between 74% and 90% for the second survey; and between 72% and 82% in the third survey (see Tables A4.10.1-4). Of particular interest is the degree of success in correctly discriminating between villages on the basis of cultivation practices used for growing HYVs. Using only labour inputs, 66% of the cases from the combined survey data are correctly classified: 80% of cases from the first survey, 91% from the second survey and 72% from the third. Clearly, just on the basis of patterns of labour inputs, there are major differences between the villages.

A similar range of differences are apparent with regard to patterns of physical inputs. For the combined data from the three seasons, between 70% and 87% of cases are correctly allocated: for the first survey between 70% and 85%; for the second survey between 78% and 100%; and for the third survey between 55% and 72% (see Tables A4.10.5-8). For the combined data on HYVs from three seasons, 71% of cases are correctly classified: in the first survey 71%; in the second survey 82%; and in the third 56%. As with labour inputs, there are clear differences between the three villages in the use of physical inputs.

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34 Given that there are three groups (villages), there exists a prior probability that, by random allocation of cases to groups, one third (33.3%) of the cases could be 'correctly' allocated. The efficacy of the method rests upon how great an improvement over a random allocation is achieved using the constructed decision rule in reclassifying the original data.

Combining the two groups of inputs substantially increases the proportion of correct classifications. For the three seasons data (886 cases), 80% to 86% of all cases are correctly classified: in the first survey between 84% and 98%; in the second between 96% and 100%; in the third between 74% and 89% (see Tables A4.10.9-12). With regard to the classification of HYVs, in particular, for the three seasons (639 cases) 83% are correctly classified: in the first survey 89% (232 cases); in the second 96% (278 cases); and in the third 81% (129 cases).

These results establish that the pattern of cultivation inputs used in each village differ substantially from one another, particularly for HYVs. Next, ANOVA is used to establish that differences that are apparent between the villages for groups of variables (labour inputs, physical inputs, and labour plus physical inputs) are a function of underlying, statistically significant differences between the villages in the amount of labour and physical inputs.

Analysis of Variance.
To ensure that differences between villages established using Discriminant Analysis are not an artifact of the groupings used, and to establish that statistically significant differences exist - inter-village differences for each of the variables used in the previous analysis are tested using an ANOVA.[35]

For each of the three seasons (sample sizes: 288, 329 and 245 cases respectively), for all the varieties combined (HYVs, NIVs and TLVs), and all of the variables (except the use of TSP and pesticide) inter-village differences in duration of work (hrs/Are) and somatic energy used (MJ/Are) for pre-harvest cultivation are all significant at the 0.1% level or greater (see Table A4.11.1). For TSP, in the first and third surveys, inter-village differences are not significant (p=0.681 and p=0.082, respectively), because of the small number of farmers that use TSP these minor similarities are not considered important. Pesticide use in the third survey

35 Variables are accepted as being significantly different if their probability of random difference is less than 5% (i.e. $p <= 0.05$). The complete results of the analysis are presented in Appendix 4.11.

did not differ significantly between villages (p=0.657), this similarity may be due to the relative cheapness of pesticide and/or rapid increase in pesticide use over the three seasons.

Only in the third season are there sufficient cases to allow an analysis of inter-village differences for TLVs; Tegal Tugu had only one case. The analysis shows that there are no significant inter-village differences in labour used for land preparation or draught labour, nor for seed and pesticide use (see Table A4.11.2). However, inter-village total pre-harvest human labour inputs are significantly different (p=0.015). The similarities between villages (Taro and Penestanan) in labour use for land preparation may be due to the small size of the sample (27 and 17 cases respectively). Similarities in seed and pesticide use may be due to the small quantities of these inputs used for these varieties.

For NIVs in seasons one and two no farmers in the sample came from Penestanan, thus the comparison is only between Taro and Tegal Tugu (see Table A4.11.3). Inter-village differences in labour inputs between these villages are only significantly different in the first season. In neither of the two seasons are there statistically significant differences between the villages in the use of physical inputs, except for the use of Urea in the second and third seasons. It is suggested that the lack of significant inter-village differences, particularly in the third season, may be due to the similarity of these varieties to traditional varieties, thus minimising any innovation-specific cultivation practices.

For the HYVs (see Table A4.11.4) in each of the three seasons (sample sizes: 231, 276 and 129 respectively), there are highly significant inter-village differences for all inputs (p=0.001 or greater), except TSP and pesticide use. The non-significant inter-village differences for TSP in the first and third surveys (p=0.681 and p=0.133 respectively) are considered to be unimportant, because of the small numbers of farmers using TSP; as are the non-significant inter-village differences in pesticide use in the third season (p=0.476).[36]

Multiple Analysis of Variance.

This technique complements the two foregoing analyses, and allows some quantification of the degree of inter-village differences for the combination of labour and physical inputs used in cultivation. However, some caution is needed in interpreting the analysis. First, the use of this method assumes a multivariate normal distribution of values. These data, while following a normal distribution within (about) two Standard Deviations of the mean, have extended, non-normal distributions in both tails of the distribution. Second, the variance and covariance matrices of the groups of variables being analysed are significantly different, whereas the method depends for reliability on equal matrices .[37] The differing variance and covariance matrices are, however, in themselves, a strong indication that underlying inter-village differences in cultivation practices exist. Logarithms of the variables are used in the analysis. Thus, the results of the MANOVA need to be conservatively interpreted, and little reliance should be placed on statistical differences close to the limit of significance (i.e. p=0.05 or 5%).

The MANOVA includes both villages and rice varieties as factors in the analysis (analysis relating to rice varieties is dealt with in the section on Inter-Variety Differences). For each of the seasons, and for the pooled data for the three surveys, there is no instance where the probability that the inter-village differences are random rose above 0.2% (see Table A4.12.1-4) for pre-harvest labour and/or physical inputs. These results, despite the foregoing caveats, confirm that the inter-village differences in overall pre-harvest cultivation patterns are substantial.

36 First, in economic and energetic terms the use and application of pesticide is relatively 'cheap', having little effect on the total cost of production or total labour inputs; second, during the period (1982-83) the Agricultural Service (Dinas Pertanian) were particularly active in promoting the use of pesticides - thus 'artificially' modifying established farming practices.

37 The equivalence of the variance-covariance matrices is tested using Box's M test. For every combination of villages, varieties and seasons the test showed the matrices to be significantly different (p = 0.000 in all tests), see Appendix 4.12.

On the basis of the (re)classification using Discriminant Analysis it is clear that in excess of two thirds of the cases in each season and for each variety can be successfully allocated to their 'home' village on the basis of the pre-harvest labour and/or physical inputs used in cultivation. Because of the preponderance of farmers growing HYVs in the sample for each season (first season 80%, second season 84% and third season 52%) inter-village differences for these varieties masked some similarities between villages for NIVs and TLVs (except for pesticide use). Generally, however, it is clear that significant inter-villages differences do exist for labour and physical inputs, particularly for HYVs.

It is, therefore, reasonable to accept the fourth proposition that significant inter-village differences in cultivation practices do exist - particularly for the varieties of main interest, the HYVs. Because of the preponderance of farmers growing HYVs, detailed analyses in the following chapter are restricted to HYVs (IR36 and IR50).

4.5.2 Village Socioeconomic Characteristics.

The fifth proposition is that there are significant differences between the three villages in the relative importance of different sources of family income and patterns of expenditures. Before presenting an overview of the results of the Socioeconomic Surveys (Surveys 1A and 1B) in this regard, some background information on the construction of the survey instruments is necessary.

Methods.

These surveys were designed to provide data from a random sample of families in each village on a range of variables associated with each family's agricultural resources, income and expenditure. Although each family living in a compound operates as semi-autonomous economic unit, the living space, housegarden, family temple, tools and implements are commonly shared among families. There are also common responsibilities in maintaining the family shrine, preparing for and performing religious ceremonies and general maintenance of compound walls and grounds.

The survey questionnaires were constructed after a wide-ranging survey of literature on the measurement of socioeconomic welfare, particularly in Third World agrarian societies,[38] and after prolonged informal conversations with numerous people from local villages and members of the government civil service. Like the agricultural surveys, the text of these surveys was composed directly in Indonesian and later checked for correctness and clarity with members of the survey team and local people.

The resulting survey had two parts: the first (Survey 1A) relates to the compound as a whole; the second to each family unit within the compound (Survey 1B).[39] The Indonesian language original and English translation of the survey forms are presented in Appendix 4.7. Based on an initial mapping of each village[40] and assigning a code number to each compound, a strict random sample of 60 compounds in Taro and 70 compounds in Tegal Tugu were selected; in Penestanan all 56 compounds were surveyed. Overall, the survey encompassed 357 families and 1,908 people: 135 families and 652 people in Taro; 124 families and 626 people in Penestanan; and 98 families and 630 people in Tegal Tugu.[41]

Data Collection.

A small team of interviewers was trained in the methods to be used in conducting the survey interviews. Training methods included role-playing and various techniques that could be

38 The survey incorporated questions about physical quality of life (QoL) found to be important in previous studies of QoL (OECD 1973; UNESCO 1975; Liu 1975, 1976, 1977 and 1978; Boyden and Millar 1978), these are reviewed in Foley, B (1982). And, second, items used in two previous studies of QoL in Indonesia (World Bank 1978; Downey 1981) using data from the National Socioeconomic surveys (SUSENAS) and one study of QoL in Eastern Bali (Poffenberger 1979) were considered for inclusion.

39 The survey has 21 sections. The first part sought data from the compound as a whole on: Migration and Travel outside the Desa; Electricity/Lighting; Compound Garden; Births and Deaths; Housing; Compound Possessions; Electrical Equipment; Religion. The second part sought data from each family unit on: Ricefield ownership, rental and crops; Dryland ownership, rental and crops; family Occupations and Wage Income; Non-wage sources of income; Property Transactions; General and Transport Expenditures; general Financial Situation; Food Consumption; Woodfuel and Kerosene Consumption; Family Health history; and Feelings about Life.

40 The mapping was undertaken using a land measuring-wheel and prismatic compass. Maps at 1:100 scale were prepared from sketch maps and field notes. Smaller maps (A4 size) were used as an interviewing aid by the assistants undertaking various surveys. During this mapping, the area of each compound and housegarden was measured and the inhabitants of each compound informed that shortly they might be visited by a survey worker.

41 The details of the fieldwork methods used in administering Survey 1A and 1B may be found in Appendix 4.5. The data used in the following analysis are based on Sections 10, 13, 14, 17 and 19 of the Socioeconomic survey (Survey 1B, Appendix 4.4).

used to gain co-operation and resolve uncertainty about the intent of questions or the precision of quantitative answers (see Appendix 4.8 for details).[42]

Taro was the first village surveyed, then Tegal Tugu and lastly Penestanan. The surveying of each village lasted about 10-14 working days. Survey 1A was administered to the senior person in each compound surveyed. This questionnaire was administered prior to the more detailed questionnaire dealing with the situation of each family living in the compound (Survey 1B). As the questionnaires were completed they were immediately returned for checking, prior to the interviewer starting the next questionnaire. Any omissions or anomalous responses were corrected by revisiting the compound and seeking clarification on specific points.

Responses to questions were recorded on prepared survey forms. Rarely during these surveys was the interviewing carried out in private. Usually the principal respondent was surrounded by other members of the compound, who freely interjected to correct what they perceived as incorrect answers or provide information that the principal respondent had forgotten or did not know. This typical Balinese social practice probably added to the reliability of the answers recorded.

Discriminant Analysis is used to analyse differences between the three villages, in terms of sources of family income, patterns of family expenditure, and a combination of income sources and expenditure patterns.

Differences in Sources of Income.

The overall grouping of sources of income (see Section S.13 of questionnaire) is into Wage and Non-Wage income.[43] To establish the relative importance of each income source, and to eliminate the effects of wide variations in the absolute

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42 These interviewers were all high school graduates, and came from villages similar in many ways to those they were being asked to survey. They were required to draw upon their local knowledge in both presenting the questions and evaluating the 'reasonableness' of the answers received.

43 Sources of Non-Wage income are then combined to arrive at 12 types of source: Gifts, Finance, Crafts, and Subsistence; sale of produce from Ricefields, Secondary Crops, Dryland and/or Housegardens; and sale of livestock and produce from Cattle, Pigs, Ducks and/or Chickens. The sum of these 13 income sources (Wage and 12 Non-Wage) multiplied by 12 is used to provide an estimate of the each family's Total Annual Income (see Section S.14).

amounts of various sources of income, each of the sources was divided by an estimate of the family's total annual income (the sum of all specific incomes), and then expressed as a proportion. These proportional contributions to total annual income are the variables to which Discriminant Analysis was applied.

The first canonical discriminant function accounts for 82% of total variance, the second for the remaining variance. As a result of applying these two functions, 66% of the cases are correctly re-classified.[44] This result indicates that, despite similarities (overlaps), major differences exist between the villages in terms of income sources (see Table 4.2). This finding confirms, tentatively, the working hypothesis of substantial inter-village differences in sources of income.

Table 4.2:
Proportional Contributions from Sources of Income.

Actual Village	No. of Cases	Predicted Village Membership (%) Taro	Penestanan	Tegal Tugu
Taro	135	68.9	8.1	23.0
Penestanan	124	4.0	53.2	42.7
Tegal Tugu	98	4.1	18.4	77.6
Total Cases:	357	Percentage Classified Correctly 65.8		

Differences in Patterns of Expenditure.

Differences in patterns of expenditure are more clear-cut than those for sources of income, with expenditure patterns in Taro clearly standing out as a distinct grouping.[45] The first canonical discriminant function accounts for 98% of inter-village variance, the second for the remaining variance.[46] The application of these two functions results in 82% of the cases being correctly re-classified (see Table 4.3). Clearly there are distinct inter-village differences in patterns of family

44 Three of the variables, income from Finance and sale of poultry (Ducks and Chickens) were insufficiently statistically important to be included in the analysis.

45 Data on the 15 items included in the questionnaire under Section S.17 and expenditure at the markets on food (Section S.19, Q.5) were combined into 9 categories of expenditure: Health, Education, Religion, Finance, Transport, Fuel, Marketing (food basics), Consumer Goods/Services and Community.

46 Two of these, Education and Fuel, were eliminated from the analysis due to statistical insignificance.

expenditure, particularly between Taro and the other two villages.

Table 4.3:
Proportional Expenditure on Goods and Services.

Actual Village	No. of Cases	Predicted Village Membership(%) Taro	Penestanan	Tegal Tugu
Taro	135	98.5	0.0	1.5
Penestanan	124	0.8	71.8	27.4
Tegal Tugu	98	0.0	26.5	73.5
Total Cases:	357	Percentage Classified Correctly 82.4		

Combination of Incomes and Expenditure Differences.
In this analysis all the variables (22) used in the previous two analyses are included in constructing the discriminant functions. The first discriminant function, constructed from the remaining 14 variables, accounts for 96% of the variance, the second function for the remaining variance.[47] Using this combination of income and expenditure variables, 88% of cases are correctly re-classified, Taro standing out as having a quite distinct socioeconomic pattern, in comparison to the other two villages. Clearly, when sources of income and patterns of expenditure are jointly analysed, there remains little 'overlap' between the villages in terms of family economics (see Table 4.4).

Table 4.4:
Proportional Sources of Income and Patterns of Expenditure.

Actual Village	No. of Cases	Predicted Village Membership(%) Taro	Penestanan	Tegal Tugu
Taro	135	98.5	0.0	1.5
Penestanan	124	0.0	79.8	20.2
Tegal Tugu	98	0.0	15.3	84.7
Total Cases:	357	Percentage Classified Correctly 88.2		

Although this method of assessing annual family income is somewhat crude, based as it is on a single cross-sectional survey of each village, the success of the approach lies in

47 Eight variables were eliminated as insignificant in explaining inter-village differences: income from Wages, Finance, Pigs, Ducks, Chickens and Housegarden crops; expenditures on Health, Education, Fuel and Marketing.

its ability to differentiate between each of the villages in terms of the relative importance of different income sources and patterns of expenditure. These results confirm the contention that each of the villages is, in important ways, representative of different methods of adapting to biogeographic necessities and evolving to incorporate the particular, location-specific opportunities and constraints of modernisation.

4.6 Conclusions.

Even in the cultivation of HYVs of rice, where meeting specific technical demands to maximise yields might be expected to reduce or minimise inter-village differences in cultivation practices, substantial differences between the villages are still evident. The importance of different sources of income between villages can be related, broadly, to differential access to local natural resources (ricefields, dryfields and housegardens) and the relative availability of non-agricultural and/or non-traditional sources of income.

The analyses of the differences in demographics, rice morphology and cultivation practices, and the differing relative importance of agricultural and non-agricultural sources of income and differences in patterns of expenditure, provide confirmation of the five propositions or 'working hypotheses'. Most importantly, this confirmation clearly demonstrates that each of the three villages have distinct agricultural and socioeconomic patterns.

In the next two chapters rice agriculture and socioeconomic patterns are analysed in greater detail and related to the impacts of modernisation. In Chapter 5 the changes in the energetics and economics of rice cultivation are analysed. In Chapter 6 differences in inter-village and inter-income group patterns of income and expenditure are analysed and discussed.

Chapter 5

The Transformation of Balinese Rice Cultivation.

5.1 Introduction.

The traditional technology of rice cultivation in Bali was stable, simple, elegant and well-adapted to the tasks and terrain.[1] For over a thousand years Balinese farmers had at their disposal only energy from the sun, stored photosynthetic energy applied as green and animal manure and the somatic energy supplied by cattle and their own labours. Transportation of all the necessary inputs for rice cultivation and the distribution of the output occurred over very short ranges; everything required could be carried by human labour. Green manures were gathered from local vegetation, seed used from the previous crop, and the fields intermittently manured by cows and ducks. Irrigation water was delivered by the *Subak*-maintained network; and labour was supplied by family and village members who planted, tended, harvested and dried the crop. The harvested, dried rice (*padi kering giling*) was stored in the compound's 'rat-proofed' rice-barn (*lumbung*) until needed and hand-pounded before use.[2] All of this being regulated by traditional socio-religious institutions, based on collective intra- and inter-village decisions, actions and resources.[3]

Traditional rice cultivation was interwoven with social and religious life and aesthetic standards. With the new rice varieties many farmers feel that the fields are not as beautiful as before - spiky yellow-green has replaced waving golden-green. Less noticeable changes have also occurred in the range of fauna that feed and live in the ricefields. The

1 Lightly built wooden ploughs and harrows; precisely proportioned coconut and soft-stone water dividers for regulating irrigation flows; locally made knives for cutting grass, leafy branches and weed control; hand-knives (ani-ani), often lovingly decorated, for harvesting; and stone mortars and coconut and metal-tipped bamboo pestles for husking and polishing the harvested grain.

2 See Foley (1979) for a full description of the processes involved; Poffenberger and Zurbuchen (1978:5-22) present a fairly detailed picture of traditional practices and the changes taking place with the introduction of HYVs in part of Kecamatan Sukawati, Kabupaten Gianyar.

3 These networks were partially overlaid by various competing and co-operating court centres (e.g. Tegallalang, Ubud and Payangan); after about 1915, further overlaid by centralised Dutch colonial authority; and, since 1949, by national, centralised, neocolonial direction.

seasonal swarms of dragonflies have all but vanished, so today one rarely sees children with slender bamboo poles pursuing them.[4] At night the fields are no longer transformed by the magical sparkle of myriad fireflies. In the water and mud of the fields it is now rare to find eels, mudfish or fish. Previously frequent streams of small black ants have all but vanished, as too have various species of small spiders and geliids. The abundance of these and other species is likely to have declined due to fertiliser and pesticide use. The white egrets and lesser heron, however, still range across the ricefields during the day, feeding on various insects and snails. As harvest approaches, thousands of tiny grain eating birds descend in clouds, seeking food; although, possibly because of the morphology of the new rice, their numbers, too, seem to have declined.[5]

During the last fifty years Balinese rice agriculture has undergone profound changes in its organisation, technology and sustainability. In the pre-1940 period the changes instigated by the Dutch colonial government were relatively slow and occurred largely within the traditional administrative and technological framework.[6] Population increases during this century forced a general shift from a single annual crop of rice to double-cropping, probably during the late-1930s or WWII, independent of technological changes.[7] In the last 15 years administrative and technological changes have accelerated, fundamentally affecting almost all aspects of Balinese rice cultivation - cultural, social, economic, energetic and environmental. Central to these changes has

4 Dragonflies, and other ricefield fauna (mudfish, eels, snails and frogs) traditionally provided a supplement to diets that were commonly low in animal protein. Most of these additional sources have now all but disappeared - most probably because of: a) the detrimental interactions of nitrogenous fertiliser and pesticides on their reproduction and survival; and b) the general elimination of a dry inter-crop fallow period in favour of virtually continuous rice cultivation.

5 These important changes in the ricefield ecosystem were not studied in detail, however, a brief survey of farmer's impressions of changes over the last five years was made. The results are not presented here, although they support this contention.

6 These earlier changes imposed a further layer of taxation on the traditional extractions by the nobility, they did not, as in Java, lead to the growth of a commercial plantation sector.. They provided the basis for 'regularising' Balinese agriculture: by land-tax (cadastral) surveys; initiated a basis for centralised agricultural administration and extension services; and, with corvee labour, improved some major irrigation structures and began constructing the road network essential for supplying manufactured inputs and transporting food to the new urban centres.

7 No specific date can be placed on these changes. During the 1930s it is apparent that single-cropping still prevailed, by the early 1950s it is clear from the only records that survive (Raka 1955:76) that double-cropping had already become widespread.

been the introduction and almost universal adoption of High Yielding Varieties (HYVs) of rice.

Today farmers still make use of these traditional inputs, with the broad exceptions of green manures and hand-pounding of rice. To these traditional resources and technology are now added manufactured seed, fertiliser and pesticides - made available by pipelines, factories, ships and trucks. Grain is husked and (over)polished in mechanical mills; and, commonly, a portion of the output sold, trucked away and stored in large, modern warehouses, before being sold to (mainly) urban-dwelling people throughout the archipelago. All of these new manufactured (indirect) inputs (goods and services) are relatively 'energy intensive', requiring a significant amount of non-renewable energy for their production and delivery, compared to traditional resources - the direct inputs to cultivation.[8]

The HYVs of rice were bred specifically to give substantial increases in yield in response to large inputs of nitrogen fertiliser and good crop management (careful control of irrigation water and the timely application of fertilisers and pesticides). In these respects, the new varieties were 'aimed' at rice growing areas in the Third World where administrative, irrigation and transport infrastructures were relatively well developed, and capable of maintaining the supply of information and materials necessary for successful adoption. In these respects, Bali was almost an 'ideal' case for the successful introduction of HYVs. The rice farmers of Bali have a long-held reputation for achieving high rice yields, based on cultivation of fertile volcanic soils, a sophisticated traditional irrigation system and meticulous cultivation and care of their crops.[9]

The analysis in this chapter shows that the adoption of HYVs has led to an average increase of about 30% in yield and an

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8 By way of illustration: a kilogram of urea fertiliser requires about five time the energy for manufacture, packaging and delivery as is required to maintain proper human functioning for 24 hours (53 MJ vs 10 MJ), i.e. 1 kg of urea is the energy equivalent of 5 days of human labour.

9 The is a long list of authors who have been impressed by the yields achieved by Balinese farmers - see for instance: Raffles (1817:ccxxxiii), Crawfurd (1820:347), Earl (1850:541), Swellengrebel (1960:9), Poffenberger and Zurbuchen (1980).

increase of about 50% in annual rice production. However, the apparent success in increasing yields and production by means of Green Revolution technology has been at the cost of:

> undermining of the traditional self-sufficiency, dependability and sustainability of Balinese rice cultivation; and
>
> the socioeconomic impact of these changes on thousands of farmers who have adopted HYVs, many reluctantly, in terms of decreased income stability and increased economic dependency.

Moreover, maintaining this increased production requires considerable 'overheads' in the form of: continuing importation of substantial quantities of non-renewable resources, i.e. manufactured fertilisers, biocides and machinery; an extensive administrative, agricultural extension and input supply network; ongoing improvements in irrigation and transport infrastructures; and, not least, a struggle by rice breeders to keep developing new varieties resistant to emergent pests and diseases.

The changes in self-sufficiency and cropping energetics, in particular, have important longer term consequences for the successful maintenance of staple crop agriculture in Bali (and Java). In the shorter term, increased variability in yields associated with HYVs and the dubious economic advantages of cultivating them have serious implications for the welfare of the thousands of small farmers - the nominal beneficiaries of the Green Revolution. The analysis shows that:

> the energetic efficiency of rice cultivation in Bali has declined about fivefold from traditional levels and is now comparable to that of industrialised Western agriculture;
>
> despite a significant yield advantage over traditional varieties, the relatively high costs of inputs necessary for cultivating HYVs results in net per crop returns that are only marginally above likely returns from traditional varieties;
>
> adoption of HYVs has resulted in increased inter-year yield variability and, hence, income variability, compared to traditional varieties - due to increased losses to pests and lower than optimum yields resulting from delays in the supply of essential material (and information) inputs;

> the dominance of HYVs has resulted directly in the wholescale loss of the *irreplaceable* genetic material contained in hundreds of micro-adapted traditional varieties and widespread disruption of the macro and micro ecology of ricefields.

5.2 Island-Wide Changes in Rice Cultivation.

To place the case studies in context, the island-wide energetics of rice cultivation for 1939 and 1982 in Bali are first discussed; second, the inter-year variability in yields for all Bali for the periods 1929-39, 1957-68 and 1969-82 are compared, and 1969-82 for Kabupaten Gianyar - before proceeding with an analysis of fieldwork data. These analyses are made using government data on cropped area, seed, fertiliser and pesticide inputs, and yields; and fieldwork data for inputs of human and draught labour.[10]

In the period between 1969 and 1982[11] rice cultivation in Bali has passed from what the FAO report typified as 'low' input to 'high' input farming (Higgins et al 1982:10).[12] During this period, HYVs of rice (and the use of fertiliser and pesticide) have come to dominate rice cultivation in Bali, and are now planted on virtually all (98%) the 165,483 ha of irrigated ricefields cropped in 1982.[13]

Energy Intensification.

By 1982 total production of milled rice per annum had risen to about 473,000 tonnes (some 70% over 1969), of which 89,000 tonnes (19%) was exported in 1982 to other parts of Indonesia (see Tables A3.23.1-2).[14] To achieve this level of production about 70,000 tonnes of fertiliser and 621 tonnes of pesticide

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10 The analysis is made assuming that 80% of fertiliser and pesticide imports are used for rice cultivation: that seed use per hectare for 1939 and 1982 are identical (but the energy cost of producing HYV seed is twice that of traditional varieties); traditional human labour inputs are 95% traditional levels (assuming 5% of HYV labour inputs are used for fertiliser and pesticide application); and draught labour inputs for 1939 and 1982 are identical.

11 By 1981 the traditional varieties of rice had been almost wholly displaced by HYVs - mainly IR36.

12 Low input farming is characterised by no use of improved seeds, fertilisers or pesticides; high input farming as 'full use of all [industrial] inputs' with fertiliser inputs of at least 80 kg/ha nutrients (175 kg/ha urea approx.), equivalent to Western European farming.

13 This figure (see Table 3.7) is somewhat at odds with those estimated by the 1983 Agricultural Census for this period: for all Bali, 1982/83 crop season 86% planted to HYVs/NIVs and 14% to traditional varieties; 1983 crop season 89% to HYvs/NIVs and 11% to traditional varieties. For Gianyar, 1982/83 crop season 95% HYVs/NIVs and 5% traditional; 1983 96% HYVs/TLVs and 4% traditional (BPS Jakarta 1986:83-6). The census figures are probably closer to the truth.

14 The level of exports of rice from Bali dropped sharply after 1982, to about 20,000 tonnes in 1983 and 1984 (see Table A3.20.1).

were imported in 1982.[15] Thus, by the mid-1980s, as a consequence of these changes, rice production in Bali had achieved (more than) the level of inputs seen as necessary by the FAO report. Despite these changes, average per capita staple food availability had not improved over pre-WWII levels.[16]

The energetic analysis shows that in 1939 an average of approximately 2.8 GJ/ha of energy inputs resulted in 35.3 GJ/ha of edible output, giving an Energy Ratio (ER) of about 12.5. In 1982 an average of about 20.5 GJ/ha of energy inputs resulted in approximately 56.7 GJ/ha of edible output, an ER of about 2.7 (see Tables A5.1.1-2 for details). Hence, an increase of about 60% in edible yield has required, on average, an increase of some 725% in energy inputs, almost entirely energy 'embodied' in fertiliser. Thus, even in an agricultural setting such as Bali - with highly developed social institutions and good physical infrastructure - it seems that a 10-12% increase in input energy may be required for a 1% increase in food output, rather than the 2.4% increase suggested by FAO (1981).[17]

Variability in Yields.

Another facet of the intensification of rice production in Bali is that variability in yields has increased since the widespread adoption of HYVs in the late 1960s.[18] In the pre-WWII period the CoV was 3.3%, in the earlier post-WWII period (1957-68) 8.3%, and during the latter period 14.5%.[19] An

15 Details of irrigated rice production for 1929-39 can be found in Table A3.24.1 (last column), details for 1953-84 can be found in Table A3.18.2. For details of rice exports see Table A3.20.1 and Tables A3.23.1-2 for details of fertiliser and pesticide imports.

16 In 1939 about 47% of staple food energy came from rice by 1984 about 66% was from rice (see Table A3.21.1).

17 A number of studies of the comparative energetics of traditional and HYV rice technology were discussed in Chapter 2, later in this chapter these analyses are compared with field work data from this study.

18 Here, inter-year yield variations during the traditional period (1929-39), the pre-HYV period (1957-68) and HYV period (1969-84) are compared using the coefficient of variation (CoV), the standard deviation divided by the mean yield.

19 Despite the lack of electronic calculators and other modern equipment, there is no reason for assuming that yield data during the pre-WWII period are any less accurate than currently, indeed the opposite may be the case. In the earlier period systematic crop cuttings were made by extension/taxation officials using a 5m x 5m plot, in the latter period the plot size has been reduced to 2.5m x 2.5m - a fourfold reduction in plot area. Assuming adequate sampling methods in both periods, pre-WWII yield samples had to be multiplied by 400 to give a per hectare yield, in the latter period they had to be multiplied by 1600. Thus, for instance, a 0.25 kg error in sample weight in the earlier period would lead to a 100 kg/ha error, in the latter period a 0.25 kg error would lead to a 400 kg/ha.

increase of about 400% between 1929-39 and 1969-84, and 75% between 1957-68 and 1969-84.[20] In general, variations in yield are 'evened-out' as a normal consequence of aggregating yield data from a number of different regions.[21] Much of this increased variability seems to be the result of widespread losses to new pests and diseases that have accompanied the adoption of HYVs, despite the use of pesticides (see Appendix 3.24). As will become clear below, current, island/region-wide levels of variation greatly underestimate the inter-seasonal variation revealed in the analysis of fieldwork data.

At the macro level the Green Revolution in Bali has resulted in markedly reduced energy efficiency in rice cultivation - during the last 15 years it has declined by a factor of about five. In parallel with this decline, there has also been a radical increase in inter-year variability in yields - island-wide an increase of at least 75% since the 1960s. It would also be instructive to compare the relative economics of pre- and post-HYV rice cultivation in Bali, unfortunately lack of data for the earlier period makes this impossible. However, in a later section of this chapter on the economics of rice cultivation, survey data are used to simulate a comparison between the costs and returns of traditional and HYV cultivation methods.

From this brief analysis it is clear that:

> the traditional high degree of self-sufficiency and evident sustainability of rice cultivation in Bali has been undermined; and
>
> even at the macro level, the year-to-year dependability (stability) of yields has been reduced - as a result of the direct and indirect effects of the new technology.

Consequently, the increased productivity of this staple is now largely dependant on continuing imports of energy-intensive

20 If 1963 is excluded from the analysis, the year Gunung Agung erupted devastating large areas in Eastern Bali, covering much of South Central Bali with a deep layer of ash, the CoV for the Pre-HYV period is slightly reduced, to 8.1%. On the other hand, the devastation and losses caused by the 1974-75 brown plant hopper (wereng) plagues, which seriously affected all south central Bali's main rice growing areas, goes almost unreported in official statistics. Data for these calculations is drawn from Tables A3.20.1-2 and A3.21.1.

21 By taking yearly averages inter-seasonal variations (wet vs dry seasons) are eliminated. For example, the CoV of yield for Kabupaten Gianyar is even higher than for all Bali, 18.1% for the 1969-84 period.

non-renewable resources, and changed cropping patterns (elimination of fallows and use of manures) and (indiscriminate) use of pesticides appear to have reduced yield stability.

The results and analyses of the data collected in a survey of smallholder rice cultivation in each of the three villages intensively studied in three successive seasons during 1981-83 are now presented. The following section (5.3) deals with labour and material inputs; the next two with yields and production (5.4) and the linkages between inputs and yields and production (5.5); section 5.6 uses these data to analyse and compare the energetics and economics of modern rice production; and section 5.7 analyses the relative energetic and economics of traditional and contemporary production. Section 5.8 is devoted to a discussion of some of the important aspects of the agricultural transformation in Southern Bali that are typified by the data from the sample examined. In section 5.9 the conclusions of the analysis are summarised.

As described in Chapter 4, data were collected during three crop seasons from a total of 861 farmers in Taro, Penestanan and Tegal Tugu Of this total the 'long form' was used to gather data from 559 farmers (65%) and the 'short form' from the remaining 302 farmers. In this discussion of labour inputs data from the 'long form' are used, in preference to the less complete data from the 'short form'. As in the previous chapter the various components of labour inputs are grouped under three headings: Land Preparation, Crop Maintenance and Harvesting.[22] As the amount of labour used for Harvesting cannot logically affect the success of a crop, it is discussed only briefly.[23]

Two other village agricultural sub-systems, dryfields (*tegalan*) and housegardens (*pekarangan*), are not discussed here, although reference to their economic role is made in the next chapter. There have been few major changes in

22 The activities included under each of these headings are listed in Table 4.5.
23 Making the assumption that harvesting labour is available when required and, hence, that yields are not reduced due to lodging, for instance.

agricultural practices in either of these systems, although two new cash crops (cloves and vanilla) have been widely adopted in the last five years. The most important crops in these two systems are the perennials coconut, banana and papaya; and the annuals cassava and sweet potato. Although a small proportion of this produce is sold, commonly to meet pressing family cash needs, most is used for subsistence and/or stock feed. None of these crops are labour intensive, all are harvested throughout the year and farmers do not use manufactured fertilisers or pesticides on any of them. In the higher areas, coffee is an important cash crop, requiring a significant amount of seasonal labour for harvesting and processing.

5.3 Rice Cultivation - Labour and Material Inputs.

5.3.1 Human and Animal Labour Inputs.

Because the HYVs (IR36 and IR50) are currently the most widely grown rice varieties in Bali, and farmers growing these varieties form the majority of the sample (436 or 78%), the discussion of labour inputs is confined to the cultivation of these varieties.[24]

Figure 5.1 and Table 5.1 present data on human labour inputs used for rice cultivation in each village and each season. In Table 5.1 the two pre-harvest activity categories: Land Preparation (Prepare) and Crop Maintenance (Maintain) are summed to give total pre-harvest (PreHarvest) human labour inputs. The labour used for harvesting (Harvest) is added to this subtotal to give the total human labour inputs (Total Labour) per rice crop.[25]

24 The results for all of the varieties, using both the 'long' and 'short' survey forms, are presented in Appendices 5.2 and 5.3 for comparison. The figures in parentheses in Appendix 5.2 indicate that, on average, the 'short form' under-enumerates human labour inputs/Are by about one third, a variable proportion of which is due to not collecting data on labour used for applications of fertiliser and pesticide when using the 'short form' survey. In addition, the 'short form' did not record data on the labour required for harvesting rice.

25 The results are presented in the form of hours of human labour per Are, multiplying by 100 converts this to the more conventional form of hours/ha; and, as Balinese farmers commonly work a 7-8 hour day, dividing by 8 gives the number of person-days/ha.

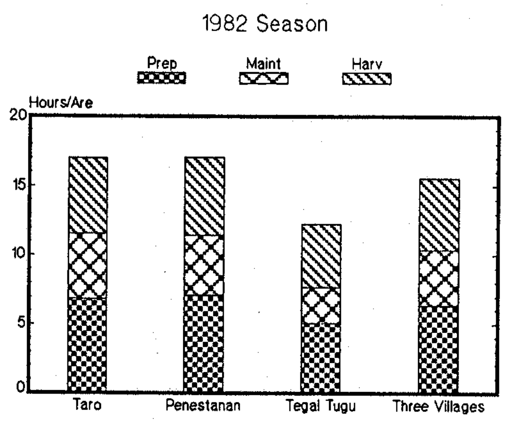

Figure 5.1a: Human Labour Inputs to Rice Cultivation (1982).

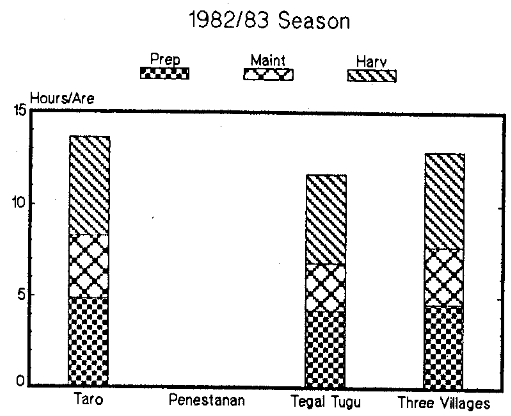

Figure 5.1b: Human Labour Inputs to Rice Cultivation (1982/83).

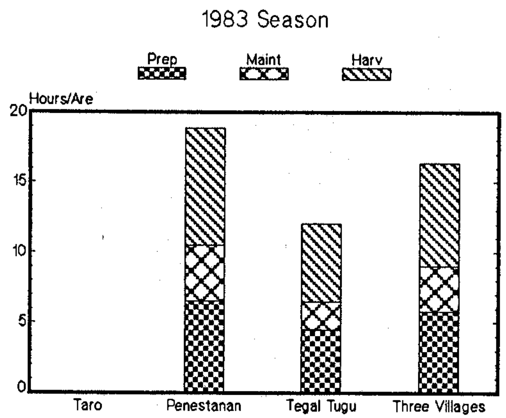

Figure 5.1c: Human Labour Inputs to Rice Cultivation (1983).

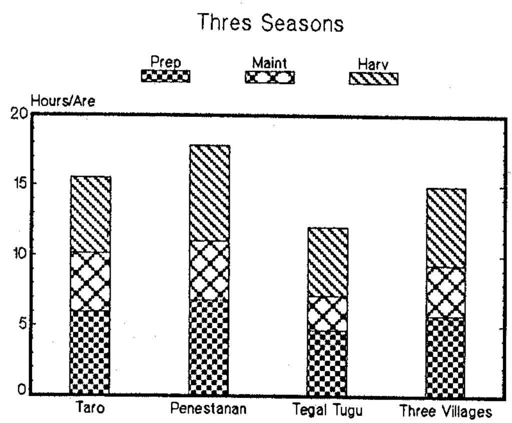

Figure 5.1d: Human Labour Inputs to Rice Cultivation (1982-83).

Figure 5.1: Human Labour Inputs to Rice Cultivation (1982-83).

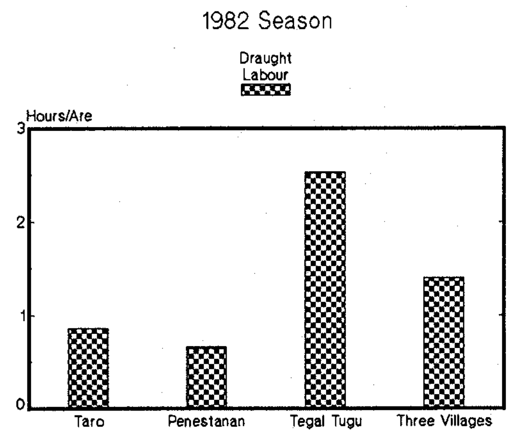

Figure 5.2a: Draught Labour Inputs to Rice Cultivation (1982).

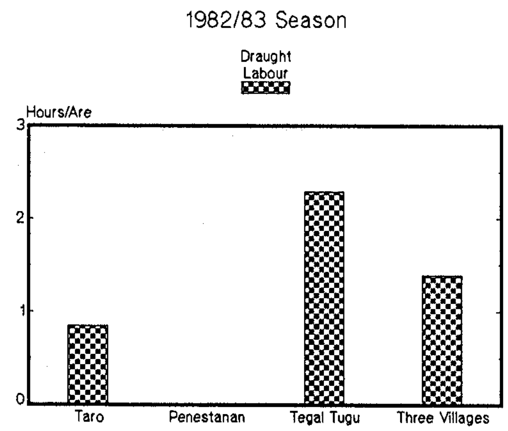

Figure 5.2b: Draught Labour Inputs to Rice Cultivation (1982/83).

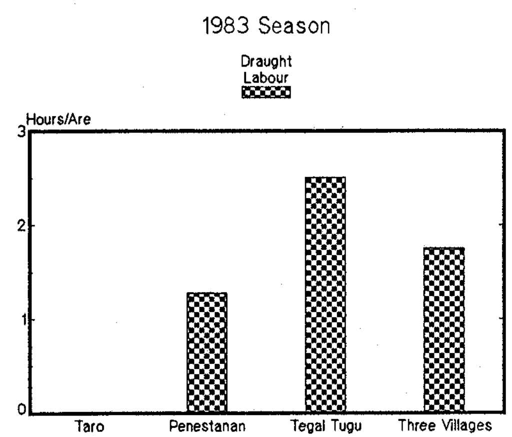

Figure 5.2c: Draught Labour Inputs to Rice Cultivation (1983).

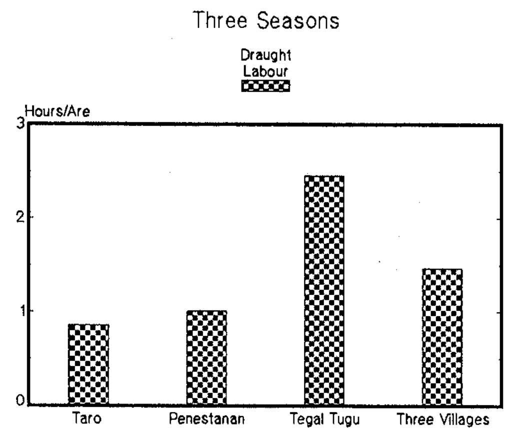

Figure 5.2d: Draught Labour Inputs to Rice Cultivation (1982-83).

