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FARMING SYSTEMS RESEARCH IN PAPUA NEW GUINEA

by Bruce Carrad & R.Michael Bourke



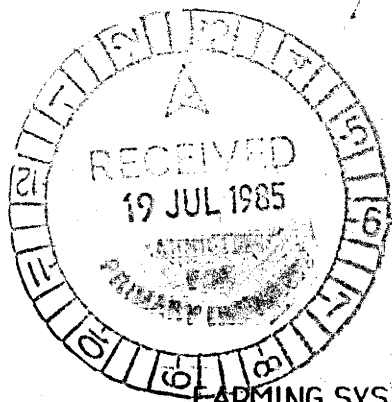
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FARMING SYSTEMS RESEARCH IN PAPUA NEW GUINEA.

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FARMING SYSTEMS RESEARCH IN PAPUA NEW GUINEA.*

1. Introduction

The physical and social environments in which farmers in Papua New Guinea live and their resulting farming systems are extremely diverse. Food and export crops are grown in environments with wide ranges of rainfall (1000 to over 8000mm pa), altitudes (sea level to 2800 metres a.s.l.) and soil types. There are some 500 species of crops grown for food (B.French, pers.comm.) for both subsistence and the market. There are no less than 8 species used as major staple foods (sweet potato, Colocasia taro, Xanthosoma taro, bananas, sago, greater and lesser Asian yam and cassava). Tree crops dominate the agricultural export sector with arabica and robusta coffee, cocoa, copra, oil palm, tea and rubber all being grown. The only other export crops are pyrethrum, cardamom and a small amount of chillies. Pigs are the major type of livestock raised and they consume at least 50% of the sweet potato staple in the highlands, but less in the lowlands.

Cultural diversity influences farming systems in, for example, beliefs about food, pig management practices in times of relative scarcity of sweet potato, and the influence of male/female roles and their contribution to labour supply. There are also wide differences in the period of contact with Westerners and Asians (less than 15 years to over 100 years) and in access to markets and social services, with resulting differences in the levels of development. So although most rural people (over 80% of the population) undertake a combination of subsistence and export tree crop activities in a semi-traditional village setting, and form the dominant agricultural export sector, their development opportunities are uneven and are strongly influenced by a wide range of social, environmental and economic issues.

This diversity has several implications for agricultural research and extension. Firstly, it is difficult for an individual scientist to comprehend the range of systems in which farmers live; this has been compounded by losses of experienced staff in recent years. Secondly, there has been until recently an inadequate data base with which to assess and monitor rural change and allocate agricultural research resources. Finally, the decentralisation of political and administrative functions into 19 Provincial Governments has separated extension services from research, making information exchange more difficult. Papua New Guinea is thus fortunate to have a relatively strong descriptive literature on many of the farming systems in the country. The following sections mention the most accessible of these studies, the present work and likely future directions.

* The views expressed are not necessarily those of D.P.I.

2. Previous Farming Systems Research in Papua New Guinea.

2.1 Descriptions of Farming Systems.

From the time of Parkinson (1907) and Malinowski (1935), there has existed a tradition of the description and analysis of farming systems in Papua New Guinea. This has been generally based on extended periods of residence in villages by academic anthropologists and geographers. Much of this work has also been influential in other countries. Some of the better known workers have been Brookfield and Brown (1963) and Hide (1981) in Chimbu, Howlett (1962) in the Eastern Highlands, Clarke (1971) and Rappaport (1968) in the Simbai Valley, Waddell (1972) and Wohlt (1978) in Enga and Lea (1964) in the East Sepik. This tradition has continued with recent descriptions of local agricultural systems given by, for example, Simpson (1978), Boyd (1975), Allen (1982), Ohtsuka (1983) and Bourke (1983). The descriptive literature is voluminous, particularly for the highlands and the highlands fringe. It provides a valuable data base for reviews of components of farming systems, such as cultural practices, individual crop species and pigs. It is, nevertheless, uneven: for example, it is possible to extract numerous recordings of sweet potato yields but only a few on subsistence firewood consumption.

