The contribution of crop-plant genetic diversity to economic development and sustainable rural livelihoods in the Pacific region

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The challenge of food security is of great concern for the governments and people of the Pacific region. The United Nations Food and Agriculture Organization (FAO) has identified many Pacific island countries as having poor food security status, indicated by low food production, increasing volumes of imported food, a decline in purchasing power, and poor indicators of health and nutrition. The Pacific region is home to many exotic and under-utilised fruits, nuts and vegetable species and is a secondary centre of diversity for sweet potato, taro, yam, cassava and cooking banana. Despite this, several island countries are experiencing production and food security problems, and successful export markets are seen in only a few countries. Inflation is high in many island countries, contributing to low purchasing power. The demands of climate change and globalisation further challenge this already difficult situation. This paper details the contributions that crop-plant genetic diversity has made to economic development in the region and suggests how the region could further exploit this rich resource for the benefit of present and future generations.

The Pacific represents one of the most biologically diverse areas on earth. Its island nations are located within the largest marine ecosystem, the Pacific Ocean, and the larger islands have forest habitats that contain a rich genetic diversity of food crops and timber species.

The production of staple food-crop species is the most important agricultural activity for the majority of the indigenous peoples of the Pacific. For example, more than 85 per cent of the indigenous population of Papua New Guinea lives in rural areas that rely on agriculture for their livelihood. Agricultural production in the region follows a complex farming system in which staples such as taro (Colocasia esculenta), yam (Dioscorea spp.), sweet potato (Ipomoea batatas), cassava (Manihot esculenta), cooking bananas (Musa spp.), breadfruit (Artocarpus altilis), pandanus (Pandanus spp.), leafy vegetables aibika/bele (Abelmoschus manihot) and amaranths (Amaranthus spp.) are cultivated in an integrated system of cropping. Food production is largely in the hands of small subsistence farmers, but there are farmer organisations and marketing agencies in some island countries that have members who grow crops specifically for export.

It is difficult to estimate the production figures and economic values for food crops in the region because of the subsistence production systems under which these
crops are grown. McGregor (2006) estimated the production of staple food crops for Solomon Islands at 432,000 tonnes a year—a figure that could indicate the production situation in other large island countries of the region.

Throughout the centuries, the livelihood of Pacific people has been sustained by what they can grow in their gardens, collect from the forests, and harvest from the sea. However, their focus is shifting from food production for household consumption to producing additional food to sell.

The contribution of plant genetic resources to sustainable livelihoods

In agricultural systems, a diversity of crop species and varieties is needed to combat the risks farmers face from pests, diseases, and variations in climate and environmental conditions. A crop-plant genetic resource underpins the breadth of dietary needs of consumers as societies advance from an agricultural to an industrial base. The large islands of the Pacific have a rich diversity of staple root and tuber crops, which provide their main carbohydrate requirements. For example, as of March 2007, the numbers of sweet potato, taro, yam and cassava in the PNG national germplasm collection stood at 2,658 accessions.

Another important staple is the cooking banana. There are two genera (Musa and Ensete) and six species of banana found in the Pacific region. The edible species are from the Musa genus, which has more than 300 accessions and landraces. Pacific bananas have some unique traits that are useful for nutritional purposes—for example, the bananas of the Federated States of Micronesia (FSM) have a high carotenoid content that is used in addressing vitamin A deficiencies, anaemia, and diabetes.

Although some genetic diversity is being maintained by farmers, a high percentage is being lost through the breakdown of traditional farming, cultural, and customary practices. This has prompted island countries to develop strategies to collect, conserve, and maintain genetic diversity in ex situ collections.

Local community initiatives

The campaign by the people of the FSM to ‘go local’—consuming local rather than imported food—is an excellent example of crop-plant genetic resources enhancing the livelihoods of island people. Englberger and Lorens (2004) reported that 42 banana cultivars from FSM had been documented, including the Karate bananas, which contain 670–918 micrograms of beta-carotene. The Karate is from the Fe’i group of bananas; some cultivars from this group contain even higher levels of beta-carotene—from 1,250 to 6,360 micrograms (Englberger and Lorens 2004). Other banana genomes also have cultivars with high beta-carotene content and some common cooking diploids (AA) and triploids (AAB/ABB) found in Papua New Guinea, Solomon Islands and Vanuatu could also contain high levels of carotene.

Other Pacific island countries should be encouraged to go back to basics and grow and consume a diversity of food crops, not only for nutritional enhancement but also to ensure that the rich genetic diversity of the Pacific food-crop species is maintained for food security for present and future generations.

Another story of utilising crop-plant genetic resources to provide food for local communities is the initiative taken by the non-governmental organisation (NGO) Kastom Gaden Association and the Planting Materials Network (KGA/PMN) of the Solomon Islands. The membership of the KGA/PMN, who are from local communities, formed a network to maintain,
multiply and distribute planting materials of local food crops and seeds of introduced crop species among themselves and their neighbouring communities. The diversity of planting materials is conserved in the fields and maintained by the members of the network, while the association provides administrative and technical support.