Figure 5.2: Draught Labour Inputs to Rice Cultivation (1982-83).

Table 5.1:
HYVs: Human Labour Inputs (hours/Are).

Season	Taro Mean	Penestanan Mean	Tegal Tugu Mean	All 3 Mean
1982 N*	101	61	70	232
Prepare	6.86	7.10	5.07	6.38
Maintain	4.69	4.34	2.59	3.96
PreHarvest	11.55	11.43	7.66	10.35
Harvest	5.42	5.57	4.61	5.22
Total Labour	16.97	17.00	12.20	15.54
1982/83 N*	77	0	47	124
Prepare	4.84	-	4.23	4.61
Maintain	3.43	-	2.57	3.10
PreHarvest	8.27	-	6.80	7.71
Harvest #	5.33	-	4.87	5.16
Total Labour	13.60	-	11.57	12.83
1983 N*	0	51	29	80
Prepare	-	6.52	4.50	5.79
Maintain	-	3.97	2.01	3.26
PreHarvest	-	10.49	6.51	9.05
Harvest	-	8.38	5.51	7.33
Total Labour	-	18.71	12.02	16.28
1982-83 N*	178	112	146	436
Prepare	5.99	6.84	4.69	5.77
Maintain	4.14	4.17	2.47	3.59
PreHarvest	10.13	11.01	7.15	9.36
Harvest	5.38	6.83	4.88	5.59
Total Labour	15.51	17.78	11.96	14.91

Notes see Footnote 26.

It is apparent that a large amount of human labour is required to grow a crop of rice - on average some 1491 hours or 186 work-days/ha.[27] There is considerable inter-village and inter-seasonal variation in labour inputs, mainly resulting from differences in the amount of labour devoted to crop maintenance (water control, weeding, fertiliser and pesticide applications). Setting aside the inter-seasonal differences, farmers in Tegal Tugu, on average, use only about 70% as much pre-harvest labour/Are as do farmers in the other two villages use. For land preparation farmers in Tegal Tugu use on average only 77% of the labour/Are that farmers in the other

26 PreHarvest = Prepare + Maintenance; Total Labour = PreHarvest + Harvest. * N = Sample Size. # Indicates non-significant inter-village difference. Source Table A5.2.1. See Tables A5.2.2-4 for details on NIVs, TLVs and all varieties; and Tables A5.3.1-4 for details on data collected using the 'short' form.
27 For an average holding of 22 Are about 43 work-days per crop, including harvesting.

two villages, and for crop maintenance only about 60% as much; they also use less labour/Are for harvesting (despite higher average yields). Overall, farmers of Tegal Tugu use about 77% of the total labour/Are of farmers in Taro, and only 67% of the average in Penestanan.

Table 5.2:
HYVs: Draught Labour Inputs (animal hours/Are).

Season	Taro Mean	Penestanan Mean	Tegal Tugu Mean	All 3 Mean
Dry Season 1982				
Prepare Land	0.86	0.66	2.53	1.40
Proportion using	64%	57%	96%	70%
Dry Season 1982				
Prepare Land	0.85	-	2.29	1.39
Proportion using	68%	-	85%	73%
Dry Season 1983				
Prepare Land	-	1.28	2.51	1.75
Proportion using	-	71%	91%	74%
All Three Seasons				
Prepare Land	0.86	1.01	2.45	1.46
Proportion using	64%	64%	91%	72%

Notes see Footnote 28.

For the majority of farmers, cattle play an important role in land preparation: ploughing, harrowing and flattening the flooded plots prior to planting. Overall, 72% of farmers use draught labour during land preparation, reducing the amount of hand-hoeing required to achieve a well-puddled and even plot (see Figure 5.2 and Table 5.2). In Tegal Tugu about 90% of farmers make use of draught labour, whereas in the other two villages only about 64% do; these differences are consistent over the three seasons. In addition, about two to three times as much draught labour per unit area is used in Tegal Tugu (2.45 hours/Are) as in Taro (0.86) and Penestanan (1.01). Greater use of draught labour in Tegal Tugu helps account for the relatively lower level of human labour/Are for land preparation, in comparison with the other two villages.[29]

28 Source: Table A5.4.1. See Tables A5.4.2-4 for details on NIVS, TLVs and all varieties.
29 Appendix 5.3 gives details of draught labour use for all the rice varieties.

5.3.2 Material Inputs.

In contrast to the under-enumeration of labour inputs resulting from the use of the 'short form', the data on inputs of seed, fertilisers and pesticides collected using this form tallies closely with that gathered using the 'long form'. Using these combined data has the advantage of providing additional information for Penestanan (wet season 1982/83) and Taro (dry season 1983), when no farmers in these two villages were surveyed using the 'long form'. As with labour inputs, the discussion is limited to the HYVs.[30]

Seed.

Because of genetic instabilities farmers growing HYVs have to purchase fresh seed every season or two. Unfortunately much of what is sold as 'certified seed' by distributors appears to be only normal HYV seed 'dressed up' in a plastic bag with a label and higher price tag. There is no way of knowing how widespread this practice is, neither do farmers have a way of distinguishing 'certified' from normal seed, until too late.

The agricultural extension service recommends using 35 kg/ha of seed; from experience farmers adjust this figure according to their estimates of how large the effective planting area of their land is and the spacing they prefer to use when transplanting seedlings. On average, farmers in Tegal Tugu use about the recommended amount (34 kg/ha), farmers in Taro considerably less (28 kg/ha), and farmers in Penestanan well over the recommended amount (49 kg/ha) (see Figure 5.3 and Table 5.3).

Fertilisers.

All of the farmers growing HYVs use urea fertiliser, although only a small percentage use TSP (6% overall, and none in 1982/83). The agricultural extension service recommend applying 250 kg/ha of urea and 100 kg/ha of TSP per crop (2.5 kg/Are and 1.0 kg/Are respectively). They recommend applying the urea as a 'split dose', half shortly after transplanting

30 The data on material inputs collected using both types of survey form for all varieties and seasons is presented in Appendices 5.4 and 5.5.

and half at panicle initiation;[31] the TSP as a 'basal dose' immediately prior to transplanting. The granulated fertiliser is applied by hand-broadcasting; this does not ensure even application but is the only method available to farmers. Collateral data collected during the surveys indicate that farmers follow advice on the timing of fertilisation fairly closely.

The farmers in Tegal Tugu consistently apply more urea (3.45 kg/Are) than farmers in Penestanan (3.01 kg/Are) or Taro (2.59 kg/Are), this pattern holds true for each of the three seasons. Moreover, the degree of variation in rates of application in Tegal Tugu is lower than in either of the other two villages (see Tables A5.5.1-4), indicating a more 'finely tuned' approach to cultivating HYVs.

Pesticides.

Commonly farmers do not spray pesticide until there is clear evidence of pest infestation or damage. Pesticides are applied using hand-pumped back-pack sprayers.[32] Recently, agricultural extension officers have been encouraging farmers to spray their crop a number of times before maturity, as a matter of course. Thus, it is not possible to tell from these data whether farmers in Tegal Tugu, almost all of whom use pesticides, are responding to this advice or to markedly higher levels of pest infestation.

As with fertiliser, the farmers in Tegal Tugu use more pesticide than farmers in the other two villages. However, in each of the villages there is considerable inter-seasonal variation in rate of application. Less pesticide is applied during the wet season (mean 0.04 kg/Are) than in the dry seasons (overall means of 0.05 and 0.09 kg/Are respectively); and a lower proportion of farmers use pesticide during the wet season (mean 33%) than in the dry seasons (overall means of 68% and 86% respectively).

31 This is in-line with IRRI's recommendations: "The most efficient times for applying nitrogen fertilizer are at transplanting and at panicle initiation." (Vergara 1979:111).
32 No protective clothing is worn and farmers usually do not wash carefully after spraying before eating, drinking or smoking. Even if farmers could afford the correct clothing, and it was available for purchase, wearing it in humid tropical conditions would lead to the rapid onset of heat stress (Kemp 1987).

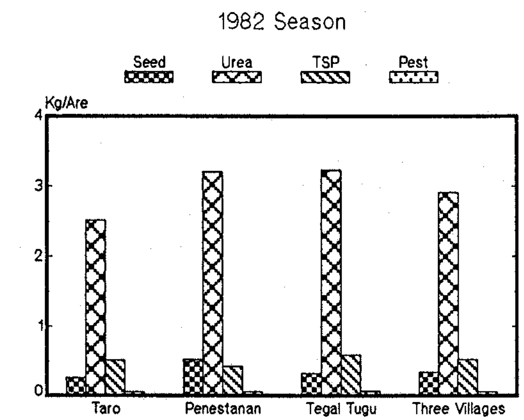

Figure 5.3a: Material Inputs to Rice Cultivation (1982).

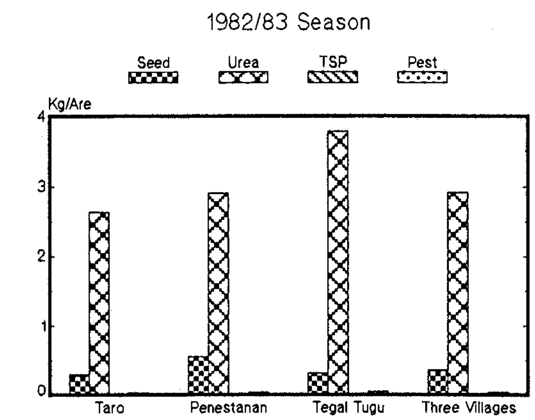

Figure 5.3b: Material Inputs to Rice Cultivation (1982/83).

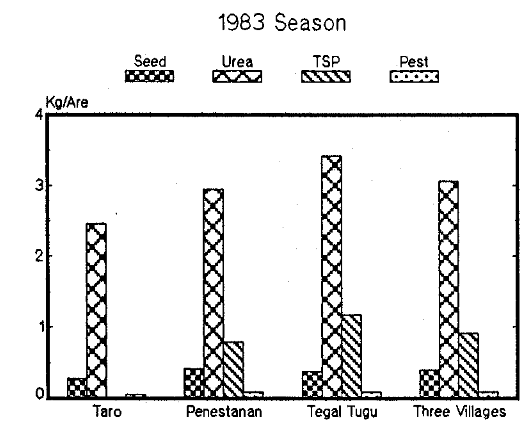

Figure 5.3c: Material Inputs to Rice Cultivation (1983).

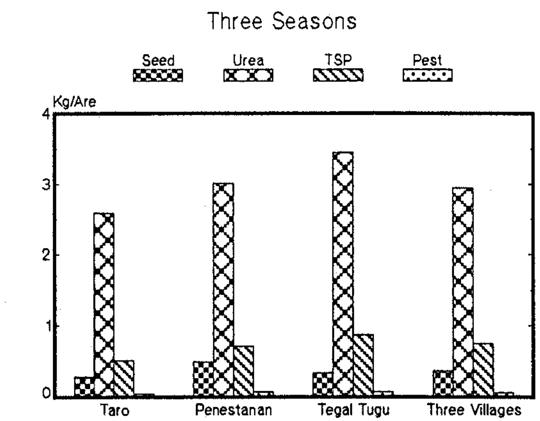

Figure 5.3d: Material Inputs to Rice Cultivation (1982–83).

Figure 5.3: Material Inputs to Rice Cultivation (1982–83).

Table 5.3:
HYVs: Seed, Fertilisers and Pesticide Inputs (kg/Are).

Season	Taro Mean		Penestanan Mean		Tegal Tugu Mean		All 3 Mean	
Dry Season 1982								
N	101		61		70		232	
Seed	0.26		0.52		0.32		0.34	
Urea	2.52		3.21		3.23		2.91	
TSP	0.51	3%	0.42	8%	0.59	11%	0.52	7%
Pesticide	0.05	50%	0.05	67%	0.06	94%	0.05	68%
Wet Season 1982/83								
N	166		60		52		278	
Seed	0.30		0.56		0.32		0.36	
Urea	2.64		2.90		3.78		2.91	
TSP	-		-		-		-	
Pesticide	0.03	13%	0.04	37%	0.05	92%	0.04	33%
Dry Season 1983								
N	11		75		43		129	
Seed	0.28		0.42		0.38		0.40	
Urea	2.46		2.94		3.42		3.06	
TSP	-		0.79	21%	1.18	16%	0.91	18%
Pesticide	0.05	27%	0.09	89%	0.09	95%	0.09	86%
All Three Seasons								
N	278		196		165		639	
Seed	0.28		0.49		0.34		0.36	
Urea	2.59		3.01		3.45		2.94	
TSP	0.51	1%	0.71	11%	0.87	9%	0.75	6%
Pesticide	0.04	27%	0.07	66%	0.07	94%	0.06	56%

Notes see Footnote 33.

The above data clearly show the degree to which new manufactured inputs have been adopted by rice farmers. In 1979 none of the farmers in Taro grew HYVs, but by 1983 almost none were growing TLVs. This transformation occurred in Penestanan in the late 1970s and in Tegal Tugu in the mid-1970s. These three villages are indicative of the island-wide transformation that has occurred, this is also clear from the continually rising area under HYVs and imports of fertiliser and pesticides in the period 1969-80 (see Tables A3.23.1-2).

Importantly, farmers are hampered in 'scientifically' adopting these new inputs and methods by two factors. First, very few

33 The figures alongside TSP/Pesticide is the percentage of farmers using them in each village/season. Source: Table A5.5.1, see Tables A5.5.2-4 for details on NIVs, TLVs and all varieties; and Tables A5.6.1-4 for details on material inputs collected using the 'short' form.

farmers know reasonably exactly the area of ricefield they are cultivating (and very few are functionally literate). Thus they cannot accurately estimate the quantities of inputs needed and are forced to rely on a process of trial-and-error over several seasons to 'optimise' input levels. Second, because of delays and inefficiencies in the input supply network, fertilisers and pesticide are frequently unavailable when required. This problem is often compounded by farmers lacking the necessary cash to purchase the inputs at the time required. All these factors make it difficult for farmers to meet the more demanding levels of quantitative and temporal accuracy needed to achieve maximum yields with HYVs.

Traditional varieties grown under traditional conditions required no extra-local inputs; although, by the time they were being progressively displaced by HYVs during the 1970s, they were being double-cropped and supplied with relatively small amounts of urea (10-100 kg/ha). Their death knell was sounded from 1974 on by widespread and persistent losses to, in particular, plant-hoppers (mainly brown, but also green and white biotypes); and the tungro virus carried by plant-hoppers, none of which they were resistant to (see Table A3.24.4). This new vulnerability of TLVs coincided with government programmes advocating and subsidising adoption of ever new varieties of HYVs, recently developed and (temporarily) resistant to the pests and diseases that earlier HYVs had brought to Bali.

5.4 Variations in Rice Yields and Production.
The yield results of the adoption of HYVs are much more variable than the official statistics on rice yields reveal (see Table A3.24.2). In each of the three villages there is a wide gulf between the highest and lowest rice yields, and this variation is equally marked between the villages and seasons. As will be shown, there is only a very tenuous (statistical) linkage between levels of labour and material inputs and the yield of rice.

The data also allow an examination of two aspects of the 'Agricultural Involution' hypothesis put forward by Clifford

Geertz (1963), and the linking of one of these (population density and the labour needed to obtain subsistence) to the notion of ecological transition. First, however, it is necessary to discuss yields and production; second, the linkages between inputs and yields. As before the discussion focuses on the HYVs.

The data used to compile Table 5.4 combine both 'long' and 'short' form measurements.[34] Over the three seasons it is clear that average yields are lowest in Taro, intermediate in Penestanan and highest in Tegal Tugu (15.75, 18.48 and 29.57 kg/Are respectively). Superficially one might conclude, as input levels of fertiliser and pesticide follow the same general pattern (see Table 5.3), that higher levels of material inputs in Penestanan and Tegal Tugu have a dominant influence on yields and are, therefore, fairly closely correlated. This is not the case, as will be shown below. What is apparent from this table is the high degree of variation even in average yields between villages and seasons, and the wide range between minimum and maximum yields.

Figure 5.4 illustrates the degree of inter-village and inter-season variation in yields; in Table 5.4 the Coefficient of Variation is used to quantify this variability. The variation is significantly higher during the wet season (overall 71%) than the dry season (overall 35% and 26% for 1982 and 1983 respectively). It is also clear that there is no secular trend towards higher average yields over the three seasons, nor towards more stability in the range of yields obtained by farmers in each village or overall.

34 In general, yields calculated using only the 'long form' data are slightly higher than those calculated using the combined data (see Appendix 5.6).

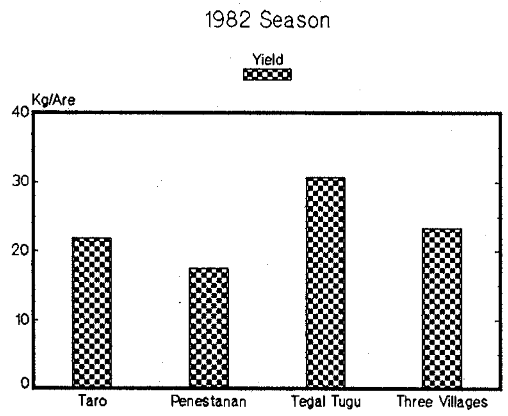

Figure 5.4a: Yields of Milled Rice (1982).

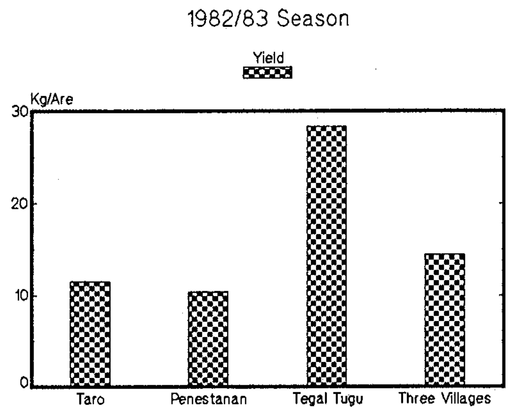

Figure 5.4b: Yields of Milled Rice (1982/83).

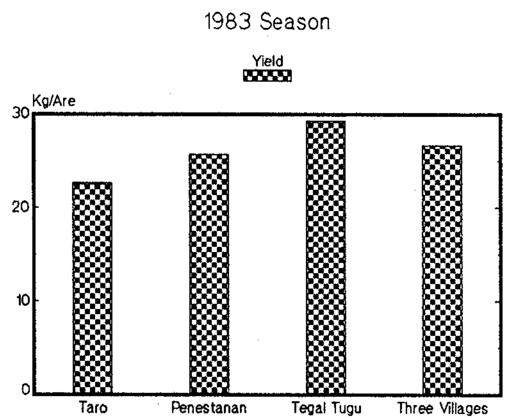

Figure 5.4c: Yields of Milled Rice (1983).

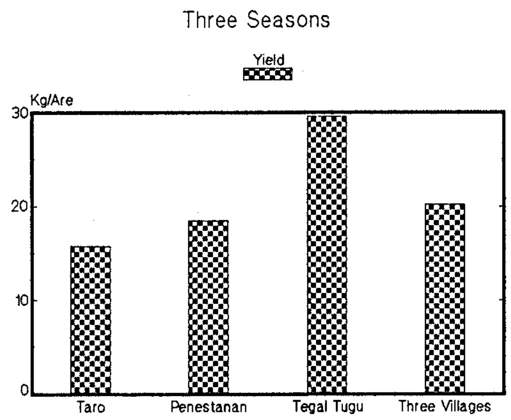

Figure 5.4d: Yields of Milled Rice (1982-83).

Figure 5.4: Average Yields of Milled Rice (1982-83).

Table 5.4:
HYVs: Yields of Milled Rice per Are 1982, 1982/83 and 1983.

Village	N	Mean	Median	S.D.	CoV	Min	Max
Dry Season 1982							
Taro	101	21.86	21.50	6.44	29.5	8.29	41.72
Penestanan	61	17.55	17.61	6.15	35.0	5.45	31.22
Tegal Tugu	69	30.71	29.53	6.12	20.0	15.52	45.69
All Three	231	23.37	23.40	8.07	34.5	5.45	45.69
Wet Season 1982/83							
Taro	164	11.53	10.05	7.37	63.9	1.23	46.75
Penestanan	60	10.40	9.53	5.08	48.8	2.68	24.04
Tegal Tugu	52	28.31	28.68	10.65	37.6	5.41	63.31
All Three	276	14.44	11.69	10.19	70.6	1.23	63.31
Dry Season 1983							
Taro	11	22.61	23.18	6.24	27.6	11.18	32.84
Penestanan	75	25.70	26.88	7.07	27.5	6.50	38.94
Tegal Tugu	43	29.27	28.60	6.36	21.7	11.26	47.94
All Three	129	26.62	27.08	7.03	26.4	6.50	47.94
All Three Seasons							
Taro	276	15.75	14.79	8.66	55.0	1.23	46.75
Penestanan	196	18.48	17.93	8.88	48.1	2.68	38.94
Tegal Tugu	164	29.57	28.97	7.91	26.8	5.41	63.31
All Three	636	20.15	19.86	10.24	50.8	1.23	63.31

Notes see Footnote 35.

Clearly, a proportion of intra-village variation results from localised differences in soil fertility and irrigation sufficiency; and a portion of between-season variation must be put down to variations in rainfall, insolation and pest predation. Naturally, inter-season variation in yields directly affects the family subsistence and income of farmers; it also affects other members of the village who rely on their harvest-share for a portion of their subsistence. Improvements in irrigation, using artificial fertilisers and pesticides aim at dampening these variations and, hence, increasing yields and yield stability - as a payback for the extra fixed and variable capital used to achieve subsistence.

The data clearly show that, despite good irrigation and applying large amounts of nitrogen fertiliser, significant inter-seasonal variability in yields is a fact of life for

35 Combined 'long 'and 'short' form survey data. Identical weighing and measuring methods with both 'long 'and 'short' form surveys were used to collect data on cropped area, and the weight and moisture content of harvested rice. See Tables A5.7.1 'long' form data and A5.7.2 for 'short' form details.

farmers growing HYVs in Bali. From a broader perspective, this unpredictability signifies a 'decoupling' between the effort expended and material inputs invested in cultivating a crop and the results of the farmer's endeavours. In such circumstances it is reasonable to speculate that farmers, given limitations on the timely delivery and sufficiency of inputs previously mentioned, may adopt a policy of applying the maximum amount of fertiliser and pesticide they can afford (i.e. enough is good and more is better still) - and then hope for the best. If this is the case, then not only are labour, cash and energy resources (generally) being wasted, but an analysis should reveal rather weak correlations between labour and material inputs and output of rice (see section 5.6).

5.5 The Relationship Between Inputs and Yields.

What is the relationship between the labour and material inputs supplied by the farmer and the size of the harvest achieved? If as has been suggested, correlations between inputs, particularly new manufactured inputs, and yields is weak (and/or counter-intuitive) farmers are not achieving a 'payback' commensurate with their investment of material and labour in each crop.

5.5.1 Interactions Between Labour, Material Inputs and Area.

For the purposes of analysis it is initially convenient to divide inputs into two types: labour inputs and material inputs, and examine their separate effects on yields, before examining their joint effects. First, however, it is necessary to briefly discuss the effect of cropped area on labour and material input levels and yields, using Pearsons correlation between variables.

Table 5.5 presents the simple correlations for labour inputs, yield and area for all three villages and seasons (see Tables A5.8.1-4 for seasonal details). Human and draught labour input rates are all inversely correlated to the area of land farmed; and, excepting Penestanan, positively and significantly correlated with yield.[36]

36 In the summary table above the effect of the non-significant labour-yield correlation for Penestanan (see Table A5.8.2) eliminates the overall significance of labour-yield correlations.

Table 5.5:
HYVs: Labour Inputs 3 Villages 1982-83 (Pearsons Correlation).

Input Yield	Prep	Main	Drft	PreH	Total	
N=436						
Main	0.546 a	-	-	-	-	-
Draught	-0.190 a	-0.263 a	-	-	-	-
PreHarvest	0.914 a	0.839 a	-0.251 a	-	-	-
Total Human	0.820 a	0.765 a	-0.240 a	0.903 a	-	-
Yield kg/Are	-0.029	-0.085 b	0.479 a	-0.060	0.032	-
Area (Are)	-0.124 a	-0.148 a	-0.211 a	-0.152 a	-0.203 a	-0.140 a

Notes see Footnote 37.

In terms of further analysis of input-output relationships, it is apparent from these tables that statistical allowance must be made for:

interactions between area and material inputs;

material inputs and labour inputs; and

between labour inputs and area.

Initially this is achieved by using partial correlations to control for the effects of material inputs when examining the influence of labour inputs on rice yields.

37 Labour inputs are in hours/Are; Total labour input is the sum of human work hours, including harvesting. Yield is in kg/Are milled rice (see Tables A5.8.5-8 for further details). Correlation significances: a=<0.005, b=<0.02 and c=<0.05. Source: Table A5.8.8.

Table 5.6:
HYVs: Area and Material Inputs, three seasons combined, 1982, 1982/83 and 1983. (Pearsons Correlations)

Input	Seed	Urea	TSP	Pest	Total	Yield
Taro (N=178)						
Area	-0.427	-0.377	0.061	-0.080	-0.423	-0.016
(Are)	a	a		a	a	
Penestanan (N=112)						
Area	-0.228	-0.254	0.035	-0.402	-0.343	-0.279
(Are)	a	a		a	a	a
Tegal Tugu (N=146)						
Area	-0.359	-0.427	0.078	-0.277	-0.485	-0.220
(Are)	a	a		a	a	a
All Three Villages (N=436)						
Area	-0.199	-0.309	0.070	-0.219	-0.344	-0.140
(Are)	a	a		a	a	a

Notes see Footnote 38.

In each of the villages and seasons, unit area material inputs of seed, urea and pesticide are inversely related to the area of land cropped (see Table 5.6 and Tables A5.8.5-8 for details). The only exception to this pattern is for TSP, used only by a relatively small number of farmers (6% overall). Yields are also inversely related to the area farmed. With a few exceptions (mainly for Penestanan), yields are significantly and positively correlated with each of the four possible material inputs; and with the summed energy equivalent of these inputs. However, the interaction of these use rates with area farmed indicates that area negatively biases the relationship between material inputs and yield. That is, farmers with larger areas of ricefield use lower levels of material and labour inputs per unit area than do smaller farmers.

5.5.2 Labour Inputs and Geertz's Hypothesis.

Until about 40 years ago Balinese farmers generally planted only one crop of rice per year, for the remainder of the year the ricefield was either fallow or planted with a non-irrigated crop (e.g. sweet potato, groundnuts). Increasing population has meant that the intensity of rice cultivation

38 Material inputs are in kg/Are; Total input is the sum of the energy content of material inputs; Yield is in kg/Are milled rice. Correlation significances: a=<0.008. Sources: Based on the last row of Tables A5.8.1-4.

has steadily increased and currently (1982-83) two to three crops of rice are harvested from most ricefields each year.

In the late 1950s Clifford Geertz advanced his hypothesis of Agricultural Involution, and a book with this title was published in 1963. The hypothesis attempted to link the social, ecological and economic aspects of rice cultivation, population growth and income distribution in Java and Bali. His main statement of the hypothesis is as follows:

> Wet-rice cultivation with its extraordinary ability to maintain marginal labour productivity by always managing to work one more man in without a serious fall in per capita income, soaked up almost the whole of the additional population that the Western intrusion created, at least indirectly. It is this ultimately self-defeating process that I have proposed to call "agricultural involution". (1963:80)

Geertz's hypothesis is that in the Javanese rural situation (closely comparable to the Balinese situation), with fixed land resources and continually rising population, one way that people cope with the work-food-population problem is by 'making room' for their 'excess' relatives and fellow-villagers in more carefully cultivating rice (worksharing). As a result of this more intensive care, he hypothesised, the output of rice per unit area increases. Naturally, average labor productivity falls, but more people are employed and more people (presumably) share in the distribution of this, marginally augmented, output of rice: a social phenomena van der Muijenberg (1975) called "shared poverty".

Interestingly, Geertz offered no quantitative evidence to support his hypothesis. Yet the notion, initially, received widespread acceptance - possibly because of the elegance of his writing, and the neatness with which it apparently explained complex social and ecological phenomena emerging in rural Java. The acceptance of the hypothesis by scholars of rural change in Java (and Bali) has now faded, and little remains of the socioeconomic aspects of the hypothesis: the concepts of 'worksharing' and 'shared poverty' (ibid 1975). There have been many critics of the social aspects of the hypothesis, Collier (1978, 1981) and Alexander and Alexander

(1978, 1979, 1982), to name but two of the most trenchant. However, it is probably Benjamin White (1983) who best sums up the outcome of this twenty year long critical process, concluding:

> that almost no element in the Geertzian view of Javanese agrarian change is supported by available evidence.

Population Density, Labour and Material Inputs.

In contrast to White's view, some of the agricultural data collected during fieldwork may support one aspect of Geertz's hypothesis (higher population densities leading to greater labour inputs); while, paradoxically, refuting the biological basis of the hypothesis (that greater labour inputs result in higher yields). The first of these results is in line with Wilkinson's (1973:102) and Common's (1987) analyses that increasing population pressure requires a greater per capita amount of labour (and other resources) to maintain the same level of per capita subsistence. As will be shown, families with less ricefield per capita do, on the whole, invest more labour per unit area in rice cultivation than families with more land per capita. However, as will also be shown, this increased labour does not lead to higher rice yields - raising, but leaving open the question: Why do these families invest more labour in cultivation if yields do not increase?

Analysis of per capita staple food availability in Bali shows that there has been no substantial change over the last 45 years, despite increased cropping intensity, new varieties, fertilisers and pesticides. This relative stagnation of per capita output despite increased per capita and per unit area inputs indicates that at the island level, substantially increased resources per unit of food output are now required to maintain basic subsistence. From an energy perspective this is expressed as a declining Energy Ratio in staple crop production, especially rice (see section 5.2). Economically, this is experienced as higher levels of fixed and working capital required to operate the island's food system, so as to maintain staple per capita food availability.

Partial correlations, controlling for the effect of area, are now used to test the relationship between the density of people per hectare of ricefield and labour and material inputs. The results, presented in Table 5.7, show that for Taro, with the lowest average population density, increasing density leads to more intensive use of material inputs; in Penestanan it leads to greater labour inputs; and in Tegal Tugu results only in more labour for land preparation and greater pesticide use. Overall, however, there is a significant correlation between population density and total preharvest and total labour inputs, and a significant correlation of the same order (0.15 - 0.25) between individual material inputs, total energy inputs and population density.

Thus, tentatively at least, this aspect of Geertz's hypothesis (and Wilkinson's analysis) is supported: those families with less ricefield per capita do indeed 'work it harder'. The positive results of additional labour inputs (increased yield and output) are, however, less than clear-cut.

Table 5.7:
HYVs: Population Density, Labour and Material Inputs (Means and Partial Correlations).

Variable	Taro Mean	Penestanan Mean	Tegal Tugu Mean	All 3 Mean
N	178	112	146	436
Persons/Family	5.4	7.5	6.9	6.4
Area (Are)	21.1	24.5	20.9	21.9
Density (people/ha) .3		31.4	40.0	39.3 36
Yield (kg/Are)	17.50	22.01	29.75	22.76
Energy Ratio	2.0	2.0	2.5	2.2
Partial Correlation of Ricefield Population Density with Labour Inputs - Controlling for Ricefield Area with:				
Labour Inputs (work hours/Are)				
Prepare	0.057	-0.187 c	0.155 c	0.138 a
Maintain	-0.022	0.204 b	0.031	0.056
PreHarvest	0.026	0.222 b	0.110	0.117 b
Harvest	0.164 b	0.324 a	0.029	0.228 a
Total Human	0.096	0.345 a	0.108	0.197 a
Material Inputs(kg/Are)				
Seed	0.182 b	-0.045	-0.003	0.147 a
Urea	0.170 b	0.032	-0.117	0.126 a
TSP	0.038	-0.055	-0.051	0.010
Pesticide	0.141 c	0.203 b	0.127	0.254 a
Total Energy Inputs				
Lab & Mat'l (MJ/Are)	0.232 a	0.086	-0.092	0.191 a
Energy Ratio	-0.003	-0.131	0.100	-0.007

Notes see Footnote 39.

Yields and Labour Inputs.

What has not been confronted anywhere in the literature in the debate about agricultural involution is whether a biological basis ever existed for Geertz's notion that:

> the output of most terraces can be almost indefinitely increased by more careful, fine-comb cultivation techniques; it seems that it is almost always possible to squeeze just a little more out of even mediocre sawah by working it just a little bit harder. (1963:35)

39 Ricefield Population Density is persons/ha of ricefield. PreHarvest = Prepare + Maintain; Total Human = Preharvest + Harvest. Correlation significances: a=<0.005, b=<0.02 and c=<0.05.

Geertz was commenting on the Javanese agricultural scene as he found it in the mid-1950s, and it is more than probable that by then labour inputs had already reached such a high level that any additional increment in yield from "fine-comb cultivation techniques" had already been gained. That is, given the existing technology, yields had already been maximised and any increase in output would require new technology (such as HYVs), rather than just a more intensive application of the available inputs. Such a situation might be represented graphically by the familiar logistic (S-shaped) curve, with labour, etc (inputs) along the horizontal axis and yield (output) on the vertical axis. By the 1950s, at the latest, the curve had flattened-out at the upper limb and no further yield response to existing inputs was possible. Such a view of the relationship between inputs and yield fits much better with what is known of biological responses to additional inputs, than do yields that can mystically be "almost indefinitely increased".

To identify the role of labour inputs in affecting yields, the cross-cutting influences of area farmed and rates of seed, fertiliser and pesticide use have been statistically 'removed' from the summary in Table 5.8. These results indicate that the level of human labour inputs is generally not significantly correlated with yields and, where a statistically significant relationship exists, it is marginally negative. However, as before with summary data on simple correlations between material and labour inputs and yields, the aggregated analysis of data from each village obscures the lack of seasonal, positive and significant correlation between labour inputs and yield of rice (cf Tables A5.8.9-12 for details).[40] Overall, for all three villages and

40 Hobart (1979:169-70) emphasises the point that many if not most farmers (owner-operators and sharecroppers) do not have a simple productivity (economic profit) maximising approach to rice cultivation. Instead cultivation decisions, including whom to call on for additional labour and what shares harvesters should receive, are based on an assessment by the farmer of how their agricultural activities will (dis)advantage their social standing in the village. Moreover, in deciding whether to, for instance, use casual labour for land preparation and/or crop maintenance the farmer is aware that this type of labour is generally less efficient/effective than family labour but may decide to employ casual labour for non-economic, social reasons to do with his social standing in the village. The impact of these factors and the impact of variations in 'farmer skill' on yields are, clearly, unquantifiable. However, these same factors were operating when Geertz undertook his research.

seasons combined, there is a small, marginally negative correlation linking all preharvest labour inputs and yield. The conclusion, then, is that the level of labour inputs have no discernible positive effect on yields.

Table 5.8:
HYVs: Human/Draught Labour and Yield 1982-83 (Partial Correlations Controlling for Area and Material Inputs).

Variable	Prep	Main	Drft	PreH	Harv	Total
Taro (N=178, df=172.)						
Yield	0.212 a	0.146 b	0.053	0.215 a	0.308 a	0.320 a
Penestanan (N=112, df=106.)						
Yield	-0.125 c	-0.020	0.331 a	-0.096	0.255 b	0.017
Tegal Tugu (N=146, df=140)						
Yield	0.079	0.070	0.122 c	0.090 b	0.255 a	0.225 a
All Three Villages (N=436, df=430)						
Yield	-0.066	-0.094 b	0.389 a	-0.088 b	0.067 b	-0.044

Notes see Footnote 41.

It is intriguing, however, that the amount of draught labour used has a fairly consistent, significant and positive relationship to yield. On average only about 1.5 hours/Are of draught labour are used, as against an average of 6.9 hours/Are of preharvest human labour. This linkage tempts speculation that the more thorough cultivation achieved by ploughing, and the incidental manuring of the ricefield during ploughing, is linked to higher yields. On the other hand, the marginally negative influence of additional maintenance on yield may be the result of incidental damage to the rice plants root system(s) caused by trampling during weeding.

On the basis of these results it is clear that Geertz's hypothesis of a positive relationship between labour inputs and yields is, at best, unsupportable for contemporary rice cultivation in Bali. It is also probable that such a linkage did not exist in the 1950s, the period with which Geertz was most familiar. In any case, given that Geertz failed to provide any quantitative evidence, there were no grounds in

41 Labour inputs are in work hours/Are. Yield in kg/Are. Controlling for the influence of Area, Urea, TSP and Pesticide. Correlation significances: a =<0.005, b=<0.05 and c=<0.08. Source: based on Table A5.8.12.

the first instance for even tentative acceptance of the biological aspects of his hypothesis .

5.5.3 Yields and Material Inputs.

Having shown that above a necessary minimum labour inputs do not significantly affect yields, attention is now directed to the relationships between yield and material inputs of seed, fertilisers, pesticide. Partial correlations are again used to control for the effect of cropped area on both inputs and yields. At the outset it is reasonable to expect, given the 'designed in' characteristics of HYVs, that yields will be significantly and positively affected by material inputs, particularly urea fertiliser.

Table 5.9:
HYVs: Material Inputs and Yield 1982-83 (Partial Correlations Controlling for Area).

Input	Seed	Urea	TSP	Pesticide	Total
Taro (N=178, df=175)					
Yield	-0.093	0.201 b	0.108	0.284 a	0.209 b
Penestanan (N=112, df=109)					
Yield	-0.252 b	-0.020	0.363 a	0.234 c	-0.006
Tegal Tugu (N=146, df=143)					
Yield	0.098	0.145 c	-0.042	0.251 b	0.178 c
All Three Villages (N=436, df=433)					
Yield	-0.016	0.290 a	0.146 a	0.397 a	0.314 a

Notes see Footnote 42.

The effect of material inputs on yield are much more varied than for labour inputs (again, this summary table disguises major inter-seasonal differences). Except for seed, Table 5.9 shows that material inputs, and their total energy equivalent, are positively and significantly correlated to yields. However, in Tegal Tugu (the village with most experience with HYVs), for instance, in two out of three seasons (1982 and 1982/83) the rate of urea use is not significantly correlated with yield (see Tables A5.8.13-14). This is probably an indication that urea application rates are already so high in

42 Material Inputs are in kg/Are, Total is the sum of the energy equivalent of inputs of seed, fertiliser and pesticide; Yield is in kg/Are of dry, milled rice. Correlation significances: a=<0.001, b=<0.005 and c=< 0.05. Source Table A5.8.16.

Tegal Tugu (mean 345 kg/ha) that no further yield response is obtainable. It is clear that, because of the energetic 'dominance' of urea, where there is no significant urea-yield correlation the energy input-yield correlation is also non-significant.

The 'patchy' strength and significance of the linkage between material inputs and yields in each season, and the positive and significant correlations over the three seasons may have a somewhat subtle explanation. If farmers cannot be 'certain' each season that their efforts and the use of purchased inputs will be rewarded by greater production (yields), they may feel compelled, in any case, to invest high levels of labour and material inputs to maintain their subsistence. It may be that farmers make their 'investment' in anticipation of a payoff during favourable seasons. Some evidence of this is given by the higher than average yields obtained in the 1983 dry season, despite average material input levels somewhat below those used in the preceding two seasons (cf Tables 5.3 and 5.4).

5.5.4 Combined Effects of Labour and Material Inputs on Total Production and Yields.

Multiple regression analysis is now used to examine the combined effects of labour inputs, material inputs, crop losses, water management and irrigation sufficiency on total production and yields.[43] Using this technique permits identification of the contribution each factor makes to total production and yield, while statistically controlling for interactions between factors. Crop losses, water management and irrigation sufficiency have not previously been introduced into the analysis. These three variables are now included, to take into account differences in the estimated amount of the crop lost to pests and diseases, the amount of labour used (and needed for controlling irrigation flows by each farmer,

43 Molster (1978), using data from the Jogjakarta region in Java, 2,274 observations (collected by other workers, before and after the introduction of HYVs) devoted a whole PhD thesis to exploring the relationships between urea use (and other factors) and yields. He developed and tested a number of quadratic and generalized power production (GPPF) functions, using yield without fertiliser as the only independent variable - concluding that a properly specified quadratic function performed best (pp.55-7). His analytic methodology was tested with the data from this study, and gave poor results; and, given that data on other variables is available, a model incorporating these variables is used here.

and each farmer's estimation of the sufficiency of irrigation water available to him (a four point scale was used).

Total Production, Inputs and Area Farmed .
The results of this analysis for total production in all three seasons is presented in Table 5.10.[44] In each village and overall the variables included in the analysis account for half or more of the variation in total output of milled rice. However, a comparison of the Multiple R^2 and the r^2 for the Area-Output Correlation shows that total production is dominated by the area farmed, as expected, leaving only a relatively small proportion of variation in production to be accounted for by labour and material inputs and irrigation.

Overall, the Multiple R^2 (three villages and seasons) is 0.60, of this the area accounts for 63% of the variation in total output (R^2 divided by Area-Output r^2). For the 1982 season, area accounts for between 82% and 91% of variation in output in each village; in the 1982/83 season for between 24% and 56% of variation; in the 1983 season for between 81% and 93% of variation; and, for the 1982 and 1983 dry seasons combined, for between 79% and 95%. Thus, the use of all the resources of labour, material inputs and irrigation, while making a significant contribution overall, only explain a minor proportion of the differences between the total production achieved by farmers. Where cropped area accounts for less than 60% of the variation in output (1982/83 season), crop losses and pesticide use account for a major proportion of the variation in total output (see Table A5.9.2).

44 Details for each season and village, and for the combined data for Dry seasons 1982 and 1983, is presented in Appendix 5.9.

Table 5.10:
Regression Analysis: Output (dependent) and Inputs(1982-83).