2.2 Studies until 1978

Some 30 farming systems trials had been conducted on food cropping systems until the the end of 1978. A list of these and a bibliography is given by Bourke (1982). Further trials on cropping systems were conducted on pulse crops and stock feeds in the Markham Valley by, for example, Vance and Sumbak (1979). Most of this work was initiated with minimal consideration of existing cropping systems and farmer practice.

In the early 1950s, crop rotation and soil exhaustion trials were laid down at Kerevat (20m) in the wet lowlands and at Aiyura (1620m) in the highlands. The trials were conducted to devise alternative cropping systems to the long forest fallow systems (lowlands) or grassland fallow systems (highlands), particularly for locations experiencing pressure on agricultural land from population growth and the introduction of export tree crops. Baseline data on intensive cropping systems were also sought. Whilst none of the rotations tried proved as effective in maintaining yield per unit area of food crops as the methods in use, the trials did provide valuable long term data and a partial basis for recommendations (eg Bourke, 1979). The Kerevat trials ran for almost 30 years and the Aiyura ones for over 20 years. Papers by Kimber (1979), Newton and Jamieson

(1968) and Bourke (1977a,b) have given results for part of the trials' duration, but a complete analysis has not been done and would be useful.

The only formal trials that have examined the interactions between export tree crops and food crops were a cocoa/bananas interplanting trial and a coconut/food crops interplanting trial at Kerevat. Results of the coconut/food crops interplanting trial (Gallasch, 1976) indicated that existing farmer practices were agronomically and economically sound and that there was no basis for the then existing recommendation against intercropping. Carrad (1982) has argued theoretically in favour of the mixed coffee/food crop cultivation practices used in the highlands.

Some of the other trials prior to 1978 examined component technologies of farming systems, such as the effect of compost on yield or the evaluation of leguminous cover crops. A continuous cropping trial using a "composted contour mound method" at the Wau Ecology Institute (1230 m) claimed a successful alternative to grassland fallow systems, but no data were offered to substantiate the claims (Gagne, 1980).

2.3 Farming Systems Research Studies since 1978.

In 1978 a three week multidisciplinary survey was conducted on the Nembi Plateau in the Southern Highlands Province (Allen, 1984). The team sought explanations for the very high rate of child malnutrition on the Plateau and concluded that this was associated with extended periods of cropping (with minimal inputs of organic fertilizer) and very low sweet potato yields. The 1978 survey was followed up by a farm based research programme on which sought appropriate technologies to increase crop yield (D'Souza and Bourke, 1984). The follow up research did not however proceed past researcher-controlled experiments in village gardens.

The 1978 Nembi Plateau survey marked a watershed in FSR in Papua New Guinea, demonstrating the value of village studies by a team which combined biological and social scientists (in this case an agriculturalist, soil scientist, nutritionist and several geographers). It influenced the Enga Rural Development Study (Carrad et al, 1982) and the design of the National Nutrition Survey, conducted in 1982/3.

It also influenced the Simbu Land Use Project (SLUP) which undertook studies in land use, soils, nutrition and agriculture in both north and south Simbu. Its main objective was to assess the status of subsistence agriculture and nutrition, and likely future directions. The SLUP project, like the Nembi work, did not proceed past base data collection and description of the existing situation, as well as some agronomic field

trials. As a project, its funding concluded before recommendations could be fully developed and tested. However it provides a valuable base upon which to design a programme with an interventionist objective. The South Simbu study (Hide 1984), has recently been used for this purpose.

A list of 15 farming systems studies conducted since 1978 (excluding descriptive work) is given in Table 1. The strong links between agriculture, land use and human nutrition are apparent, as is the slim economics input in the work so far. Most studies have concentrated on the highlands and relatively little work has been done in the lowlands.

