Improving food security in Timor-Leste with higher yield crop Varieties

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Improving food security in Timor-Leste with higher yielding crop varieties

Modesto Lopes[1] and Harry Nesbitt[2]

Introduction

Timor-Leste (East Timor) is a small country situated at the Eastern end of the Indonesian archipelago and to the north of Australia lying between 8.1 and 9.5° S and 125.0 and 127.3°E (Figure 1). It is approximately 1500 square kilometres in area and occupies the Eastern half of the island of Timor plus the small enclave of Oeccussi on the north coast of W. Timor. Once a colony of Portugal for over 400 years and under Indonesian rule for 24 years, Timor-Leste is now a democratic republic after 85% of its population voted for independence in a referendum during 1999. In 2010 the country's population was 1.07 million (DNE 2010) with the 2010 national census classifying 70.4% as living in rural areas. Subsistence agriculture is the main activity of the rural population as it is for many of the residents in district towns. The low level of cash income and food insecurity suffered by the farmers is reflected in the poor level of the nation's health, education and living standards with Timor-Leste ranking 147 out of 187 countries in the UNDP 2011 Human Development Index (UNDP, 2011). Food insecurity is a national problem but is particularly prevalent in the rural areas where agricultural resources are poor and unstable. Farming area is not a constraint with only 30% of arable land being used for cropping or in combination with animal grazing (GOTL, 2007). However, there are labour constraints, particularly during weeding which limit the area that can be cultivated by individual farm families. In the uplands, farmers generally employ slash and burn techniques, dibbling upland crops directly into uncultivated soil. Much of the soil is infertile; fertilizers are rarely used; traditional crop varieties are particularly low yielding and other productivity improving technologies lacking; infrastructure is underdeveloped making markets inaccessible; finance is unavailable and research and extension facilities are in the developmental stage. Low productivity from the farming community is exacerbated by the highly variable rainfall pattern resulting in food insecurity being a major issue in Timor-Leste. This paper describes some of these issues in more detail with particular emphasis on a program to improve food security through the increased productivity of food crops.

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Figure.1. Location of Timor-Leste (East Timor) in SE Asia

Food production in Timor-Leste

The island of Timor is on the edge of the Australian and Pacific geological plates and is one of the upward lift "crimps" as the plates press against each other. Deep ocean trenches are found to the north and south of the island and a mountain range reaching 3,000 m in height forms its backbone. Many of the mountain sides are steep, with 44% of the slopes being greater than 40% (Barrett *et al,* 2007). The mainland of Timor-Leste is approximately 250 km long and 75 km wide at its widest point (Figure 2) but because of the mountainous nature of the country, only 40% (600,000 ha) is suitable for crop and livestock production (FAO, 2011). The uplifted rock is sedimentary in nature and the soils on the slopes are shallow, rocky and often leached of nutrients. Some more fertile alluvial soils are located in the valleys and along the north and south coasts but these are generally small in area. The south coast is also underpopulated due to widespread existence of malaria and other mosquito borne diseases. Some soils, although fertile in appearance possess yet to be described macro and micro-nutrient deficiencies.

Figure 2. Topographical map of Timor-Leste*

*Map from the Ministry of Agriculture and Fisheries Agricultural Land Geographical Information System

Rainfall in the north of the island ranges from 800-1300 mm with a majority of it falling during the months of November to February (Figure 3) while in the centre and to the south of the island there is a bimodal rainfall pattern with rainfall exceeding 2000 mm in the mountains and up to 1500 mm on the south coast. For example the long term rainfall for Fatumaca (Baucau) on the north coast is 995mm and at Betano (Manufahi) on the south coast is 1329mm.