Variable Three	Taro	Penestanan	Tegal Tugu	All
Seasons	'82 &'83	'82 &'82/83	'82 -'83	'82 -'83
N	178	108	144	424
Constant	4.55	3.58	2.84	3.25
SE	0.58	0.35	0.42	0.28
Sig	a	a	a	a
Area	0.81	0.90	0.81	0.82
SE	0.08	0.07	0.05	0.05
Sig	a	a	a	a
Preparation	0.15	-0.06	0.47	0.20
SE	0.12	0.07	0.12	0.07
Sig			a	b
Draught	0.01	0.01	0.03	0.03
SE	0.02	0.01	0.02	0.01
Sig		b		a
Maintenance	0.14	0.08	-0.03	-0.01
SE	0.10	0.06	0.06	0.05
Sig				
Seed	-0.12	-0.08	0.07	-0.11
SE	0.15	-0.08	0.11	0.08
Sig				
Urea	0.06	0.15	0.22	0.28
SE	0.13	0.11	0.11	0.09
Sig			b	a
TSP	0.003	0.01	0.001	0.01
SE	0.02	0.01	0.01	0.01
Sig		c		c
Pesticide	-0.01	-0.01	0.01	0.03
SE	0.01	0.01	0.02	0.004
Sig				a
Crop Losses	-0.59	-0.02	-0.01	-0.05
SE	0.06	0.01	0.01	0.01
Sig	a			a
Water Management.	-0.002	0.003	-0.002	-0.002
SE	0.002	0.001	0.001	0.001
Sig		c	b	c
Irrigation	0.19	-0.02	-0.002	0.08
SE	0.06	0.04	0.02	0.03
Sig	c			b
Adj.Multiple R^2	0.66	0.75	0.71	0.60
F-value	29.797	26.423	29.272	55.276
Significance	0.000	0.000	0.000	0.000
Area-Output Corr.				
r	0.54	0.78	0.79	0.62
r^2	0.29	0.61	0.62	0.38
Of Tot.Variance(%)	44	81	87	63

Notes see Footnote 45.

45 See Appendix 5.14 for details. Significances: a=<0.001, b=<0.005 and c=<0.05. Figures in round parentheses are Standard Errors; figures in square parentheses are the proportion of the Multiple R^2 accounted for by the Area-Output Correlation (r^2). Source:Table A5.9.5.

Generally, land preparation and draught labour make a significant positive contribution to output, while the amount of labour used for crop maintenance has an insignificant effect. The quantity of seed used has an (inexplicable) negative, but insignificant, effect on output. Urea, TSP and pesticide use rates all have, overall, positive and significant effects on total output, though there are marked inter-village and inter-seasonal differences in the magnitude and significance of these effects. Water management, where significant, has a negative effect on production (except for the combined data on dry seasons), suggesting that more attention to water control is an indication of difficulty in acquiring sufficient irrigation water. Only in one instance (Penestanan 1983) is irrigation sufficiency significantly and negatively correlated to output, indicating that, on the whole, water availability is not a factor limiting production.

In every instance, the magnitude and significance of the constant in the regression equation for each village and season is far larger than any of the other coefficients; signifying that, whatever else occurs, a farmer will usually obtain some output as a result of his investment of labour and material inputs. In two instances the negative influence of crop losses is about equal in magnitude to and more significant than the positive contribution made to output by urea fertiliser (Tegal Tugu 1982 and Taro 1982-83). In the discussion below further attention is drawn to the effect of crop losses on yields and, hence, production.

Crop Yields and Inputs.

Approximately one third of the farmers failed to achieve per crop yields greater than those they obtained when they grew traditional varieties (see section 5.7). Despite this, average HYV yields for the whole sample are one third greater than traditional yields. This is a substantial achievement, although one bought at the price of massive increases in inputs and infrastructure; and, as has been shown in the introduction and Chapter 3, yields (and hence total production) are subject to much greater inter-seasonal fluctuation than traditionally.

Of particular importance is the fact that in the three villages over the three seasons, the amount of urea fertiliser used is only in two instances (Taro 1982, Tegal Tugu 1983) significantly related to yields (see Tables A5.10.1-3).[46] Below the impact of crop losses is analysed and shown to account for a major, but differing, proportion of variation in yields (see Table 5.11). Over the three seasons crop losses account for more of the variability in yields (-0.04 or 16%) than the combined effects of TSP and pesticide (0.01 plus 0.02); and in Taro crop losses have a dominant effect on yields in each season. In Tegal Tugu, where farmers are more experienced with HYVs and use pesticide more frequently, crop losses, except in the 1982 season, play an insignificant role.

There is an increasing amount of evidence emerging that the (indiscriminate) application of pesticides may be the proximate cause of serious outbreaks of rice pests, particularly Brown Plant Hoppers, by sundering the natural population controls effected by predation on pests by natural enemies, spiders and geliids (IRRI 1985, Kenmore et al 1985). So serious have these 'counter-intuitive' effects become that on 5th November 1986 a Presidential Decree (No.3/1986) was issued, banning the use on irrigated rice crops of almost all the pesticides most commonly used in Bali (and Java), including: Basudin 60 EC and 10 G, Diazinon 60 EC, Dursbane 20 BC and 15/5 E, Sevin 5 E, 5 G and 85 S, and Thiodan 35 EC. Attention is also drawn to the (negative) synergistic effects on plant health caused by applications of fertiliser and pesticide mentioned in Chapter 2.

In every instance the larger the area cropped the lower the unit area yield, although the relationship is not always statistically significantly; and the amount of draught labour

46 The fate of nitrogen fertilisers applied to flooded-rice crops is very complex and difficult to quantify. However, under conditions prevailing in Bali, at least three processes are at work competing with the plant for the applied nitrogen: runoff, volatilisation and immobilisation in the soil - accounting (very approximately) collectively for 60-65% of broadcast nitrogen (Wetselaar et al 1986). Additionally, at the high rates of application common in Indonesia (and Bali) it is unlikely that the rice plant is efficiently expressing (as rice) the nitrogen taken up - this may be due to nitrogen induced sterility, resulting in empty spiklets (seeds) (Wetselaar et al 1984). These are effects that take place after the nitrogen has been taken up and, after also making allowance for losses after application, may help account for the weak relationship between rates of fertiliser application and yields.

Table 5.11:
Regression Analysis: Yield (dependent) and Inputs(1982-83).

Variable Three	Taro	Penestanan	Tegal Tugu	All
Seasons	'82 &'83	'82 &'82/83	'82 -'83	'82 -'83
N	173	107	137	406
Constant	4.10	3.20	2.78	2.88
SE	0.59	0.34	0.35	0.25
Sig	a	a	a	a
Area	-0.18	-0.12	-0.13	-0.18
SE	0.08	0.07	0.05	0.04
Sig	c		b	a
Preparation	0.14	-0.01	0.26	0.13
SE	0.12	0.07	0.10	0.06
Sig			c	c
Draught	0.01	0.02	0.01	0.02
SE	0.02	0.004	0.01	0.01
Sig		a		a
Maintenance	0.15	0.04	0.01	-0.03
SE	0.10	0.06	0.05	0.05
Sig				
Seed	-0.08	-0.14	0.01	-0.09
SE	0.15	0.09	0.08	0.06
Sig				
Urea	0.07	0.15	0.19	0.37
SE	0.13	0.10	0.09	0.07
Sig			c	a
TSP	0.003	0.01	-0.002	0.01
SE	0.02	0.004	0.004	0.004
Sig		c		c
Pesticide	-0.01	-0.002	0.02	0.02
SE	0.01	0.01	0.01	0.003
Sig	c			a
Crop Losses	-0.60	-0.02	-0.01	-0.04
SE	0.06	0.01	0.01	0.01
Sig	a			a
Water Management.	-0.001	0.003	-0.002	-0.002
SE	0.002	0.001	0.001	0.0001
Sig		c	c	c
Irrigation	0.12	0.01	0.01	0.06
SE	0.06	0.03	0.02	0.02
Sig	b			
Adj.Multiple R^2	0.52	0.38	0.18	0.37
F-value	16.570	5.208	2.515	20.586
Significance	0.000	0.000	0.007	0.000
Loss-Yield Corr.				
r	-0.68	-0.10	-0.02	-0.24
r^2	0.46	0.01	0.0003	0.06
Of Tot.Variance(%)	89	3	<1	16

Notes see Footnote 47.

47 See notes to Table 5.11 above. See Appendix 5.10 for details. Source Table A5.10.5.

generally has a significant positive effect on yields. On the other hand, human labour for land preparation and crop maintenance has a significant positive effect in only one instance (Tegal Tugu 1982/83)[48]. Thus, after taking into account the other factors under the 'control' of the farmer, the amount of labour used does not influence yields. It is fair to conclude, therefore, there remains no observable biological basis for continuing to accept Geertz's original hypothesis.

More importantly, having taken into account all the factors generally thought to be significant in explaining yield variations (see for instance IRRI 1979:1-123), factors reasonably within the control of farmers, more than half of the variability in yields remains unexplained. Only where crop losses account for a major proportion of variation does the Multiple R^2 exceed about 0.40, e.g. 1983 Wet season (Table A5.10.2). In general, farmers in Southern Bali are faced with a situation where about two thirds of their yield (hence total production) is affected by factors beyond their individual control. Such a situation is well-characterised by saying that physical and labour inputs to rice cultivation and the output from the system are, for most practical purposes, 'de-coupled' from each other.

5.6 Contemporary Energetics and Economics.

5.6.1 Contemporary Energetics of HYV Rice Cultivation.

In this section the inputs and output of rice cultivation are quantified according to the amount of energy they consume during application (e.g. hoeing, weeding etc), or the amount of energy required for their production and delivery (e.g. petrol and diesel fuel, fertilisers etc).[49] Both of these types of inputs are expressed in energy units (MegaJoules or MJ), then added to derive the total energy input per unit area (MJ/Are) and/or operation; and finally compared to the food energy content of the rice produced. The Energy Ratio (ER),

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48 It should be noted that the strength of this single instance dominates the overall significance of preparation labour for both Tegal Tugu and the three villages in the table above.

49 Inputs of human and draught labour are considered 'direct' inputs to production; fuels, fertiliser and tools as 'indirect' inputs - more correctly manufactured inputs.

the most commonly used, dimensionless, 'order of merit' figure is used to compare energetic efficiency: the energy content of output(s) divided by the sum of all energy inputs.[50]

As a result of agricultural intensification the energy efficiency in rice cultivation in Bali has declined markedly, as it has elsewhere. Focussing just on the energetics of rice production, Leach (1976:118-22) reports a traditional ER of 10.5 (subsistence rice in India), an ER of 5.5 for 'transitional' rice cultivation in the Philippines, and for intensive, mechanised cultivation in California and Surinam, ERs of approximately 1.3. Reporting on the Philippines, Freedman (1978) gives ERs for traditional cultivation of 13.8 and of 2.9 for 'Green Revolution' practices; and Kuether and Duff (1981) estimate the Green Revolution ER for the Philippines as 3.2.[51] More recently, the ERs for irrigated dry season HYV rice in the Philippines were calculated as 2.8-3.0 (IRRI 1986:355).[52]

For (semi)traditional rice cultivation in Southern Bali in 1979 the author estimated an ER of 7.5 for farmers growing TLVs, but using small amounts of urea (average 13 kg/ha); and an ER of 3.5 for farmers growing IR36 and using urea (average 160 kg/ha) (Foley 1979:87-9). The values of energy inputs, output and ERs for HYV and TLV rice, estimated on the basis of the current survey data, are in good agreement with the range of values found in the literature. Confirming, in detail, the marked decline in energy efficiency resulting from the intensification of rice cultivation in Bali.

Figure 5.5 and Table 5.12 summarises average energy inputs and output for HYVs grown during all three seasons (1982, 1982/83 and 1983) for each of the three villages.[53] Later in this section these figures are compared to estimated traditional

50 The relevant labour-to-energy and material-to-energy conversion factors, conventions used in calculations and more detailed results can be found in Appendix 5.7 and its footnotes.
51 The methodological shortcomings of Kuether and Duff in estimating traditional energy flows are noted in Chapter 2.
52 Energy inputs to cultivation of 17.5-23.7 GJ/ha are similar to those found in Bali (macro and micro) as are (corrected) edible outputs, 48.4-70.0 GJ/ha and ERs of 2.8-3.0. Estimating the energy content of output based on un-milled rice, a (deliberate?) mistake that Kuether and Duff (1981) from IRRI also make, inflates the energetic value of production by about 35%.
53 Based on the tables in Appendix 5.7, it uses only data collected with the 'long form' survey questionnaire.

flows. The last row of the table (Proportion of Industrial Inputs) shows the degree to which new, indirect inputs dominate energy flows in contemporary rice cultivation - on average 86% of the energy now used. Second, remembering that this table summarises three different crop seasons, there is a striking uniformity of pattern across the three villages in the magnitudes of the energy equivalents of human labour and material inputs to cultivation, levels of output, ERs and proportion of industrial inputs. Energy inputs and output per unit area and ERs in Tegal Tugu are significantly higher than in Taro, and energy inputs in Penestanan equivalent to those in Tegal Tugu, but output and ERs are notably lower.

Energy inputs to HYVs are dominated by the energy embodied in urea fertiliser, averaging 77% of total energy inputs.[54] Interestingly, the energy equivalent of inputs of seed, TSP and pesticides (all used in relatively small quantities) equals or exceeds the direct energy supplied by human and draught labour. These inputs, with the possible exception of seed, all come from non-renewable resources, whose supply is well beyond the control of local farmers. It is difficult to imagine a clearer demonstration of the degree to which Balinese rice cultivation, in the span of a decade, has been transformed from effective self-sufficiency to (almost) complete dependence on resources imported to the island.

54 Generally applied well in excess of the (already generous) recommended rate of 250 kg/ha.

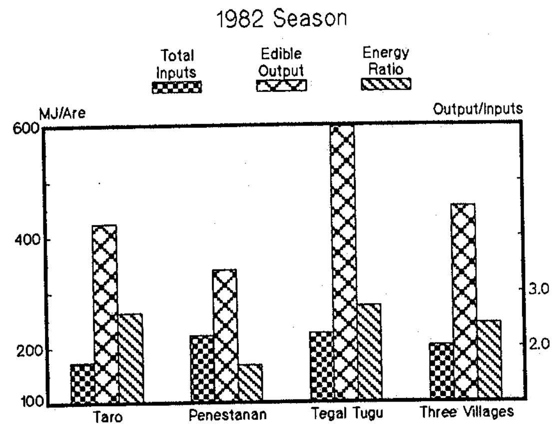

Figure 5.5a: Energy Inputs and Output and Energy Ratio (1982).

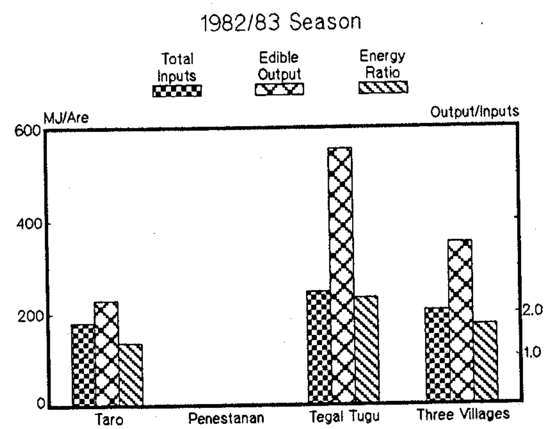

Figure 5.5b: Energy Inputs and Outputs and Energy Ratio (1982/83).

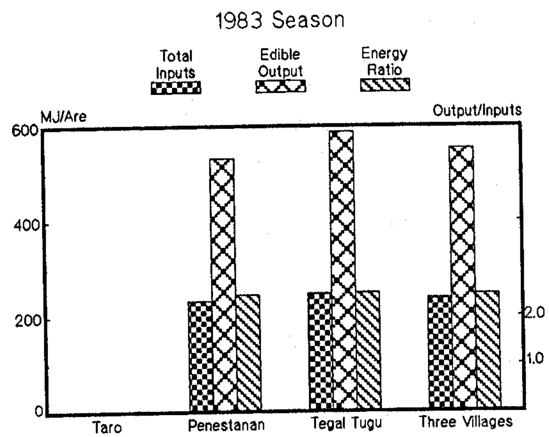

Figure 5.5c: Energy Inputs and Outputs and Energy Ratio (1983).

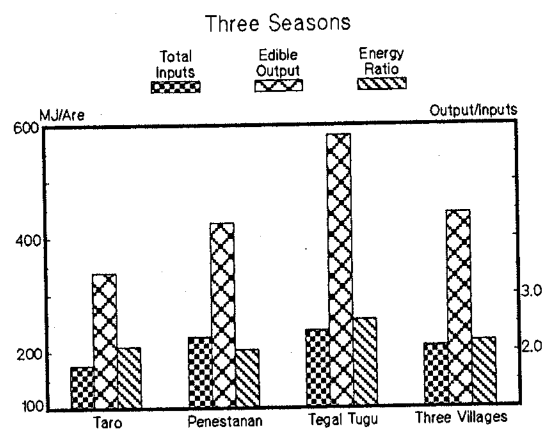

Figure 5.5d: Energy Inputs and Outputs and Energy Ratio (1982-83).

Figure 5.5: Energy Inputs and Output and Energy Ratios (1982-83).

Table 5.12:
HYVs: Energy Inputs and Output for Three Seasons Combined: 1982, 1982/83 and 1983 (MJ/Are).

1982-83	Taro Mean	Penestanan Mean	Tegal Tugu Mean	All 3 Mean
N	178	112	146	436
Area(Are)	21.1	24.5	20.9	21.9
Labour Inputs				
Prepare	8.40	9.88	5.62	7.85
Maintain	5.17	5.22	2.94	4.43
Draught	6.85	8.08	19.59	11.69
PreHarvest Subtotal (H & D)	20.34	20.94	28.02	23.06
Harvest	4.13	5.24	3.74	4.28
Total Labour (H & D)	24.46	26.13	31.71	27.32
Material Inputs				
Seed	11.08	18.31	12.82	13.52
Urea	138.78	170.68	183.20	161.85
TSP	6.22	8.77	10.39	9.18
Pesticide	5.64	10.24	8.82	8.58
Total Material	151.96	200.69	205.30	182.34
PreHarvest Subtotal (Labour plus Material)	172.29	221.63	233.31	205.40
Total Energy Inputs (PostHarvest)	**176.42**	**226.82**	**237.00**	**209.65**
Total Energy Output	339.54	**427.08**	**581.19**	**442.63**
Energy Ratio (PostHarvest)	**2.03**	**1.98**	**2.52**	**2.18**
Proportion of Industrial Inputs	86%	88%	88%	86%

Notes see Footnote 55.

5.6.2 Contemporary Economics of HYV Rice Cultivation.

The introduction of HYVs in the late 1960s was accompanied by government subsidies to farmers adopting the new technology (BIMAS/INMAS). The subsidies included cash advances for land preparation, large subsidies on essential fertiliser and pesticide inputs and low-interest credit for purchasing these inputs. In addition, agricultural extension services were greatly expanded, both to provide basic technical information to farmers and collect statistics on production. During the

55 (H & D) = Human and Draught Labour. See Tables A5.11.1-4 for details on each season. Also see the notes in Appendix 5.9 for explanations. Source: Table A5.11.4.

last 15 years the system of subsidies and agricultural extension has undergone a series of revisions, resulting by the 1980s, generally, in reduced subsidies and expanded extension and statistical services.

The modernisation of staple crop agricultural technology in Bali, and elsewhere in the Third World, has three interlocking aims, two overt and one 'covert': a) to increase food production to meet the (staple) foods needs of a growing population; b) to raise the 'purchasing power' of farmers and rural communities by increasing their agricultural productivity (per man-hour and per hectare), thereby giving them access to modern goods and services; and, covertly, c) to draw rural communities into a dependant and subordinate economic relationship with urban centres - by virtue of urban control of the (new) material, energy and information resources essential for practicing 'modernised' agriculture.[56] In this respect, it is also worth recalling that one of the (minor) aims of the Green Revolution was forestalling Red Revolutions, ones spurred by increasing poverty and socioeconomic inequalities.

The economics of contemporary rice cultivation have been estimated from survey data, based on the amount of labour used (family and hired), inputs of seed, fertiliser and pesticide used in cultivation and the quantity of harvested rice.[57] The analysis shows that for a cash outlay of Rp 800-1300/Are the average farmer can achieve a net return of Rp 1500-4600/Are; equivalent to a return of Rp 200-700/hour of pre-harvest human labour inputs (see Figure 5.6 and Table 5.13). There are, however, significant differences in the total value of inputs

56 As long ago as 1925 Chayanov recognised this approach to the central development of capitalist agriculture, and the demise of 'peasant economics': "...agriculture comes out of its semi-natural existence and becomes subject to trading capitalism that...draws masses of scattered peasants farms into its sphere of influence and, having bound these small-scale commodity producers to the market, economically subordinates them to its influence (Chayanov 1925:257, cited in Kitching (1982:53)). Kitching goes on "...it then becomes possible...to begin to interfere directly in the production process, often by laying down quality standards...[with which] comes a whole package of controlled seed distribution, fertiliser applications, forms of crop rotation, etc." (p.53). Lipton (1977:117) shows the pattern is universal in application: "Communist development, like capitalist development draws the farm sector into the cash nexus making it dependent on the city...manipulate[ing] prices to increase the resource drain out of the villages.".

57 Family labour is valued at zero (opportunity) cost and hired labour at the rate reported by the farmer. Urea and TSP fertiliser at Rp 75/kg and pesticide at Rp 1200/litre; unmilled HYV rice at Rp 120/kg and milled HYV rice at Rp 120/kg.

and outputs, both between seasons and villages. Over three seasons, farmers in Taro made the smallest inputs of cash (for hired labour and materials) and farmers in Tegal Tugu the largest, with intermediate levels of inputs and output in Penestanan; the net cash equivalent of the harvest follows the same pattern.

In terms of the flows of economic resources, HYVs require average expenditures of Rp 290-479/Are (per crop) on material inputs that come from outside the village economy. On the other hand, outlays for labour (in cash or kind) remain within the village economy. Thus, in Taro with 58 ha of ricefields some Rp 1.68 million per crop leaves the village; in Penestanan with 66 ha of ricefields about Rp 2.93 million per crop; and in Tegal Tugu with 130 ha of ricefields some Rp 5.49 million per crop. From a broader perspective, it is worth noting that a recent study found that two thirds of the net additional economic benefits (welfare) in Indonesia flowing from the adoption of HYVs in the period 1977-83 have gone to non-farmers (generally urban dwellers) (IRRI 1986:347-9).[58] It is clear, therefore, that the adoption of HYVs has, and is, resulting in a relatively significant transfer of actual and potential economic welfare from rural to urban areas.

58 This analysis estimates that as a result of government policies regarding rice and fertiliser pricing and investments in irrigation, and assuming a closed economy and semi-commercial rice production, as is typical in Indonesia, that for all Indonesia, two thirds of the annual total social benefit of HYVs went to consumers and only one third to producers (farmers), over 1977-83 ($US553 vs US$180 million in 1983 prices). The distribution of benefits swings even more strongly in favour of the urban population if the distribution is calculated on a per capita basis, 8 to 1 in favour of non-farmers - as approximately 75-85% of the population lives in rural areas.

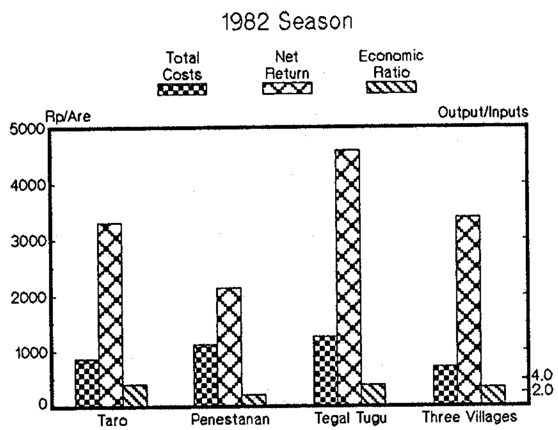

Figure 5.6a: Economic Inputs and Output and Economic Ratio (1982).

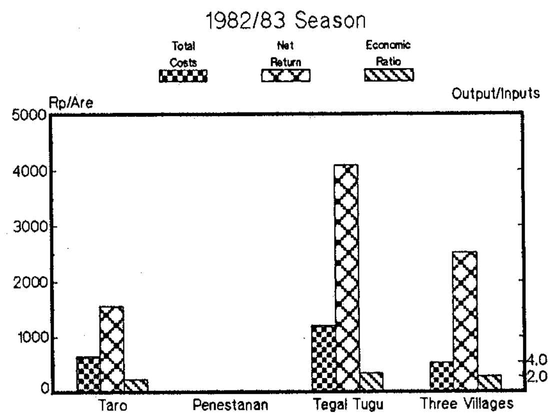

Figure 5.6b: Economic Inputs and Output and Economic Ratio (1982/83).

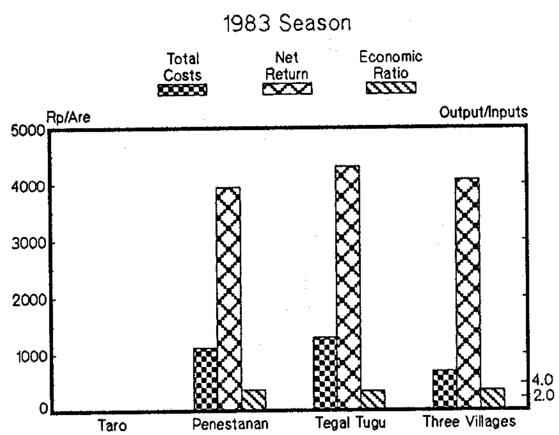

Figure 5.6c: Economic Inputs and Output and Economic Ratio (1983).

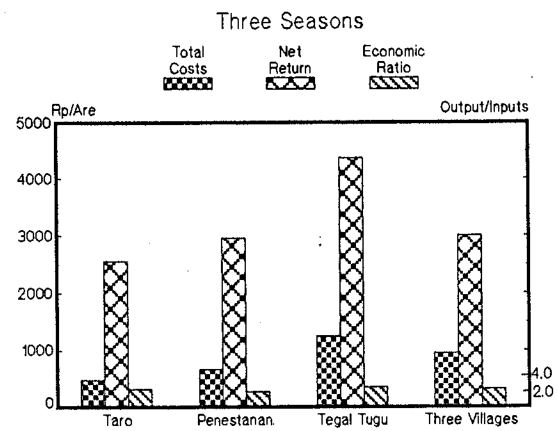

Figure 5.6d: Economic Inputs and Output and Economic Ratio (1982-83).

Figure 5.6: Economic Inputs and Output and Economic Ratios (1982-83).

Table 5.13:
HYVs: Economic Inputs and Output for Three Seasons Combined: 1982, 1982/83 and 1983.

Village	Taro	Penestanan	Tegal Tugu	All 3
N	178	112	146	436
	Input Costs (Rp/Are)			
Materials				
Seed	71	118	83	87
Urea	196	242	259	229
TSP	1	10	6	5
Pesticides	18	76	74	52
Subtotal	**286**	**444**	**422**	372
Labour				
Hired Labour	81	170	91	108
Harvest Labour	404	498	733	491
SubTotal	**485**	669	**824**	599
Total Costs	**771**	**1113**	**1246**	**955**
	Value of Output (Rp/Are)			
Gross Income	3323	4072	5616	3957
Net Income/Are	**2552**	**2959**	**4370**	**3001**
	Output/Inputs			
Net Income/Costs	3.29	2.83	3.59	3.21
Return/Hour	276	336	648	361
Proportional Costs				
Materials	0.42	0.42	0.35	0.41
Labour	0.58	0.58	0.65	0.59

Notes see Footnote 59.

The net income results from this study are in broad agreement with estimates prepared by the government statistical service for the 1981-82 period for Bali (BPS Jakarta 1983:58).[60] BPS estimates material costs at Rp 327/Are, labour costs at Rp 688/Are and total costs at Rp 1428/Are; net income in 1982 was estimated as Rp 4446/Are.[61] The main differences between this survey and BPS estimates are in the amounts of fertiliser used. According to the survey data farmers use an average of 2.94 kg/Are of Urea and 0.06 kg/Are of TSP; whereas, BPS estimate that the 'average' farmer used 2.13 kg/Are of Urea

59 See Tables A5.14.1-8 for details.
60 There are no significant differences between the BPS estimates for Bali for 1980, 1981 and 1982 (1983 estimates are not yet available). The similarities include the size and value of the harvest, the amounts and costs of material inputs and the cost of hired labour. This is in marked contrast to the inter-seasonal differences found by this research; it should be noted, however, that the BPS estimates are for a calendar year, including both wet and dry seasons.
61 The BPS method also assumes the value of the families own labour to have an (opportunity) cost of zero. Their analysis also includes costs for irrigation (Rp 37/Are) and taxes etc (Rp 100/Are), which are not included in the analysis of survey data. BPS costed seed at Rp 273/kg, Urea at Rp 87/kg, TSP at Rp 86/kg and pesticide at Rp 1671/kg; output (unmilled rice) was valued at Rp 132/kg - these values are all slightly higher than the values used in analysis of the survey data.

and 0.48 kg/Are of TSP.[62] BPS estimates that about half of the labour costs are incurred at harvest time (Rp 364/Are), in contrast to this research which estimates that approximately two thirds are incurred at harvest time.

What this table, and the BPS analysis, do not reveal are the inter-season differences in average net income/Are (see Tables A5.14.2-5). In Taro there is a 100% difference in income/Are between the 1982 and 1982/83 seasons (Rp 3303 vs Rp 1567); in Penestanan, comparing the 1982 and 1983 dry seasons, the difference is of the same order (Rp 2140 vs Rp 3983). Only in Tegal Tugu is average net income/Are roughly similar across the three seasons (Rp 4583, 4092 and 4310 respectively). While the flow of money out of the village economy to purchase material inputs to production remains fairly similar in each season (in the range Rp 281-479/Are), net farm incomes/Are from rice cultivation vary by up to 100%, on average. These variations in net income have a major impact on the whole village economy, reducing disposable income available to buy extra staple food to make up for shortfalls in production and financial access to other essential items of consumption.

5.7 Comparative Energetics and Economics of TLV and HYV Rice.

5.7.1 Comparative Energetics of TLV and HYV Rice Cultivation.

Expressing all the relevant flows in energy units makes possible a direct comparison with estimated energy flows prior to the adoption of HYVs. This per crop comparison is made assuming that: a) farmers reported reasonably accurately and honestly about the average quantity of traditional rice they harvested; and b) that, after making allowance for new labour inputs,[63] each farmer used identical amounts of human and draught labour for the whole process of crop production and harvesting as they do currently.[64] First, however, these reported yields are compared with other data on TLV yields.

62 All the farmers surveyed in this research used Urea fertiliser, though as other sections in this chapter show the rate of application varies widely between seasons and villages. On the other hand only 8% of farmers reported using TSP over the 1982-83 period, and none reported using TSP in the 1982/83 wet season.
63 Human labour used for fertiliser and pesticide applications are not included in the calculations.
64 The energy inputs for processing the harvested rice are omitted for both TLVs and HYVs.

Comparison of the TLV yields reported by farmers in this survey (village averages of 16.7-29.9 kg/Are milled rice, overall average 19.9 kg/Are) is in good agreement with other data on traditional yields. According to government statistics, Bali-wide yields in the 1929-39 period averaged 18.1 kg/Are (see Table A3.24.1) and for 1950-59 averaged 17.9 kg/Are (see Table A3.18.2). In the year immediately prior to the widespread adoption of HYVs (1969) the average yield for the island and Kabupaten Gianyar was 20.7 kg/Are (see Tables A3.18.1 and A3.19.1). Based on data collected from 80 farmers by the author in 1979 (Foley 1979) in Desa Ubud, adjacent to Penestanan, the average yield of traditional rice was 17.8 kg/Are.[65] Clearly then, the farmer's estimates of their traditional yields are a reasonable starting point for comparisons between HYVs and TLVs.[66]

Overall, the average per crop level of energy inputs (HYVs divided by TLVs) has increased some seven times, from 30 to 213 MJ/Are (by 710%); output of food energy has increased by about 20%, from 387 to 464 MJ/Are; and average ERs declined to one fifth of traditional levels, from 12.0 to 2.3 (see Figure 5.7 and Table 5.14). Only for a few of the most productive (energy efficient) farmers have these greatly increased energy inputs been balanced by commensurate increases in food production, i.e. at the top of the range of HYV energy ratios in Taro (and Tegal Tugu).

Common sense dictates that farmer's recollections of traditional yields probably omit those seasons in which their harvest failed. To test this idea, all farmers whose current yield of HYV was below their reported traditional (TLV) yield were eliminated from the comparison (see Table A5.13.2). This selection has no effect on average energy inputs for TLVs or HYVs; however, it decreases average reported TLV yields by 5-10% and increases measured HYV yields by 10-20%, somewhat

65 A minority of the farmers in the sample from Ubud used small amounts of urea fertiliser (average 13 kg/Are) but no pesticide. Data collected by Hobart (1979:646-51) from 104 farmers in Desa Tegallalang, just south of Taro, in 1972 gives a conservative average yield of traditional rice of 13.8 kg/Are ("on the low side compared with tests done in the field.", ibid).

66 In the next section (5.7) this yield data is used to compare the economics of HYVs and TLVs.

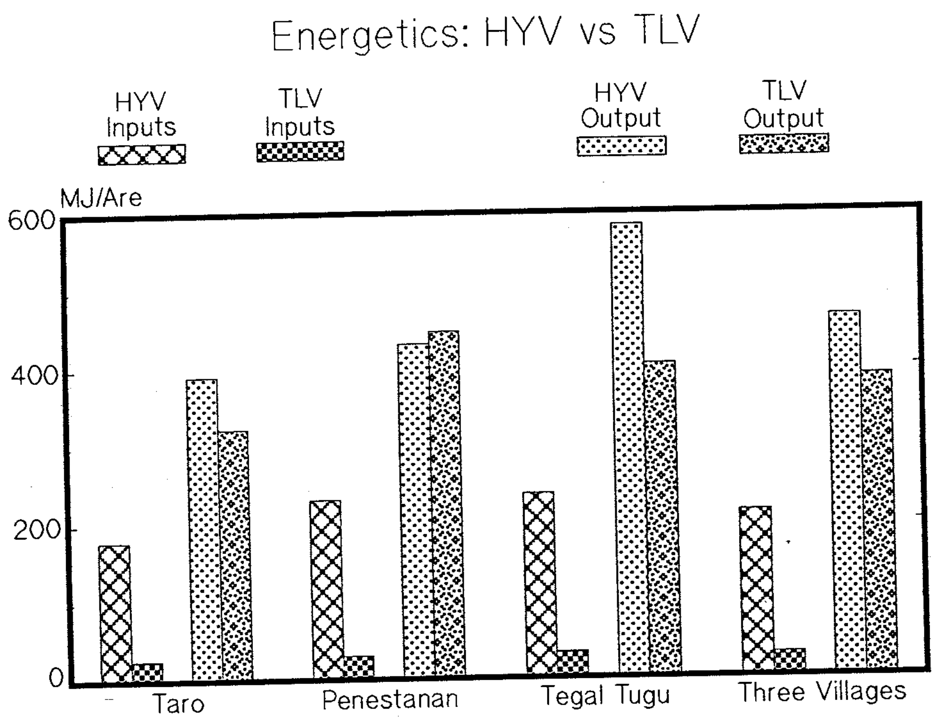

Figure 5.7: Comparison of TLV and HYV Energy Flows.

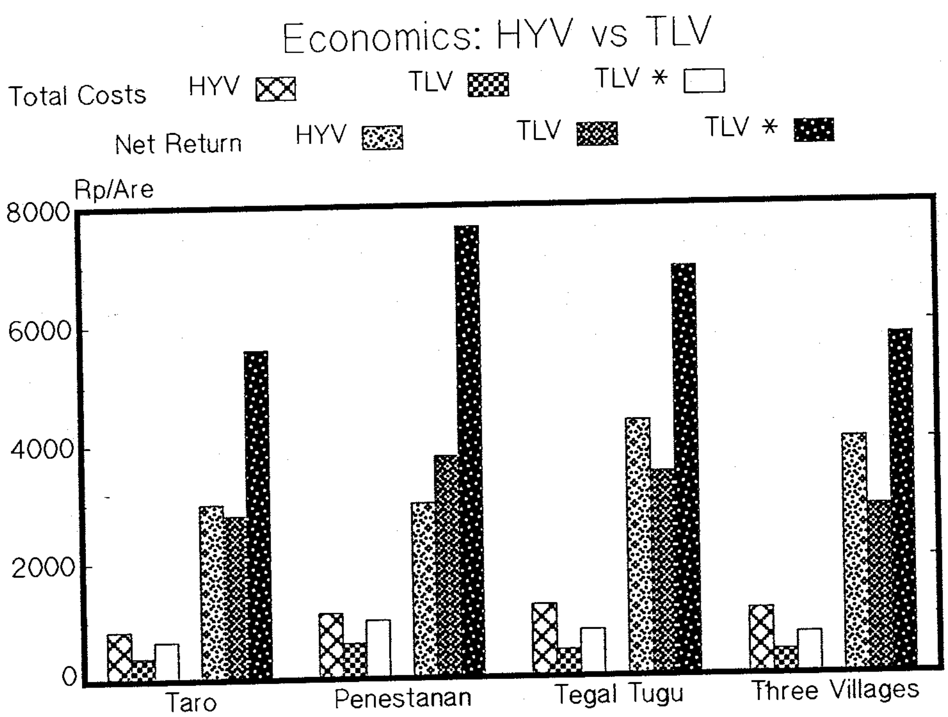

Figure 5.8: Comparison of HYV and TLV Economics.

reducing ERs for TLVs and increasing ERs for HYVs. Most significantly, this selective comparison has the effect of increasing the difference (yield/output advantage) between overall TLV and HYV yields (from 1.34 to 1.68 times). However, one third of the sample has to be eliminated for this degree of yield advantage to be obvious, as their current HYV yields are lower than their reported TLV yields.

Table 5.14:
HYVs and TLVs: Comparison of Energy Flows - Three Seasons Combined (MJ/Are).

All Three Seasons	**Taro** Mean	Penestanan Mean	Tegal Tugu Mean	**All 3** Mean
N	116	93	98	307
Traditional Varieties (Padi Cicih)				
Total Labour and Material Inputs				
Mean	26.0	30.4	33.1	29.6
Total Edible Output				
Mean	324.4	446.7	403.8	386.7
Energy Ratios				
Mean	**13.4**	**15.8**	**12.6**	**11.9**
High Yielding Varieties (IR36/50)				
Total Labour and Material Inputs				
Mean	178.6	231.3	237.2	213.2
Total Edible Output (Yield)				
Mean	391.3	431.5	583.5	464.4
Energy Ratios				
Mean	**2.3**	**2.0**	**2.6**	**2.3**
Inter-Variety Comparison (HYV divided by TLV)				
Total Energy Inputs				
Mean	**7.32**	**8.18**	**7.33**	**7.58**
Total Energy Output (Yield)				
Mean	**1.33**	**1.11**	**1.56**	**1.34**
Energy Ratios				
Mean	**0.20**	**0.15**	**0.23**	**0.19**

Notes see Footnote 67.

Only if current 'crop failures' are disregarded when calculating average HYV yields, do these results approximate the optimistic heights of average official yield levels for the 1981-83 period: these data (three seasons 1982-83) mean 27.5 kg/Are, officially (three years 1981/82/83) mean 31.5

67 See notes to Table A5.13.1 for details on data and methods. Source Tables A5.13.1-2.

kg/Are - a 13% difference in yield (cf Tables A5.6.1-4 and A5.7.3). It is also clear that intra- and inter-seasonal yield variability (even the variability in averages) is higher now than traditionally; evidence has already been presented that, on average, traditional crop losses (and yield variability) were markedly lower than today (see section 5.2 and Appendix 3.24 for details).

In summary, greatly increased intermediate (manufactured) inputs are now required to achieve a much smaller and less reliable increment in edible output of rice than 10 to 15 years ago.[68] If the data presented above are reasonably representative of Gianyar (and Southern Bali), this major rice growing region is now markedly less resource efficient than traditionally. The increase in production achieved by the HYV technology has required a 700% increase in energy inputs to achieve approximately a 20% increase in food energy output. Moreover, rice cultivation is now effectively industrialised and largely dependent on manufactured inputs to maintain production levels. It is, in a word, Westernised.

5.7.2 The Comparative Economics of TLVs and HYVs.

As the focus of this chapter is on the effects of the shift from traditional to modernised rice cultivation, it is the comparative economics of these two technologies that are of interest. Given that no data are available on the economics of rice cultivation in Bali prior to the introduction of HYVs, the relative economics of the two technologies are contrasted by simulating what the current returns for cultivating TLVs would be and comparing these to the returns currently achieved with HYVs. The simulation is made using data from a sub-sample of farmers who previously cultivated TLVs and now grow HYVs. As part of the survey these farmers provided estimates of the yield they used to achieve with TLVs.

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68 In an attempted rewriting of the Second Law of Thermodynamics (the entropy law) the authors of the IRRI 1985 Annual Report (IRRI 1986:355) blithely asserts that "The marginal productivity of energy remains relatively constant - moving from low input, low capacity systems to high input, high capacity systems. Across all systems, the incremental output to input energy ratio [ER] remains nearly constant at between four and five output units per unit of input." The evidence they present contradicts this assertion, which also flies in the face of physical laws (see for instance Georgescu-Roegen 1972) and the evidence accumulated in this and other studies (see Chapter 2 and section 5.2).

This per crop simulation is made assuming that: a) farmers reported honestly and fairly accurately on yields of TLVs; b) they used identical amounts of human and draught labour (family and hired) as they do currently, after making allowance for new labour inputs (fertiliser and pesticide application); and c) these farmers used no artificial fertiliser or pesticides for growing TLVs.[69] The likely range of net returns for cultivating TLVs are 'bracketed' by using two values for the rice produced: a) that the value of milled TLV rice is the same as for HYVs in 1982 (Rp 190/kg); b) that the value of milled TLV rice is the current (1982) market price (Rp 375/kg).[70]

Table 5.15:
HYVs and TLVs: Comparison of Economic Returns - Three Villages and Seasons Combined (Rp/Are).

Variety	HYV	Traditional	Rice
N	307	307	*307
Inputs (Labour and Material)			
Seed	88	42	67
Urea	232	0	0
TSP	6	0	0
Pesticides	57	0	0
Subtotal Materials	383	**42**	**67**
SubTotal Labour	669	**428**	**734**
Total Costs	**1052**	**470**	**801**
Edible Output (kg/Are)	**23.91**	**19.87**	**19.87**
Gross Income	4474	3776	7452
Net Income/Are	**3422**	**3306**	**6651**
Net Income/Costs	3.38	7.72	8.54
Return/Hour	425	401	807
Comparative Costs and Income (HYV/Trad)			
Total Costs		2.54	1.43
Net Income		1.15	0.56

Notes see Footnote 71.