3. Lessons

Much of the early research into food and export crops was component not systems oriented. It was undertaken on research stations and extended to the community with a standard set of cultivation recommendations. As the client group(s) were only broadly identified (smallholders or largeholders), without the benefit of systematic grower surveys, recommendations were based on station experience and not oriented toward specific needs or management constraints.

Where food crop staples were concerned the methods of conducting selection trials for improved varieties were often at variance with the range of on-farm practices and paid little attention to variations in soils, planting densities, mixed cropping practices and the labour constraints which apply at village level. It is probably fair to say that the number of successful innovations in this area have been limited as a result and most success has come from introductions of new crop species and new cultivars of existing crops. The introductions phase is virtually over however for new species, and future growth in farm productivity and incomes from food crops will rely on management improvements. This research however laid the foundation for future work, for example, by identifying technologies that are not suitable for PNG conditions, such as legume rotations in the wet lowlands.

Export tree crops on the other hand, have enjoyed more success from experimental station based component research. In particular hybrid cocoa and oil palm breeding in PNG has resulted in improved farm incomes, even though larger-scale farmers have benefitted most to date in these industries. For smallholders to benefit fully from, for example, new hybrid cocoas, research will need to pay specific attention to the trade-offs between yield and disease resistance. Where higher yielding but disease susceptible cocoas are planted by smallholders (as is

happening at present), research is needed to develop appropriate input delivery systems and recommendations (Moxon, 1983).

However, as we noted earlier, there has been village based research conducted as well. The village work of the 1950s and 1960s which led onto the early 1980s work in the Highlands (Table 1), has given insights into the diversity of farming practices. Yet where agricultural practices have been described, quantifiably in some cases as a result of surveys or longitudinal village observations, this work has not generally then been used in technology development. The one exception we know of has been on the Nembu Plateau, and this work was halted before early positive signs could be fully supported. The reason is that this recent work has been done on projects with limited life spans. The survey and descriptive phases have dominated project work and before the findings could be used as a basis for trialling innovations the projects had finished.

So where component improvements have been developed they have been rarely based on any systematic prior assessment of grower practices, resource endowments or market opportunities; where such assessments have been made they have not then been used for improved technology development. The main reasons for this dichotomy is that institutionalised government services have been doing the former, whilst fixed life projects or academics have been doing the latter; only rarely (eg Nembu Plateau) have the two approaches come together. This is not to say that there has been no contact between the two approaches: the work of Brookfield in the 1960s influenced government research thinking and subsequent priorities and the project experiences of the early 1980s have influenced the decision to establish multi-disciplinary highlands and lowlands food crop research teams within the Department of Primary Industry.

Although agricultural practices have been described in many cases (section 2.1), they have been rarely evaluated in terms of grower objectives and returns to critical inputs such as labour. Land use researchers are only now developing methodologies for appraising smallholding systems in the South Pacific (McAlpine *et al.*, 1982). In view of the dominance of the smallholder sector in the major export tree crop industries and the widely held view that this is a 'low productivity' sector (eg, Howlett, 1973, Ward and Proctor, 1980), therefore with potentially high returns to productivity improvements (Hardaker *et al.*, 1984), these are important gaps in the work to date.

Another lesson from past work has been the lack of analysis of off-farm influences on farmer decision making. For example, there has been very little research into smallholder supply response to prices,

risk, credit, the influence of seasonal employment opportunities on investment and production decisions or the influence of education on aspirations, although more has been done on market access and rural-urban migration. One reason for this has been the lack of economic inputs into agricultural research.

The strong social inter group and intra group links which feature reciprocal gift giving and important non market influences on production behaviour in most social groups, mean that analysis of the individual household outside the group context is risky. Definitions of 'a household' and 'a family' likewise require reference to the group context.