Conservation of food-crop diversity on-farm

On-farm conservation is defined as the maintenance of traditional cultivars or landraces by farmers within traditional agricultural systems (Hodgkin et al. 1993). On-farm conservation also allows evolutionary processes to continue in the natural environment, unlike ex situ conservation, where evolution is discontinued (Brush 1995).

Farmers have been practising on-farm conservation—in which they select and maintain desirable planting materials from old gardens to plant in new gardens each season—for centuries. Minor or under-utilised food-crop species are conserved in the wild and harvested whenever needed. The progenitors of some food crops are collected from the wild as well.

The diversity of food crops maintained by farmers in the past has been depleted and farmers are maintaining species and varieties that are in demand from consumers or those varieties that can withstand unfavourable environmental conditions. In most island countries, increased populations have placed pressure on arable land, and declining fallows, decreased soil fertility, and problems with pests and diseases have forced farmers to rely heavily on species that are hardy and have a short growing season.

The disappearance of crop diversity on-farm is a global concern. The FAO, through the International Plant Genetic Resources Institute (IPGRI), organised numerous germplasm collecting expeditions throughout the world. A number of such trips were undertaken in the Pacific region, and national germplasm collections were established. The problem of loss of diversity has continued in ex situ collections, due mostly to maintenance problems associated with inadequate resources. This prompted agricultural authorities in some Pacific island countries to work with local farmers to return to traditional practices in conserving food-crop diversity on-farm. Four island countries that are doing some formal work in on-farm conservation are Vanuatu, Tuvalu, New Caledonia and Solomon Islands, while a study is currently being conducted in Papua New Guinea.

The impact of genetic erosion on sustainable food-crop production

Increasing environmental degradation, compounded by global warming, has contributed to a serious depletion of biological resources, including traditional food-crop resources. The rich forest habitats are home to a wide range of vegetables, fruits, nuts, medicinal plants and herbs; however, many of these valuable plants are being destroyed by mining and logging activities and commercial agricultural developments, as well as urbanisation.

The lifestyles and eating habits of Pacific people—especially the younger generations—are changing with the growth of the cash economy and the introduction of processed foods. Island people have acquired a taste for processed foods such as rice, wheat, tinned fish and meat and farmers often sell their best food crops for cash to buy such processed foodstuff.

The SPC and PAPGREN

The South Pacific Commission (SPC) has played a pivotal role in regional collaboration on plant genetic resources. It has established the Regional Germplasm
Centre (RGC), which facilitates the exchange of plant genetic materials and maintains a collection on behalf of member countries, with a particular focus on providing pest and disease-free planting materials. It also initiated the establishment of PAPGREN and participates in other networks.

Plant genetic resources remain the key to meeting future food needs, yet these resources are disappearing at unprecedented rates, with uniform crop varieties rapidly replacing the myriad local landraces, and traditional crops being abandoned. In 1996, the Pacific Heads of Agriculture and Livestock Programmes (PHALPS) resolved ‘to put in place...policies to conserve, protect and best utilise their plant genetic resource’.

The RGC began operations in September 1998, with the aim of assisting Pacific island countries to conserve the region’s genetic resources, and to facilitate access to traditional and improved crop varieties. The centre uses in vitro techniques for conservation. In April 2007, the RGC changed its name to the Centre for Pacific Crops and Trees (CePaCT), reflecting its new mandate to work on forest and tree as well as crop genetic resources.

The centre’s primary objective is conserving and promoting the use of plant genetic resources and distribution of germplasm increases annually. Research is also high on the CePaCT’s agenda, and significant success has been achieved—namely the development of an effective cryo-preservation protocol for taro and a micro-propagation technique for kava.

PAPGREN was launched in September 2001. Its objectives are to strengthen national plant genetic resource programs and collaboration at the regional level. The following countries participate in the network: Cook Islands, FSM, Fiji, French Polynesia, Kiribati, New Caledonia, Niue, Palau, Papua New Guinea, Republic of the Marshall Islands, Samoa, Solomon Islands, Tonga and Vanuatu.

A key prerequisite for collaboration is the wide availability of knowledge of national and regional germplasm holdings. Compiling information on national and regional gene-banks was a high-priority activity for PAPGREN during its first two years. Adequate safety duplication of germplasm collections is another important aspect of conservation.

As well as addressing the national priorities for conservation actions on priority crops, PAPGREN has been working on crop and regional strategies for the Global Crop Diversity Trust. To complement the strategies for staple crops, the 2006 annual PAPGREN meeting agreed on a regional strategy for the development of neglected and under-utilised crops.