69 Labour inputs to TLVs are probably slightly underestimated because no allowance is made for: a) the time taken in applying traditional green and animal manures; b) time spent on bird scaring prior to the harvest. However, because both these operations were usually carried out by family members there was no additional outlay for labour.

70 If TLVs were still widely cultivated it is probable that, at a minimum, there would be no premium for the better tasting traditional rice. As it is milled traditional rice (beras Bali) sells for at least twice the price as milled HYV rice.

71 Only those farmers who reported growing HYV and traditional varieties are included in the analysis; there is no exclusion of farmers whose reported yields of traditional rice are lower than their current measured yield of HYV rice. It is assumed that equivalent amounts of seed and labour are used for both varieties, except for time for applying fertiliser and/or pesticide on traditional varieties. Further, it is assumed that HYV milled rice is worth Rp 190/kg, the market price at the time of the survey; in the middle column traditional rice is assumed to be worth Rp 190/kg, that is the same as HYV rice; and in the third column

The results (see Figure 5.8 and Table 5.15) of the simulation show that, on average:

if the prices of HYVs and TLVs are identical, the net income/Are for HYVs are only slightly higher (15%) than for TLVs (Rp 3422 vs Rp 3306) - despite the fact that HYV yields are about 20% higher;

if the value of HYV grain is Rp 190/kg and TLV rice Rp 375/kg, the net income/Are for HYVs are only about half (56%) of those possible with TLVs (Rp 3422 vs Rp 6651) - despite higher HYV yields;

with either price for TLV rice, the rate of return for each Rupiah invested in growing TLVs (7.72-8.54) is about twice that for growing HYVs (3.38);[72]

if the values of HYV and TLV rice are identical, the net income/hour of work (labour productivity) is only slightly higher (6%) for HYVs (Rp 425 vs Rp 401), if TLVs are valued at Rp 375/kg then income/hour for TLVs are some 90% higher.

Thus, even under favourable assumptions for HYVs, that is rice prices are the same for HYVs and TLVs, there is only a slight economic advantage, on average, in growing HYVs, despite significantly higher yields (see Tables A5.15.1-4 for village details). If, on the other hand current prices prevail, there is a substantial economic disadvantage in growing HYVs and the returns to investment and labour productivity are lower, i.e. the economic risks involved in growing HYVs are higher than for TLVs.

To make the assumptions favouring HYVs more advantageous, all those farmers whose per crop yield of HYV was not greater than their previous reported yield of TLVs were eliminated from the analysis (one third of the sample), as in the foregoing energetic analysis. With HYV and TLV rice priced at Rp190/kg, the HYVs show a substantial net income/Are margin over TLVs, about 1.5 times, although production costs are approximately 3 times higher for HYVs (see Tables A5.15.5-8). However, if TLVs are priced at the current Rp 375/kg, and even after

(*) traditional rice is worth Rp 375/kg, the 'average' price prevailing at the time of the surveys. Comparative costs/income (last two rows) are differences in costs/income between HYVs and traditional rice, for both assumed values of traditional rices (Rp 190 and 375). Source Table A5.15.1.

72 Assuming that land values/Are are comparable between large and small farms, then, in neo-classical terms, the variable-capital/output ratio for TLVs is twice that for HYVs, that is TLVs use scarce capital more efficiently than HYVs.

exclusion of one third of the sample, the net income/Are of HYVs is still only about two thirds that of TLVs (0.68-0.76 times TLVs), with production costs of about 1.5-1.8 times that of TLVs. Thus, even under particularly favourable assumptions for HYVs (i.e. elimination of current HYV 'crop failures') it is still economically more 'rational' to plant TLVs, unless the existing price premium for TLVs is 'assumed away'! Why then have farmers adopted and continued to grow HYVs, if the relative economic advantages are at best marginal and, more probably, distinctly disadvantageous given the price premium for TLVs?

5.8 The Relative Merits of TLV and HYV Rice.

First, and most obviously, farmers gain significantly higher yields, on average, from HYVs compared to TLVs. Thus, if the farmer's main aim is to grow sufficient rice to feed his family, rather than sell the harvest, then HYVs offer an advantage. This is very likely the case, as collateral information from the socioeconomic survey indicates that only about one third of families sell any of the rice they grow. But, on the other hand, the farmer could grow TLVs and, despite lower yields, gain the price premium by selling the TLV rice and with the proceeds purchase a larger amount of cheaper HYV grain for family consumption. However, to the authors knowledge, almost no farmers in the main rice growing areas follow this practice, with the exception of the relatively small proportion of farmers with large areas of ricefield.[73]

Second, the question must be asked: What basis of comparison does the farmer have between HYV and TLV yields, given that nearly all farmers now grow HYVs? The answer is, almost none, although farmers are certainly aware that TLV grain commands a higher price in the market. Comparisons by farmers between varieties is complicated by the fact that the quantity of a traditional harvest was measured in *ikat* (sheaves/bundles) of

73 In the region close to the airport (between Den Pasar and Kuta) a whole Subak has reverted to growing TLVs, despite considerable 'political pressure' from local officials. In Eastern Bali many farmers, after trying HYVs, have chosen to revert to TLVs - which taste and store better than HYVs, in cooler (higher) areas tend to yield better than HYVs, and give more reliable yields than HYVs where the irrigation system is somewhat unreliable (cf Poffenberger and Zurbuchen 1978:17).

rice, whereas HYVs are threshed and bagged in the field, leaving only an indirect basis of comparison: how long the farmer's family can feed themselves from a harvest. In the case of sharecroppers, the farmer who does the work usually has no say in the variety planted, the owner of the land making this decision on the basis of the likely return to himself.[74]

Third, suitable traditional seed may no longer be available to allow the farmer to return to growing TLVs. Seed stored under the conditions available to farmers only remains viable (i.e. capable of germination) for about a year after harvesting. Thus, after the passage of only a few years from adopting HYVs the local supply of micro-adapted traditional seed has disappeared. By 1983, for example, farmers in the Penestanan area wanting to return to growing TLVs were experiencing considerable difficulty in obtaining even small quantities of suitable traditional seed. In addition, the impoverishment of the soil resulting from the higher nutritional demands of HYVs, abandonment of traditional manuring practices, and applications of artificial fertilisers and pesticides, provide circumstantial evidence that field conditions (soil, pests and fauna) are now unfavourable for traditional rice varieties.[75]

Fourth, and possibly most importantly, there are clearly strong and persistent pressures from agricultural and other government officials for farmers to do as the government wants - that is, plant HYVs. Farmers have also been encouraged to plant HYVs by use of a range of inducements offered as part of

74 In this analysis no distinction is made between owner-operators and sharecroppers regarding the sharing of input costs or on the range of harvest shares between the two parties. This is not because sharecropping is uncommon, indeed it is probably becoming more common, but because the emphasis is on the differences in unit area resources use and food and economic returns between HYVs and TLVs. In general, a sharecropper pays between half and all of the cash costs of cultivation and receives between half and one third of the net harvest. A detailed analysis of the relationships (social, political and economic) between owners and sharecroppers can be found in Hobart (1979:196-218).

75 According to many farmers in the region it was possible to grow their first crop of HYV or NIV rice without the use of artificial fertilisers, such was the 'residual' fertility of the soil after hundreds of years of traditional cultivation. The decline in ricefield macro-fauna has already been noted, to the authors knowledge there has been no systematic study of the changes in micro-fauna (bacteria, fungi etc) accompanying the shift to HYVs undertaken anywhere in the world, though undoubtably there are significant changes, that is the soil is impoverished. Discussing the effects of HYVs on soil fertility on the adjacent island of Lombok (farmed by people originally from Bali) Gerdin (1982:66) comments: "However, it seems that the intensification [i.e. fertiliser and pesticide use] of land use has meant that the limits for stability of the flooded field ecosystem have been transgressed: in the 1940s, one hectare could yield four to five tons of rice in one harvest, in the 1970s only three tons."

the BIMAS and INMAS programmes: a mix of cheap credit, subsidised fertilisers and pesticides and cash advances. Despite the positive inducements offered to farmers over the years, the socio-political impact of powerful and relatively well-educated government and semi-government officials pushing the adoption of HYVs on poorly-educated, relatively powerless farmers should not be underestimated, particularly in the political framework prevailing in Indonesia. Such pressures have the effect of causing farmers to adopt HYVs, even when their (collective) judgment dictates that they should continue growing traditional varieties. This is well-illustrated by one of the author's experiences during fieldwork.

At the end of a previous round of fieldwork in 1979 the author encountered a group of farmers from Taro (not the locus of that research) concluding a field-trial comparing the yields of three rice varieties: Traditional (Cicih), Nationally Improved (Pelita II/1) and a HYV (IR36). This simple experiment was carried out because the farmers were under considerable pressure from agricultural extension workers and the head of their irrigation association (*Pekaseh Subak*) to plant HYVs, but were reluctant to make the change; believing HYVs to be less suitable than TLVs in the cooler climate prevailing in Taro. The results of their comparison revealed that the Cicih, without fertiliser, outyielded both fertilised Pelita (100 kg/ha Urea) and IR36 (200 kg/ha Urea).[76] Whatever the accuracy of their crop trials, they were certain that they did not want to join the BIMAS programme, despite the financial inducements offered.

When I returned to the same area in 1981, almost all the farmers were by then growing IR36/50 and, as the results in this chapter show, not obtaining very high yields. Why then had they agreed to make the change? Although none of the farmers were very forthcoming about the reasons, it became clear that the socio-political pressure from extension workers

76 The results of their trials on 5m x 5m plots gave the following yield results (milled rice): Cicih 15.7 kg/Are, Pelita 12.8 kg/Are and IR36 10.6 kg/Are. This was not a sophisticated agronomic experiment with a 'replicated split-plot, randomised block' design but a simple experiment by local farmers, whose aim was to provide a 'rational' basis for resisting pressure to switch to HYVs.

and particularly from the *Pekaseh Subak* and *Perbekel* (appointed head of the Desa) had become too great to resist change any longer.[77] These leaders were concerned, publicly at least, that if the farmers did not adopt HYVs the 'village' (i.e they as leaders) would be cast in a bad light and suffer a lack of other types of government assistance in the future. So, for a variety of positive and negative reasons, the mass of the farmers gave in. It is not, however, suggested that this is necessarily typical, but it is illustrative of the very considerable social pressures that can be brought to bear on farmers to 'encourage' them to adopt HYVs.[78]

In summary, the net returns to growing HYVs are, in general, very variable from season-to-season and the financial strains on the village economy of this variability, and the need to make substantial outlays for purchased inputs, makes their economic advantages very dubious, at best. The only advantage to farm families in growing HYVs is the yield advantages they offer over TLVs. However, because of significant inter-season variations in yields even this advantage may be more apparent than real for the small farmer.[79] The most damning indictment of the economics of HYVs is that, unless heroic assumptions are made about the relative yields and returns of HYVs, a farmer growing TLVs should be able to gain a substantially larger net income/Are than a farmer growing HYVs. Some of the reasons for farmers continuing to grow HYVs despite these disadvantages are canvassed above, in the authors estimation it is mainly the relative socio-political power of the actors in this drama that prevents many farmers from reverting to traditional varieties.

77 It is worth noting that the Pekaseh owned the only rice mill in the village at that time and thus stood to make considerable financial gain, as every farmer would need to use his mill (a second mill was constructed in 1980); also, he was the head of one of the wealthiest families in the village, as was the Perbekel. Second, in contrast to most villages in the south central region of Bali both these officials held their positions in a semi-hereditary manner, rather than as elected leaders. This was particularly exceptional in the case of the Pekaseh, who had not called a Subak meeting in several years (there still hadn't been one by mid-1983) and was held in low regard by many members of the Subak.

78 In the higher altitude area close to Baturiti farmers there have also 'reverted' to traditional varieties after trying HYVs (under government pressure) - these farmers used religious/spiritual means to achieve their 'reversal' (Filloux 1987).

79 One of the only other piece of research dealing realistically with the the risks inherent in adopting HYVs is that By Grace Goodell (1984) dealing with the impact of HYVs in the Philippines. She emphasises that "although traditional rice farming in Central Luzon was uncertain it was never as erratic as...the new technology."

5.9 Conclusions.

The stated aim of the Green Revolution in Bali, and elsewhere, is to increase production by the use of specially bred varieties of rice that are responsive to industrial inputs of fertilisers and pesticides and have a shorter growing period, allowing the growing of two to four crops per year.[80] As pest and disease problems became more prevalent, these characteristics were supplemented by moderate levels of 'bred in' resistance to common predators. To encourage adoption of the new technology the government subsidised the price of fertilisers and pesticides and provided credit for purchasing the necessary inputs through the BIMAS/INMAS programmes.

By the early 1980s almost all the rice being grown in Bali was one of the modern types of HYV (IR36), farmers were harvesting about three crops every 14-15 months, annual rice production had risen to about twice pre-HYV levels (see Table A3.18.2) and average 'official' yields to approximately 40% higher than pre-HYV (1969) levels. But, as was shown in Chapter 3 this increment was the result of an almost one-for-one conversion of fertiliser and pesticide energy into food energy (see section 3.4.6.3). The average increase of one third in yield required a seven-fold increase in energy inputs, and resulted in a fivefold decline in energy efficiency.

Unfortunately, there is no possibility of a contemporary comparison between the results that could be achieved using traditional varieties, green manures and small amounts of fertilisers. The adoption of HYVs has resulted in the wholescale loss of hundreds of irreplaceable traditional varieties and the propagation of many new rice pests and diseases. Thousands of small farmers are now situated at the tail-end of an urban controlled supply-chain, stretching back to gas wells in Sumatra and Kalimantan. Further, as the foregoing analysis has shown, they have little control over

80 Rob Wetselaar of CSIRO (pers. comm) has pointed out that the fundamental advantage of early-maturing HYVs over TLVs lies in increased yield/day, given conditions that allow harvesting of more crops/year than with TLVs. In terms of the data used in this analysis, this translates into 0.228 kg/Are/day (23.91 kg/Are/crop) for 105-day IR36 and 0.142 kg/Are/day (19.87 kg/Are/crop) for TLVs, a 62% difference. If irrigation is insufficent for triple-cropping (or there are other restrictions on planting schedules), and farmers can plant only two crops/year of either HYVs or TLVs, then much of this potential advantage is lost.

the yield and production outcome from their investments of labour and material inputs.

The increases in total production that have been achieved, relying as they do on increased yields and multiple cropping, are, however, vulnerable to disruption on a number of fronts. For instance, in 1984 because of pest and disease build-ups and insufficient irrigation water for three crops per year, farmers in Southern Bali were forced to revert to growing two rice crops per year.[81] More generally, the whole HYV production process is totally dependant upon timely supplies of material inputs flowing through a complex and highly bureaucratised supply network - from oilfield to factory to farmer. Moreover, meeting the technical constraints necessary to efficiently use these energy and money intensive inputs requires the whole production system to be articulated via a complicated flow of technical and economic information. Again the farmer is in the most vulnerable position, at the tail-end of this urban-dominated system.

The ascendancy of the Green Revolution technology has also led to the eclipse of local initiatives to improve rice yields.[82] For example, the semi-experimental yields obtained in field trials during the 1960s (25 kg/Are approx.) showed that a combination of green manure and small amounts of inorganic fertilisers gave the best results. These yields were 25% higher than average HYV yields measured during fieldwork (20 kg/Are). There can be little doubt that continuation of these efforts would have resulted in the development of improved rice cultivars based on traditional varieties, making more extensive use of local sources of nutrients, more effective cultivation methods and increased yields. The loss of these localised initiatives has resulted directly in future efforts to improve and stabilise yields becoming entirely dependant on research conducted in remote institutions, wholly separated

81 Prior to the introduction of HYVs farmers were already harvesting two crops of traditional rice a year.
82 For a thorough discussion of issues concerned with the hegemony of urban-based Western science and technology in the Third World and the rise of "imitative science" in the Third World see Goonatilake (1984), especially chapters 1, 3 and 6.

from farmers and pursuing objectives set by urban elites and economists.

Goodell (1984) confirms that that the technological and socio-political framework associated with the Green Revolution in the Philippines is effectively identical to that operating in Indonesia. She concludes:

> the most dangerous aspect of the new rice technology is not the high cost of its necessary inputs or its complexity *per se*, but rather the way in which it has been set forth to hundreds of thousands of farmers as full-blown externally dictated and complete: *de facto*....How can sustained development take place when users surrender their watchdog prerogatives and society's 'packagers' remain permissively free from having to submit to ongoing and exacting public accountability?...Technology which is generated by or in close interaction with those most likely to use it...evolves in quite a different manner: piecemeal, hence gradually, with wide participation, and according to highly *pragmatic* standards. (her emphasis)

This chapter has shown that in Bali (and Indonesia) reliance for increasing rice output was placed wholly upon an urban-directed, Western 'scientific' approach to agricultural intensification, and the further development of traditional skills and resources shunned. Subsequently, benefits have flowed disproportionately to urban-dwellers, while rural communities have been forced to shoulder the ongoing risks and uncertainties of this new technological matrix. Moreover, the enforced adoption of the new rice technology has undermined the longer-term energetic and genetic sustainability of Balinese rice cultivation, bringing to an end the local evolution of technical and genetic agricultural adaptation. It is these shifts in initiatives and consequences, and their social, economic and environmental impacts, that constitute the agricultural facet of the ecological transition in Bali.

Chapter 6

The Socioeconomic Transformation in Bali.

6.1 Introduction.

Early Western visitors were clearly impressed by two contrasting features of traditional Balinese society. Among the general population, the ordinary people (*Orang Jaba*) appeared contented, exhibiting a strong material egalitarianism and religiously inspired artistic creativity. The same commentators set this against the "powerful and cruel rajas" (Baum 1973:xxviii)[1], the "despotic and arrogant aristocracy" to whom the ordinary people deferred, yet in an "unservile and unsubmissive way. By threat of passive disobedience and boycott they kept the princes from overstepping their bounds." (Covarrubias 1972:14). This thesis is most concerned with these ordinary people, who then as now, constitute some 90% of the islands population.

Paucity of detailed quantitative information available about pre-1940 traditional Balinese society inhabits absolutely reliable comparisons with the present, but five benchmarks can be used to provide a basis for assessing the 'socioeconomic transformation' of this distinctive Indonesian province. The first two were discussed in Chapters 3:

> First, the extent and fertility of present day agricultural resources of the island are similar to those of the pre-WWII period, although ricefield irrigation has improved.
>
> Second, if government statistics are accepted, average per capita staple food energy and protein availability has remained fairly constant.
>
> Third, aside from crafts, almost all traditional employment and wealth derived from agriculture. The Balinese, even until the 1930s, "work for wages only spasmodically and as an adventure" (ibid:86).[2]

1 Baum edited and set in novel form the observations and experiences of Fabius, a Dutch medical doctor who lived and practiced in Bali before, during and after the Dutch conquest in 1906.

2 One of the few detailed reports on sources of livelihood in the pre-WWII period is that by Bakker (1935) of families in 5 Desa from the dryland area (1000m) down to the coast near Kuta in what is now Kabupaten Badung. In general, he concludes that except for some trade in livestock (mainly pigs) and copra (commonly mediated by Chinese), non-local and non-agricultural sources "may be more or less disregarded...Everyone lives from agriculture. Trade outside the Desa rarely occurs."

> Fourth, aside from the opulent decadence of the aristocratic minority, a high degree of socioeconomic equality was the norm (ibid:88-9).
>
> Finally, traditional Balinese society, for more than 1000 years, was ecologically sustainable - population increased slowly and agriculture was self-sufficient, resulting in little environmental degradation.

Of course, with a markedly rich aristocracy, Bali was not free of social strife or internecine warfare, and many poorer Balinese were enslaved and shipped to Java and more distant places to serve as soldiers or concubines (Van der Kraan 1986); and many diseases, some epidemic, were common.[3]

In the past 40 years there has been widescale cultural disruption and rapid socioeconomic and agricultural transformation of previously traditional societies throughout what is now called the Third World. On balance, proponents of modernisation[4] would argue that material wealth and societal well-being has improved. In agriculture 'Green Revolution' technology has markedly increased staple food production and average cash incomes and with this, increased access to the benefits of modern health, education and transport services. A certain degree of inequality is, as we have seen (Chapter 2), conceded by even the most optimistic observers of contemporary history. But, proponents would argue, absolute wealth increases for all sectors of the economy, and although for a time inequalities may increase, this is self-correcting in the 'longer-run' and the benefits of modernisation become accessible to all as generalised capital accumulation occurs.

The previous chapter observed that widespread adoption of Green Revolution technology in Bali has lead to about a 50% increase in rice production during the last 15 years. But the analysis drew attention to the sevenfold increase in energy inputs required to achieve increased rice production; the ecological deterioration occurring as a result of (increasing) biocide use; and the increased intra-village and inter-

3 Including malaria, cholera, smallpox, plague, leprosy, paratyphoid and tuberculosis (Lovric 1987:117-41).

4 For instance the FAO reports discussed in Chapter 2 encapsulate the technocentric approach which has developed during the last 40 years, as a result of the development/modernising theory.

seasonal variability in production (due to reduced stability in yields, increased crop losses and late delivery of crucial inputs). All these factors, when viewed in the context of characteristics of modern agriculture, point to reduced long term sustainability.

Modernised agriculture, Green Revolution agriculture, is, therefore, characterised by an increased external rather than self-sufficient orientation at three levels:

> at the farm level, where it results in increased extra-local input dependency and increased production variability;
>
> as an agricultural system, where the economic costs and benefits are subject to the vagaries (and constraints) of centralised pricing, transportation and marketing structures; and
>
> ecologically, by increased reliance on non-renewable inputs requiring extensive processing and environmental degradation caused by the indiscriminate use of biocides and loss of irreplaceable genetic material.

Conventional development theory focuses on agricultural development as a primary keystone in increasing material wealth and societal welfare. The previous chapter concentrated on the agricultural transformation of Balinese rice cultivation. This chapter moves towards what may be considered the 'dependant' variable in the modernisation calculus. Where in Chapter 5 the currency of analysis was provided by production indicators, energetics and economics, this chapter focuses on socioeconomic transformation via an analysis of the patterns of income and expenditure, material accumulation and access to modern goods and services.

Many of the conclusions parallel those of Chapter 5. Island-wide changes in patterns of income/expenditure leave little doubt as to the marked improvements in the Balinese economy. Dramatic changes in the production base, occupational structure and investment have occurred to support income/expenditure growth. Despite this, analysis shows little improvement in the material situation of the poor majority. Moreover, in terms of the historically fairly egalitarian distribution of income, goods and services, considerable evidence will be presented of a widening gulf between a newly rich minority and the poorer majority. Furthermore, while time-series data is not available, there is little evidence of this gulf being bridged by upward socioeconomic mobility among the poor. Indeed in Penestanan, where the recent impact of the modern (tourist) economy is most evident and intense, indices of inequality are highest.

How is this to be explained? Modernisation theory, with its emphasis on agricultural development (transformation) would draw attention to differential access to agricultural resources, such as land and labour. In contrast, as this chapter shows, that while land is important for capital accumulation by the rich, investments in, and access to, non-agricultural sources of income, such as formal employment, are the fundamental determinants of material well-being. Currently, differentials in agricultural resources or production do not therefore explain, in absolute or relative terms, growing socioeconomic inequalities. Moreover, people dependant on agriculture for the greater proportion of their family income are found in the lower income majority. This raises the question of whether reliance on agricultural development is, for the poor majority, a partial determinant of their relative impoverishment vis-a-vis the rich.

6.2 Two Perspectives on the Socioeconomic Transformation.
In this section attention is directed towards: a)changes in the island's economy during the last 15 or so years, in particular changes in workforce composition and sectorial rates of growth, growing inequalities in income distribution and regional incomes, and the widening imbalance between imports and exports; and b) changing patterns of income and expenditure at the village level, where the material benefits of modernisation have flowed disproportionately to the wealthier, more modernised families.

At the island-level there has been a shift to greater use of extra-island resources resulting in a marked dependency for vital resources and a commensurate increase in 'outside' control of the economy Whether viewed from the macro or micro perspective, the conclusions are that there is abundant evidence of increasing socioeconomic inequality (variability) and increasing dependence on non-renewable resources - both central elements of an ecological transition.

6.2.1 The Island Economy.

Mention has already been made of the observations by Covarrubias and Bakker that in the pre-1940 period gaining income from non-agricultural sources (e.g. wage employment) was the exception rather than the rule. It is reasonable to conclude that, in general, wage income constitutes an addition to traditional sources of income and that, with some exceptions, families' non-wage incomes are broadly representative of traditional income patterns, reflecting the range of natural resources available to each community.[5] Increasing population, resulting in subdivision of family land holdings[6], and increases in the rate of exploitation of agricultural land (i.e. multiple cropping and HYVs) are, of necessity, taking place within the local resource base.

Between 1971 and 1980 the proportion of the Balinese workforce in agriculture dropped from 67% to 51%[7], despite a 141% increase in the size of the total workforce (BPS Bali 1983a:44). Most of the additional workers found jobs in the service sector, which grew from 20% to 33% of the workforce and the secondary sector which grew more slowly, from 10% to 16% of the workforce. In the service sector it is government/service employment (increasing from 55,000 to 145,000) and trade/tourist related services (increasing from 95,000 to 138,000) that account for the bulk of the new jobs (see Table A6.1.1).[8]

The shift from an agriculturally based economy, in terms of the relative share of gross regional production, has been more

5 The exceptions to this pattern are those sources of village-based (non-wage) incomes that are derived from economic activities associated with tourism: in particular, finance (which includes tourist rental accommodation) and craft incomes in Penestanan.
6 An examination of local land records indicates that there have been very few instances of land changing hands by sale; however, in areas affected by urbanisation and tourism commercial and government acquisitions of land have resulted in significant amounts of land changing ownership.
7 As Table A6.1.1 shows employment in agriculture only increased by 7% or 32,000 between 1971 and 1980.
8 Employment in secondary industry has increased only slowly, from 39,000 in 1971 to 93,000 in 1980.

marked than the shift in relative employment. During the 1975-82 period regional production (constant 1975 prices[9]) more than doubled - agricultural output growing by 175% and tertiary output by 257% (see Table A6.1.2). In 1975 approximately 48% of regional production was from agriculture.[10] By 1982 this had declined to 38%. During this period the share of the tertiary sector, the fastest growing part of the economy, grew from 40% to 48%, and the share of the secondary sector remained almost constant (see Table A6.1.3).

In the last 10 years modern transport has greatly extended the geographic range over which people from rural villages can seek and obtain wage-paying employment to supplement agricultural incomes; and provide access to markets throughout the region. In addition, various tourist locations[11] provide opportunities for jobs in urban and tourist-related service industries. More broadly, the tourist-derived demand for Balinese artifacts (paintings, sculptures and souvenirs) provides opportunities for families in villages remote from tourist 'enclaves' to add to their incomes by piece-work manufacture of tourist-artifacts.[12]

Although agricultural output (per worker and absolute) has risen markedly, from this broad picture it is clear that over the last 15-20 years the bulk of the island's formal economy has become non-agricultural in character. This is despite the fact that about 85% of the population still live and work in the 'rural' areas of the island. As a consequence, even in rural villages almost all new employment is in non-agricultural occupations, the potential for new jobs in agriculture having been exhausted some years ago.[13]

9 The general level of inflation over the 1975-82 period was 199% (base 1975), and slightly lower for household items (191%).
10 Agriculture includes arable and perennial smallholder crops, livestock, forestry and plantations.
11 Sanur, Nusa Dua and Kuta/Legian on the south coast, the urban sprawl surrounding the island capital Den Pasar, along the route linking the capital and Ubud and Tampak Siring, and inland in the region around Ubud and Peliatan.
12 This type of production is usually based on the repetitive production of a very limited range of small paintings or sculptures (commonly modern in style) which are produced in the home, sold to a middle-person at a low price and then on to an established tourist-shop, where the selling price, although flexible, is often 5-10 times the cost price.
13 See Daroesman (1973) for a survey of economic development during the 1960s and Bendesa and Sukarsa (1980) for an overview of changes during the early and mid-1970s.

With the expansion of commercial, government and tourist activity during the last 10 years the potential range of sources of income has rapidly increased. In parallel, the range of goods and services, either essential or discretionary, that families can spend their income on has broadened markedly. For example, in Tegal Tugu families have had access to imported intermediate (e.g. fertiliser), consumer goods (e.g. metal and plastic utensils) and modern services (e.g. education and health) for the longest time, by virtue of their periurban location. During the last 10 years the changes brought by tourism to the Ubud area have rapidly widened the range of modern goods and services available to families living in the adjacent village of Penestanan. In contrast, what is commonplace in terms of modern goods and services in the other two villages, has only become readily available in Taro during the last few years.[14]

During this period, according to government figures, economic growth also increased island-wide average annual per capita income from about Rp 122,000 in 1975 to Rp 260,000 in 1982 (1982 prices) (BAPPEDA/UNUD/BPS 1984:12).[15] This is equivalent to an annual average growth rate of approximately 10%, after correcting for inflation. However, there are strong indications that, at least by 1984, incomes in urban areas were significantly higher than those in rural areas, with average urban per capita income (Rp 336,000) being some 63% higher than average rural per capita income (Rp 206,500) (ibid:17). In addition to urban-rural disparities, it is also clear that the share of regional production received by the poorest people has been steadily declining during the last 15 years.[16]

14 The results presented here are based on data gathered by Sections S13 and S14 (income) and Section S17 (expenditure) of the Socioeconomic Survey (see Appendix 4.4).
15 Equal to approximately A$325 per capita/year.
16 The effects of economic modernisation on income distribution have been a frequent topic of analysis and debate among scholars of Indonesia, because of the generally unreliable quality of the data (Dapice 1980:67-9) and arguments about appropriate analytic methods (see Hughes and Islam 1981) the debate about the scale of changes in income inequalities has been somewhat inconclusive. The majority of the studies are based on data on family consumption over the three months preceding the survey round collected by the National Socio-Economic Survey (SUSENAS). Dapice has questioned the comparability of data collected during the 1970s because of differences in geographical coverage and methods between the survey rounds. The debate is further complicated by disparities between the economic situation on the most populous island Java and the rest of the country, and different trends in income distribution between rural and urban areas. Moreover, to date almost all of the analyses have used what is now 10 year old data (1976) which, given the rapid changes in the economy over the last

Focussing first on Java, it is fair to summarise the results of the analyses based on 1976 data by saying they, at best, indicate that income distribution has not deteriorated markedly during the 1970s, with most of the aggregate changes being caused by increases in rural-urban disparities (Hughes and Islam 1981). On the other hand, Yoneda (1985) using data for 1976-78, concludes that the data "show an increasing inequality in the urban and rural area in Java", with the Gini coefficient for family income in rural areas increasing from 0.30 to 0.36, and from 0.36 to 0.41 in urban areas in only two years.[17] Uppal (1985) concludes that, based on microlevel studies, the Green Revolution has worsened the lot of the poor in rural areas.[18]

In contrast to the situation in Java, Islam and Khan (1986) accord to Bali in 1976 the distinction of having the lowest level of income inequality of the (then) 25 provinces in Indonesia,[19] while ranking ninth among the provinces in the level of absolute income. Comparison of 1976, 1978, 1980 and 1981 income data by Subarwa (1983), however, shows that like Java, the distribution of income has become more skewed as the years pass.[20] More recent analysis based on 1984 SUSENAS data, while showing a less extreme skew than Subarwa's analysis, confirms that the general trend towards greater income inequality persists (see Figure 6.1 and Table 6.1). According to this analysis the Gini ratio for rural areas in Bali rose from 0.26 in 1981 to 0.32 in 1984, in urban areas it fell from 0.36 to 0.33 and overall increased from 0.31 to 0.34 during this period[21] (BAPPEDA/UNUD/BPS 1984:33).

decade, cannot inform us of the effects of these changes and only serve to obscure details of the impact of 15-plus years of intensive capitalist transformation on the economy.

17 He also draws attention to the tendency for income inequality for women to be increasing much faster than for men during this period. With an increase in the Gini ratio from 0.453 in 1976 to 0.506 in 1977 for women and from 0.0.452 to 0.466 for men.

18 See also Penny and Singarimbun (1973), Esmara (1976), White (1979), Islam and Khan (1986) and Uppal and Handoko (1986) on the question of within and between region income inequalities. In urban areas Yoneda (1985) suggests that industrialisation may be responsible for the worsening situation of the new urban poor.

19 As measured by four commonly used indices: Gini, Theil, Atkinson and L Index.

20 The rural Gini ratio rising slightly from 0.253 in 1976 to 0.256 in 1981, the urban ratio increasing from 0.265 in 1976 to 0.355 in 1981, for the island as a whole the ratio has increased from 0.259 to 0.308 during this period.

21 For Kabupaten Gianyar the changes are somewhat greater. The Gini ratio in rural Gianyar rose from 0.229 in 1981 to 0.334 in 1984, in urban areas from 0.256 to 0.321 and overall from 0.250 to 0.340.

Table 6.1:
Bali: Urban and Rural Grouped Income Shares (mid-1984).

Income Group	Urban	Rural	Overall
Lowest 40%	19.8	21.3	20.4
Middle 40%	36.6	38.0	37.9
Highest 20%	41.6	40.7	41.7

Notes see Footnote 22.

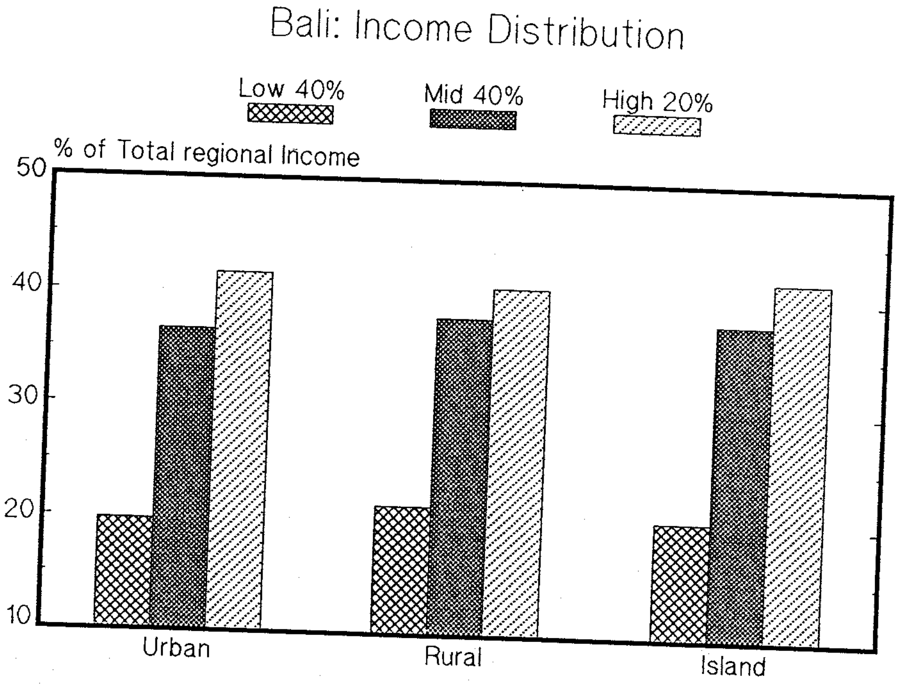

Figure 6.1: Bali: Income Distribution by Region (1984).

Even allowing for deficiencies in the data (particularly under-reporting of income by high income earners), it is clear that as modernisation proceeds the wealthier sections of the population are benefiting more than the poor, undermining the traditional egalitarian distribution of wealth in Bali. In discussions with Balinese villagers about how development (*pembangunan*) is affecting 'average' villagers it is not uncommon for people to sum up the effects of modernisation with the phrase "*Kaya makin kaya, miskin makin miskin*", translating directly as 'The rich get richer and the poor get poorer'. As the evidence will show this is certainly true in relative if not absolute terms.

22 Source: Distribusi Pendapatan di Propinsi Daerah Tingkat I Bali, Tahun 1984. BAPPEDA/UNUD/BPS (1984:21).

Parallel with widening income inequalities for individuals there is also a growing imbalance in average regional (kabupaten) income as a result of the urban/tourist dominance. Although Kabupaten Badung in 1974 had already emerged as the dominant region the imbalance between this region and others, particularly the adjacent regions of Kabupaten Gianyar and Tabanan, was not great, especially in terms of average incomes.[23] By 1984 about one third of GRDP occurred in Badung and average incomes in this region were 1.5 to 2 times greater than incomes in the other regions.[24] Despite shortcomings in the data, it is clear that the trend has been towards the economic dominance of this urban/tourist region and the relative decline of other more rural and/or remote areas (see Table A6.1.5).

Finally, the extent of the economic transformation occurring in Bali is also reflected in their patterns of trade with the 'rest of the world'. Prior to 1970 the value of exports consistently exceeded imports Hanna (1972). By 1984 the value of imports was about US$52 million and exports about $US20 million, a two and a half times imbalance.[25] The character of imports and exports are quite different, as is common in developing regions: imports are dominated, in value and volume, by petroleum (94% and 98%) of the total, the remainder being a mixture of manufactured intermediate and consumer goods; exports are dominated by textiles (65%) the remainder being semi-processed agricultural products and handicrafts (BPS Bali 1985c (imports) and BPS Bali 1985b (exports)).[26]

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23 The major 'upper class' tourist resorts are all located in Kabupaten Badung, thus major investments in tourist development have flowed directly into the regional economy; in addition, about 90% of island-wide tourist related tax receipts have accrued to Kabupaten Badung, providing the regional government with a development budget 3 to 20 times that of any other region (see Table A3.1.4). It is interesting to note that the Gini Ratio for urban Kabupaten Badung in 1981 and 1984 was the highest for the island, 0.386 and 0.340 respectively.

24 GRDP = Gross Regional Domestic Product. In 1975 25% of GRDP was in Badung, 13% in Gianyar and 15% in Tabanan; GRDP/capita was Rp 87,000, 72,100 and 70,300, respectively. In 1984 30% of GRDP was in Badung, 11% in Gianyar and 10% in Tabanan; GRDP/capita was Rp 246,600, 135,900 and 139,200, respectively (See Table A6.1.5).

25 This calculation omits the money brought to Bali by foreign (and domestic) tourists which might reduce, eliminate or reverse this export-import imbalance. Data on tourist 'dollars' is, however, unavailable. Nevertheless, in 1982/83 contributions (for various purposes) from the central government constituted approximately 95% of the provincial government's expenditure, which, in turn, was equal to approximately 10% of Gross Regional Domestic Product (BPS Bali 1983b:233,257).

26 Imports include substantial amounts of materials essential for continuing development, e.g. agrochemicals, machinery, cement, steel and other building materials; and consumer goods e.g. food and beverages, household goods and electronics (TVs, radios VTRs). The other main exports include coffee, fish, livestock (pigs) and, more recently, vanilla and cloves.

Obviously, without central government subsidisation the island could not afford to maintain this continuing trade imbalance, a pointed reminder to growing economic dependency. The reliance of the island's economy on continuing supplies of petroleum and agrochemicals highlights the radical changes that have taken place in the 'energy economy' of a previously self-sufficient island economy.

6.2.2 The Village Economy.

Today, except for some subsistence income, almost all income is in the form of cash, although mutual labour exchange (*tolong menolong*) is still common in rice agriculture. The socioeconomic transformation from local subsistence to a cash-mediated economy has been taking place during the last 50 years, but has greatly accelerated in the last 15 years. The traditional village semi-subsistence economy has been largely submerged by a urban-dominated market/cash economy. The non-cash component of family income is the (imputed) value of subsistence consumption (self-provisioning), which must traditionally have constituted almost the sum total of food consumption. This traditional subsistence 'income' would, in some cases, have been augmented by income, largely in-kind, from crafts (weaving, blacksmithing) and services (priests, traditional healers).

The rapid expansion of motorised transport within the island (and the 'low-cost' air transport bringing some 200,000 tourists to the island each year) has been central in providing access to new employment opportunities. Modern transportation has made accessible the urban oriented formal employment opportunities (public and private) in clerical, service, construction and tourist jobs; and fostered adoption of new employment patterns, irrespective of the location of a persons home village.[27] This same network also provides tourists with access to most of the island, although nearly all restrict their travels to areas immediately adjacent to the well-established tourist enclaves.

27 This pattern is in contrast to the coast-to-upland spread of the agricultural transformation resulting from the adoption of HYVs.

As a consequence, people in rural villages have both benefited from these new technologies and, to varying degrees, become dependent on them for maintaining their livelihood and well-being. However, many of the other new technologies potentially available to village people can only be adopted (purchased) if the family has enough money (e.g. television, motor vehicles, higher education); if local conditions precipitate a change because a traditional local resource has become scarce (e.g. kerosene replacing woodfuel in urban and periurban areas, tile roofing replacing thatch[28]); and/or traditional artifacts cease to be available because they have been economically 'displaced' by functionally similar, though cheaper, mass-produced products (e.g. pottery utensils by plastic ones, locally woven fabrics by machine-made textiles).

The distinction between traditional and modern expenditures is also a distinction between money once spent that stays in the village (or nearby village) and money which flows out of the village economy. All expenditures on health, education, transport, fuel, and consumer goods and services find their way more or less directly to urban centres on the island (or Jakarta), with a small proportion (via government spending) returning in the form of salaries for teachers, health workers and public servants. Expenditure on the other items (transport etc) leaves the village economy forever, although use of the resources purchased for productive purposes can result in additional local economic benefits.[29] From the perspective of an ecological transition the flow of agriculturally-derived funds out of a village and the importation of new (non-renewable) goods represents a radical shift from the traditional (semi)local economic autonomy and self-sufficiency.

Although local production is facilitated and constrained by the availability of natural resources, i.e. land and water,

28 Information on housing materials and conditions and the replacement of traditional housing styles and materials by designs originating from Java and manufactured construction materials (corrugated steel roofing, cement-plastered brick, etc) was also collected by this survey, although the results are not presented here.