Concern with the human nutrition consequences of economic development has been a feature of the research work of the past decade. Agricultural researchers have combined with nutritionists in several provinces (Chimbu, SHP in particular) and in the National Nutrition Survey (NNS). The work of Harvey and Heywood (1983) has suggested that broad based smallholder cash cropping was associated with improved growth of children over the period 1956-1981 in Chimbu Province. It is now generally considered that smallholder cash cropping has had a positive influence on nutritional status in PNG. More detailed study of this relationship is scheduled to be done as a part of the ACIAR funded Export Tree Crop Study, once the results of the NNS are available. Deciding this issue is obviously important for policy as previous anecdotal evidence of a negative association between cash cropping and nutrition (eg, Lambert, 1979), which has been strongly criticised by Hide (1980), has had wide ranging influence both in Papua New Guinea and overseas (eg, IFPRI, 1984).

Whilst farming systems type work has had a long history in Papua New Guinea, it has not followed the overseas methodologies developed at institutes such as IRRI or ICRISAT (eg, Flinn, 1978). Manpower and other resource constraints cast some doubt on the appropriateness of these approaches for Papua New Guinea, but it is fair to say that they have not been given a serious trial. The FSR type work that has taken place has rarely involved interactive teamwork.

The need for training of research staff in the principles and methods appropriate to farming systems research, beyond the disciplinary studies normally undertaken, stands out if FSR is to become institutionalised in Papua New Guinea. Related to this, there would be value in institutional support for the present and planned work, a topic ACIAR could consider.

4. The Present

Presently agricultural research is in a transitional period. Large research projects have either finished (e.g. SLUP) or will soon do so (e.g. AFTSEMU) (Table 1). They have demonstrated the value of multi-disciplinary inputs to address key provincial issues, but have suffered from the time constraints imposed by project funding. They have also provided much improved information with which to accurately focus future research and extension work.

The Department of Primary Industry's research services are being rebuilt after a number of years in decline and industry based research in the export tree crops has commenced. Joint industry/government funding of research has recently been endorsed by the Cabinet and under the Medium Term Development Plan (1986-90), agricultural research funding is likely to increase significantly. Although farming systems research has been nominated as an important area (Moxon, 1983, ISNAR, 1982), it is likely to have a less important role than either component research or cropping systems research. The present role of FSR can be summarised as follows:

4.1 Export Tree Crop Research

The need for FSR programmes has been recognised in cocoa, coconuts and coffee, but not as yet in oil palm, rubber or the other export tree crop industries. However the pro FSR view has come principally from government researchers and government will probably provide less funding than industry under the new proposals for industry based research, although the exact relative roles are not as yet clear. Although smallholder growers contribute more than larger producers to research levies in cocoa, there has been an apparent bias in the work so far and in research thinking towards crop improvements which may not be best suited for smallholders: 'trickle down' effects are still given credence by the research advisors to that industry (Turner, 1982). Any FSR programme development seems to presuppose the appointment of agricultural economists to the research institutes. These appointments have lower priority than biological scientists and will probably require aid funding to become a reality.

4.2 Food Crops Research

There has been a definite recommendation to Government that FSR become a part of an overall cropping systems thrust in the highlands and lowlands food crops research teams (ISNAR, 1982). Whilst accepting this in principle, government to date has been concerned to set up the teams.

The first, at Kuk in the highlands, is currently recruiting staff. Once the team is assembled, priorities will then be set. It is likely however, that these teams will need to concentrate their resources on high priority areas only, such as areas under increasing population pressure or areas with food supply, nutrition or low income problems. It seems possible that an FSR approach to priority setting and problem solving may be at least partially adopted. DPI is presently reviewing all past food crop research, which will be then used as a basis for deciding future priorities.

4.3 Other FSR - Related Work

There are two other projects underway at present which are doing studies which are related directly to assessing farming systems. These are the DPI/CSIRO Resource Potential Study and the DPI/Queensland DPI/ACIAR Export Tree Crops Study (Table 2).

The outputs of the DPI/CSIRO study will include the mapping and description (physical and agricultural) of over 5,000 resource units, their present resource use and the development of a methodology to assess the capacity of these units to support increased populations and intensified land use.