The contribution of plant genetic resources to economic development

Diversity as insurance

Insurance is a safety net for the uncertain future. In the Pacific, where nature makes it difficult to gain and maintain increases in agricultural productivity and where the prevalence of pests and diseases poses a constant threat to food and income security, uncertainty is compounded by the lack or underdevelopment of financial markets, including futures markets. These factors, together with changing consumer and market preferences, make future income stability uncertain under homogeneous patterns of cropping. Genetic diversity of cropping will provide the most natural and assured of all agricultural insurance schemes in the Pacific for the foreseeable future.

Even if genetic diversity is low, if food crops are diverse, problems such as crop
pests will force farmers to diversify. For example, taro-leaf blight has forced Samoa to undertake export diversification into areas such as nonu, cassava and coconut oil (Agriculturalist Online 2006). Fiji is now exporting taro, pawpaw, coconut, duruka (*Saccharum eduli*) and green ginger to New Zealand, Australia, Canada and the United States.

**Potential revenue from diversity**

The diversity of food crops accounts for much of the healthy and sustainable livelihoods and economies of the Pacific. Current income data from taro is sparse. Therefore, the best parameter to look at is the percentage of dietary calories that taro contributes (Table 1). In terms of this measure, four of the top six countries in the world are from Oceania. Hence, because of its wide genetic base, taro is an important contributor to income and food security in the Pacific.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Percentage of dietary calories derived from taro and all tubers, 1984</th>
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<tbody>
<tr>
<td>Country</td>
<td>Taro</td>
</tr>
<tr>
<td>Tonga</td>
<td>18.1</td>
</tr>
<tr>
<td>Samoa</td>
<td>16.0</td>
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<tr>
<td>Solomon Islands</td>
<td>7.7</td>
</tr>
<tr>
<td>Ghana</td>
<td>7.1</td>
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<tr>
<td>Gabon</td>
<td>4.6</td>
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<tr>
<td>Papua New Guinea</td>
<td>4.2</td>
</tr>
<tr>
<td>Zaire (Democratic Republic of the Congo)</td>
<td>0.1</td>
</tr>
<tr>
<td>Cameroon</td>
<td>0.5</td>
</tr>
<tr>
<td>Oceania</td>
<td>0.7</td>
</tr>
<tr>
<td>Asia</td>
<td>0.1</td>
</tr>
<tr>
<td>Africa</td>
<td>0.5</td>
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<tr>
<td>North and Central America</td>
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<td>South America</td>
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<td>Europe</td>
<td>-</td>
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<tr>
<td>World</td>
<td>0.1</td>
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**Food genetic diversity in cash cropping and providing foreign exchange**

While their bulkiness, fragility and perishability make taro products an 'awkward commodity', taro is an important cash crop. Where taro is exported, it earns revenue for farmers as well as foreign exchange (Onwueme 1999). For instance, Fiji earned $21 million in foreign exchange from taro in 2006 (Fiji Times Online 2007). In Papua New Guinea, the aggregate value of local sweet potato, banana, taro, Chinese taro and betel-nut was about K1.3 billion annually in 1996 (Bourke et al 2000). Given that as much as 85 per cent of the PNG rural population does not have access to markets, food crops represent a huge economic potential. A similar scenario is believed to exist in other Pacific island countries.

**Diversifying crop-based industries**

Crop diversity makes it possible to diversify crop-based industries. The collapse of
taro exports led to diversification of Samoa’s export products and markets. Crop diversity also provides opportunities for diversification in related industries. A good example is the development of bio-fuel industries from food-crop based sources. A recent development is the promotion of coconut oil as a bio-fuel. Samoa’s Electric Power Corporation is currently running a trial using 15 per cent locally produced coconut oil mixed with 85 per cent diesel in some power generators (Agriculturalist Online 2006). In Papua New Guinea, a cassava bio-fuel project was launched recently.

Conclusion

The Pacific region is a centre of secondary diversity of major staple root and tuber crops and cooking bananas and is home to many exotic fruits, nuts and vegetables. The island communities have relied on this crop diversity to sustain their livelihoods for centuries. Crop diversity provides variety in the local diet and allows farmers to minimise the risk of crop failure and respond to changing circumstances. Crop diversity also provides the raw materials for crop improvement programs, which is vital for sustainable agricultural development. Many food-crop species are an essential part of traditional ceremonies and are important to the cultural identity of Pacific peoples.

Crop genetic diversity constitutes a grossly under-utilised resource base that can spur and sustain economic and social advancement. Diversity promises variety, product differentiation and premium prices, insurance, employment opportunities, export diversification, foreign exchange earnings, and a strong connection with history, culture and identity.

Crop genetic diversity has no doubt contributed immensely to economic development in the Pacific region and holds great potential to continue to do so.

References


Fiji Times Online, 2007. ‘Breadfruit in high demand locally and overseas’, Fiji Times Online, 1 June.