29 If cash spent on agricultural 'imports' to the village (seed, fertiliser, pesticide and milling machinery) was included the amount of money flowing out of the village would be considerably magnified, possibly exceeding amounts for the items listed. Money spent on purchasing manufactured building materials would also add considerably to the total.

the growth of urban population and commercialisation of agriculture has resulted in a much greater flow of agricultural products out of village communities (agroeconomies).[30] The income received from these sales allow village families to pay for modern goods and services (e.g. fuel, plastics, clothing, health and education), provision of which is mediated by urban-based bureaucrats and/or business people. Thus, in addition to village families becoming to some degree dependent on wage income, largely urban-based and tourist employment, a significant proportion of village agricultural production is now sold (indirectly) to consumers in urban areas. Hence, the traditional independence and self-sufficiency of the village economy has in the last 10 years been replaced, to a large degree, by an economic dependence on and cultural dominance by the new centres of economic and political-cultural power - the urban and tourist enclaves.[31]

It is clear that a socioeconomic transformation is taking place throughout the island, with the material benefits flowing increasingly towards non-agricultural workers and the newly wealthy, particularly the urban based economic/political elite. The growing dependency of the island on manufactured imports, particularly non-renewable fuels and agrochemicals, is mirrored in the dependency of the expanding urban population on rural areas for food. During the past 15 years both the island and village economies have become less self-sufficient and the material benefits of modernisation less equitably distributed. At both these levels of analysis there has been a marked shift from economic (and ecological) 'equilibrium to disequilibrium'.

30 The range of agricultural products includes: rice, sweet potato, cassava (whole and semi-processed), green vegetables, bananas, coconuts, coffee and other annual fruits; more recently, cloves and vanilla. In some villages local products, bamboo and pandanus, are made up into baskets, sheets and mats for sale in local markets.

31 This influence has been spearheaded by the establishment of education and agricultural extension facilities throughout the island, the setting of development 'goals' for rural communities by the urban-based national and island bureaucracy (elite) and deliberate fostering of a 'Javanese-oriented' nationalistic popular culture by radio and television. Although traditional religious practices continue in all villages, the musical and dramatic performances that accompany major festivals have been adapted in abbreviated form for paying tourist audiences (at other palaces and times); and the traditional, unstandardised religious philosophy is now being 'rationalised' by government-employed experts and 'adapted' to the official state philosophy of Pancasila (see Lovric 1986 and Stewart-Fox 1987).

As part of the research being reported, data was collected in each of the three villages on sources of family income and patterns of family expenditures. The aim was to provide village-level details on socioeconomic changes with respect to: a) differences in sources of income between the villages (location) and between different income groups (inequality); b) to provide insights into the manner in which modernisation is affecting access to modern goods and services for families in different income groups.[32]

The location of villages in relation to the urban-originated spread of modernising influences (new technology and employment opportunities) means, for example, that Tegal Tugu has been 'exposed' to modernisation for the longest time and Taro for the shortest. These differences in exposure to modernisation provide a surrogate for a time-series analysis of the effects on income distribution of modernisation.

The following analysis shows that in the periurban (Tegal Tugu) and 'tourist' (Penestanan) villages wage/non-agricultural incomes have more importance than in the remote village (Taro); the same patterns are evident in going from the high to low income groups. Moreover, the notion of modernisations material benefits 'trickling-down' to poorer families is questioned, as it is clear that despite 15 years of exposure to modernisation, average incomes of the low income group in Tegal Tugu are almost identical to those of the low income group in Taro, where the economic impact of modernisation is very recent. These findings have serious implications for the future success of fostering improved

32 This data provides information on families' non-agricultural expenditures for a wide range of traditional and modern goods and services. For convenience these items have been grouped into outlays on 9 categories: health, education, religion, finance, transport, fuel, marketing, consumer goods and services, and community. The list of possible family domestic expenditures in the survey form was supplemented by a 'reminder list', which was used by interviewers to ensure that even minor expenditures were included in the accounting. This section of the survey incorporated many of the items included in the questionnaire for SUSENAS surveys, supplemented by questions based on local knowledge and the reminder list. The details of the particular expenses included in each category are listed at the end of Appendix 4.4.
As the aim of this survey was not to develop an input-output model of family finances no data was collected on the costs of agricultural inputs of labour or materials, for two reasons. First, from previous experience the data on agricultural costs etc was liable to be fairly inaccurate and further complicated by issues of seasonality; second, cash inputs to dryland agriculture are in almost all cases nil for labour and materials, and cash inputs for rice agriculture are, in general, related to the area cropped and could be expected to show no significant technologically related differences, with almost every farmer now growing HYVs.

living standards, particularly for poorer families, by continuing policies which emphasise agricultural modernisation, to the exclusion of more broadly based, village-level projects.

6.3 Access to the Benefits of Modernisation.

To obtain a more detailed understanding of the way in which the material benefits of modernisation are distributed, this section analyses village and family incomes and domestic expenditures. The analysis proceeds in four stages.

> First, in absolute terms, a comparison is made between average income in each village and then average income in the three income groups between the three villages.[33] This provides an impression of the impact of modernisation on incomes in the three villages and, more significantly, its selective impact on different income groups.
>
> Second, the distinctions between the low, middle and high income groups across the villages is further highlighted by indices of (in)equality - which show the impact of modernisation on income distribution.
>
> Third, the differences observed are analysed by an examination of income sources - since it is evident that access to different sources of income/employment are very closely related to the trends towards greater inequality, previously observed.
>
> Finally, as is to be expected, differential access to income and income earning opportunities are clearly reflected in domestic expenditure - or in other words access to the benefits of modernisation, the consumption of modern goods and services. This leads in Section 6.4 to further reflections of the significance of agriculture (i.e. HYV technology) in Balinese modernisation.

Families in Tegal Tugu have had the longest opportunity to take advantage of economic changes associated with modernisation, while in Penestanan the rapid growth of tourism in the area has provided many new income and entrepreneurial opportunities.[34] On the other hand, families in Taro have,

33 The three income groups are: Low (lowest 40% of incomes), Middle (middle 40% of incomes) and High (highest 20% of Incomes) - this is identical to generally accepted division of the income spectrum used by the World Bank. Second, histograms of income distribution lend themselves quite naturally to these divisions, which also have the advantage of general comparability.

34 Prior to the fairly recent changes brought about by modernisation, in this case the availability of jobs in offices, construction and (tourist) service industries, very few families gained a significant proportion of their income from extra-local wage income (cf Poffenberger and Zurburchen 1980).

until very recently, been largely confined to traditional sources of income.

6.3.1 Village Incomes and Income Distribution.

It is clear from Figure 6.2 and Table 6.2 that as a result of new income opportunities average family and per capita incomes in Penestanan and Tegal Tugu are substantially higher than in Taro, in particular average per capita income in Penestanan. However, within each of the villages there are marked differences between average incomes in each income group - in general, a doubling of average income between each income group. Most importantly, in each village the low income group's family and per capita incomes are almost identical - an initial indication that the low income group may not be benefiting significantly from modernisation.

The broad official government aim of modernisation in Indonesia is to ensure that all economic groups and regions in the nation benefit and that the income share of disadvantaged groups and regions are increased (Birowo and Sansui 1982:2). It is clear that in 'unmodernised' Taro the family and per capita income share of the lowest income group is substantially greater than in the other two villages; the share of the middle income group is similar in each village. Conversely, in Penestanan the richer 20% of families now gain over half total family income and the poorer families less than one seventh.

The rapid changes that have taken place in Penestanan as a result of new tourist-derived income and the more gradual but widespread changes in Tegal Tugu as a consequence of new sources of wage income, suggest that income distributions in these two villages may have much more in common with urban patterns.[35] As Table 6.2 shows, for all the distributional indices, income distribution in Taro is least skewed and in Penestanan the degree of inequality is greatest. This applies both to per capita and family income.[36]

35 Given generally high population densities and the small size of the island, an overly formal rural-urban distinction aids little in understanding socioeconomic changes.
36 For Taro the per capita Gini ratio is close to that based on the SUSENAS 1984 data, but in the other two villages the ratios based on this data indicate a much greater degree of income inequality than for the SUSENAS data, particularly in Penestanan. Assuming no errors in

The socioeconomic survey also sought responses from families about whether family income was adequate to meet their needs (Survey 1B, Section S18). In Taro three quarters (73%) of the families considered they had an adequate income, in Penestanan only slightly over half (54%) thought their income adequate and in Tegal Tugu about two thirds (63%) thought their income sufficient to meet their needs.[37] It is significant that Penestanan, with the highest average income and most skewed income distribution, is also the village in which almost half the families consider their income inadequate, and vice versa in Taro.

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calculation or sampling bias for either SUSENAS or the survey used in this research, one may conclude that the small sample size used by SUSENAS and their pro forma collection methods lead to serious under(over) estimation of income for the higher(lower) income groups, in comparison with the survey methods used in this research. The SUSENAS survey collected data from a random sample of one family from each of 15 Desa in 16 different Census Blocks, a total of 240 households, resulting in usable data from 212 families.
Average rural per capita income of the SUSENAS 1984 data (Rp 206,500) is about twice that based on the socioeconomic survey data (Rp 109,000) collected in mid-1982 and SUSENAS November 1981 (Rp 103,212). In fact, average income per capita from the SUSENAS 1984 data is roughly equivalent to average per capita of the highest 20% of incomes (Rp 222,000) from the socioeconomic survey. A proportion of this difference may be explained by the two year gap between the surveys, based on average income growth rates. However, this accounts for only about 20% of the difference; in addition, another 20-25% can be attributed to inflation. Making these two adjustment raises average income estimated by the survey to approximately Rp 163,500, reducing the discrepancy between the two data sets to 'only' about 26%. 'Good' and 'bad' agricultural and tourist seasons also affect estimated incomes: 1982 was about average agriculturally and poor for tourism due to a global economic recession; 1984 was a good year agriculturally and also better for tourism. After having to discover adequate reasons for differences between the results, remaining discrepancies of this order (at least 26%) between this data/SUSENAS 1981 data and SUSENAS 1984 data severely undermines the (little) confidence remaining about the inter-temporal accuracy and reliability of government income/expenditure survey statistics (cf Dapice 1980).

37 The figure for the three villages combined is almost identical to that for Tegal Tugu, 64% estimating their income as adequate. A more detailed analysis by income group of income adequacy, potential debtors and creditors, and levels of income deficit, surplus and savings are presented in Table A6.9.1.

Table 6.2:
Family and Per Capita Income Distributions - mid-1982.

	Taro	Penestanan	Tegal Tugu
N	135	124	98
		Family Income	
Average Income (Rpx1000)			
Whole Village	430	659	638
Lowest 40%	213	215	276
Middle 40%	416	599	616
Highest 20%	890	1666	1390
Income Shares (%)			
Lowest 40%	19.9	13.1	17.2
Middle 40%	38.7	35.9	38.4
Highest 20%	41.4	51.0	44.4
Distribution Indices			
Gini Ratio	0.328	0.446	0.365
Atkinson Index *	0.385	0.681	0.491
Theil Index	0.178	0.334	0.218
L Index	0.177	0.373	0.231
		Per Capita Income	
Average Income (Rpx1000)			
Whole Village[38]	96	129	103
Lowest 40%	56	57	56
Middle 40%	89	130	100
Highest 20%	190	268	202
Income Shares (%)[39]			
Lowest 40%	19.6	16.3	18.1
Middle 40%	38.4	35.6	37.1
Highest 20%	42.0	48.1	44.8
Distribution Indices			
Gini Ratio	0.334	0.402	0.362
Atkinson Index *	0.394	0.555	0.434
Theil Index	0.188	0.272	0.219
L Index	0.185	0.283	0.217

Notes see Footnote 40.

38 In this instance there is good agreement between this data and an analysis by BPS Bali of SUSENAS data for November 1981 for rural and urban family expenditures for Kabupaten Gianyar, which estimates annual per capita expenditures in urban areas at Rp 125,268, in rural areas at Rp 103,212 and a weighted average of Rp 116,712; the weighted average per capita income for these three villages (357 families) is Rp 109,305/annum (median Rp 82,471) (cf footnotes to Section 6.3.3 below).

39 This income share data (weighted averages three villages: lowest 40% - 17.6%, middle 40% - 37.4% and highest 20% - 45.0%) is at odds with that calculated from the November 1981 SUSENAS data, which gives rural income shares for Gianyar as: lowest 40% - 25.8%, middle 40% - 40.4% and highest 20 - 33.9%; and for all rural Bali as: lowest 20% - 26.5%, middle 40% - 36.7% and highest 20% - 36.8% (BPS Bali 1981c). If the SUSENAS data is to be believed, the rural income share of the lowest 40% decreased from 26.5% in 1981 to 21.3% in 1984 (cf Table 6.1).

40 For each distribution index, the larger it is the greater the degree of inequality. For The Atkinson Index the larger the poverty aversion parameter (e) the less sensitive the index is to changes in the upper tail of income distribution and the more sensitive to the lower tail, (*) here e = 3.0. See Hughes and Islam (1981) for definitions. Income Shares follow the World Bank method of subdivision.

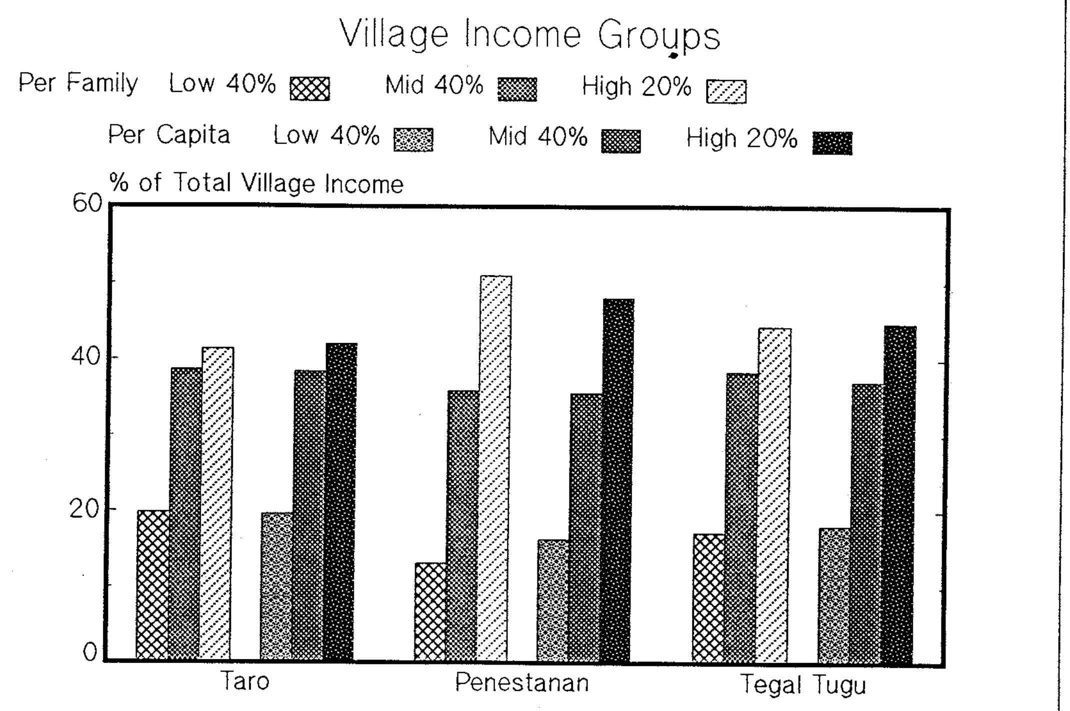

Figure 6.2: Village Income Distribution (mid-1982).

These patterns of average incomes, income shares and distribution are strong evidence that as modernisation proceeds it is the already relatively well-off that are benefiting most. In addition, it appears that the availability of new sources of income may be closely associated with the growing wealth of the wealthier 20% of the population and the lack of new income and/or employment opportunities that is responsible for the 'static' income situation of the poorer majority. These indications lead us directly to an analysis of differences in sources of income between villages and income groups.

6.3.2 Inter-Village Differences in Income Sources.

This section analyses differences in income sources between the three villages. The pattern of income sources lends itself to two types of classifications: Wage vs. Non-Wage and Agricultural vs. Non-Agricultural (non-agricultural includes wages). These are broadly indicative of the distinction between modern sources of income (wage/non-agricultural) and traditional sources (non-wage/agricultural).

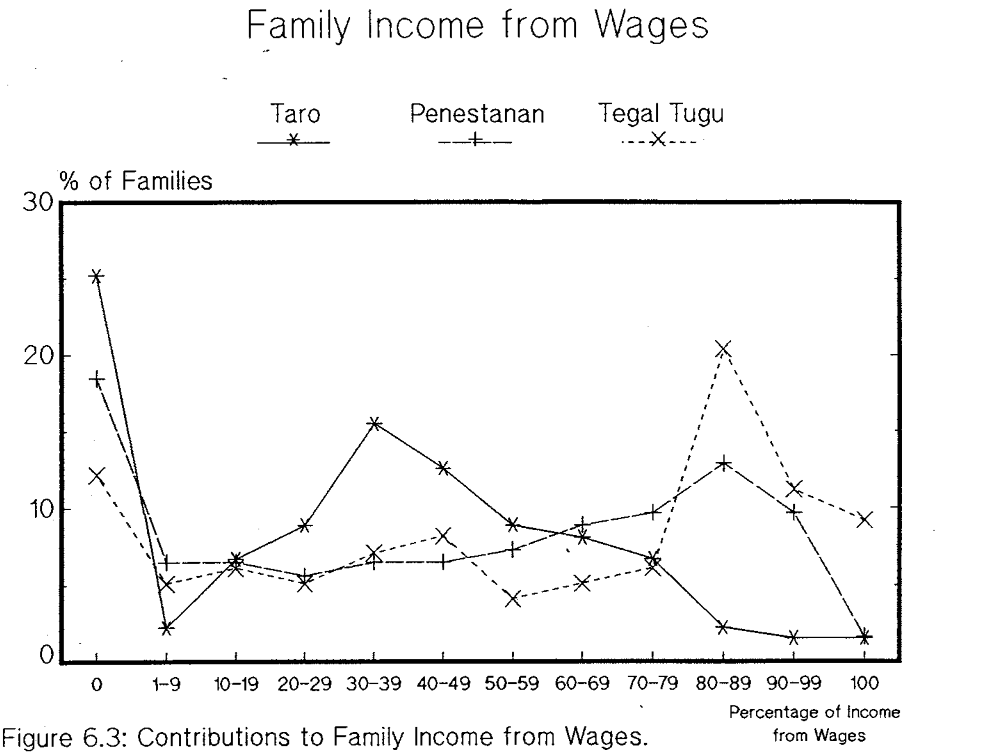

Figure 6.3: Contributions to Family Income from Wages.

The effect of location is clearly reflected in the differences between the three villages in the degree to which families depend on income from wages (see Figure 6.3 and Tables A6.2.1-2). Approximately 40% of families in Tegal Tugu gain in excess of 80% of their income from wages, and about 10% are totally dependant on wage incomes. In Penestanan, about a quarter of the population gain 80% or more of their total income from wages, although less than 5% are totally dependent on wages. In Taro only one family in thirty relies on wages for more than 80% of their income, and there is no family totally dependent on wage income. Conversely, only half as many families in Tegal Tugu as in Taro gain no income from wages. In Tegal Tugu, on average, 56% percent of all family income is from wages, somewhat less in Penestanan (47%) and only about one third in Taro. From this simple breakdown of income sources it is clear that in Taro a much higher proportion of income is generated within the village economy than in the other two villages.[41]

41 Because not every family gains income from each source, two types of calculations have been made. First, calculations in which statistics include every family, regardless of whether or not they gained income from a given source - in these instances the tables etc. are noted as being 'before exclusions'. Second, analyses in which those families which do not gain an income from particular sources have been excluded from the statistics are noted as being 'after exclusions'.

Despite the fact that families in Taro rely on wage income less than in the other two villages, it still makes an important contribution to total income for many families. However, the average amount of money earned from wages per family with wage income in Taro is only about two thirds that of Penestanan and less than one half that of Tegal Tugu. Additionally, in Taro average wage income is less than Rp 180,000/annum[42], whereas the median wage income of families in Penestanan and Tegal Tugu is higher.(see Table A6.2.3) The maximum wage income reported is in Penestanan (Rp 2,400,000),[43] a very high (total) income by local standards.[44]

The average value of Total Annual Family Income is the sum of Wage and Non-Wage income, summarised in Figure 6.4a and Table 6.3.[45] As with the major components of income, total family income is highest in Penestanan and lowest in Taro.[46] But in Taro every family gains some income from non-wage sources, whereas in Tegal Tugu about 10% of families gain nothing from these sources. If, however, median incomes are compared, differences between the villages are less marked than for average incomes (see Table A6.2.6). That is, in each village about half the families have total incomes of Rp 500,000 or less but, as will be discussed below, there are major differences between the villages in the (in)equality of income distribution.[47]

42 At the time of the survey (mid-1982) the Indonesian Rupiah had an exchange rate of US$ 1.00 = Rp 970 or A$1.00 = Rp 870, thus dividing Rupiah amounts by 1000 gives a rough approximation of their equivalent in two western currencies.
43 This is equal to approximately A$2,750/annum.
44 At the time of the surveys the starting monthly wage for a government employee (with a university degree) was about Rp 360,000/annum plus some fringe benefits, wages for less qualified people ranged from about Rp 120,000/annum (plus meals) to about Rp 300,000/annum.
45 Eighteen different sources of non-wage income were reported by the families surveyed. For ease of presentation these sources have been combined into six groups, according to the nature of each source. The groups are Gifts (cash or food), Financial (loans taken-out, loans repaid, property rental, interest on loans and savings), Craft (three possible types), Livestock (sale of cattle, pigs, ducks or chickens, sale of duck and hen eggs), Crops (sale of rice, arable, root and/or tree crops), and Subsistence (self grown and consumed food). These groups are based on the sources of non-wage income listed in question S14 of the Socioeconomic Survey.
Data was collected on the 'average' amount each source provides and the frequency with which each source is utilised. The average amount was multiplied by the frequency (per month) with which the income is gained, and this multiplied by 12 to give an estimate of annual income from each source. The contributions from each source are summed to provide an estimate of each families annual income from non-wage sources.
46 Using the 1982 exchange rate this is equivalent to a range of average annual family income of A$494-758, and a somewhat lower range for median income of A$389-566 per family.
47 The fact that median incomes are markedly lower than mean incomes is an initial indication that income distribution is heavily skewed to the left (lower) end of the spectrum.

Other scholars have noted the proliferation of part-time occupations that mediate between the Balinese village economy and the broader island/urban/tourist economy (Geertz 1963:85-99). The practice of making (minor) contributions to family income by petty-trading, piece work, and small-scale sand and rock mining have been aptly called 'economic microniches' (Poffenberger and Zurburchen 1980).[48] These new occupations are a modern addition to the range of traditional activities, such as crop and livestock husbandry.

Table 6.3:
Average Annual Family Income from Wage and Non-Wage Sources.

(Rpx1000) N	Taro 135		Penestanan 124		Tegal Tugu 98	
Wage Sources						
Mean	173	a	297	c	386	a
Non-Wage Sources						
Gifts	6		24		40	b
Finance	3	a	102	a	27	a
Crafts	8	a	62	a	9	
Livestock	94		77		48	a
Crops	96	a	52		76	
Subsistence	50		49		53	
Agriculture	240	b	174		177	b
Mean	257	b	362	c	253	
Total	430	a	659		638	a

Notes see Footnotes 49.

The relative importance of different income sources, particularly wage vs non-wage, shows a clear trend towards greater reliance on wage income in moving from Taro to Tegal Tugu (see Figure 6.4b and Table 6.4). Moreover, a similar pattern is evident with respect to the proportion of families in each village utilising a given resource. In Taro the use of local resources, particularly agriculture, accounts for almost the whole of non-wage income (96%), in Penestanan and

48 The paper by Poffernberger and Zurburchen provides a very insightful and detailed look at the impact of modernisation on traditional village economics up to 1978. The patterns they note are very much in evidence five years later, as the expansion of the modern sector of the economy (including tourism) have continued to make available more 'microniches' to enterprising individuals and/or groups. See also Rietveld (1984 and 1986) for a discussion of similar patterns in rural East Java and South Sulawesi.

49 Agriculture = livestock + crops + subsistence; Total = Wage + Non-Wage. Letters after the third column are significances between Taro and Tegal Tugu. T-test significances: a=<0.005, b=<0.02 and c=<0.05. See Tables A6.2.3 and 6 for details.

Tegal Tugu these sources account for 57% and 79% respectively of non-wage income. Only in Penestanan do incomes from financial sources and crafts play a significant role, both being closely associated with tourism.[50]

In Taro livestock account for over a third of non-wage income, crops are second in importance, followed by subsistence, with other sources making only minor contributions. Agriculture is about twice as important as a source of income as it is in the other two villages. In Penestanan livestock are the most important source of non-wage income, crops and subsistence being outranked by crafts and finance; however, here the relative importance of income from agriculture is the lowest of the three villages. In Tegal Tugu income from subsistence and crops is more important than gifts and finance, while crafts make the smallest contribution.

Table 6.4:
Average Proportional Contribution to Family Income from Wage and Non-Wage Sources (before exclusions).

N	Taro 135 %	Penestanan 124 %	Tegal Tugu 98 %
Wages *	0.343 (75) a	0.471 (82) c	0.561 (88) a
Gifts	0.013 (2)	0.020 (11) b	0.057 (8) b
Financial	0.005 (5) a	0.099 (30) b	0.038 (18) a
Crafts	0.021 (6) a	0.110 (35) a	0.012 (16)
Livestock	0.247 (90) a	0.121 (77)	0.095 (80) a
Crops	0.227 (63) a	0.075 (35) b	0.134 (56) a
Subsistence	0.144 (93) a	0.104 (94)	0.102 (76) a
Agriculture	0.618 (99) a	0.300 (96)	0.332 (85) a
Non-Wage *	0.657(100) a	0.529 (98) c	0.439 (91) a

Notes see Footnote 51.

50 Table A6.3.7 makes it clear that a fair degree of specialisation prevails in non-wage sources of income. That is, each family tends to derive a substantial proportion of their non-wage income from a small range of sources, e.g. in Penestanan income from crafts (mainly painting) provides about half the non-wage income of the families who utilise this source. Because of the range of different activities that contribute to livestock and crop income, these two sources are listed separately, see Tables A6.3.9-18.

51 Figures in parentheses are the proportion of families in each village that derive some income from each source. Agriculture is the proportion of total family income from agricultural sources (stock + crops + subsistence). T-test significances: a=<0.005, b=<0.02 and c=<0.05; letters after the sixth column are significances between Taro and Tegal Tugu. * Proportion of Total Annual Family Income. Table A6.2.4 lists the amount of income from each source before exclusions. Details, including SD's and Medians, are presented in Table A6.2.5; from Table A6.5.5 it is clear that except for income from livestock, crops and subsistence the majority of families in each of the villages gain no income from gifts, finance or crafts (i.e. the median values for each group are zero); and in Penestanan and Tegal Tugu the majority of families gain no income from cash sales of crops either.

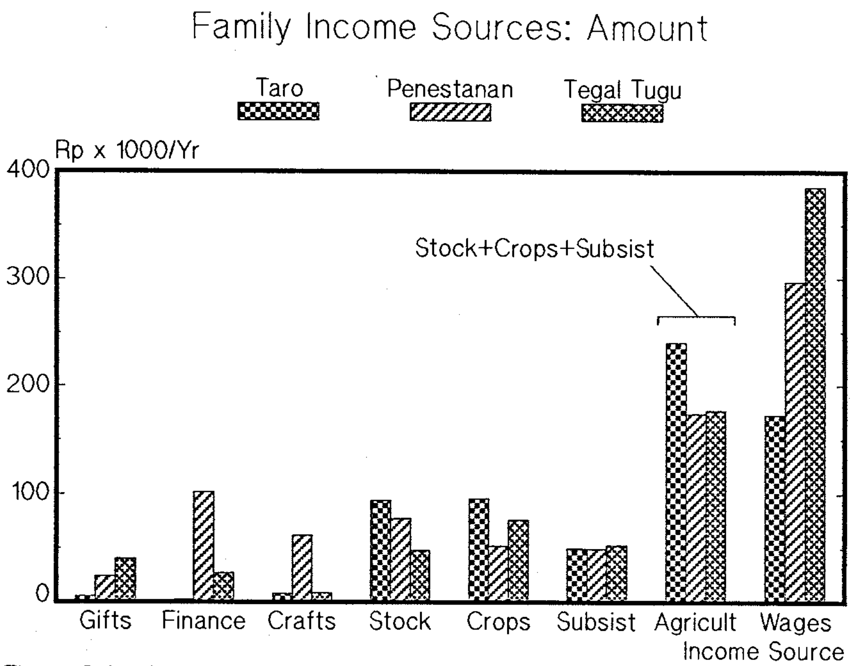

Figure 6.4a: Average Annual Family Income by Source.

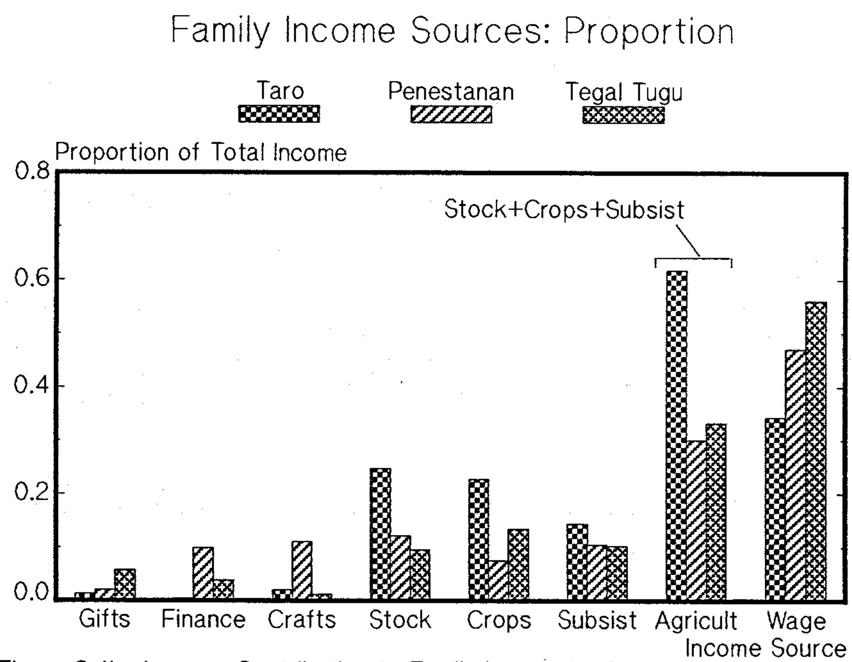

Figure 6.4b: Average Contribution to Family Income by Source.

Figure 6.4: Contributions to Family Income by Source.

6.3.3 Income Sources and Income Distribution.

If the relative importance of income sources for different income groups and the linkages (correlations) between sources and income groups is analysed in detail, it is clear that greater access to 'modern' sources of income explains much of the difference in income between the three income groups, despite differences in the relative access to income sources associated with location.

The absolute and relative importance of wage and non-agricultural income (which includes wage income) differs greatly between the three income groups (see Figure 6.5a). The 20% of families in the high income group derive a significantly smaller proportion of their total income from non-wage and/or agricultural sources, i.e. traditional sources broadly defined, than do the 40% of families in the low income group (see Figure 6.5b). However, while the relative importance of agriculture to the high income group is lower, the average amount of income derived from agriculture (and wages) by this group is two to six times greater than the level of agricultural income for the low income group (see Table 6.5).

When data from the three villages are combined,[52] it is clear that the poorest families depend most on non-wage and agricultural income sources, for families in the middle income group these two types of income are of roughly equal importance, and for families in the high income group wage and non-agricultural income sources are by far the most remunerative. Non-wage and agricultural incomes are more important than wage and non-agricultural income sources only for the low and middle income groups in Taro, i.e. income sources are generally more traditional. Except in Penestanan, where non-wage financial and craft incomes associated with tourism are important, families in the high income group derive most of their income from wage and non-agricultural sources.

52 The data from the three villages is combined to provide a (very) rough estimate of the trends in overall economic changes in village communities in South Bali, of necessity it lumps together data from explicitly dissimilar villages.

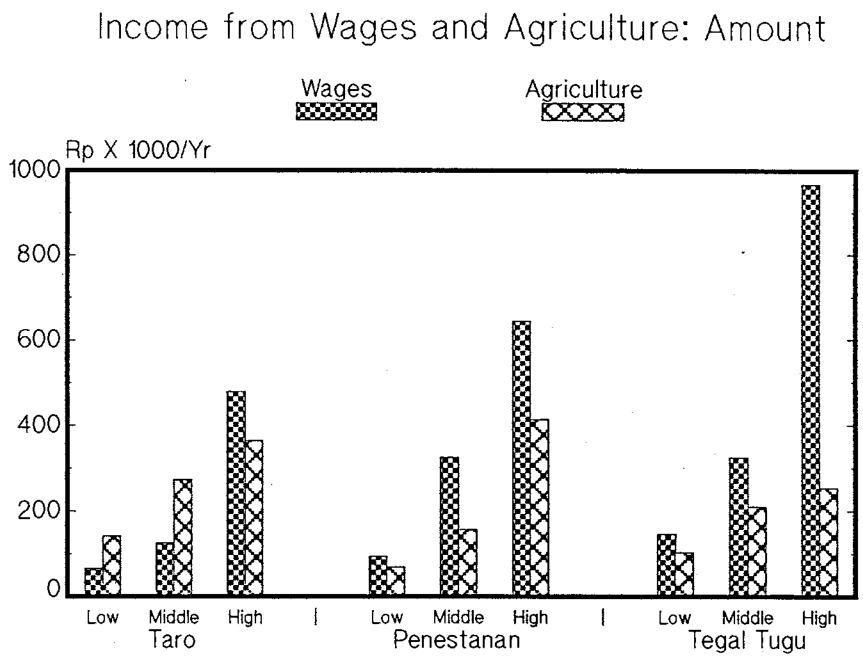

Figure 6.5a: Differences in Income Amounts by Income Group.

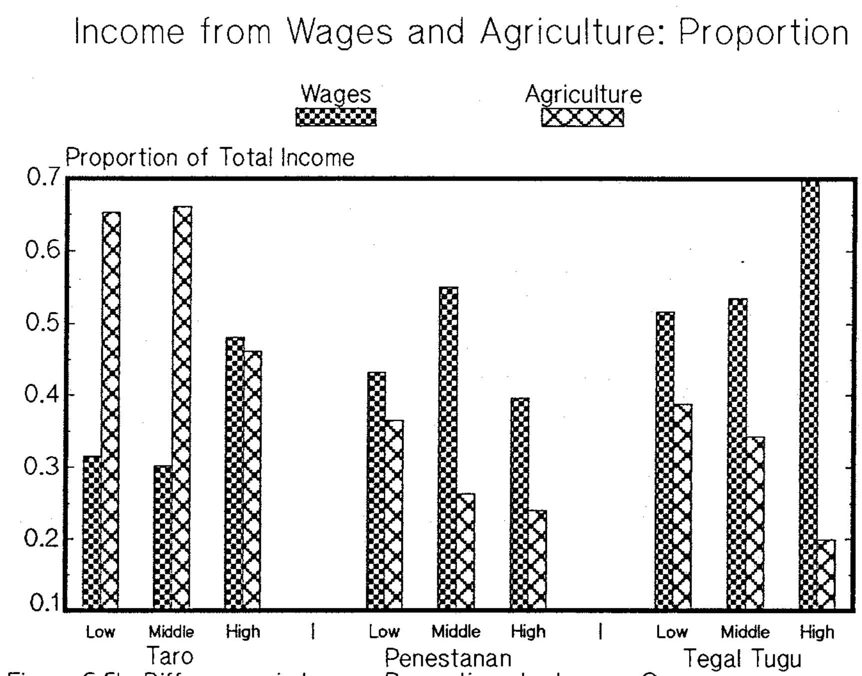

Figure 6.5b: Differences in Income Proportions by Income Group.

Figure 6.5: Wage and Agricultural Income by Income Group.

Table 6.5:
Differences between Income Groups in Income and Sources.

Income Group	Low		Middle		High	
% of Families	40	Sig	40	Sig	20	Sig
Taro (N = 135)						
Income (Rpx1000)						
Total Family	213	a	416	a	890	a
Wage	66	a	126	a	480	a
Non-Wage	147	a	289	a	410	a
Agricultural	143	a	274	b	365	a
Non-Agricultural	71	a	142	a	525	a
Income Sources (Proportion)						
Wages	0.315		0.302	b	0.481	b
Agricultural	0.653		0.661	a	0.461	a
Penestanan (N = 124)						
Income (Rpx1000)						
Total Family	215	a	599	a	1666	a
Wage	95	a	326	a	644	a
Non-Wage	120	a	273	a	1022	a
Agricultural	70	a	158	a	414	a
Non-Agricultural	144	a	441	a	1252	a
Income Sources (Proportion)						
Wages	0.432		0.550	c	0.396	
Agricultural	0.365	c	0.263		0.240	
Tegal Tugu (N = 98)						
Income (Rpx1000)						
Total Family	276	a	616	a	1390	a
Wage	147	a	326	a	968	a
Non-Wage	129	a	290		422	a
Agricultural	104	b	211		254	a
Non-Agricultural	172	a	405	a	1136	a
Income Sources (Proportion)						
Wages	0.516		0.535		0.697	
Agricultural	0.388		0.343		0.199	c
Three Villages (N = 357)						
Income (Rpx1000)						
Total Family	225	a	531	a	1342	a
Wage	87	a	249	a	712	a
Non-Wage	138	a	282	a	631	a
Agricultural	115	a	219	a	334	a
Non-Agricultural	110	a	312	a	1008	a
Income Sources (Proportion)						
Wages	0.385	c	0.465		0.539	a
Agricultural	0.515	b	0.422	a	0.265	a

Notes see Footnotes 53.

The absolute contribution of wage and non-agricultural income significantly increases total family income, except in Taro.

53 Wage and Non-Wage are mutually exclusive categories, as are Agricultural and Non-Agricultural; Wage income is included in Non-Agricultural income, Agricultural income is included in Non-Wage income. T-test significances: a=<0.005, b=<0.02 and c=<0.05; letters after the last column is the significance of the differences between families in the Low and High Income Groups.

Only in Taro is the proportion of income from agriculture significantly related to total family income; in the other two villages greater reliance on income from agriculture has a slight negative, although statistically non-significant, effect on total family income. However, even for the low income group there is a declining gradient from Taro to Penestanan to Tegal Tugu in the correlation between the amount of income from agriculture and total income - from 0.635 to 0.365 to 0.265 respectively; and an inverse gradient for income from non-agricultural sources (see Table 6.6). These patterns are a clear indication of a shift towards non-traditional income sources deriving from the generalised impact of modernisation.

For the middle income group the patterns are not quite so clear, due to the relatively equal importance of traditional and modern income sources; this is indicated by the lack of significance for the proportional contributions of wage and agricultural income sources. In each of the villages there is a similar correlation between the amount of wage income and total income, while at the same time, the declining importance of the amount and proportion of agricultural income follows a similar pattern to the high income group.

Table 6.6:
Low, Middle and High Income Groups and Significance of Income Sources by Village - Nonparametric (Spearman) Correlations.

	Taro		Penestanan		Tegal Tugu	
Lowest 40%	Taro		Penestanan		Tegal Tugu	
N	54		50		39	
Family Income (Amount)						
Wage	0.206		0.332	b	0.327	c
Non-Wage	0.582	a	0.599	a	0.294	c
Agricultural	0.635	a	0.365	a	0.265	c
Non-Agricultural	0.129		0.725	a	0.442	a
Income Source (Proportion)						
Wage	-0.099		-0.004		0.083	
Agricultural	0.242	c	-0.172		-0.056	
Middle 40%	Taro		Penestanan		Tegal Tugu	
N	54		49		39	
Family Income (Amount)						
Wage	0.258	c	0.291	b	0.230	
Non-Wage	0.453	a	0.286	b	0.284	c
Agricultural	0.397	a	0.266	b	0.081	
Non-Agricultural	0.219		0.671	a	0.415	a
Income Source (Proportion)						
Wage	0.087		-0.078		-0.041	
Agricultural	-0.046		0.013		-0.073	
Highest 20%	Taro		Penestanan		Tegal Tugu	
N	27		25		20	
Family Income (Amount)						
Wage	0.761	a	0.285		0.723	a
Non-Wage	-0.135		0.379	c	0.173	
Agricultural	-0.135		0.033		-0.168	
Non-Agricultural	0.762	a	0.800	a	0.895	a
Income Source (Proportion)						
Wage	0.555	a	0.079		0.137	
Agricultural	-0.524	a	-0.169		-0.319	

Notes see Footnote 54.

For the high income group the pattern is quite different from the other two groups. For this group there is no significant correlation between the amount of income from agriculture and total income, indeed in Taro and Tegal Tugu there exists a slightly negative relationship. Except in Penestanan, where the amount of non-wage income makes a significant contribution to family income for reasons previously mentioned, total income is highly correlated with the amount of income from wages for this income group. In each village the proportion of income from agricultural sources is negatively correlated to total income, although the relationship is not

54 See notes to Table 6.6. T-test significances a=<0.005, b=<0.02 and c=<0.05; letter after the last column are the significances between Taro and Tegal Tugu.

statistically significant in Penestanan. As with the other two income groups, correlations between the amount of non-agricultural income and total income are progressively more important, from Taro to Penestanan to Tegal Tugu, rising from 0.762 to 0.800 to 0.895 respectively.

It is clear from this table that significant differences exist between each of the income groups in terms of the average amounts of family income from wage and non-wage, agricultural and non-agricultural income sources. In general, the middle income group has an average income from these sources approximately twice that of the low income group. The differences in the average amount of income from each source between the middle and the high income groups is more varied, ranging from about two to five times in absolute value. In terms of the proportional contribution of income sources there is, on the whole, little difference between the low and middle income groups, and a significant difference between these two groups and the high income group. That is, significant differences exist between the income groups in terms of the importance of what can be typified, broadly, as traditional and modern income sources. Attention is now directed to the significance of these sources for total family income.

When the data for the three villages is combined the significance of different sources of income for each income group is very similar to that for individual villages (see Table 6.7), despite differences between the villages in terms of the duration of modernisation, location and agricultural resources. The correlations between the amount of wage income and total income increases from the low to the high income groups (from 0.226 to 0.453), while the importance of the amount of income from agricultural sources declines in both weight and significance (from 0.401 to -0.045).

Table 6.7:
Three Villages Combined: Low, Middle and High Income Groups and the Significance of Income Sources (Spearman Correlations)

Income Group	Low		Middle		High	
N	144		143		70	
Family Income						
Wage	0.226	a	0.280	a	0.453	a
Non-Wage	0.513	a	0.256	a	0.356	a
Agricultural	0.401	a	0.098		-0.045	
Non-Agricultural	0.353	a	0.450	a	0.881	a
Income Source (Proportion)						
Wage	-0.017		0.046		0.040	
Agricultural	0.000		-0.111		-0.336	a

Notes see Footnote 55.