The outputs of the DPI/QDPI/ACIAR study will include the development of efficient and low cost methodologies for monitoring and assessing the economic situation and trends in large, medium and small-scale coffee, cocoa and coconut production, and developing indicators on the relationship between smallholding cash cropping and subsistence, including the effects on nutrition from increased production of cash crops.

5. What has Farming Systems Research to offer Papua New Guinea?

This has been a frequently asked question in recent years. The answers given have been just as frequently vague. Although we have noted the long history of agricultural/social/farming systems type research, we have also noted the limited amount of interactive team involvement, systematic surveys of client groups to determine priorities, and the lack development, testing and evaluation of technology under village conditions. In other words a complete FSR approach, as developed in other countries, has not been tested in Papua New Guinea. However, aspects of it have been tested (eg, Nembu Plateau, AFTSEMU, SLUP) and the positive results from these experiences suggest that this kind of approach, modified to suit local resources, may well be superior to its

alternatives.

An FSR approach would seem to offer greater opportunities for asking the correct research questions. There are several reasons for this:

(a) The FSR approach commences an enquiry with an open mind to the issues involved, narrowing these down as a result of on-farm surveys and other enquiries which would call on data such as that which is either available now or will be in future at a local and macro level. As there is such a useful array of recent macro level data and resources available (Table 2), it will soon become possible to place areas and farming systems into a nationwide context and to broadly see the results of the present systems in terms of cash income, level of reliance on subsistence and nutritional status. The individual researcher will be able to undertake analysis from many of the above sources for his particular location and needs, and therefore be able to focus an enquiry more skilfully.

(b) Local level FSR enquiries take into account on and off-farm influences. In Papua New Guinea on-farm influences to food and cash crop production include the size of pig stocks at any time, the demands (sometimes delayed) of reciprocal exchanges, and a steady round of social obligations, apart from the normal influences of the quality of planting material, labour and land availability and seasonal tasks. Off-farm influences include market access for sellers and buyers, information flows with respect to price, demand, cultivation techniques and inputs, and security issues, particularly from inter-group fighting in the highlands.

(c) FSR enquiries would integrate cash and food crops as well as the animals raised in a village. This would prevent the separation of food and cash crops research which will be a natural tendency following the decision to establish specific research institutes for the major export tree crops. Preliminary work has indicated that the practices of integrating tree and food crop production are basically sound, but further research is needed on such systems.

The above list of macro and local level influences, which is far from exhaustive, is a good deal wider in scope than yields of staple foods or export tree crops, which could be said to have dominated research priorities to date. Yields may indeed turn out to be the most critical area for focus, but to determine this researchers should look wider than the biological and ecological determinants of crop yields to decide their priorities.

But is this list too wide already, ruling FSR out in practical terms for Papua New Guinea? This question has been rightly asked by experienced government researchers for the foods area. It may be that the time involved in accurately specifying a set of priorities (given the inordinate real world constraint of rapid staff turnover and recruitment delays) is so great that politicians and others will become impatient for action. Better, it could be said, to concentrate on getting some results as quickly as possible: therefore the focus would be pre-determined, and the decision to concentrate on quality improvement (higher yields especially) in food crop staples and export tree crops appears obvious.

These are the main issues surrounding FSR at present: it seems attractive, but appears long winded and may be beyond the resources available. Our conclusions are that an FSR approach should be tried and evaluated as it offers a better chance of accurately focussing research resources on the most relevant issues.

For the immediate future we would suggest that ACIAR become involved to assist in the **planning and monitoring** of FSR. Of particular use would be advice on methodologies to determine priorities, on-farm research needs and the experiment station/on-farm research relationship. During the period of research startup in the food and export tree crop areas, an FSR collaborative input could be very useful to assist local researchers to establish a viable research programme.