Thus, the balance of traditional vs modern family income sources strongly influences income levels, even when the cross-cutting effects of the duration of modernisation are eliminated from the analysis, as in Table 6.7. Those in the low income group rely significantly more on local, agricultural resources for the bulk of their income, while for families in the high income group neither the absolute nor relative amount of income from agriculture has any marked effect on their total income. Taken in conjunction with the significant differences in access to land between the income groups (see below Table 6.11) it appears that, even although the high income group has access to significantly more agricultural land than the low income group, their current income level is not significantly dependent on access to land.[56]

6.4. Income Group and Expenditure Patterns.

First, average village expenditures on goods and services are presented (see Figure 6.6 and Table 6.8). These data clearly show significant differences in expenditures between the villages, related to both location and the general level of income. It has been shown previously that the income situation of low income families appears to be relatively static, whereas families in the high income group are enjoying

55 T-test significances a = <0.005, b = <0.02, c = <0.05; letters after the last column are significances between the Low and High income groups.
56 The corollary of this, if the aim of modernisation were really to make income shares 'more equal', would be the redistribution of agricultural land to provide poorer members of the community with greater access by ownership, rather than as share-croppers or paid labour.

average incomes some four to six times higher (see Table 6.5). The widening economic gulf that separates these groups of families makes its effects most apparent in the amount of money that those in the high income group can devote to providing education for their children[57], purchasing food, borrowing money for (productive) investments and mobility for access to non-local markets and employment.

The range of items of domestic family expenditure can be broken down into two, somewhat overlapping, classes: Traditional and Modern. Traditional items of expenditure include, as far as it is possible to judge: the major proportion of religious, marketing and community outlays[58]; whereas, modern items encompass: health, education, finance, transport, fuel and consumer goods/services - and a (unknown) proportion of each of the traditional items.[59] Unlike the foregoing analysis of income, greater attention here is directed to the absolute amounts outlaid on particular constellations of items, rather than the pattern of proportional expenditures.[60]

In almost every category of expenditure (except consumer goods and services) families in Taro spend significantly less, on average, than families in Penestanan and Tegal Tugu; average family expenditure in Taro is about half that of Penestanan

57 Expenditure on education includes school fees, books, clothing transport and pocket money. While primary education is nominally free, outlays are still necessary for the items above, except fees. The cost of junior and senior secondary education rises steeply, with additional outlays for fees and, unless there is a suitable school within walking/cycling distance, outlays for transport. Based on the authors experience, meeting the costs of secondary education, which is highly valued, places a heavy financial burden on any but the relatively wealthier families; in addition prolonged education reduces the available family labour force for families relying on agricultural or labouring incomes.

58 As modern manufactured artifacts have become more available they have replaced traditional artifacts in all areas of life. For example, it is not now uncommon to see holy water for religious ceremonies being carried in or dispensed from a glass soft drink bottle, or offerings placed on the alter for blessing in a cheap plastic or aluminum tray; families and village groups no longer make pilgrimages on foot to more distant religious festivals, the family or village hires a bemo or truck, and complete, what traditionally was a 4-5 day expedition in one day or less. Community outlays include village (banjar) dues, levied equally on all families and land tax (IPEDA) which, as it is calculated on the area and class (quality) of land owned, cost larger landowners (generally, the wealthier families) more per family.

59 In more modernised areas, e.g. Tegal Tugu, a substantial trade in ready-made religious offerings and essentials operates, thus allowing people to pay cash for what would have traditionally been made by the women of the family. In the case of finance, the making and taking of loans within villages is traditional but today a much greater proportion of this activity is now mediated by formal banking institutions - with the exception of 'saving clubs' (arisan) of various types which are still active.

60 The reasoning being that it is the amount of money outlayed that commands use of purchased resources, whereas the relative size of the expenditure provides and indication of the social importance to the family of the purchase.

and two thirds that of Tegal Tugu (see Table 6.8). For instance, the average amount spent in Penestanan on finance is twice that of Taro. Bearing this in mind in regard to transport, it is clear that the people of Penestanan and Tegal Tugu are much more 'mobile' than the average family in Taro - despite the remoteness of Taro. A similar pattern exists with respect to purchased fuel for lighting and cooking (kerosene), average family spending in Penestanan is significantly more than in Taro.[61] Thus, taking into account just transport and fuel expenditures, it is clear that the direct use of fossil fuels plays a much greater role in Penestanan and Tegal Tugu than it does in Taro.[62]

Two anomalies in this table require discussion: the amounts spent on religion, and consumer goods and services, as the scale of expenditures on these items directly affects the relative balance between traditional and modern consumption patterns. In Taro the average amount spent on religion is only about 10% of that of the other two villages; and only in Taro are significant amounts (reportedly) spent on consumer items. Consumer goods and services include purchases of large and small durables (clothing, bedding, buckets, soap etc), entertainment/sports expenditures.[63] Whatever the explanations for these anomalies, in Taro they have the effect of biasing traditional expenditure downward and modern expenditure upward; and vice versa in the other two villages.

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61 Outlays on fuel do not include payments for electricity; however, less than 10% of the families from the sample in Tegal Tugu are connected to the mains and almost all families in Taro pay modest fees (about Rp 5,000/year) for connection to the village electricity co-operative for 4-5 hours of power per night.

62 A survey carried out by the author (not reported here) of domestic fuel use for cooking shows that families in Taro have easier access to good quality woodfuel than families in Tegal Tugu, in particular.

63 Part of the explanation of the differences in cash outlays for religion may lie in the larger share that home production plays in preparation of offerings in Taro, and part in the possibility that better-off families in Penestanan and Tegal Tugu use elaborate religious ceremonies as an indication of their new found wealth. Discussions with Barbara Lovric, who undertook contemporaneous research on medico-religious aspects of Balinese life, tends to indicate that the level of religious expenditures in Penestanan and Tegal Tugu are similar to those revealed by her work for the Sanur area. Thus expenditures in Taro may be significantly under-reported. The fact that almost all families in Penestanan and Tegal Tugu did not report any outlays on consumer goods and services may result from a failure of interviewers to make adequate use of the 'reminder list' accompanying the questionnaire, the possibility that most families have already acquired the modest range of durable consumer items commonly owned and/or the fact that sport and entertainment outlays are often made by adolescents, independently of the main family budget; in Penestanan a contemporary depression in income from tourism may also have caused families to postpone major outlays. The author's considered opinion is that religious outlays in Taro are seriously under-reported, as are consumer outlays in Penestanan and Tegal Tugu.

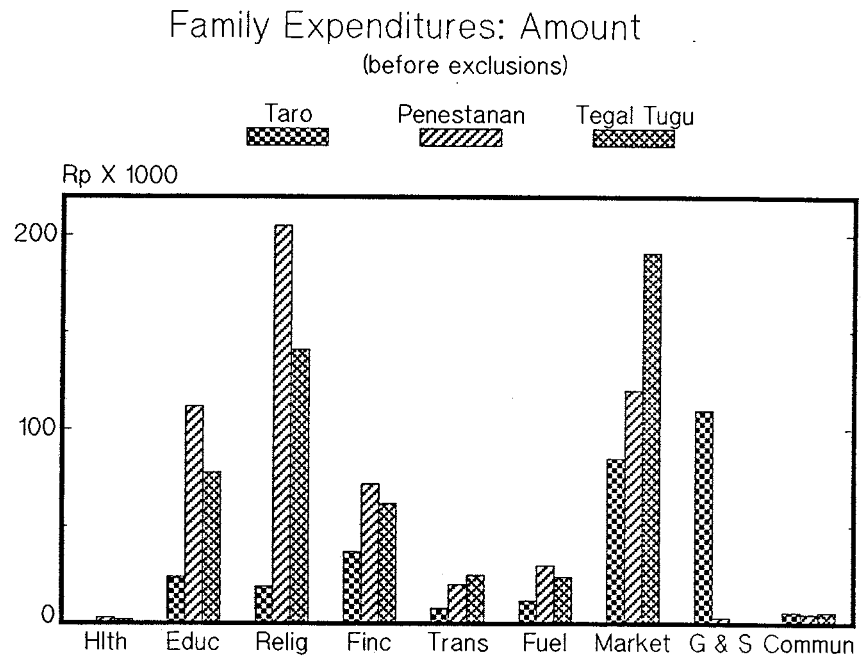

Figure 6.6a: Average Amount of Family Expenditure (before exclusions)

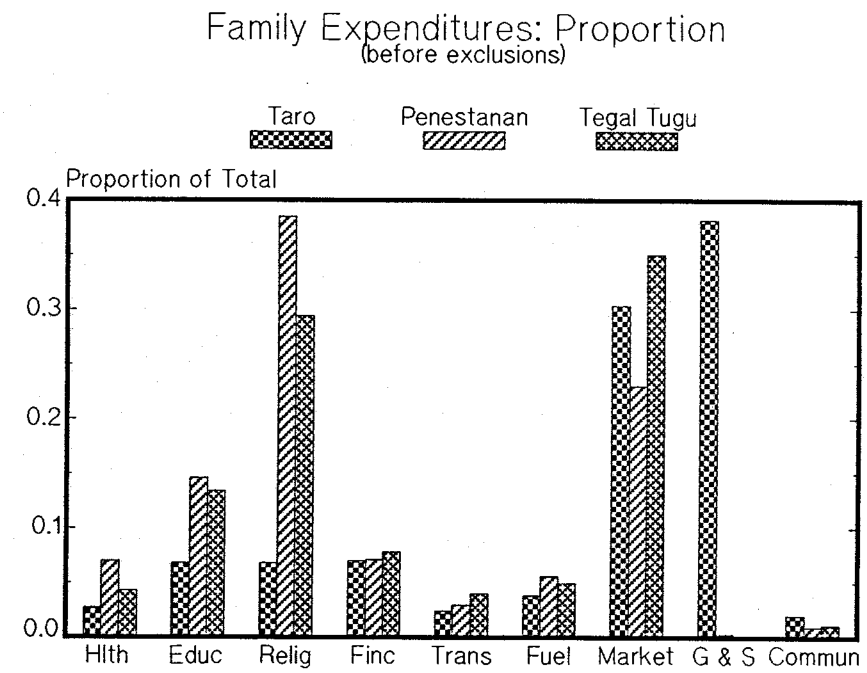

Figure 6.6b: Average Proportional Family Expenditures (before exclusions).

Figure 6.6: Family Expenditures on Goods and Services (before exclusions).

Table 6.8:
Average Family Expenditure on Goods and Services.

(Rpx1000)	Taro		Penestanan		Tegal Tugu	
N	135		124		98	
Health	1	a	3	b	2	a
Education	24	a	112		78	a
Religion	19	a	205	a	141	a
Finance	37	c	72		62	
Transport	8	a	20		25	a
Fuel	12	a	30		24	a
Marketing	85	a	120	a	191	a
Consumer G&S	110	a	3		1	a
Community	6		5		6	
Traditional	110	a	330		338	a
Modern	192		239		191	
Total	312	a	599		549	a

Notes see Footnote 64.

The differences between the villages in estimated outlays for (food) marketing highlights both differences in agricultural resources and the effects of greater cash resources - a result of higher wage incomes. The effects of modernisation are also reflected in the amounts spent on health and education. In Taro these facilities are much less accessible than in the other villages, particularly Tegal Tugu; in parallel, longer exposure to the benefits offered by these services has, arguably, encouraged families in Penestanan and Tegal Tugu to devote more resources to maintaining better health[65] and acquiring for their children a longer period of formal education. Families in Taro spend significantly less on purchased food than do families in the other villages.[66] Finally, the material advantage offered by higher incomes (at a village-wide level) are well illustrated by the differences

64 Traditional = Religion + Marketing + Community; Modern = Health + Education + Finance + Transport + Fuel + Consumer. T-test significances: a=<0.005, b=<0.02 and c=<0.05; letters after the third column are significances between Taro and Tegal Tugu. Expenditures do not include outlays for agricultural inputs.

65 Outlays on health include the costs of both traditional and modern treatments. However, in many cases traditional treatment is free or very cheap, while modern treatment requires payment of set (relatively low) fees at government health centres (PUSKESMAS) or private doctors charges (relatively high). In some cases (known to the author) government employed paramedics use their spare time and government supplied medication to run a profitable 'private practice' in their local area.

66 Because of lower total outlays, marketing constitutes a larger proportion of average expenditures.

between the villages (and income groups) in the average number of modern consumer goods owned.

Wideranging, recorded observations by the author of household conditions and possessions in the three villages clearly indicate that, in general, families in Penestanan and Tegal Tugu have both a larger complement of modern durable possessions (e.g. radios, TVs and furniture) and that, on average, they also make use of a wider range of smaller consumer goods (toothpaste, plastic utensils etc). This observation is born out by survey data on household possessions (see Tables A6.3.1-4), which shows that for almost every modern item families in Taro, on average, both own less than families in the other two villages and that fewer families in Taro have these possessions.[67]

On the other hand, a larger proportion of families in Taro have a larger average complement of livestock than families in the other villages, reflecting the fact that livestock agriculture is more important in Taro than in the other two villages. A further indication of this is given by the fact that ownership of traditional agricultural and craft tools (ploughs, carpentry, stonemasonry) is highest in Taro.[68] We turn now to differences between the income groups in expenditures on traditional and modern items. In each of these categories families in the high and middle income group spend significantly more than those in the low income group. Figure 6.7 and Table 6.9 present average absolute and proportional expenditures for all three villages by each income group.

We turn now to differences between the income groups in expenditures on traditional and modern items. In each of these categories families in the high and middle income group spend significantly more than those in the low income group. (see Figure 6.7 and Table 6.9).

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67 This is also the case in each village for each of the three income groups (see Tables A6.6.1-7 for details). In general, more families in Tegal Tugu have more of each of these items than families in each income group in Penestanan.

68 With few exceptions, families in the low income group in each village have fewer productive livestock than families in the middle and high income groups (see Tables A6.5.1-3).

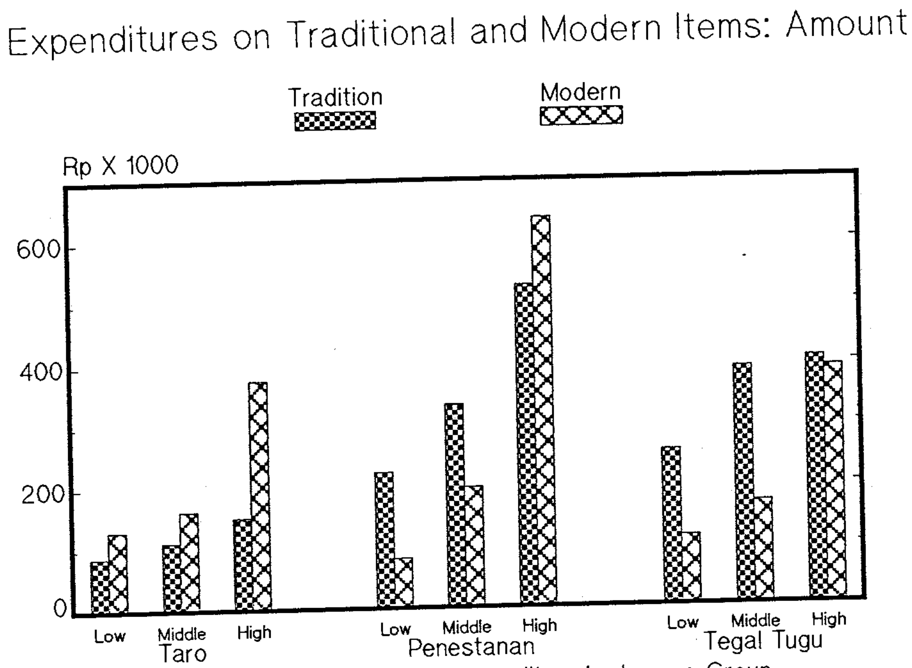

Figure 6.7a: Differences in Amounts of Expenditure by Income Group.

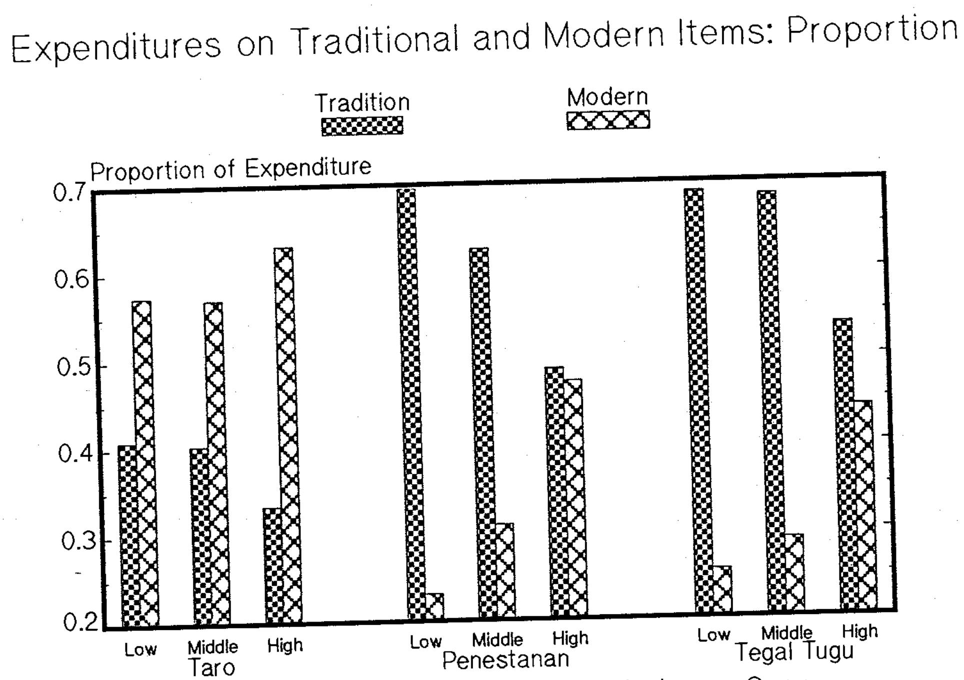

Figure 6.7b: Differences in Proportional Expenditure by Income Group.

Figure 6.7: Average Family Expenditures on Traditional and Modern Items.

Table 6.9:
Average Amounts and Proportions of Expenditure by Income Group.

Village	Taro		Penestanan		Tegal Tugu	
% of families	40		40		20	
			Low Income Group			
(Rpx1000)						
Total Family Expend.	222	a	334		392	a
Traditional	88	a	223		254	a
Modern	130	a	82		113	
Proportion of Expenditure						
Traditional	0.409	a	0.695		0.688	a
Modern	0.574	a	0.231		0.254	a
			Middle Income Group			
Total Family Expend.	283	a	564		571	a
Traditional	112	a	333		389	a
Modern	163		197		168	
Proportion of Expenditure						
Traditional	0.403	a	0.625		0.683	a
Modern	0.570	a	0.309		0.289	a
			High Income Group			
Total Family Expend.	549	a	1201	b	810	b
Traditional	151	a	527	c	405	a
Modern	376	c	636	c	389	
Proportion of Expenditure						
Traditional	0.333	a	0.487		0.535	a
Modern	0.631	a	0.472		0.440	a

Notes see Footnote 69.

There is a clear trend for absolute expenditure on all items to rise as income increases, and for the proportion of expenditure devoted to modern items to rise as income increases. However, with few exceptions (finance, transport, consumer goods and services) there are non-significant differences between the income groups in average proportional outlays for basic items such as health, education and marketing. Indicating that the importance to all families of these items remains fairly constant for each income group (see Tables A6.5.1-7 for details).

This trend towards increasing consumption of modern items as income rises is most apparent when correlations between income and the absolute and relative expenditure shares on traditional and modern items are examined. In each of the villages there is a large and significant correlation between income and absolute outlays on modern items. As regards

69 See Tables A6.4.1-7 for details. T-test significances: a = <0.005, b = <0.02, c = <0.05; letters after the last column are significances between Taro and Tegal Tugu.

proportional outlays, in each village there is a significant negative correlation between income and the proportion of total expenditure for traditional items and, except in Taro, a significant positive correlation between income and the proportion spent on modern items. It is interesting, in relation to the new 'tourist' wealth in Penestanan, that this pattern is most pronounced in this village for both absolute and relative expenditures (see Table 6.10).

Table 6.10:
Nonparametric Correlations between Total Family Income and Family Expenditures (no exclusions).

Village N	Taro 135		Penestanan 124		Tegal Tugu 98	
Expenditure - Amount						
Health	0.297	a	0.373	a	0.108	
Education	0.330	a	0.528	a	0.307	a
Religion	0.283	a	0.498	a	0.143	
Finance	0.412	a	0.316	a	0.474	a
Transport	0.189	b	0.540	a	0.479	a
Fuel	0.209	b	0.558	a	0.190	c
Marketing	0.571	a	0.490	a	0.429	a
Consumer G&S	0.485	a	0.074		0.063	
Community	0.307	a	0.367	a	0.099	
Traditional	0.592	a	0.634	a	0.459	a
Modern	0.534	a	0.686	a	0.591	a
Expenditure - Proportion						
Health	0.103		-0.231	a	-0.110	
Education	0.237	a	0.334	a	0.127	
Religion	-0.324	a	-0.351	a	-0.027	
Finance	0.344	a	0.238	a	0.439	a
Transport	-0.009		0.197	b	0.331	a
Fuel	-0.191	b	-0.164	c	-0.136	
Marketing	-0.125		-0.164	c	0.033	
Consumer G&S	-0.265	a	0.073		0.063	
Community	-0.122		0.045		-0.176	c
Traditional	-0.201	a	-0.460	a	-0.350	a
Modern	0.123		0.482	a	0.432	a

Notes see Footnote 70.

70 See Tables A6.6.1-7 for details. T-test significances: a=<0.005, b=<0.02 and c=<0.05; letters after the last column are significances between Taro and Tegal Tugu.

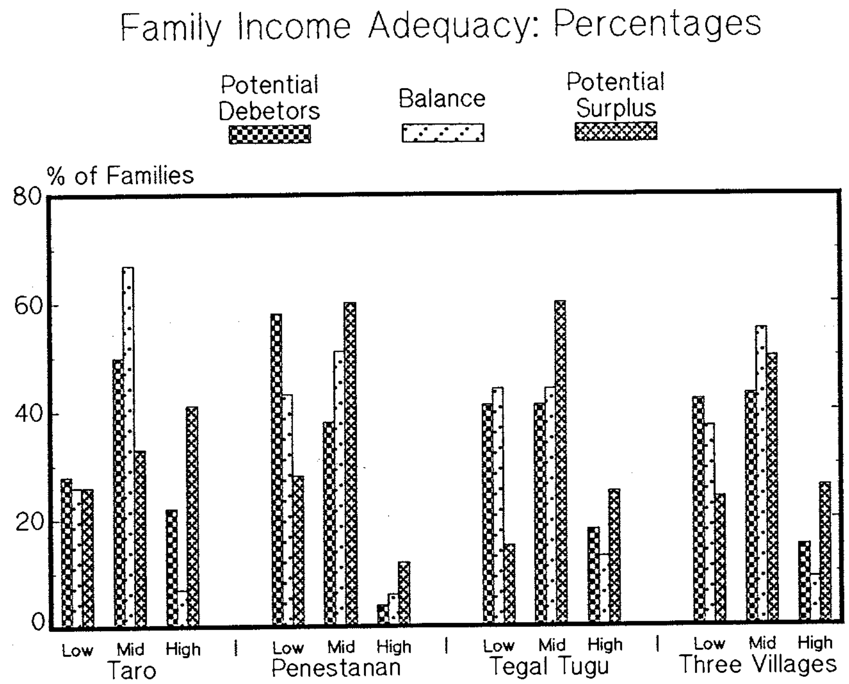

Figure 6.8a: Average Family Income Adequacy by Income Group.

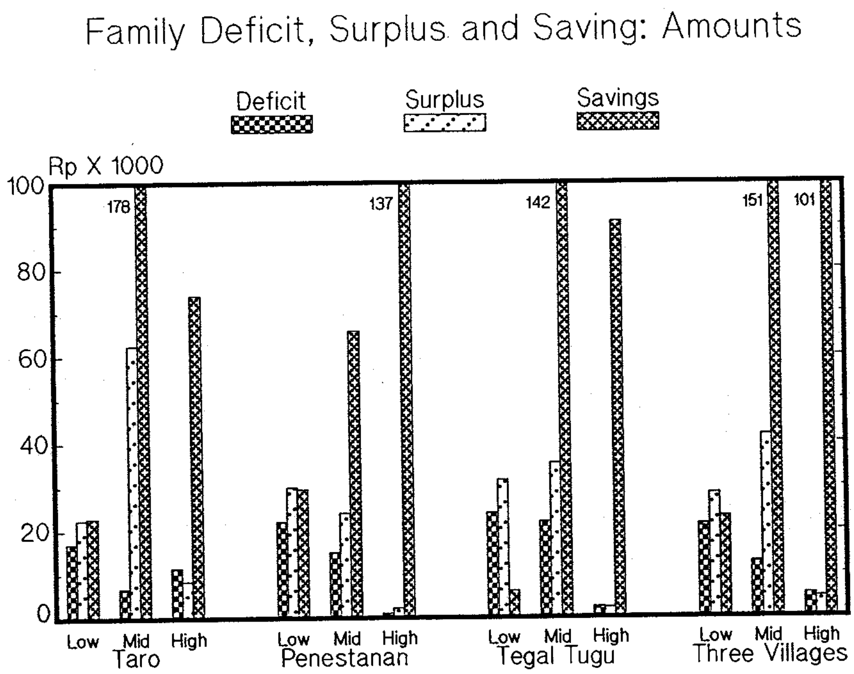

Figure 6.8b: Average Family Deficit, Surplus and Saving by Income Group.

Figure 6.8: Family Income Adequacy and Financial Balances.

Given the wide gap in expenditures between low, middle and high income groups, correlations were also calculated independently for each income group. The results show that the pattern of correlations presented in Table 6.10 are similar for each income group in each village and for the combined data for each income group, except for absolute traditional expenditures by the high income groups in Penestanan and Tegal Tugu (see Tables A6.6.1-7 for details). However, it is also clear that the shift of relative expenditures from traditional to modern is significantly less marked in Taro for all three income groups; and that the patterns of relative expenditures are strongly away from traditional and towards modern ones in high income group families of Penestanan and Tegal Tugu.

The differences between villages and income groups in patterns of expenditure are somewhat less clear than differences in the relative importance in sources of income. This is due, at least in part, to the anomalies in relative expenditures on religion and consumer goods and services. Second, it is due to the fact that access to modern items of consumption is less a factor of prior advantage (i.e. location and/or education) than of purchasing power, whatever the source of funds, and is thus, potentially at least, open to all. This difference between the effects of modernisation on income and expenditure explains, for instance, the tendency of the better-off families in Penestanan to devote more of their resources to modern goods and services - the more so, since the advantages of modernisation (*kemajuan*) in social and material terms are clearly demonstrated by urban-dwelling Balinese and tourists.

The differences between villages in average absolute incomes and expenditures may be summarised by pointing to the easier physical access by people in Penestanan and Tegal Tugu to income from the modern sector of the economy, tourism and urban work. This means that more money comes into these villages from extra-local work and, on the other hand, significantly greater amounts are spent purchasing goods and services from outside the village economy. This additional cash income has also allowed more families to accumulate a larger number of modern household possessions.

The comparisons between the villages of income and expenditure, made in this and the last section clearly show:

> that average family incomes and expenditures in a remote village like Taro are significantly lower than in the other two more modernised villages;
>
> the economy of a 'traditional' villages like Taro is significantly more reliant on agriculture, and hence local resources, than 'tourist' or peri-urban villages;
>
> average absolute and relative outlays on modern goods and services in Taro are significantly lower than in the other two villages, thus requiring less extra-local imports; and,
>
> it is the richer families in each of the villages that have significantly greater access to the material benefits of modernisation, as access depends almost wholly on income.

Turning briefly to the question of families' self-estimated income adequacy - deficit or surplus and cash savings - it is clear that, on the whole, there are a significantly larger proportion of families in the low income group who are potential debtors (i.e. they estimate that their income is insufficient to meet their expenses) than in the high income group (see Figure 6.8a). Conversely, a significantly higher proportion of families in the high income group are potential lenders (i.e. income is estimated as being in excess of expenditure). Moreover, whereas families in the low, middle and high income groups who are potential debtors have a roughly similar estimated short-fall of income, families in the high income group have significantly greater surpluses than those in the low income group (5 to 30 times greater) and significantly more cash savings (7 to 140 times as much) (see Figure 6.8b and Table A6.9.1). It is abundantly clear, then, that the high income group not only has greater access to goods and services on a day-to-day basis, but also have and are accumulating capital at a significantly greater rate than the low (or middle) income group. This pattern of differential accumulation entrenches the potential for the future benefits of modernisation (via their childrens' education, for example) to flow disproportionately towards the already relatively well-off.

It is worth noting that while some of the families surveyed can be considered quite 'well-off' by Balinese standards, none of the families surveyed could be considered very wealthy, even by local standards. However, the author is personally acquainted with several Balinese (extended) families in tourist and urban areas who can be considered rich by international standards. It is very probable that if families with this level of income were included in income surveys the indices of inequality (Gini ratios etc.) would be considerably higher.[71]

6.5 Determinants of Access to Modernisations Benefits.

How are the great differences in material welfare between the income groups to be explained? Modernisation theory would argue, in general, that increased agricultural production (via higher areal and human productivity) leads to increased income and expenditure and thence to increased accumulation of social and physical capital. Moreover, these changes lead, over time, to the growth of the non-agricultural sectors of the economy - the summary at the beginning of this chapter reflects this general pattern for Bali. However, the above analysis shows that the pattern of agricultural modernisation followed to date in Bali has not resulted in any significant improvements in the material welfare of the (poorer) majority of the population. Yet this poorer segment of the population is (still) significantly more dependant on agricultural and non-wage income for their sustenance than the relatively wealthy. To what extent then does differential access to agricultural resources explain growing differences in income?

In this section attention is directed to four factors closely linked by modernisation theory to increased agricultural productivity: first, relative access to the basic agricultural resource - land; second, differences in the availability of

71 It is very unlikely that SUSENAS or other government income/consumption surveys collect data from this economic strata, particularly in urban areas (for a variety of status and political reasons); there is, thus, in all probability a consistent, long-term under-estimation of the real extent of income inequality in Bali (and Indonesia generally).

adult labour; third, access to agricultural credit for purchasing the range of new inputs needed to cultivate HYVs; fourth, relative access to agricultural markets. Finally, the importance of access to non-agricultural sources of income to relative material well-being is discussed.

6.5.1 Access to Agricultural Land.

Agricultural land is the primary natural resource for most village families in Bali: ricefields (*sawah*), dryfields (*tegal*) and housegardens (*tebe/pekarangan*). A family may have access by ownership and/or rental to all three types of land, although rental of dryland and housegardens is generally uncommon. Ricefields are locally considered to be about twice as valuable as dryfields, for a mixture of productivity and cultural reasons. Dryfields and housegardens, while requiring little work to achieve the usually low levels of per area productivity, are also an important source of woodfuel stockfeed and, occasionally, building materials.[72]

In the last 50 years the population of Southern Bali has more than doubled, and in Kabupaten Gianyar slightly less than doubled.[73] Because detailed information on population at the local (village) level is not available for 1930-70, one is forced to make the assumption that the population growth rate in each village is similar to the rate for the region as a whole. On this basis, the population of each of the three villages studied has (approximately) doubled in the last 50 years, while the area of agricultural and intra-village land available has generally remained fixed at 1930 levels.[74] The pressure of people upon local natural resources has, one can conclude, at least doubled during the last half century.

72 See Christanty et al (1986:132-58) for analysis of the economic and ecological role of housegardens in West Java; and Adboellah and Marten (1986:293-325) for an analysis of the nutritional roles of ricefields and dryland agriculture in West Java.
73 Island-wide population in 1930 was 1.1 million, in 1980 2.5 million; in Southern Bali (Kabupaten Tabanan, Badung and Gianyar) population increased from 0.53 million in 1930 to 1.15 million in 1980; in Kabupaten Gianyar from 164 thousand in 1930 to 306 thousand in 1980 (see Table A3.5). It is not strictly true that the area of intra-village land (housegardens etc) available for agriculture has remained constant, because as population has increased vacant plots within villages have been built on and new compounds established, and within existing compounds new structures have been built, in many cases, in the traditional housegarden area (pekarangan/tebe).
74 Immediately to the north of Taro an area of new irrigated ricefield has been developed, adding to the agricultural area available. In each of the villages a number of smallish areas of land have been alienated from village control for use as schools and polyclinics during the last 15 years.

Ricefields.
The majority of families in each village have access to less than half a hectare of ricefield, the most productive form of landuse, while a quarter of the families have no access at all.[75] Average access to ricefields in Taro and Penestanan is quite similar, while families in Tegal Tugu have, on average, access to about one and a half times as much as in the other two villages. A comparison of this data with that for the whole of Bali (Table A3.19.1), indicates that the pattern observed in these three villages is typical of ricefield ownership and rental for the island.[76]

In Taro two thirds of the 135 families surveyed own ricefields, of these 21 families also rent additional ricefields. Fifteen families only rent ricefields, while 48 families (slightly more than one third) neither own nor rent ricefields. For the sample as a whole, average access to ricefields is 25 Are per family (see Table A6.7.1). In Penestanan the pattern of access to ricefields is slightly less favourable than in Taro. Of the 124 families surveyed (every family in the village) slightly over half own ricefields and 11 of these families rent additional fields. About one quarter of families have access only by rental, and another quarter of the families have no access to ricefields. For the village as a whole average access is 28 Are per family (see Table A6.7.2). In Tegal Tugu slightly over half the 98 families surveyed have access to ricefields by ownership only, while 14 families rent additional ricefield. About a quarter of the families have access only by rental, and a quarter have no access to ricefields. Overall, average access to ricefields is 45 Are per family (see Table A6.7.3).

Dryfields.
In Taro a larger proportion of families have access to dryfields than to ricefields. The average area owned is 48 Are, average area rented 21 Are and those families owning and

75 Access here is defined as access by ownership and/or rental. It should be borne in mind that experience gained in the surveys of rice cultivation shows quite clearly that farmers (hence families) do not have an accurate idea of the extent of land that they own/rent. For details see Tables A6.2.1-4.
76 Attention is drawn to the notes to Table A3.19.1, concerning the accuracy of the figures on which the table is based.

renting have access to an average of 60 Are, overall median access is 30 Are. However, the range of access is very broad, from 3 to 400 Are (see Table A6.7.5). Only one fifth of the families in Penestanan have access to dryfields by ownership and/or rental. Average access for the 22 families owning and/or renting dryfields is 5 Are, median access for the whole village, however, is only 0.1 Are per family (see Table A6.7.6). Less than one fifth of the sample of families in Tegal Tugu have access to dryfields by ownership and/or rental. Average access among families that own and/or rent is 9 Are, and median access only 0.1 Are (see Table A6.7.7).

It is clear that, simply due to lack of access, dryfield agriculture in Penestanan and Tegal Tugu is much less important than in Taro. In Taro more families have access to larger amounts of land than in the other two villages, where few have access and the average size of the fields is quite small.[77] In Taro, although drylands are not generally intensively cultivated, substantial areas of corn and root crops (sweet potato, cassava and taro) are seasonally cultivated and most fields have large numbers of coconut and other fruit- and nut-bearing trees of nutritional and economic significance.

Ricefields and Dryfields Combined.

On a per family basis, Taro is the best endowed with land resources and Penestanan the least well endowed. The balance between the villages in terms of potentially productive land (wet vs dry fields) favours Tegal Tugu most and Taro least; however, within each village the balance of access to wet and dry fields between families is very variable.

In Taro, on average, families have access to a combined area of 67 Are of wet and dry fields (median 55 Are). Almost half have access to less than 50 Are and only 19 families (14%) have access to more than 100 Are (1 ha). In Penestanan, average access is only 33 Are (median 30 Are), over three quarters of the families have access to less than 50 Are and

77 Although detailed data are not presented here, most dryfields in Penestanan and Tegal Tugu have little more growing on them than a few coconut and banana trees, the majority of the fields being overgrown by alang-alang (I. cylinderica).

only two families to more than 100 Are. In Tegal Tugu families have, on average, more land than in Penestanan and less than in Taro. Average access is 54 Are (median 35 Are), almost three quarters of the families have access to less than 50 Are and only 12 families out of 98 have access to more than 100 Are (1 ha).

Access to agricultural resources, the traditional basis of livelihood and wealth, has become less important as other sources of income have become available. Between the three villages there is a clear gradient in terms of how important access to land is for the three different income groups (see Figure 6.9). In Taro greater access to both ricefields and dryfields is significantly linked to a families' income level, i.e. those with more land are highly likely to have a higher income. In Penestanan access to land, particularly ricefields, while important, is less so than in Taro, while in Tegal Tugu there is no significant linkage between the income groups and access to agricultural land (see Table 6.11).

Table 6.11:
Three Villages: Access to Agricultural Land and Income Group.

Income Group % of Village	Low 40		Middle 40		High 40	
Land Access (Are)						
		Taro				
Ricefield	17		26	c	39	a
DryField	29		40	b	72	a
Total	46	c	65	b	111	a
		Penestanan				
Ricefield	18	a	32		42	a
DryField	3		4		10	c
Total	21	a	36		51	a
		Tegal Tugu				
Ricefield	37		46		58	
DryField	11		11		3	
Total	46		57		61	

Notes see Footnote 78.

The import of this pattern is that as modernisation proceeds access to agricultural land, of itself, becomes a less and less significant factor in the differentiation of income and,

78 T-test significances: a=<0.005, b=<0.02 and c=<0.05; letters after the last column are the significance between families in the Low and High Income Groups.

hence, economic well-being. More generally, it is an indication that as the ecological transition proceeds access to local, sustainable resources declines in importance as extra-local income sources, many dependent on non-renewable resources, become more important.

Arguably, it is the high income groups greater access to land and capital accumulation that has allowed them to take earlier and greater advantage of non-agricultural income sources than the low income group - via better health, more education or socio-political influence in obtaining wage incomes and relatively higher paying employment. There is, for instance, a clear trend for husband's and wife's average years of education to increase from the low to high income group (see Table A6.8.1 and 4). In each of the villages there are significant correlations between the household head's years of formal education and total family income; and, except in Taro, more education also correlates significantly with higher income from wage and non-agricultural sources (see Figure 6.10 and Table A6.8.2 and 5). Whereas, except in Taro, there are no significant correlations between the husbands access to land and education.[79] Given the average ages of husbands and wives in each income group (about 41 and 35 years respectively) the education they received occurred 30 to 25 years ago, well before the current wave of modernisation.

6.5.2 Availability of Adult Labour.

The second factor that might help account for the development of differences between income groups is the availability of adult labour.[80] This is because the effective adoption of new rice technology, which is generally more demanding in the timeliness of operations (e.g. applying fertiliser, weeding) than traditional cultivation, requires adequate labour be available 'on time'. The analysis in the previous chapter

79 There does not appear to be any clear trend in the age of husbands and wives, either across villages or income groups. For computational convenience female household heads are included with male heads.

80 Chayanov (1925) was probably the first writer to fully analyse the importance of available adult labour to peasant agriculturalists - emphasising the 'labourer/consumer balance', the ratio between producers (adults) and dependents (family size). See Kitching (1982:47-9) for a clear exposition of this analysis and, more generally, pp 47-56 for a lucid summary of Chayanov's overall analysis of 'peasant economics' and its contrasts with neo-classical economics.

clearly shows that families with lower per capita access to ricefields devoted significantly more labour per unit area to cultivation, i.e. the poorer members of the community worked their ricefields 'harder' than wealthier families. This is a direct indication that poorer families do not lack sufficient adult labour for effectively adopting and working with the new rice technology. However, wealthier families having access to more land may well be supplementing family labour with hired agricultural labour, as they now devote more of their energy to obtaining income from non-agricultural activities.

Differences in adult labour allow wealthier families to have more family members gaining income from wage and/or non-agricultural sources. Except in two instances, low income families in Penestanan and Tegal Tugu, adult labour is not significantly correlated with total family income (see Table A6.4.7); indeed for middle and high income groups in each village there are as many (non-significant) positive as negative links between adult labour and family income. Nor, except for low income families, is family income correlated with family size - indicating, possibly, that contributions by younger and older family members may be more important in gaining income for poorer families.

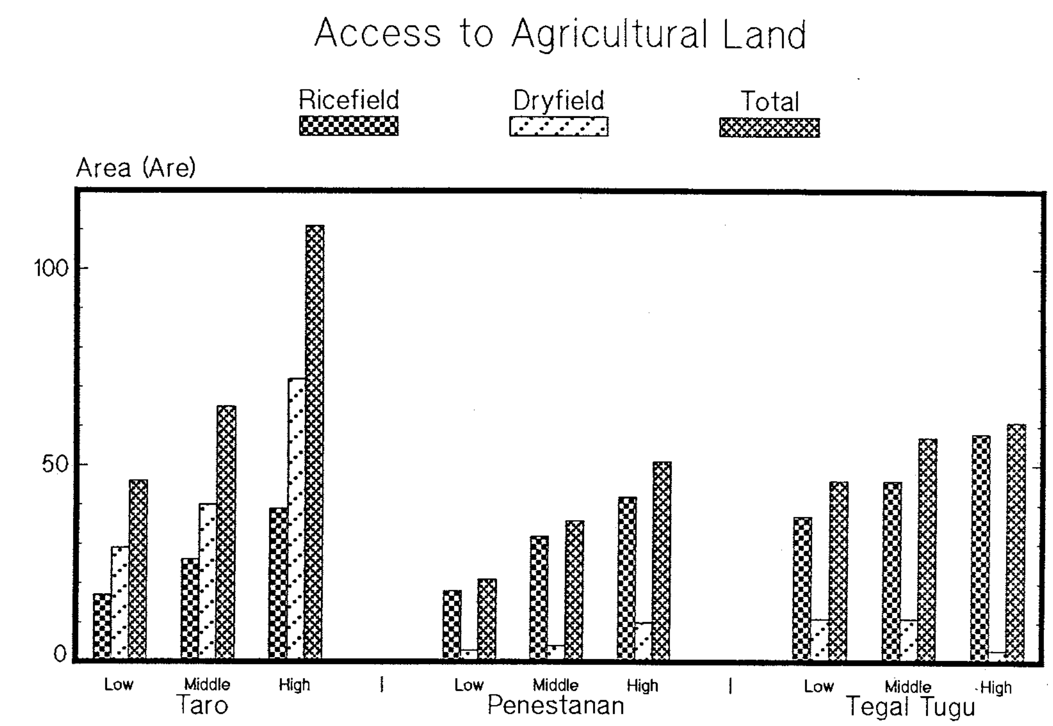

Figure 6.9: Access to Agricultural Land by Income Group.