Table 1. Farming Systems Research in PNG since 1978

<u>Study</u>	<u>Main Linkages</u>	<u>Reference</u>
1. Nembi Plateau Survey	Agriculture-land use-nutrition	Allen, 1984
2. Crop Intensification, Nembi Plateau	Agriculture-land use	D'Souza & Bourke, 1984
3. Sustenance, Seasonality and Social Cycles	Agriculture-nutrition	Crittenden, 1982 Baines, 1983
4. AFTSEMU, Southern Highlands	Agriculture-land use-nutrition-economics	Research concludes September, 1985
5. Tari Land Use	Agriculture-land use-soil fertility-nutrition-health	Wood, 1984 Ongoing (Allen)
6. Simbu Land Use	Agriculture-land use-nutrition-soil fertility	Hide, 1984; Harvey & Heywood, 1983; Humphries, 1984
7. Enga subsistence Team	Agriculture-land use-nutrition	Ongoing (Wohlt)
8. Coffee FSR Project	Economics-agriculture-nutrition	Carrad, 1981
9. Land Use, Inland Madang Province	Agriculture-nutrition	Spencer and Heywood, 1983
10. Variation in Subsistence Food Supply	Agriculture-human behaviour	Ongoing (Bourke & D'Souza)
11. Crop Intensification, Lowlands	Agriculture	Leng, 1982
12. Wau Ecology Institute	Agriculture-forestry	-
13. Atzera Range	Agriculture-forestry	-
14. DPI/CSIRO Resource Potential Study	Land Use-Agriculture-Cartography	McAlpine <i>et al.</i> , 1982 (ongoing)
15. DPI/QDPI/ACIAR Export Tree Crops Study	Economics-Agriculture-nutrition	ACIAR (1984) (ongoing)

Table 2. Major National Data Sources and Reviews since 1980

1. 1980 National Population Census	National Statistical Office
2. CSIRO Resource Potential Study (ongoing)	McAlpine <u>et al.</u> , 1982.
3. 1982-3 National Nutrition Survey	Analysis ongoing
4. 1983 Review of Subsistence Agriculture	UNDP/DPI, 1983
5. 1984-Rural Household Survey (ongoing)	National Statistical Office
6. 1985-7 Export Tree Crop Study (ongoing)	ACIAR/DPI/QDPI
7. Analysis of CPI Food Price Data in 5 Urban Centres, 1970-1984	DPI, 1985 (in prep.)
8. Topographical Maps of PNG (1:100,000)	National Mapping Bureau
9. Food Crops Research Review	DPI, 1985 (prep.)

References

- ACIAR (1984) Papua New Guinea Export Tree Crop Study. Project 8383. Australian Centre for International Agricultural Research, Canberra.
- Allen, B.J. (1982) Subsistence agriculture: three case studies. In Carrad et al. (Eds.), pp 93-127.
- Allen, B.J. (Ed.) (1984) Agricultural and nutritional studies on the Nembi Plateau, Southern Highlands. Dept. Geogr. Occas. Paper 4 (New Series). Univ. of PNG & SHRDP, Port Moresby.
- Baines, J. (1983) Dietary patterns of pregnant women and birthweights on the Nembi Plateau, Papua New Guinea. Unpubl. M.Sc. thesis, Univ. of London, London.
- Bourke, R.M. (1977a) A long term rotation trial in New Britain, Papua New Guinea. In Proc. Third Sympos. Internat. Soc. Trop. Root Crops. C.L.A. Leakey (Ed.), ISTRC/IITA, Ibadan, pp 382-388.
- Bourke, R.M. (1977b) Sweet potato (Ipomoea batatas) fertilizer trials on the on the Gazelle Peninsula of New Britain: 1954-1976. Papua New Guinea Agric. J. 28(2,3,4): 73-95.
- Bourke, R.M. (1979) Food crop farming systems for institutions in the lowlands. In Agriculture in the Tropics. B.A.C Enyi & T. Varghese (Eds.). Univ. of Papua New Guinea, pp 88-103.
- Bourke, R.M. (1982) Agronomic field trials on food crops in Papua New Guinea: 1928-1978. Tech. Rep. 82/3. DPI, Port Moresby.
- Bourke, R.M. (1983) Fifty years of agricultural change in a New Guinea highland village. Paper presented at First PNG Food & Nutrition Conference, Goroka, Nov. 1983.