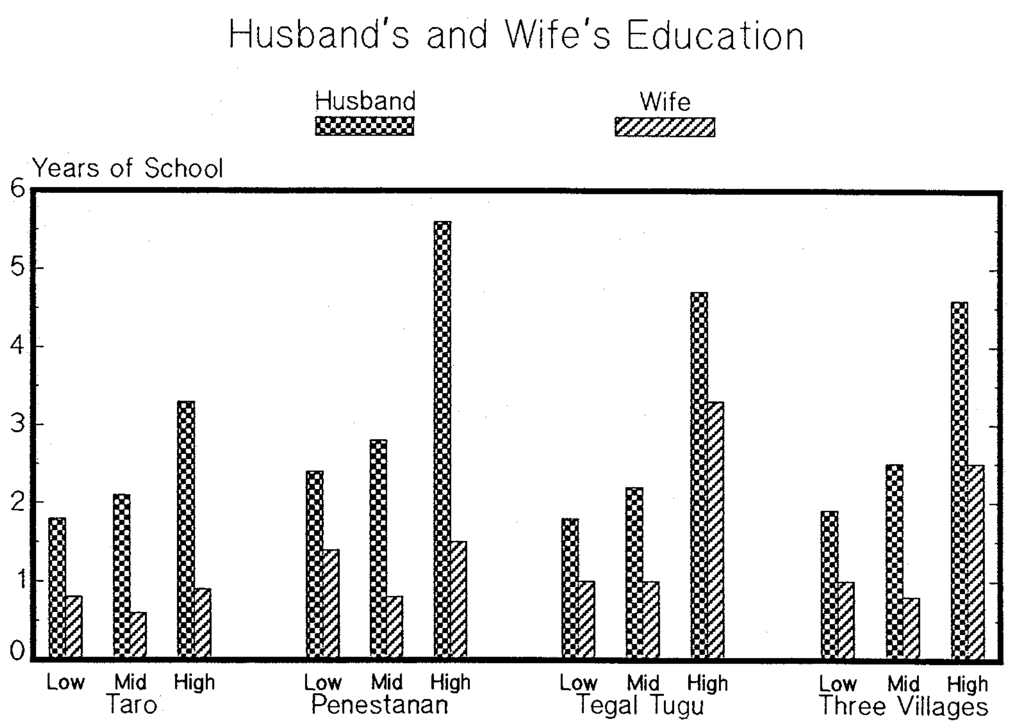

Figure 6.10: Husband's and Wife's Formal Education by Income Group.

6.5.3 Access to Agricultural Credit.

As part of the introduction of HYVs, farmers were offered low-interest credit for purchasing seed, fertiliser and pesticides, land preparation and pre-harvest living costs, via the BIMAS programme. The amount of credit was linked directly to the amount of land owned, and farmers with less than 12.5 Are were not (initially) eligible. The exclusion of the smallest land holders meant, because of the linkages between land access and income, that the poorest farmers did not have access to government subsidised agricultural credit.[81]

Because the amount of credit was linked to area, farmers with the most land, that is those already relatively well-off, received substantially more government assistance in absolute and per capita terms than (poorer) families with less land.[82] The combination of these two factors resulted directly in the initial financial advantages of the new rice technology flowing disproportionately to the already well-off.[83] Moreover, the diversion of cheap government credit by wealthier families to other non-agricultural investments allowed them to take an early advantage of non-traditional income sources, associated with agricultural diversification, urbanisation and tourism.[84]

6.5.4 Access to Agricultural Markets.

Tegal Tugu's peri-urban location certainly gave farmers there earlier access to modern inputs for HYVs and broader general access to markets for the sale of their 'surplus' production. Due to improvements in the marketing, transport and agricultural extension system, the initial benefits enjoyed by Tegal Tugu had, however, all but disappeared by 1982/83.[85] If

81 Farmers owning less than 12.5 Are (0.125 ha) constitute approximately 20% of the sample in Taro, 2-10% of the sample in Penestanan and Tegal Tugu, and 10-20% over the three villages (see Tables A6.2.1-4).
82 Currently (1982-83), despite these earlier disadvantages, smaller farmers use more labour and material inputs per unit area; although as the analysis in Chapter 5 shows, the linkage between inputs and yields is tenuous at best.
83 The (ab)use of this credit for the purchase and/or investment in goods and services not related to rice cultivation has been well documented (see for instance, Husken 1984 and Maurer 1984).
84 For example, agricultural processing, new dryland crops, petty trade in new consumer goods, providing tourist accommodation. In addition, additional income would have provided funds for extending their childrens education, thus increasing their potential income in the future.
85 The desire of the government to purchase all the rice they could, mainly for shipment to urban and 'rice deficit' areas, prompted them to both ensure that inputs were widely

any residual differences in input and output markets still exist then these are related to location rather than income, as within each village farmers can buy and sell agricultural necessities with equal facility.

In summary, factors of agricultural production (labour, credit, markets) are not currently the primary factors distinguishing between richer and poorer families; and agricultural income, absolute or relative, is not currently a significant source of income for wealthy families. In fact, the greater investment of labour and physical inputs by smaller farmers generally results in (markedly) higher rice production per unit area. Despite this, rice production is almost totally determined by the area cultivated, thus favouring larger over smaller landholders.

Access to land must have, however, played a significant role in capital accumulation (social and/or physical) by providing wealthier families with continuing access to more education, greater general knowledge of new economic opportunities, greater mobility and, quite probably, better general nutrition and health. These factors, plus earlier and larger surpluses of income from growing HYVs, allowed them to expand their range of income sources until, by now, it is non-agricultural and extra-local income sources that are most significant in explaining income differentials.

6.5.5 The Importance of Non-Agricultural Income.

The key to explaining differences in access to the material benefits of modernisation is closely associated with the size of wage and/or non-agricultural income. It is wealthier families that derive the greatest proportion of their income from wage and non-agricultural sources, whose importance increases as modernisation proceeds, that is from Taro to Tegal Tugu. Despite the fact that wealthier families have significantly greater access to land and very probably derived most benefit from cheap agricultural credit, currently it is <u>not</u> agricultural income that is significant in differentiating

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available to maximise yields and that farmers (or rice mills) could confidently sell all their surplus rice at a guaranteed price.

between the three income groups. Wage and/or non-agricultural incomes are the critical determinant.

Two hypotheses are possible:

> Greater access to land provided the necessary surplus for a family to make a shift towards taking more advantage of the expanding 'modern' sector of the economy by investing in non-agricultural income sources; or
>
> Access to land was not directly relevant to the growing importance of the modern sector to wealthier families, but more education, better health and so on, enabled them to take greater advantage of new opportunities.

On the basis of the available evidence it is not possible to determine which of these hypotheses is correct. However, the second hypothesis has the advantage of better accounting for the initial advantages that wealthier families had and the manner in which these, in combination with additional agricultural income, have allowed them to benefit disproportionately from modernisation.

6.6 Conclusions.

Analysis of the trends in the scale and sources of income clearly show that as modernisation proceeds there is a widening gap in income differences between families with low and high incomes in each community. Families in the high income group gain significantly more income from wage and/or non-agricultural sources than low income families. One of th factors associated with the level of income is the number of years of formal education received by the household head, as more education is required for access to better paying wage employment. As for the relative scale of average incomes, tl low income group currently has the most restricted access to the fruits of modernisation, in particular education.

The conventional analysis would suggest that, even if the po do not benefit from modernisation as quickly as the rich, th fruits of development will eventually reach even the poores people. Yet, in each of the villages the average income of families in the lowest four income deciles is almost identical. Whereas, the average income of the top 20% of t income spectrum are about four times that of the lowest 40%, and their range of income sources broader and more closely linked to generalised changes in the economy.

The 'static' income situation of poor families leads to the conclusion that, even after an extended period of modernisation, (15 plus years in Tegal Tugu) the per capita and family income situation of the poorer families has not been markedly improved by widespread changes in the island's economy. The economic benefits of modernisation have not 'trickled-down' to the poorest parts of the population. Further, if the government statistics on income distribution for the period 1971-84 are even partially accepted, the situation of both the poor and the rich has become more entrenched over time.

In periurban communities, such as Tegal Tugu, longer contact with modernising influences has provided the population with more time to adopt and/or adapt to changes in opportunities offered by new types of employment. In contrast, in communities where tourism has brought a sudden 'new wave' of income opportunities, such as Penestanan, a radical departure from the traditional pattern of income sources has rapidly occurred. Changes in income sources and differentials (inequality) in a community such as Penestanan offer new, economically rewarding entrepreneurial opportunities outside the evolving traditional economy and social constraints, and are more extreme than in a 'slowly modernising' village such as Tegal Tugu or a remote village such as Taro.

The general pattern is that families with most access to wage and other non-agricultural incomes are those faring best. These families have higher total and per capita incomes and have reserves in the form of cash savings (see Tables A6.3.1-4). Conversely, those families which rely most on agriculture for their income are the most likely to be in straitened economic circumstances and have no savings to fall back on in the event of illness or harvest failure.

From the perspective of resource use, families making the most use of a wider geographic range of non-traditional income sources (generally wages) are consequently making greater direct and indirect demands upon extra-local natural resources (e.g. energy and manufactured goods) to maintain their incomes. This dependence ranges from the use of motorised transport to get to-and-from urban-based work and transport of people and goods to-and-from the island (e.g. tourists and consumer goods), to the general reliance on indirect energy inputs for construction of urban, transport and communication infrastructures essential for operation of contemporary government and commercial activity.

The chapter began by outlining macroeconomic changes occurring in Bali. Attention was directed to changing patterns of production and employment, the declining importance of agriculture and the rapidly increasing importance of the tertiary sector of the economy, particularly tourism. When these changes are taken in conjunction with the rapid increases during the last 10 years of direct and indirect energy imports (fossil fuels, agrochemicals, and construction, transport and consumer goods) it is clear that Bali has and is undergoing a major socioeconomic transformation. The tendency is for income inequalities to increase, both between urban and rural areas and within rural communities, undermining the rough economic equality of traditional village communities.

In this chapter it has been argued that one of the aspects of the ecological transition i.e. modernisation, is increasing income inequalities and, as a consequence, increasing inequality or discrimination in access to the advantages of modernisation. In the three Balinese communities studied these inequalities take the form of poorer members of the community having less access to more economically rewarding wage-paying and/or non-agricultural employment than the better-off members of their communities. Moreover, although access to agricultural land no longer seems to be a significant determinant of income levels for the high income group, their prior (and continuing) access to more agricultural land correlates positively with longer formal education and, hence, earlier and readier access to modern jobs and higher income levels, although no definite causal links can be demonstrated.

In turn, higher incomes allow greater purchasing power for the better-off members of each community, for both traditional and modern items of consumption. Despite some caveats it is quite clear that families in the high income group in each village consume more, both absolutely and relatively, of the range of items classed as modern than do low or middle income families. Further, it is apparent that high income families have greater income adequacy, less potential indebtedness and significantly higher surpluses and cash savings than low (or middle) income families. There is, thus, emerging a situation within each of these relatively small communities where the poorer families cannot afford to spend as much for feeding, housing, clothing, health and educating their children as do richer families. The effects of this distinction seem to be appearing most rapidly in Penestanan, the village where modern sources of wealth are most recent.

The twin notions of increasing variability and declining sustainability were originally introduced in relation to widespread changes in the energetics and economics of rice cultivation, brought about by adoption of HYVs of rice and the technological transformations accompanying these changes. Here it may be possible to extend these notions to include the impact of modernisation in the more diverse socioeconomic sphere.

Traditional rice cultivation was genetically, ecologically and economically self-sufficient within the local area. The Green Revolution rice agriculture is dependent on a chain of urban-mediated, extra-local inputs. The parallel in the socioeconomic sphere, which includes agriculture, is increasing dependence on extra-local employment, manufactured goods and energy supplies, all of which are urban dominated. In addition, the modernisation under way is being accomplished at the cost of increasing economic variability, that is, growing inequalities in income within the villages studied (and island-wide). Moreover, because many of the changes are being initiated from outside the village community, indeed the island, economic modernisation carries with it a divestment of (traditional) local control similar to that occurring in (rice) agriculture.

There are, thus, three parallels between rice agriculture and the socioeconomics of family income and expenditure:

> modernisation in every sphere of village life is leading to increasing variability - in rice cultivation to reduced yield stability due to crop losses, in socioeconomic welfare to widening income inequalities, due partly to the income advantages of the very limited non-agricultural job opportunities;
>
> a loss of local sustainability - in agriculture an increasingly crucial dependence on extra-local and non-renewable resources, and for family income an increasing dependence on urban and/or tourist based employment, which is reliant on (inter)national economic priorities and the vagaries of tourist preferences;
>
> a widening sphere of loss of local control over information and local resources - in rice cultivation a reliance on more 'expert' scientific information and control, loss of genetic material and growing dependence on government agricultural price policies, in socioeconomic welfare a trend towards requiring extra-local information (education) for maintaining economic well-being, the remoulding of traditional village institutions to suit government development policies and a growing 'export' of local resources (wealth), in order to acquire the material and social fruits of modernisation.

With the exception of increasing economic inequality, the above changes are all consequences that Bennett (1976) identified as part of the ecological transition, the shift from "equilibrium to disequilibrium" (Chapter 2). It may be that in the medium term growing economic inequality (variability), a social outcome that Kuznets (1966:47) associated definitively with economic development, will result in serious breakdowns in traditional village social solidarity, leading to the development of self-recruiting groups of 'rich' and 'poor' families within relatively small village communities. To some extent this appears to be already occurring, and there is growing evidence that such a trend has been underway for some years in Java (Alexander and

Alexander 1982; Husken 1984; Hart 1986). In the longer term, continuation of current practices and trends, particularly in agriculture, commercial and demographic pressures may lead to the adoption of new cropping practices, crop varieties and agrochemicals that are even more detrimental to the health of farmers, the soil and the longer term sustainability of food production levels necessary to meet local nutritional needs.

Chapter 7

The Ecological Transition in Bali.

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:
> . the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
> . the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. (WCED 1987:43)[1]

7.1 Introduction.

Around the waists of temple statues all across Bali are wrapped *sarongs* of chequered black and white cloth. This pattern symbolises the inextricable intertwining of good and evil in the material world. It is also a metaphor for the traditional role that humans play in this 'middle' world, living between the realms of beneficent spirits 'above' and malelovent spirits 'below'; balancing the spiritual forces of good and evil by fulfilling ritual obligations to gods and ancestors. This ancient symbolism provides a potent metaphor for the ecological costs and benefits of modernisation. For only if the human-environment patterns (ecological relationships) built-up by the Balinese over hundreds of years can be thrown aside without detriment may it be said that the benefits of modernisation carry with them no significant losses. This is not the case, and the costs and benefits are as inextricably interwoven as the chequered cloth.

Traditional Balinese cosmology and moral philosophy defined humans' role in relation to the natural and spiritual worlds.[2] The Balinese believed, in general, that: a) humans reflected in their physical and spiritual existence the larger universe in miniature - a congruence of the micro and macro universe; b) the Balinese considered that they had usufruct of the

1 The World Commission on Environment and Development (WCED).
2 See notes in the introductory chapter by Swellengrebel (1960:36-61) and Goris (1960:79-100) for a fuller description of the integration of spiritual and material life in traditional communities.

natural world, but did *not* stand in position of ownership or dominance; c) that the success or failure of human actions, individual and collective, depended crucially on maintenance of a complex of ritually correct relations with the underlying spiritual order of the universe; d) the individual or community was not 'progressing' towards anywhere, that is life consisted of a decliningly perfect repetition of forms handed down from an earlier, mythical golden age.[3]

These beliefs entered into and constrained all types of traditional productive activity, and pervaded and guided the whole lifestream of individuals and communities. This complex of beliefs and practices stands in clear contrast to the 'rational' beliefs and actions embodied in the ideology and practice of modernisation. Moreover, given that the traditional society was ecologically sustainable, the belief structure was integral to this sustainability, providing an ideological framework that placed humans in a supplicant role vis-a-vis the natural world and the resources it provided. It is also true that traditional Balinese society lacked the technical means to undertake the types of transformations occurring today, although the terraced ricefield landscape bears witness to their ability to organise human labour so as to transform the major components of the whole region of Southern Bali.

The ideology of modernisation contrasts sharply with these traditional beliefs. At the root of the extraordinary value placed on the advantages of modernisation are assumptions that:

> what is traditional is 'irrational' - i.e. unscientific within the Western reductionist tradition;
>
> traditional use of natural resources is technically inefficient - i.e. productivity can be significantly increased solely by the adoption of modern methods;

3 This paragraph is deliberately written in the past tense, to emphasise the contrast between the traditional stream of belief and the changes in their belief system being wrought by modernisation.

traditional harmony within and between nature and society is less productive than modern, industrialised production - i.e. maximum productivity can only be achieved by striving for domination over the natural world; and

finally, and most importantly, the traditional intertwining of the socio-cultural milieu and economic production must be sundered, if the material advantages of modernisation are to be realised.

Only if most of these assumptions are at least partially valid, is it possible for the benefits of modernisation to be realised without significant costs to individuals, civil society and the environment.

In this final chapter evidence on agricultural and socioeconomic transformations occurring in Bali is brought together and the conclusion reached that an ecological transition is taking place, the like of which the Balinese have not previously experienced. This latest transition began some fifty years ago and is intimately bound-up with changes in the regional political economy of Balinese society. In ending Bali's political independence at the turn of the century the Dutch started the process of Bali's eventual incorporation into the nation state of Indonesia. The majority of agricultural and socioeconomic changes occurring in Bali, particularly since 1965, mirror Jakarta-initiated changes taking place throughout Indonesia, especially Java.[4]

Within a broader historical context of earlier ecological transitions in Bali, this chapter first draws attention to the fundamentally different character of the current wave of modernisation. Second, the empirical results of the research are summarised. In two tables (7.1 and 7.2) the main features of the agricultural and socioeconomic transformations are presented in point form.[5] Third, these results are contrasted

4 The only, vaguely similar, historical precedent in political economic terms was the final Majapahit invasion of the island in the 14th century, which established the political basis for rule by court-based gentry until this century. The extractions of labour and produce imposed another economic 'layer' upon the existing political economy. They also acted as a focus for religiously-inspired creativity in the plastic and performing arts (cf Geertz 1980).

5 It is not suggested that these summaries cover all aspects of the changes occurring Balinese society. The aim is to focus attention on features of village life in which there have been profound changes in the relation between the inhabitants and their environment, both natural and socio-political.

with traditional system of decision-making in Balinese villages and the profound changes that modernisation has wrought in information flows. Fourth, the import of these changes are set within the broader context of the concepts and methods used in human ecology. Fifth, the central argument of the thesis is restated, and related to criticisms of conventional styles of capitalist modernisation made by other scholars.

The final two sections of the chapter return to a discussion of the practical implications of the research. The first of these locates the 'ecological failure' of the Green Revolution in the unwillingness of institutionally-based researchers to take advantage of and incorporate 'real world' farmers' knowledge in devising modifications to traditional cropping systems. The final section examines some practical constraints on and options for increasing food supplies in the future.

The conclusion is that the recent rapid decline in population growth rates, the current world surplus of grain supplies, new approaches to agricultural intensification and active co-operation between farmers and scientists offer unparalleled opportunities for placing future increases in agricultural production on a sustainable footing, in Bali and elsewhere.

7.2 Ecological Transitions in Bali.

The current ecological transition is not the first change in human-food production relations that has occurred in Bali, or Indonesia. After a transition to settled communities, albeit using slash-and-burn technology, the adoption of irrigated rice cultivation constituted the first major transition. The introduction of new staple crops by the Portuguese marked a further transition in food production possibilities. Finally, introduction this century of shorter-maturing rice varieties provided a new biological foundation, facilitating and simplifying double-cropping rice. Each earlier agricultural transformation led to technological innovations, furthering local human control over the food-base and stabilising output levels, by improving the degree of environmental control and diversifying the staple crop base.

The first ecological transition occurred during the long period after the introduction of wet-rice cultivation (*pertanian sawah*). The advantages of the 'new' technology of irrigated agriculture - higher and more stable yields - ensured its dominance over earlier dryland agriculture (*ladang* and *tegalan*), particularly in the southern part of the island. The 'new' technologies of irrigated rice cultivation both added to and supplanted agricultural technologies, already thousands of years old. During this period countless thousands of 'person-years' of work must have been devoted to channeling, tunneling and terracing of today's nearly 1000 km^2 of irrigated ricefields. This investment of human labour in modifying the original landscape is the 'capital' upon which much of what is regarded as especially Balinese (socially, culturally and spiritually) has depended until recently.[6] Contemporary modernisation efforts in agriculture also depend upon this environmental and organisational base.

A second transition occurred after introduction of new staple crops - sweet potato, cassava and corn (*ketela rambut/selo, ketela pohon* and *jagung*) - to the archipelago, sometime during the 17th century. Prior to this the Balinese would have had access only to various taro species and other minor root crops for carbohydrates to supplement rice. Little information is available about how long it took for the new crops to be integrated into the agricultural system. Comments from visitors during the early 19th century give the impression that by then these crops had been widely adopted and formed part of the staple diet (Crawfurd 1849:237-8).

The third major transition took place during the late 19th and early 20th century. This was the result of Dutch sponsored improvements to traditional rice cultivars, in particular, carried out in Java; seeds of which would probably have found

6 Social investments of this type are sometimes referred to as landesque capital: "any investment in land with an anticipated life well beyond that of the present crop, or crop cycle. The creation of of landesque capital involves substantial 'saving' of labour and other inputs for future production." (Blaikie and Brookfield 1987:9).

their way to Bali prior to the Dutch invasions of 1906-08. It is also probable that the Dutch (or Japanese) introduced new rice cultivars with shorter growth periods (130-50 days), in the 1930s or 1940s; traditional landraces of rice require some 210 days for maturity.[7] In Southern Bali this led to a cropping pattern with traditional long-maturing varieties (*padi del/tahun*) grown during the wet season (October-April) and a second shorter-maturing crop (*padi cicih*) during the dry season (May-September).

Each of these ecological transitions adapted piecemeal ideas and materials as they became available - new technologies gradually being integrated with existing practices. Importantly, additions to the local technological base had to fit within available energy resources: solar energy, human and draught labour. The ecological advantages (for humans) of these new technologies lay in being able to more efficiently convert these resources into food. This meant that, once established, no further extra-local inputs were needed to maintain new, higher levels of food production. Thus, despite a slowly increasing population, Bali continued to produce significant surpluses of food for export until the depression of the 1930s.

In sharp contrast to contemporary agricultural and socioeconomic transformations, none of the earlier transitions led to increased extra-local resource dependency nor, arguably, to increased variations in yields (the reverse being more likely). Neither did they result in 'urban-like' concentrations of population, whose livelihood was divorced from agriculture and rural life.[8] The current ecological transition is of a very different nature and order.

7 The 130-50 day rices are know as padi cicih (roughly 'quick' in Balinese) and the 210 day varieties as padi del ('long' or 'slow') or padi tahun (210 days = half a Balinese ceremonial year).

8 There are two minor caveats to this assertion: first, communities in the irrigated areas probably benefited more than those in the higher, drier parts of the island (i.e. above about 6-700 m) from new rice cultivars; second, the larger court centres in some places did have significant numbers of artisans engaged in specialised, non-agricultural, production of luxury cultural items for the gentry - however, even by 1920 the total population in the large court-centre of (what is now) Den Pasar only numbered 8,500 (5%) out of 173,300 people in the Badung Regency (Kabupaten) and about 1% of the population of all Southern Bali; even by 1930 urban population island-wide only constituted 2.6% of the island population of 1.1 million (see Tables A3.4.1 and A3.11.1).

The distinguishing characteristics of the current transition in agriculture, setting it apart from previous ones, are:

> the deliberate and state-initiated introduction of new plant cultivars, specifically rice;
>
> the requirement that there be a continuing supply of extra-local, industrial inputs (seeds, fertilisers and pesticides) to maintain productivity of new varieties;
>
> divestment of local agricultural institutions (*subak*) of major elements of responsibility and control over irrigation and agricultural planning to the state;
>
> the role of the new HYV technology in subsuming the traditional 'peasant economy' within the national cash economy; and
>
> continuing extra-local (urban) control over the flow of information necessary for meeting ever-new environmental threats to HYVs.

If these were the only agriculturally-related transformations, they would provide sufficient grounds for concluding that a major ecological transition has been taking place in Bali during the last 50 years. However, broadscale economic and technological changes, catalysts for a socioeconomic transformation, add further dimensions to changes in staple crop agricultural ecology.

7.3 Results of the Research.

The empirical investigations undertaken for this thesis have focused on two activities central to the ecological transition - the nature of staple food production and economic activities - using data from three villages to examine in detail the transformation of traditional practices.

First, the effects of modernisation on the energetics and economics of rice production were investigated. Second, access to the material benefits of modernisation were studied by analysing changes in sources of family income and patterns of family expenditure. These changes were set in the context of broader transformations in Balinese society and resource use during the last 15 years, in particular.

The two previous chapters analysed how modernisation affects the variability, resource dependence and sustainability of traditional systems of rice cultivation and village incomes and expenditures. Here the results of these two chapters are summarised, prior to discussing their broader significance for Balinese society and, by implication, Indonesia.

7.3.1 The Transformation of Rice Cultivation.

At the advent of the New Order in Indonesia in 1965/66 the technology of rice cultivation in Bali was much as it had been prior to independence in 1945. The varieties of rice were largely those grown for hundreds of years. Likewise, the technology used for cultivation and processing were almost wholly traditional, and the area of irrigated rice under cultivation remained almost as in the 1920s. There is no evidence that significant numbers of farmers were using inorganic fertilisers or that rice agriculture had become commercialised. Within this socio-technical framework, the only major change was a response to increasing population by a gradual increase in the area of rice fields double-cropped. Dryland agriculture changed even less, according to government statistics. Examination of staple food availability for the pre- and post-WWII periods shows that, if anything, average per capita food energy and protein availability had fallen slightly by 1969 over pre-WWII levels.

Between 1969, the advent of the Green Revolution in Bali, and 1982 rice agriculture changed from what the FAO has typified as 'low' input to 'high' input farming (Higgins et al 1982:10). During this period island-wide official rice yields rose by some 40% and annual production increased by about 70%. By 1982 these production increases were based on large imports of fertilisers (70,000 tonnes) and pesticides (621 tonnes).[9] An analysis of the production increment achieved by the use of HYV seed-fertiliser-pesticide 'package' showed that there had been an almost one-for-one exchange between the increment in food energy produced and the fertiliser imported for use in rice production (see Section 3.4.6.3). Despite, or because of, these technical changes the year-to-year stability of production declined. Prior to WWII annual variability (CoV)

9 In parallel, widespread improvements in irrigation facilitated almost universal double or triple-cropping of rice.

of production was low (3.3%), rising to about 8.3% by 1957-68 and reaching 14.5% during 1969-84, largely reflecting marked increases in losses due to the growing range of rice pests and diseases[10] and also the extension of irrigation into areas with more marginal water supplies.[11]

At the island-level it is clear that there has been a trade-off between increasing production (by pushing the agricultural system 'harder') and decreasing reliability (by upsetting/undermining traditional ecological balances) - in addition to a growing dependency on imported energy-intensive agrochemicals. The changes between traditional and contemporary rice cultivation are summarised in Table 7.1.

Looking at these changes from the macro (government) level the trade-off between increased production and decreased reliability has been beneficial on the whole, matching food production increases to population growth. Moreover, there have been significant 'surpluses' in many years for export to the rice-deficient area of Indonesia.

10 In contrast to published official statistics, which show little change in losses to pests, unpublished official data show annual losses over 1969-83 averaging about 7% of total production, the area affected each year increasing and the range of serious pest and disease species expanding markedly.

11 In addition to crop losses to pests and diseases the shorter growing period of the HYVs (about 100 days after transplanting) in comparison to TLVs (about 130 days) compresses the time available for the plant to recover from any disruption of growth processes. Thus, a brief period of water stress has a much greater affect on potential yields with HYVs than for TLVs; in addition, HYVs are more physiologically susceptible to water stress than TLVs.

Table 7.1:
Summary of Major Differences between Traditional Varieties and High Yielding Varieties of Rice and Systems Management.

Traditional Varieties	High Yielding Varieties
Seed: Seed for the next seasons crop is selected by the farmer from the current seasons crop; receives extra attention in drying and storage; different cultivars obtainable from other farmers.	Developed from selected seed in the Philippines, requires special facilities for seed multiplication, testing, packaging and distribution; seed reliable for only 2-3 crops before replacement required.
Genetic Qualities: Result of hundreds of years of farmer selection for: higher yield, height, pest and disease resistance - minimax rather than maximising strategy; 140-210 days from germination to maturity; long, thin stems; susceptible to lodging with fertiliser; superior grain quality.	Result of special breeding and backcrossing, selected for: high yield-response to nitrogen fertilisers; shorter time from germination to maturation (110 days); variable resistance to a range of common pests and diseases: short, thick stems less susceptible to lodging; acceptable grain quality.
Germination: Heads of seed rice placed in carefully arranged rows, in prepared and manured seedbed; offerings made.	Carried out in wet bags, but generally directly seeded to seedbed; responds to basal application of Urea/TSP.
Fertilisation: Yields well with sufficient green and animal manures; good response to low to moderate (10-100 kg/ha) application of Urea; severe lodging at higher rates due to excessive vegetative growth.	Requires several applications of Urea at rates of 200-300 kg/ha to achieve yield potential, may also require TSP; low and unsystematic use of green and animal manures.
Irrigation: Traditional varieties capable of withstanding moderate to high water stress; local control and maintenance of irrigation; inter-subak coordination for water allocation within a watershed.	Requires very careful water control; more susceptible to water stress; improvements in traditional system has resulted in control over local systems increasingly being taken by government officials.
Crop Protection: Insect pests controlled by careful inspection and removal; locally made, ingenious devices to scare away birds; pests and diseases controlled by special cropping patterns; crop protection integrated with religious beliefs.	Manufactured chemical fungicides, pesticides purchased for cash; applied using backpack sprayers, no safety precautions generally taken; widespread destruction of non-target organisms and disruption of ricefield predator-prey balance.
Harvesting: Only top 25-30 cm of stem harvested, each stem cut individually with small knife; grain on the stem made into sheaves for transport and storage; harvested by special village teams; share to team 1:10-12 of harvest.	Stems cut low to ground with sickle; grain threshed in field; low to moderate losses due to shattering of panicle during harvesting and scattering during threshing; increasing use of contract labour and/or pre-selling prior to harvest; share to harvest team 1:8-10 of harvest.
Grain Drying: Sheaves of grain stood on-end, opened and sun dried prior to storage and handpounding.	Loose grain spread on dry, flat surfaces and sun dried, prior to storage and/or milling.

Hand Pounding: Used to separate stalks from grain and, prior to introduction of mills, used to render clean grain from unhusked grain; work done by women working in small groups; non-family labour receiving 1:8-10 of clean rice as payment.	Not possible, as the husk is too thick and firmly attached to endosperm to be feasible; reportedly like rubber to pound; traditional mortars and pestles in disuse.
Processing: Traditionally by hand-pounding, grain brought down from rice barn when needed; currently nearly all mechanically milled; slightly higher milling yield than HYVs; cost 8-10% of clean grain.	Requires the establishment of mechanical mills, drying and storage facilities; overmilling results in lower yields and loss of bran, with consequent loss of nutrient quality; milling yield slightly lower than TLVs; cost 2-5% of clean grain.
Storage: Good storage qualities, with nil to low losses during prolonged storage - reportedly 5-10 years without deterioration of grain stored in sheaves.	Poor storage qualities, with losses of up to 20% reported after 3-4 months storage; longer storage results in higher losses and a rapid decline in grain quality (inedibility).
Taste: Most varieties, if not overmilled, have a nutty flavour; taste, texture and cooking qualities markedly preferred over HYVs.	Regarded by the population as being almost tasteless, or very bland, having only marginally acceptable cooking qualities; sometimes called '<u>padi plastik</u>'.
Energy Flows: Dependant only on solar derived inputs (flows and stores); input energy mainly human/draught labour. No dependence on non-local sources of energy; energy efficiency in the order of 1 in:12 out.	Dominated by energy content of Urea fertiliser (86%), energy value of human/draught labour now minor proportion of inputs; dominated by inputs depending on non-renewable sources. Sevenfold increase in energy inputs, one fifth rise in energy output: resulting in fivefold decline in energy efficiency: 1 in:2.3 out.
Economics: Traditionally no cash resources required for materials or labour; many transactions carried out on a barter basis with other farmers or members of the farmer's extended family group; essential credit available from subak; currently, 100% price premium over HYVs.	The need to purchase seed, fertiliser and pesticides means that farmers must have cash resources and/or credit extension facilities are required; may increase rural debt burden due to crop failures; net unit area income possibly lower than from TLVs.
Information: Essential skills and information passed on from one generation to the next; religious mythology contains didactic tales on the manner in which farmers should relate to their crop, ceremonies necessary for crop protection and giving thanks for a good harvest.	Introduction of HYVs requires the training and employment of extension workers; continual updating of information on new methods, pests and diseases; critical information, now generally, monopolised by urban-based, government functionaries with no direct interest in farmers welfare; traditional, elected leaders now largely incorporated into this structure.

System Management: Local control of irrigation by irrigation association (subak); inter-subak co-ordination of watershed-wide scheduling for irrigation and planting; planning integrated with religious calendar; subak organisation of system maintenance/expansion.	Bureaucratic (Public Works Dept.) control of major irrigation works down to secondary-level distribution; inter-subak co-ordination of irrigation and planting subordinated to Agricultural Service; integration with religious calendar broken; subak only responsible for low-level maintenance work.

If, as this study has done, these changes are examined from the point of view of the farmer or village, the advantages of adopting HYVs are less clear cut:

> A comparison of HYVs with traditional varieties revealed that about one third of farmers were obtaining lower yields than with the TLVs they had formerly cultivated.[12]
>
> In each of the three seasons surveyed the variability (CoV) of yield never fell below 20% and was, more typically, in the range of 30-40% (see Table 5.4).
>
> Consequently, individual farmers are faced with large season-to-season swings in productivity and net income.
>
> Therefore, village economies are subject to substantial unpredictability in income (in cash or kind) from rice cultivation, while having to fund large, fairly irreducible investments in the commercial inputs necessary for each season's cultivation .

This variability in yields led to an examination of the linkages between levels of inputs (labour and material) and the yields obtained. A detailed analysis of input-yield relationships showed that yields are statistically independent of levels of labour and material inputs, and that yields are linked more significantly to losses to pests/diseases than to inputs. It was suggested in Chapter 5 that the yield of HYV rice had become 'decoupled' from production factors under the control of farmers. In addition, the analysis threw light on the relationship between agricultural population density and labour intensity, adding weight to Wilkinson's (1973) hypothesis that higher population densities necessitate greater per capita labour inputs to maintain a given level of subsistence. The analysis also undermined the biological

12 Measured yields of HYVs are substantially below those claimed in official statistics for the areas around each village.

basis of Geertz's (1963) hypothesis of agricultural involution, higher levels of labour inputs did not result in higher yields, when other intervening factors (area cultivated and level of material inputs) were accounted for.

Attention was then turned to the energetics of rice cultivation, where human-mediated energy exchanges in food production are the 'currency' of analysis. Here the analysis confirmed that the generalised decline in energetic efficiency associated with agricultural intensification has also occurred in Bali. The main reason for this decline is the radical increase in the energetic content of inputs, particularly nitrogenous fertiliser, without a commensurate rise in the energy content of the food produced. On average, energy inputs increased sevenfold, while energy output increased by only one fifth. These calculations took into account direct and indirect energy costs of actual cultivation, while making no allowance for the ancillary energy costs of processing, storing and transporting the rice produced to other rural and urban areas. If the energy costs of these activities were also taken into account, then the energetics of contemporary rice production and distribution in Bali (and Indonesia) would be even less favourable than traditionally.

The comparative economics of HYVs and TLVs comprised the final step in the investigation of the impact of the Green Revolution on Balinese rice cultivation. This revealed that farmers would be economically better-off growing traditional varieties, unless heroic assumptions were made about the relative prices of HYV and TLV rice. The average cost of inputs for cultivating HYVs were about 2.5 times those for TLVs, while net income per unit area was only 1.2 times that of TLVs - assuming that the sale prices of HYVs and TLVs were identical at Rp 190/kg. If, alternatively, the prices of HYV and TLV rice were as in the market (Rp 190/kg and Rp 375/kg, respectively) then the net income per unit area from HYVs was only about 56% of that attainable from traditional varieties, despite lower yields. Several alternative explanations for farmers persisting in growing HYVs were canvassed, with the tentative conclusion that socio-political pressures are probably central in determining farmers' choices.

The direct consequences upon farm families' welfare caused by lower relative prices for the HYVs they are required to grow (and wide inter-seasonal variations in net income), immediately raises the question: Who is benefiting from the Green Revolution? In terms of the subsidies on inputs and credit provided through BIMAS, it is clear larger farmers have received greater absolute benefits than smaller farmers, as the amount of subsidy and/or credit has been tied directly to the area of land farmed. Additionally, an analysis by IRRI (1986:347-9) of distribution of net social welfare from the Green Revolution in Indonesia over 1977-83 indicates that two thirds of the net benefits have flowed to non-farmers (i.e. urban families) who, on a per capita basis, have received about eight times as much as the farm population. As a corollary, it is probably the poorer farm families who benefited least, and/or suffered most from the adoption of HYVs.

7.3.2 The Socioeconomic Transformation.

In Chapter 6 the socioeconomic transformations at the village level were set against a background of rapid changes occurring in the island economy, in particular: changes in workforce composition and sectorial rates of growth; growing inequalities in income distribution, rural-urban incomes and regional incomes; and the widening imbalance between imports and exports. The proportion of the workforce in agriculture (the dominant traditional source of income) declined during the last 15 years (from 67% to 51%), while the proportion employed in the tertiary sector grew (from 20% to 33%) and the proportion employed in the secondary sector increased (from 10% to 16%). Parallel changes in the value of sectorial production were even more marked, with agriculture now contributing less than half of gross regional production. Improved transportation and the growth of new wage-paying jobs in tourism, government and commerce have been central in facilitating access to and employment in a wide range of new, largely urban-oriented economic activities.

While average per capita income in Bali more than doubled between 1975 and 1982 (at 10%/annum after inflation) average incomes in rural areas grew more slowly than in urban areas and income inequality (as measured by the Gini Ratio) increased. The growing disparities in rural/urban and per capita incomes are also reflected in widening differences in regional incomes, as a result of an urban/tourist development imbalance which favours the island capital (Den Pasar) and its region (Kabupaten Badung). The range of modern consumer goods and services available via imports has also increased rapidly during the last 15 years, for those with sufficient income. As a result of these new imports the degree of Bali's trade imbalance has been growing. By 1984 the value of imports exceeded exports by 2.5 times, despite a doubling in the value of regional production. Currently, Bali's general economic viability largely depends on continuing subsidies from the central government in Jakarta to support government services and commerce via the development budget.

Differences in income sources and patterns of expenditure in the three villages showed that the wider rural-urban and modern-traditional imbalance is also having a major impact at village level. Table 7.2 presents a summary of the main elements of village life that are being changed by the impact of modernisation.[13]

13 It is not suggested that today one could find even a single village which is 'traditional' - the differences highlighted in Table 7.2 are between village agroeconomies as they were prior to about 1930 and contemporary villages. Moreover, while the differences are expressed as a dichotomy between 'ideal types', these characteristics represent end-points of a spectrum along which changes are taking place, any given village may well be 'situated' at different points of this spectrum in regard to any combination of the characteristics listed in the table.

Table 7.2:
Summary of Major Socioeconomic Differences between Traditional and Modernising Villages.

Traditional.	Modernising.
Food and Diet: Daily - rice/sweet potato or rice/corn mix, leafy spiced vegetables (including ferns), coconut, spiced duck eggs, small amounts of pork and chicken (no beef), water, tea (no coffee); palm sugar for sweetening (no cane sugar); food cooked in morning and eaten throughout day. Ceremonial - as above but unmixed rice, suckling pig and smoked duck and <u>lawar</u> (finely chopped mixture of vegetables, coconut, spices, raw meat and (sometimes) blood), rice based confectionary.	Similar to traditional, but rice/sweet potato-maize mix common only for poorer families; addition of - carrots, cabbage, Irish potato, green beans; small amounts of beef and chicken eggs now common, also coffee and bottled drinks; cane sugar in common use; wide use of MSG in cooking; commercial sweets and biscuits. Many families purchase 1-2 meals a day from roadside stalls.
Housing: Constructed wholly from local materials - timber frame, grass thatch/fired tile roof, brick/ earthen/dressed stone floor, minimal furniture. Earthen walls around compound.	Newer houses from cement-rendered brick, corrugated steel/fired tile roofing, concrete tile floors, glass windows, commercially made furniture. Concrete fore-courts and compound walls.
Lighting: Oil lamp (coconut) in ceramic pots with cotton wick; larger versions used for public occasions.	Electric light (incandescent and fluorescent), where mains power available; kerosene wick and pressure lanterns; poorer families generally cannot afford connection to mains.
Household Utensils: Very simple (and elegant), made from local materials (timber, coconut and ceramic), imported iron and steel used for knives and choppers; cooking pots made from ceramics.	As traditionally, but with addition of mass-produced glass, plastic and metal (steel and aluminum) containers for storage, cooking and eating; metal knives, spoons and forks.
Wastes: Indiscriminate discarding of all wastes. Human excreta detoxified by absorption in soil or aquatic aeration. Food and goods wrappings of natural origin, absorbed as compost.	Maintenance of indiscriminate disposal habits, generally. Natural purification systems overloaded, resulting in skin and internal diseases. Manufactured packaging (plastic) now a common source of pollution. Glass containers meticulously re-cycled and traded.
Clothing and Footwear: Only <u>sarong</u> worn and loose shoulder cloth normally, local or Javanese cloth; ceremonial cloth locally woven; footware not common. Women draped a broad scarf about their upper body, in addition to a <u>sarong</u>.	Imported, largely synthetic, fabrics and cheap, western-style clothing, 'safari suits' and dresses in modern sector, school uniforms for children; ceremonial clothing usually machine-made cloth; footwear: rubber sandals for poor, Western shoes in modern sector.
Grain Storage: Stored in sun-dried sheaves in family rice barn; communal village and temple storage also common; minor trade in local markets.	Major storage in government and private warehouses; some residual local storage; major trade in milled rice.