- Bourke, R.M. & Kesavan, V. (Eds)(1982) Proceedings of the Second Papua New Guinea Food Crops Conference. Dept. of Primary Industry, Port Moresby.
- Boyd, D.J. (1975) Crops, Kiaps and currency: flexible behavioral strategies among the Ilakia Awa of Papua New Guinea. Unpubl. Ph.D. thesis, Univ. of California, Los Angeles.
- Brookfield, H.C. & Brown, P. (1963) Struggle for Land: Agriculture and Group Territories among the Chimbu of the New Guinea Highlands. Oxford University Press, Melbourne.
- Carrad, B. (1981) The coffee farming systems research project. Research Newsletter 1(1): 7-10. Coffee Industry Board, Goroka.
- Carrad, B. (1982) Economic aspects of smallholder practices: mixed cropping of food and coffee. In Bourke and Kesavan (Eds.), pp 294-302.
- Carrad, B., Lea, D.A.M. & Talyaga, K.K. (Eds)(1982) Enga: Foundations for Développement. Univ. of England, Armidale.
- Clarke, W.C. (1971) Place and People: an Ecology of a New Guinean Community. Univ. of California, Berkeley.
- Crittenden, R. (1982) Sustenance, seasonality & social cycles on the Nembi Plateau, Papua New Guinea. Unpubl. Ph.D. thesis, ANU, Canberra.
- D'Souza, E. & Bourke, R.M. (1984) The subsistence agriculture research project. In Allen (Ed.), pp 101-111.
- Etherington, D.M. & Carrad, B. (1984) The appropriate scale for South Pacific agriculture: some evidence from PNG & The Solomon Is. In Economic Policy Issues and Options in Papua New Guinea, Working Paper No.41, D. Gupta & S. Polume (Eds), Development Studies Centre, ANU, Canberra, pp 85-102.
- Flinn, J.C. (1978) Focussing farming systems research on smallholder agriculture: experience from West Africa. In The Adaptation of Traditional Agriculture: Socioeconomic Problems of Urbanisation. E.K. Fisk (Ed.), Development Studies Centre Monograph 11, ANU, Canberra.
- Gagne, W.C. (1980) Stabilising shifting agriculture. Harvest, 6(4): 192-195.
- Gallasch, H. (1976) Integration of cash and food cropping in the lowlands of Papua New Guinea. In 1975 Papua New Guinea Food Crops Conference Proceedings. K. Willson & R.M. Bourke (Eds) DPI, Port Moresby, pp 101-115.

- Hardaker, J.B.,
Fleming, E.M. &
Harris, G.T. (1984) Smallholder modes of agricultural production in the South Pacific: prospects for development. Pacific Viewpoint 25(2): 196-211
- Harvey, P.W.J. &
Heywood, P.F. (1983) Nutrition and Growth in Simbu. Research Report of the Simbu Land Use Project, Vol.4, IASER, Port Moresby.
- Hide, R.L. (1980) Cash crop and food crop production in Chimbu. History of Agriculture Working Paper No.44, UPNG/DPI, Port Moresby.
- Hide, R.L. (1981) Aspects of pig production and use in colonial Sinasina, Papua New Guinea. Unpubl. Ph.D. thesis, Columbia Univ., New York.
- Hide, R.L. (1984) South Simbu: Studies in Demography, Nutrition, Subsistence. Research Report of the Simbu Land Use Project, Vol. 6, IASER, Port Moresby.
- Howlett, D.R. (1962) A decade of change in the Goroka Valley, New Guinea: Land use and development in the 1950s. Unpubl. Ph.D. thesis, ANU, Canberra.
- Howlett, D.R. (1973) Terminal development: from tribalism to peasantry. In The Pacific in Transition, H. Brookfield (Ed.). Edward Arnold, London. pp 249-273.
- Humphries, G.S. (1984) The environment and soils of Chimbu Province, Papua New Guinea, with particular reference to soil erosion. Research Bull. 35. Dept. of Primary Industry, Port Moresby.
- IFPRI (1984) The Income and Nutrition Effects of Shifts from Semi-Subsistence to Cash Cropping. Research Proposal (mimeo). International Food Policy Research Institute, Washington
- ISNAR (1982) Review of the Program and Organization for Crops Research in Papua New Guinea. International Service for National Agricultural Research, The Hague.
- Kimber, A.J. (1974) Crop rotations, legumes and more productive arable farming in the highlands of Papua New Guinea. Science in New Guinea 2(1): 70-79.
- Lambert, J.N. (1979) The relationship between cash crop production and nutritional status in Papua New Guinea. History of Agriculture Working Paper No. 33. UPNG/DPI, Port Moresby.
- Lea, D.A.M. (1984) Abelam land & sustenance. Unpubl. Ph.D. thesis, ANU, Canberra.
- Leng, A.S. (1982) Maintaining fertility by putting compost into sweet potato mounds. Harvest 8(2): 83-84.
- Malinowski, B. (1935) Coral Gardens & their Magic. American Book Company, New York.
- McAlpine, J.R.,
Bleeker, P., Freyne, D.
& Keig, G. (1982) Assessing resource potential for food crop production in Papua New Guinea. In Bourke & Kesavan (Eds), pp 325-329.

- Mitchell, D.D. (1976) Land and Agriculture in Nagovisi, Papua New Guinea, Monograph No.3, IASER, Port Moresby.
- Moxon, J.E. (Ed.)(1983) Review of the research requirements for cocoa in Papua New Guinea. Tech. Rep. 83/7, DPI, Port Moresby.
- Newton, K. & Jamieson, G.I. (1968) Cropping and soil fertility studies at Keravat, New Britain. 1954-1962. Papua New Guinea Agric. J. 20(1,2): 25-51.
- Ohtsuka, R. (1983) Oriomo Papuans, Ecology of Sago-Eaters in Lowland Papua. Univ. of Tokyo Press, Tokyo.
- Parkinson, R. (1907) Dreikig Jahre in der Sudsee (Thirty Years in the South Seas. N.C. Barry, translator). Strecker and Schroder, Stuttgart.
- Rappaport, R.A. (1968) Pigs for the Ancestors. Ritual in the Ecology of a New Guinea People. Yale University Press, New Haven.
- Simpson, G.J. (1978) The Mulim: a case study of the potential and limitations for rural development in a marginal agricultural area, Southern Highlands Province, Papua New Guinea. Unpubl. B.A. (Hons.) thesis, UPNG.
- Spencer, T.J. & Heywood, P.F. (1983) Seasonality, subsistence agriculture and nutrition in a lowlands community of Papua New Guinea. Ecol. Food Nutr. 13.
- Turner, P.D. (1982) Research Requirements and Priorities for Cocoa. Report to the Cocoa Board.
- UNDP/DPI (1983) Profile & Planning Study for Subsistence Food Production. Dept. of Primary Industry, Port Moresby.
- Vance, P. & Sumbak, J. (1979) Cropping patterns for rainfed farming in the Markham/Ramu Valleys. Harvest 5(2): 123-127.
- Waddell, E. (1972) The Mound Builders: Agricultural Practices Environment & Society in the Central Highlands of New Guinea. Univ. of Washington Press, Seattle.
- Ward, G.R. & Proctor, A. (Eds.)(1980) South Pacific Agriculture: Choices and Constraints. South Pacific Agricultural Survey 1979. ADB, Manila.
- Wohlt, P.B. (1978) Ecology, agriculture and Social organisation: the dynamics of group composition in the highlands of Papua New Guinea. Unpubl. Ph.D. thesis, Univ. of Minnesota, Minneapolis.
- Wood, A.W. (1984) Land for tomorrow. Subsistence agriculture, soil fertility and ecosystem stability in the New Guinea highlands. Unpubl. Ph.D. thesis, Univ. of PNG, Port Moresby.