Marketing: Three day 'round' of market locations, with overlaps between rounds; main items for sale/exchange from local agricultural and specialised craft production from local materials; few permanent, daily markets.	Similar pattern of market 'rounds'; local agricultural and craft products still available; addition of range of manufactured/imported domestic and agricultural utensils (generally of poor quality and expensive by world standards) and food items; permanent, daily markets operate in sub-regional administrative and urban centres.
Health Services: Based on traditional herbal and magical remedies; no effective treatment available for epidemic diseases; village-based priest/ healers.	Mix of traditional and modern treatments; urban hospitals, sub-regional polyclinics and sub-clinics in rural areas; virtual elimination of major epidemic diseases.
Education: Children learnt by working with and copying adults and verbal instruction; specialised instruction by apprenticeship to traditional experts.	Formal mass-education, based mainly on post-1918 Dutch system; largely by rote and generally inappropriate to rural employment opportunities. Cost precludes access beyond junior secondary school to all but well-off.
Income Earning Activities: Males: almost wholly based in agriculture, seasonally variable labour demands directed primarily at maintaining subsistence. Women: domestic duties, main agricultural activities in housegardens (tebe/pekarangan) and dryfields (tegalan). Children/adolescents involved in wood and water carrying, cattle and duck herding and domestic chores. Craft activities an adjunct to these activities.	Traditional activities still operational, now overlain by extra-local formal employment in government, tourism, construction, commerce and transport; some jobs in rural agricultural processing and craft industry (tourist oriented); extraction of sand, coral and rock for (largely urban) construction. Jobs for educated people in agriculture, education, health and administration.
Income Distribution: Except for court-based gentry, rough equality generally related to size of land-holding(s); no rural-urban inequality; intra-village redistribution to prevent pauperisation.	Growing income inequalities favouring those with access to income from modern sector of the economy; growing rural-urban and inter-regional disparities; no government social security.
Village Organisation: Decisions affecting any aspect of the community made in regular meetings of representatives from each household; village head (Kelian Adat) and other officer-holders elected by community on the basis of character, skill and experience.	Village Councils still functioning but its range of authority now constrained and overlain by programmes and directives from government and its bureaucrats; village leadership now split between Kelian Adat and government appointed and paid Kelian Dinas, who is responsible for collecting statistics and organising co-operation with development programmes.

The locations of the three villages were used as a surrogate for a time-series analysis of the impacts of economic modernisation: Tegal Tugu (peri-urban) having been exposed to modernising influences for the longest time, Penestanan (tourist) more recently and Taro (remote) most recently. The analysis of village socioeconomic patterns clearly shows material benefits of modernisation flowing disproportionately towards non-agricultural workers. Nevertheless, the incomes of those with more land have risen and are rising faster than their land-poor or landless neighbours. And, significantly, the average income of the lowest 40% of village populations is effectively unchanged, even in Tegal Tugu after 15-plus years of 'development'.

In terms of the transformation of income sources and levels, the analysis reveals an emerging distinction between income sources that are of most importance to 'rich' and 'poor' families. Agricultural/non-wage income, absolute or relative, is no longer a significant determinant of total income for the top 20% of the income range, except in Taro; while it is still the prime determinant of total income for the lowest 40% of the range. High income families' total income is much more closely linked to absolute and relative contributions of income from non-agricultural/wage sources; and vice versa for low income families. Despite this, the high income group still earn 2 to 6 times more (absolutely) per annum from agriculture as low income families.

The effect of location on the transformation of income sources shows that agricultural income sources for all income groups have less importance moving from Taro to Penestanan to Tegal Tugu, as expected. The conclusion is that sources of family income (broadly, traditional vs modern) are the central determinants of total family income. High income families are far more dependent on extra-local resources, of all types, for their income than low and middle income families, whose incomes still depend largely on local resources.

Unsurprisingly, the pattern of family possessions and expenditures follow the trend of incomes and location. When the pattern of family outlays is considered in terms of traditional and modern items, it is clear that high and middle income families spend significantly more on modern goods and services than do low income families. There is also a strong correlation between income and proportional outlays on modern items, except in Taro. In regard to outlays on health, education and marketing roughly similar proportional expenditures by each income group indicates that the perceived social importance of these remains fairly constant across all income groups. In terms of self-assessed income adequacy, families in the low income group are much more likely to be potential debtors than those in the middle or high income groups; while families in the high income group have much larger surpluses available for saving and investment than their poorer neighbours.

The final part of the analysis examined the determinants of access to the material benefits of modernisation. Four factors were examined: access to agricultural land, availability of adult labour, access to agricultural credit and access to agricultural markets. Earlier access to the technological and economic advantages of the Green Revolution, via prior access to land, provided higher income families with preferential access to non-agricultural/wage sources of income. When the linkages between access to land and education, and access to land and modern sources of income are analysed it is clear that these prior resource endowments of higher income families provided the basis for taking greater advantage of the growing range of new, non-agricultural and extra-local sources of income - the central determinants of current income levels and growing income inequalities.

This raises the question of whether rural development strategies emphasising modernisation of agriculture, as in Bali, are an effective way of ensuring that the poorer members of the economic community have access to the material benefits of modernisation? The bulk of the financial benefits from the Green Revolution have flowed to those with more land, who already have access to new extra-local employment in the modern sector, via better education. The result of this double 'windfall' has been to entrench their privileged position. The poorer majority, on the other hand, have had access to neither of these, government-sponsored, economic benefits. Consequently, the distribution of material benefits from agricultural and economic modernisation, as practiced in Bali, have largely by-passed the poorer majority.[14]

7.4 Village Organisation and Decision Making.

Here, the differences between traditional and modern decision-making processes at the village level are discussed from the point of view of the information necessary for villagers to make informed and sensible decisions; and some changes in political relations between a village and the wider world are noted. There has been some discussion over the years in the literature on Balinese villages about, whether they constituted 'village republics' (*dorpsrepublik*) or whether their political independence was so severely compromised by the power of court centres and their shifting allegiances, that they were almost feudal appendages of these courts (for instance Korn 1933, Goris 1960:79). However, from the perspective of an ecological transition, either system of political power and decision-making depended almost entirely on commonly-held knowledge about essentially stable environmental resources and traditional technologies. In these respects, it is clear that decisions did not have to take account of rapid changes in essential technologies or initiatives about social and economic arrangements suggested or imposed by remote elites.

The traditional pattern of decision making stands in contrast to that required and imposed, as part of the modernisation process. First, it should be noted that the people whose well-being is most directly affected by government modernisation projects were not and are not asked, in most cases, if they want to 'participate' and, if so, on what terms. That is, rural people, *qua* people, are only

14 The consumer-orientation of the BIMAS programme in Indonesia is alluded to in many passing comments by Indonesian commentators, for instance "Government efforts to solve the rice problem in Indonesia has long been reflected in production efforts and price and import policies...such efforts have traditionally been consumer-oriented, in accordance with...promotion of higher rates of nonagricultural growth. (Widodo et al 1979b:161).

instruments in broader, national development strategies. Second, assuming that they are willing to participate, their socioeconomic and technical roles are determined, again in most cases, by a remote government agency. Third, while some of the benefits are likely to flow to local people, commonly the overall aim of a project is to benefit the 'nation' or urban dwellers (e.g. with cheaper staple food). Fourth, whatever the distribution of benefits, it is certain that any socioeconomic and/or environmental losses will have to be borne directly by the local community, and may well outweigh the putative benefits. In short, local communities now generally tend to be powerless participants, mere instruments, in development 'game-plans' drawn up by outsiders. Outsiders who not only lack knowledge of local conditions, but are insulated from the local consequences of poor planning and/or failures in implementation.

This breaking of the nexus between decisions and consequences is one of the features of the ecological transition that Bennett hints at (1976:62-8) - although he bypasses the disequilibrium wrought by post-WWII development on the sustainable ecological characteristics of traditional societies. However, from the previous discussion it is apparent that the role of information is central in the organisation of ecosystems, human or natural; and changes in information flows are a central characteristic of an ecological transition. In the last sections of this chapter, the policy suggestions made for redressing contemporary 'ecological failures' hinge on 'reversals' in the pattern of information flows that have developed as a result of urban-centred modernisation.

7.5 The General Human Ecology Perspective.

The human ecology perspective focuses on the level of and changes in quality of life, and the effects of related socio-technical changes on ecological sustainability. Human ecology facilitates the 'crossing' of inter-disciplinary academic boundaries and, in this respect alone, assists in studying the multifarious changes that are consequences of modernisation. Moreover, it seeks to identify links between what humans do and the results of their actions, on other humans and the social and natural environments in which they live. Asserting that the characteristics and consequences of environmental and societal changes are critical aspects of sustainability. In attempting to quantify the impacts of human-initiated changes, human ecology commonly uses two metrics: energy and money.

Changes in energy use provide a currency for assessing changes in natural resource dependency brought about by modernisation, particularly with respect to non-renewable resources. Money, provides the metric for identifying who (individuals and social groups) have gained access to the increased material benefits of modernisation - although by itself manifestly imperfect in assessing the effects of changes on overall material well-being. In this study these two metrics have been employed to gain insights into the pattern of changes that modernisation has brought to three traditionally egalitarian and sustainable village communities.

Changes in the use of non-renewable sources of energy in rice agriculture illustrate how the output of this staple has been increased in line with population size. However, maintaining this increased level of production has made it wholly dependent on remotely located, non-renewable energy sources. It is also questionable whether the HYV technology has improved the economic situation of farmers vis-a-vis non-farmers, in comparison with the likely returns from TLVs. Further, given this energy dependency and declining energy resources, it is hard to visualise how, without major modifications, this HYV technology will be capable of meeting the future staple food needs of a continually increasing population. For, in the background, are the poorly studied questions of the cumulative effects of fertilisers and pesticides on the natural ecology of ricefields and human health.[15]

Aside from methodological concerns, two major aspects of quality of life have to be addressed in asking questions about

15 See Bull (1982) for a survey of the pesticide problem in the Third World, especially Chapters 7 and 8, for an overview of the costs and benefits for both food production and humans.

the effects of socioeconomic and organisational changes on quality of life. In this respect it is convenient to consider that quality of life has two broadly-based components: material well-being and socio-psychological well-being.[16] In this thesis only part of the assessment of material well-being has been attempted, through analysis of changes in socioeconomic patterns.[17] Linkages between material conditions of existence and self-assessed quality of life experiences have been left unexplored.

It is clearly recognised that the money metric is a poor measure of changes in overall quality of life, a major theme of human ecology. Instead, changes and differentiation in patterns of family income and expenditure have been used in this study, to illustrate how modernisation is increasing socioeconomic variability (inequality) and extra-local resource use (dependency), both components of the ecological transition. The clearly unequal distribution of material benefits raises serious questions of the social justice of the style of modernisation being pursued in Bali, partially at the initiative of the state.

The trends give rise to concern about the sustainability of the social, cultural and economic solidarity of traditional village communities. More specifically, the empirical conclusions raise doubts about whether the strategy of agricultural modernisation as a base for industrialisation and/or commercialisation via service industries, is redressing or exacerbating the absolute and relative poverty experienced by the majority. This study indicates that these strategies in Bali do little to relieve the absolute material poverty of the majority. Relative poverty and differential access to the material and social benefits of modernisation are radically increasing .

Both metrics (energy and money) imperfectly measure the impact of change, and involve many theoretical and practical

16 Boyden (1987) calls these, respectively the 'biophysical state' and the 'biopsychic state'.
17 Complementary research assessing the affective and cognitive aspects of mental well-being were undertaken in conjunction with the socioeconomic surveys (using a stratified sub-sample of respondents), the results of this work await analysis.

difficulties in measurement and/or quantification. To date, however, they are central to holistic assessment of the effects of human actions upon human welfare and the environment. These two concepts in research lead to fundamental questions about the condition and security of human existence *within* natural and social environments, consciously taking into account what is known about biospheric and social processes. Hence, human ecology tends to be 'subversive'; persistently examining fundamental assumptions upon which, in this instance, theories of modernisation are built. For instance: 'Economic development with what aims and for whom?'; 'Are current patterns of modernisation likely to result in social or environmental 'breakdowns' in the medium-term?'; If so, 'Where and when are the breakdowns most likely to occur; and what are the possible consequences for human well-being?'.

7.6 The Central Argument.

The central argument of this thesis is that modernisation without sufficient attention to sustainability may render the material benefits very short-lived, thus placing at risk the possibility of a 'good' quality of life for future generations. Natural systems will be damaged and essential resources will be exhausted, in particular, high-quality energy resources; and also soil fertility and species richness and diversity will be lessened. Further, without attention to equity issues (social justice), modernisation will lead to increasing social tensions and community fragmentation.

In a very real sense, some of the worst fears of the critics of conventional styles of capitalist modernisation are being realised in Bali:[18]

> a growing dependency on imported goods and services, many like fertiliser and petroleum products that are basic to continual functioning; while prices for the island's exports stagnate or decline - placing the island's economy in deepening debt (albeit to the central government);

18 See for instance, Singh (1976:123-30), Riddell (1981:139-74), de Silva (1982:485-8), Chambers (1983:104-39), Warren (1985:128-45), Blaikie and Brookfield (1987:249).

> widening material inequalities between the rich minority and poor majority, and between the urban minority and the rural majority - doubly disadvantaging the children of the rural poor by restricting their access to improved health and education.

The transformation of Bali's society, ecology and economy was illustrated in Chapter 3. Against the background of these island-wide transformations were set the analyses of specific changes occurring in the three village agroeconomies. The analysis highlights the change from a largely self-provisioning society, in ecological equilibrium with its environment, to one in dis-equilibrium, dependent in important ways on imports of non-renewable resources, and with growing material inequalities. Collectively, these transformations constitute an ecological transition, characterised as a move into "'free space' ...seek[ing] resources wherever they are to be found" (Bennett 1976:138).[19]

The type of modernisation (economic development) practiced in Bali fits the pattern characterised by Schnaiberg (1980) as the *economic synthesis* - an attempt to maximise growth with scant regard for environmental and social consequences (e.g. loss of genetic resources and increasing material inequality). More recently, however, there is some evidence that the consequences of the *economic synthesis* are forcing a shift toward a *managed scarcity synthesis* - a policy perspective aiming to contain the most pernicious forms of resource pollution and depletion (e.g. the banning of many pesticides commonly used in rice cultivation). This shift, however, leaves unanswered issues to do with the increasingly inequitable distribution of material welfare - an important aspect of social justice. The next step to be taken, therefore, is towards development strategies that address both ecological and social issues.

Schnaiberg's *ecological synthesis* addresses both these issues, linking them inextricably with concerns about the longer-term

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19 In this respect it should be remembered that in the 'new' economy of Bali, wages (hence the incomes of people dependent on hiring-out their labour power) are also just another factor of production - now also in 'free space'. Given the large and increasing number of people seeking work outside agriculture, this is likely place further downward pressure on wages. 'Modern' employers, now outside the social constraints of the 'traditional' economy will, naturally, seek to pay the lowest wages possible.

sustainability of current development policies. These in turn link with other critiques of current policies and practice (e.g Singh 1976; Redclift 1984), and to rural development policies and practices that fall within the general ambit of 'rural populism' (e.g Kitching 1982; Chambers 1983; Richards 1985). These alternative approaches to development propose 'bottom-up' strategies, as opposed to the conventional, 'top-down' policies and practice.

They advocate organising agricultural development around measures of biological efficiency, rather than the current industrial model derived from notions of mechanical and factory efficiency (Bender 1984), which forms the analytic basis of conventional (neo-classical) economic thought (Strange 1984). Second, they advocate transfering part of the search for new agricultural knowledge and practice out of institutional laboratoraties and experimental stations and into the hands of farmers, in co-operation with these institutions (Riddell 1981; Beets 1982; Chambers 1983). These are the two technical bases of agricultural principals characteristic of the ecological synthesis. One further point needs to be added to fully-round such an alternative approach - commitment to maintaining or achieving social (material) justice (Worster 1984). The spirit and intent of this, 'fully-rounded', approach is captured in Wendell Berry's phrase: "A sustainable agriculture does not deplete soils or people".[20]

Biological principles of efficiency suggest that the effectiveness of an agricultural system should be gauaged from the perspective of the maximum level of production that can be maintained without the (over)use of non-renewable resources; and without (over)use of chemicals causing (cumulative) collateral damage to other organisms: mammals, birds, fish, insects and plants. In practice, this means minimising the use of industrial fertilisers and biocides - seeking other, biologically-based methods of maintaing the food system's fertility and protecting it from 'weeds and pests'. It is in achieving this goal that the ecological knowledge of 'real-

20 Quoted in Colman (1984:x).

world' farmers comes into focus. Although many farmers in the Third World lack formal education, their knowledge of the agroecology which sustains them is unparalleled and goes largely untapped by institutional researchers.

7.7 Broader Significances.

What significance does this research have beyond Bali? That is, what do these results suggest about the impact of modernisation in Indonesia and elsewhere in the Third World? As mentioned, the island and society of Bali have a number of historical, geographical and social features that make it particularly suitable for examining the impacts of modernisation on social and ecological sustainability. While making its society somewhat different from the rest of Indonesia (.e.g Java), these features make it close to an ideal location for research into the effects of modernisation.

The emphasis on increasing agricultural production and productivity has two roots in contemporary development theory and practice. First, total food production needs to increase at at least the rate of population growth - if nutritional standards are to be maintained. Second, the productivity of and net returns to small-scale farmers needs to be increased - if they are to have the resources to take advantage of modern goods and services; and if they are to be able to produce a surplus over current consumption needs to facilitate capital accumulation and investment, both private and social.

The policies and practices of the Green Revolution, in Bali and elsewhere, are aimed at providing a simultaneous solution to both these problems: increasing total food production by increasing per unit area agricultural productivity; and increasing agricultural labour productivity, using new seeds, fertilisers, biocides and information. It is apparent that total food production in Bali and Indonesia has more than kept pace with population growth to date. However, because of the price premium available for traditional varieties compared to HYVs, it is probable that a policy nominally beneficial to the population as a whole can be disadvantageous to individual farmers - growing HYVs is not economically advantageous, despite higher yields.

In terms of an ecological transition the changes in energy flows are of central importance. Energy flows are in a fundamental sense 'the currency of nature' in comparison to economic flows, which are social units of account established by the mode of production and which tend to reflect the short-term operation of supply and demand. Energy flows reflect real transfers of resources from one location to another and, because the quality of energy (its 'density') is degraded when used to perform work, increases in entropy reflect the nature of the 'match' between an energy source and the task to which it is applied. Further, as energy passes only once through any given system (social or natural) energy flows also reflect the *actual and final* consumption of scarce resources, in a manner which economic flows are incapable of approximating.[21]

Indonesia, and hence Bali, is following the path of agricultural intensification described and advocated by the FAO (1981): Raising unit area productivity by increasing application of energy-intensive, industrial inputs. In adopting this path Indonesia has tended to ignore other approaches to increasing areal productivity; such as exploring methods of using green manures (terrestrial or aquatic) or drawing on traditional knowledge in combination with modern 'scientific' approaches. Second, attention, until very recently, has been almost wholly focused on irrigated rice cultivation - a sensible strategy in terms of short-term paybacks - while largely ignoring increases in productivity potentially available from the much larger areas of dryland (rainfed) agriculture.

These two characteristics of agricultural intensification in Indonesia can be explained, at least in part, by:

21 Georgescu-Roegen (1972), in an article in The Ecologist, presents a succinct introduction to the differences between thermodynamics and economics in their treatment of the consumption of natural resources; fuller and more technical discussions can be found in Georgescu-Roegen (1971 & 1976).

the ready availability of relatively cheap indigenous resources of oil and natural gas necessary for producing and transporting manufactured inputs (fertilisers and pesticides) and moving local rural food 'surpluses' to growing urban areas;

the strong cultural preference for rice as a staple carbohydrate - a preference that seems to have grown markedly stronger over the last 10-20 years - thus increasing the demand for rice in comparison with other sources of carbohydrate;

the pervasive attitude in Indonesia that what is traditional is of little worth in comparison to what is new and/or imported - leading to a confusion of modern forms (technology) with effective or useful content (results);

technocratic hegemony - the domination of research policy formulation by urban and/or foreign-trained personnel, who strongly exhibit the bias mentioned above, and exclusion of both farmers and their knowledge from the processes of developing policy and the carrying through of research.

Inexorably this strategy of agricultural intensification is increasingly dependent on non-renewable resources, has paid only passing attention to the food producing potential of non-irrigated land, has demeaned traditional ecological knowledge and cultural sensibilities, and has led to economic benefits flowing disproportionately to wealthier families and/or non-farmers.

The impetus for developing the technologies involved in the Green Revolution came from elite, urban institutions in the United States - and the process of disseminating the technology to farmers was directed by urban-based government organisations, in Indonesia and elsewhere. Only at the final stage did 'real' farmers have a significant part to play in this process. Their given role was to rapidly abandon cultivation practices handed down for generations and, with promises of 'miracle' yields and encouraged by subsidies and some social coercion, adopt wholesale the new package of inputs and cropping practices.

It is worth repeating that at no stage in this process were the livelihoods of those who developed and promoted this package at risk. Their institutional jobs and incomes were secured. Farmers and their families, with minimal inputs to the development of new technology, have borne and are bearing all the risks. This process, here briefly sketched, is of itself a major transition in the social ecology of agricultural practice, in that the informational links almost all flow one way - from urban to rural - and the return flow of information from farmers about problems and crises (negative feedback) is all but missing, at least in the short term.

Widespread failures by farmers to achieve the yield results that scientists obtained in pot-trials under controlled conditions has resulted in the farmers being blamed for the short-fall - for not having applied the inputs adequately or at the correct time, etc. This is a classic case of 'blaming the victim'. It is as if the scientists and economists believe that farmers were deliberately 'messing up' their experiments.[22] Only after a number of years were tardy and reluctant admissions from technicians and bureaucrats forthcoming that some aspects of the new technology might be unsuitable for 'real world' conditions, or that the package of practices had any major shortcomings.[23] Farmers were blamed for their lack of education; for attempting to seek a 'middle-way' between the old and the new; or for being reluctant to make additional outlays for extra fertilisers or pesticides, and so on. One searches the literature in vain for any admission of failure on the part of the institutions or scientists to design a workable package or for an explanation of their abject failure to acknowledge or take advantage of

22 Aside from the bias implicit in the title of this source "Farm-Level Constraints...", this book opens with a quote from the retiring director of IRRI (R.F.Chandler) "...the only real disappointment I felt was that somehow we did not understand sufficiently why the Asian farmer who had adopted the new varieties was not doing better. Somehow, I felt that the rice scientists who had obtained yields of 5 to 10 metric tons per hectare still could not explain why so many Filipino farmers (for example) obtained, on average, less than one metric ton per hectare increase in yield after shifting from traditional to HYVs. All of us were a bit mystified..." (cited by Barker in IRRI 1979:1). Barker in the conclusions to the introduction sets the blame firmly with the farmers "There is a wide range of constraints to high yields, including those factors that affect the yield potential of the crop under the farmers' environment and those that affect the ability and willingness [sic!] of the farmer to achieve the potential yield on his own farm." (p.23) - as if any farmer anywhere does not aim to do as well as they can for themself and his/her family!

23 "Policy makers are beginning to realize that BIMAS's thin spectrum technology is probably one of the major causes of the production shortfall...If the BIMAS program is to perform as expected...it must offer technology that is more specific to the locality." (Widodo et al 1979a:95, emphasis original).

the vast store of traditional knowledge, freely available from farmers, if they had bothered to ask (Conklin 1987 pers.comm).

In terms of the social context and consequences of natural science, the Green Revolution provides an example of one of the great scientific frauds of modern times: An 'experiment' where the supposed beneficiaries have commonly been the victims and the bulk of the benefits have flowed to non-farmers.

7.8 What of the Future?

It is clear that despite a remarkably successful programme of birth control in Bali during the last 10 years the population of Bali will continue to increase (Hull 1978). Although the rate of natural increase has declined, it is estimated that by 1990 Bali's population will reach about 2.8 million, and by the year 2000 it will be about 3.0 million, an increase of some 500,000 or 20% over 1980.[24] An initial analysis suggests that over the next 10-15 years the quantity of food produced will have to increase by at least this amount. This immediately raises the question: Can Bali's farmers produce enough food for a population of this size? And what resources, natural and manufactured, might be required to achieve the required increase in production?

Maintaining the 70% increase in rice production achieved between 1969 and 1982 currently requires some 70,000 tonnes of fertiliser and 620 tonnes of pesticide per annum. Would increasing the amount of fertiliser imported and applied assist in achieving further increases in rice production? It has been observed that by about 1982 increases in rice production were levelling-off - partially as a result of having reached the upper limit of the fertiliser-yield response curve, and partially because irrigation resources were already being fully utilised. Thus it is unlikely that application of more fertiliser per unit area will lead to

24 An analysis by Streatfield (1987 pers.comm), taking into account the marked decline in fertility between 1980 and 1985, suggests that with a population growth rate of 1.4%/annum Bali's population will be about 3.3 million in 2010 and 3.5 million in 2020; with a 1.2% growth rate it would reach 3.2 million in 2010 and 3.4 million in 2020; and at a 0.8%-1.0% growth rate it would reach 3.2 million in 2020. The most likely outcome, taking into account a slight rise in mortality after 2000, is for a growth rate in the 1.2-1.0% range over 1985-2020.

increased production. Nor, given that irrigation resources are fully extended, does increasing either the area of irrigated ricefields or the number of crops per year seem a feasible approach to achieving major rice production increases. The conclusion, tentatively at least, is that any major increment in staple food production will have to be the result of increased dryland (rainfed) production.

It is not particularly significant, as some argue (Smil et al 1983), that direct use (agricultural production) and indirect use (food processing, transport, storage and preparation) of non-renewable energy resources are a relatively small proportion of total energy use in an economy.[25] Whatever the proportion of total energy used, the 'smooth' and reliable functioning of the food-supply system forms the foundation for *all* other social, cultural and economic activities (Fluck 1984). Moreover, the larger the proportion of the population living in urban centres, remote from the loci of agricultural production, the larger and more critical are the indirect energy costs of maintaining the food supply system - and the more vulnerable (urban) populations become to even relatively minor and/or short-term disruptions in agricultural input, production or distribution networks.[26]

Most important, from an energy perspective, is the fact that rice production is now dependent upon supplies of manufactured inputs, which in turn depend wholly upon resources of fossil fuel for their manufacture and transport. At current rates of extraction it is thought that Indonesia has oil reserves sufficient for approximately 30 years and natural gas reserves sufficient for approximately 60 years (Pauker 1982). In this respect it is significant that current rates of extraction are substantially higher than the rate at which new reserves are discovered; even though Indonesia has had a moderately high,

25 In Western industrialised nations direct use of energy amounts to 3-4% of total energy use and indirect use to about another 10-16% (Dovring 1985). In nations such as Indonesia both these proportions are probably somewhat lower, particularly if the contribution of non-commercial energy sources is taken into account Moreover, Pimentel et al (1973) clearly demonstrated 15 years ago that known and prospective energy resources are insufficient for the worldwide application of Western, energy-intensive agricultural practices.
26 There is no direct attempt here to include agricultural production in western, industrialised nations, in part because about four times as much energy is consumed outside the 'farm gate' as on the farm; this proportion is much lower in the Third World. However, the general thrust of the suggestions made also applies to cultivation practices in the West.

but declining, rate of exploration success (18% of wells drilled, Gaffney 1986). Thus, *ceteris paribus*, the resources necessary for maintaining energy-intensive agriculture are likely to be unavailable, in short supply or prohibitively expensive within one to two human generations.

The effective life of these resources can be extended by a number of means. First, if substantial new reserves of oil and gas are proved then the necessary energy will be available for a longer period. However, even a doubling of reserves will only extend availability by a generation or two, at best - a very short span in relation to the length of human occupation of the archipelago. Second, if new, more energy efficient means of converting natural gas to urea fertiliser are developed then this would extend the effective life of natural gas reserves. Unfortunately, this is not likely, as the current production methods are already close to the thermodynamic maximum conversion efficiency (Gutschick 1977; Mudahar & Hignett 1985). Third, increasing the ratio of food energy/protein output to energy inputs (i.e. increasing the ER), by further exploring more efficient methods of using these energy-intense resources, especially urea, leading to improved agricultural practices. Given the previous constraints, this third approach would seem to be the only realistic method available for maintaining or increasing total production of staple foods - and moving towards a more sustainable agricultural system.

Increasing the energy efficiency of staple crop production in Bali and Indonesia might be approached in the following manner. Such a strategy would need to have at least two major thrusts, the elements of which would involve:

> First, exploring a range of methods for maintaining yields of irrigated rice production by a combination of, for instance:
> - systematic cultivation of nitrogen-fixing algae (*azolla* spp);
> - encouraging use of a range of dryland green/animal manures;
> - integrated pest control methods to reduce crop losses; and
> - more active use of the traditional knowledge of farmers;

Second, shifting some of the burden of staple crop production away from the current over-concentration on irrigated rice by:

- active development of dryland polycultures (multi-species, multi-storied agriculture) to provide carbohydrate alternatives, e.g.sweet potato, cassava, taro; and
- a wider range of fruits and vegetables for improving the quality of peoples' diets and a range of trees and shrubs grown as cash crops.

The essential technologies required for both aspects of this strategy are already quite well-known, by both scientifically-trained agriculturalists and many semi-traditional farmers.[27]

To be successful this type of approach requires a deliberate shift in policy towards active co-operation between workers in research institutions and 'real world' farmers. However, difficulties in the development of new institutional farmer-scientist links, as required by a new co-operative approach to research, are probably the largest impediment to adopting such a strategy. The point is, however, that the changes in attitudes necessary to make a start, particularly among institutional employees, does not have to occur 'overnight' but can be encouraged over a period of years, as part of the education and training systems already in place.

As already noted, the concentration over the last fifteen years or so on increasing irrigated rice production has led to a general neglect of the production potential of dryland agriculture, in Bali and elsewhere. As a consequence of this neglect, opportunities for increasing dryland production in Bali are substantial. It is significant in this regard that the area of dryland in Bali (257,000 ha, including tree crops) greatly exceeds the area of irrigated ricefields (99,000 ha). However, total dryland area (harvested) for staple carbohydrates (maize, sweet potato and cassava) has declined slightly since 1969 (to about 77,000 ha); yields have increased less than for irrigated rice; and total production

27 There is a diverse and growing literature in the area of agroecology, and the development of sustainable polycultural systems based on traditional and modern knowledge. For a discussion of temperate and tropical examples see, for instance: Gliessman et al 1981, Beets (1982:31-64), Gliessman 1983, Altieri 1983:19-34, Richards 1985:117-59, and Gliessman 1986.

of these staples has declined by about 10% over 1969-84.[28] These data provide indications that it should be possible to substantially increase production of dryland staples by use of improved cultivars, selective use of organic and/or manufactured fertilisers and more intensive crop management practices.

Looked at from a different viewpoint, there are good reasons for policy makers to consciously 'pause' and reassess the ordering of agricultural priorities for the coming 5-20 years. The people of Bali (and Indonesia) are probably in the best position for the last 50 years to make significant, long-term readjustments to their agricultural economy and ecology.

Four major factors form the basis of the assessment that the time is now opportune for such reassessent and redirection:

> First, Bali's population growth rate is the lowest for about the last 50 years, and still declining;
>
> Second, Indonesia, as a nation, currently has the highest level of staple food reserves for the last 50 years;
>
> Third, the cost of cereal imports in the world market is the lowest in about 30 years.
>
> Fourth, a complementary factor, returning to growing traditional rice varieties for local consumption and *export* would allow Bali's farmers to gain economic advantage from the premium prices paid in the world market for high quality traditional rices, such as Basmati from Pakistan.[29]

Let us consider each of these factors in turn:

Slowing Population Growth.
Bali is entering an era of significantly slower population growth, despite the 'bulge' of population now in the 5-25 years old age range. Current estimates place the rate of natural increase at about 1.3% per annum, markedly lower than the 2.3% rate of the 1960s and the 1.7% rate of the 1970s. Thus the rate of 'population driven' increase in demand for

28 In contrast, the harvested area and production of ground nuts has increased substantially during this period, although yields have remained stable; while there has been little change in soybean area, production or yield (see Tables A3.18.5-9)

29 I am indebted to John Darling both for this suggestion and the many insights about Bali he has offered in discussions we have had over the last 10 years.

staple foods is slowing, removing some of the pressure for increasing output 'at all costs'; although the 'income driven' effects on demand are probably rising - albeit slowly because of a highly skewed income distribution

Food Reserves.

The financially subsidised and fertiliser supplemented rice production that accompanied the widespread adoption of HYVs, and more general increases in agricultural food production, have gained for Indonesia a "fragile self-sufficiency" (Mears 1984) in staple foods. Thus, Bali, indeed Indonesia, potentially has time to start rapidly diversifying its 'staple food base' - in general, moving away from *fertiliser driven monocultures* towards *fertiliser catalyzed polycultures*. In brief, this would involve maintaining rice production at more or less current levels, but shifting the research and extension focus towards dryland crops of all sorts - primarily food crops, secondarily cash crops.

However, serious and persistent efforts need to be made to overcome the obvious reluctance of many agricultural extension and administration personnel in government service for meaningful contact with *pak petani*, the real farmer. Currently it is almost impossible to ever see an extension agent in the field talking to a farmer; farmers must come to them in their offices.[30]

Cheap Cereal Imports.

During the 1960s and 1970s Indonesia imported massive quantities of rice costing, generally, about US$600/tonne. It can now, if desired or required, import rice at about US$255/tonne (Asiaweek 31/5/87:60). As the domestic rice 'support price' in Indonesia is above world prices, imports are an economically rational option. In addition, wheat and maize are available on the world market at the lowest 'real' prices for 30 years.[31] How long these prices will persist is

30 Dhalberg (1979:98) raises this point emphatically, and cites Myrdal concerning South Asia "... the educated [agricultural extension workers] tend to regard their education as a badge that relieves them of any obligation to soil their hands [or feet]." (Myrdal 1968:1646).

31 The European and US subsidies for grain production are well-known and have resulted in 'mountains' of surplus grain and a trade-war which has forced down prices on the international market. In constant (1980) terms, the price of rice has fallen from US$570/tonne (Bangkok) in 1969 at the start of the Green Revolution in Bali to US$266/tonne

unknown, but for the world price to move upward once more a major restructuring of American and European grain production economics is required, this would probably take some years. Because of these factors there is an unparalleled opportunity for Indonesia, specifically Bali and Java, to allow the national rice production level to remain fairly static, shift the focus of effort to dryland polycultures and, if necessary, make-up shortfalls in rice production by relatively cheap imports of rice (or maize or wheat).

Exporting Premium Rice.

The fourth factor, suggesting that Bali might return to being an international rice-exporter may seem a little radical, given the current and growing need to feed the local population. However, such a strategy has four economic and ecological advantages. First, by entering the rice trade with a premium traditional rice Balinese farmers could hope to realise up to twice the value per tonne of rice harvested than currently with HYVs.[32] This, in turn, would go some way towards relieving Bali's growing trade imbalance. Second, because of the price premium, the 'value added' by farmers' labour would be greater than with HYVs - directly transferring to rural areas, particularly farm families, some of the advantages that derive from the *mystique* of Bali and its rice agriculture. Third, growing only two crops per year of traditional rice would alleviate the current strains on irrigation resources, consequently improving its reliability. Fourth, and most important from the perspective of this thesis, a reversion to traditional varieties (mainly the 140-day *Padi Cicih* cultivars) would allow a significant reduction in the quantities of fertiliser and pesticide required and imported - with substantial ecological, energetic and/or economic advantages for farmers, wildlife and the soil.[33]

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by 1984; over the same period the maize price has fallen from US$202/tonne (Argentina) to US$ 177/tonne and wheat from US$171/tonne (USA) to US$148/tonne (World Bank 1986:52-5) - there have been further major price declines since 1984. In constant 1980 terms, these are the lowest prices since 1950.

32 Bali could export both to other parts of Indonesia, aiming at the top-end of the rice market, and/or to the US, Europe, Japan and Australia, where premium traditional varieties command extraordinary prices.

33 Continuous cultivation of traditional rice varieties, on a sufficiently wide scale, also offers one of the best, possibly the only, method by which the genetic base can be preserved and, most importantly, be accessible to farmers.

A return to growing Padi Cicih, for instance, and renewed use of green manures would reduce urea fertiliser needed per unit area from about 300kg/ha to 25-50kg/ha - directly reducing the material costs of production by about 50% (conservatively) and increasing energy efficiency by about 150-200%. In terms of yields, any decline in per crop yield is likely to be small, according to data on yields obtained in the Ubud area for growing Padi Cicih using small quantities of fertiliser. Further, the development of effective integrated pest management practices, so as to minimise pesticide use, would have the dual effects of decreasing season-to-season yield variability by stabilising predator-pest populations, and minimising collateral damage to other insects and animals (e.g. supplementary protein sources), and humans.

The advantages for Indonesia, and Bali, of such a policy are threefold:

> First, this 'breathing space' could be used for a thorough-going reflection on and consequent review of the headlong rush towards fertiliser driven monocultures in staple crop production.
>
> Second, it can provide time to make effective use of Indonesia's farmer and institutional knowledge of dryland agriculture, for with well-organised co-operative research this combined base of traditional and modern information can make village agriculture more productive (and sustainable) than at present.
>
> Third, such changes in policy emphasis have potential for actively minimising medium-term environmental degradation by an indirect process: placing greater emphasis on dryland production, leading to a re-evaluation of the natural resource economic value of both ricefields and dryland, (*sawah dan tegalan*) and the ecological and economic costs of undermining natural soil fertility.

As in all peasant societies, modernisation of the economy has resulted in the socioeconomic rationale of traditional 'natural' or 'peasant economies' being undermined by industrial and other urban-oriented developments (Kitching 1982:53); with agriculture becoming an ever smaller part of the economy. The traditional, semi-independent agroeconomies of Balinese villages are now a thing of the past - they have been subsumed within the island and national cash economy.

There is, thus, no possibility of returning to an earlier 'idyllic' economic era - broad-scale transformations of the political economy of Indonesia during the last decades place this beyond even casual argument. Also, there is no indication that Balinese villagers and farmers wish to economically isolate themselves from the modern sectors of the economy, even the island's regional economy. Clearly, therefore, policy changes that might lead towards more productive and ecologically sound dryland and rice agriculture, at national or regional levels, will have to take place largely within existing political and institutional frameworks.

What might be done then turns, initially, upon issues related to changes in emphasis given to different systems of agriculture. This might cover, briefly: a campaign aiming at a reorientation of extension service staff behavior; finding ways of actively incorporating farmers' skills and knowledge into both suggestions for change and assessments of progress; and, more general programmes to inform all people directly involved in agriculture about new cropping opportunities and the specific importance of evolving sustainable (conservation) practices.

As it happens, current work on dryland (rainfed) agriculture in Africa by IITA[34], has made significant progress (by evolving techniques based on existing subsistence agronomic practices and improved cultivars, but using little in the way of costly industrial inputs) and has succeeded in radically raising yields while greatly reducing soil erosion. These advances were (only) made possible because scientists, after many failures over the last fifteen years, eventually discarded their intellectual and social 'temperate climate-industrial agriculture' perspective (Harrison 1987) and turned to local farmers' approaches for inspiration.

34 International Institute of Tropical Agriculture (IITA). Other research institutes have also made significant progress in developing new cultivars and cropping practices for 'real-world' farming conditions in Africa, e.g. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

The achievements in Africa, and elsewhere where there has been a 'reversal' in approaches to improving traditional and/or subsistence agriculture and cash cropping, contain two fundamental lessons. First, they make no attempt to 'put back the clock' in the wider economic sphere. Second, they take as their starting point the real-world political economic and environmental situation of small farmers. They are 'bottom-up' approaches. This approach represents a reversal of the 'top-down' philosophy that initiated and pervades almost all aspects of agricultural modernisation to-date (Richards 1985:36-9); the approach embodies the policy elements outlined in the previous paragraph. As a consequence it encourages a balanced and complementary use of the human and natural resources available (farmers' skills, technocratic research and economic institutions, and natural and industrial cropping inputs) resulting, generally, in increased land and labour productivity and hence incomes, while improving conservation of soil, nutrients and water.

7.9 Conclusions.

The results of combining traditional and modern knowledge and techniques in Africa have been very successful, despite infertile soils, low and unreliable rainfall, poorly developed transport networks and labour shortages (Harrison 1987). Bali, and Indonesia, on the other hand, suffer none of these fundamental disadvantages. Bali and Java, in particular, have fertile volcanic soils and high and fairly reliable monsoon rains (and well-developed irrigation systems). In the past 10 years public and private investments in roads and vehicles has made transport of people and goods speedy, flexible and relatively cheap. Thus the Indonesian situation with regard to physical constraints on increasing the productivity of dryland agriculture are minimal, the opposite of the African situation.

In contrast to labour shortages prevalent in Africa, Bali and Java have a great surplus of un- and under-employed labour, most of it eking out a living in rural areas. Thus, intensification of dryland agriculture by labour-intensive means offers one of the few new opportunities available for providing sorely-needed gainful employment, particularly in rural areas; and, hopefully, for reducing the rural-to-urban population drift. Because of the greater involvement of women in dryland agriculture and housegardens, means should also be developed to provide them with preferential access to the higher incomes that cultivation and marketing of products that intensive polycultures offer. Moreover, if government could find ways of increasing the social and financial status of agriculture, the new skills of young people, resulting from massive investments in education, could be put to productive use; and, again, help prevent the draining of much needed talent from villages to urban areas. For, it is clear, the development of highly productive polycultures will require the acquisition and application of analytic and scientific skills generally beyond the reach of traditional farmers.

Thus, by a series of complementary 'reversals', potential does appear to exist for meeting the nutritional needs of a growing population, reducing the dependency of food production on non-renewable resources, increasing rural employment and incomes, and making better use of public and private investments in transport and education. None of these objectives will be easily or rapidly achieved, given the momentum of current policies and practices. However, the active development and implementation of national or regional policy (and practice) along these lines has the potential for meeting human needs, while at the same time preserving the natural resource base upon which human civilization depends.

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