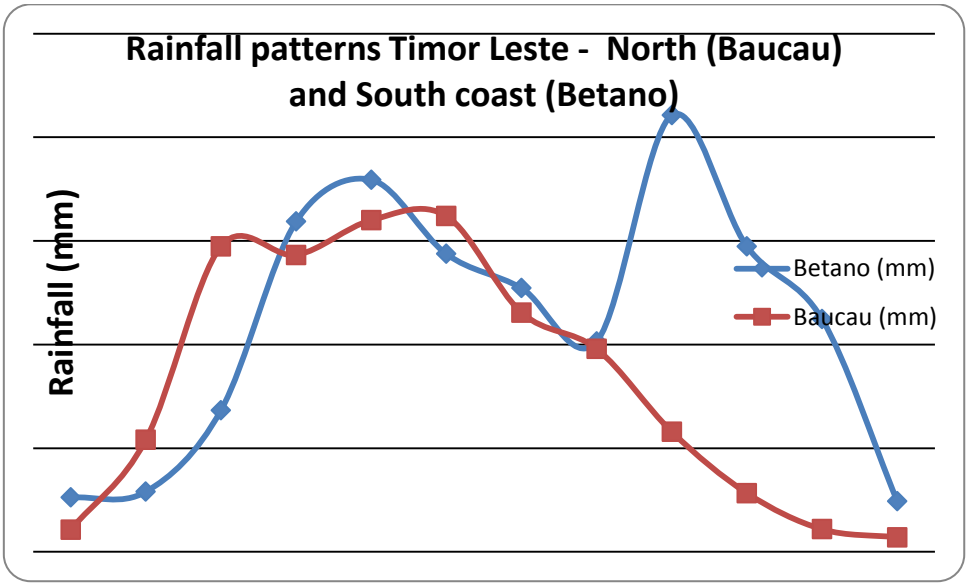

Figure 3. Rainfall patterns in the north and south of Timor-Leste (long term means)

Maize (*Zea mays* L.) and rice (*Oryza sativa* L.) are the staple crops in Timor-Leste. The diet is also supplemented with sweet potato and cassava, peanuts and other legumes (climbing beans (*Phaseolus vulgaris L.)*, pigeon peas (*Cajanus cajan)*, bitter bean (*Phaseolus lunatus L.)*, mungbean(*Vigna radiata*)) plus fruit. Yams and other local foods may also be harvested from forest areas during lean seasons. Meat in the rural areas is consumed only during festivals when a chicken, pig or head of cattle are slaughtered.

Approximately 70,000 ha of maize and 38,000 ha of rice are sown each year (FAO, 2011). Dibbling directly into hillsides is the predominate method of planting maize although small areas of flatter land are ploughed with the assistance of Government supplied tractors. Most of the maize is grown during the main wet season from December to February but approximately 6,000 ha as the second crop (May to July). Most rice is lowland paddy and only very small areas of upland rice are sown. If tractors are unavailable, buffaloes puddle the paddies. Otherwise, there is little animal traction in Timor-Leste. Land suitable for lowland rice production is limited and irrigation water in many of the rice areas is available only from rivers thereby limiting double cropping. Sweet potato (*Ipomoea batatas* (L.) Lam.), cassava (*Manihot esculenta Crantz*), legumes, spices and some vegetables are often intercropped with the maize. Government estimates put the area under sweet potato, cassava and peanuts (*Arachis hypogaea* L.) at approximately 7,000ha, 9,000ha and 4,000 ha respectively (FAO, 2011).

The most common commercial crops are coffee (*Coffea arabica)*, chimeri (candlenut tree)(*Aleurites moluccana.L*), vanilla (*Vanilla planifolia*) and coconut (*Cocus nucifera*). Coffee is grown largely at high elevations in the districts of Liquica, Ermera, Ainaro, Bobonaro and Aileu.

Crop yields are low compared with international standards. Maize yields for example remain below 2 t/ha compared with 4 or more t/ha in other SE Asian nations (Figure 4). Rice yields are similarly low at 3.0t/ha in Timor-Leste compared with 5.0t/ha in Indonesia. Sweet potato and cassava yields are also low. Coffee yields are 1.5 to 2.0 t/ha are half those of Vietnam. There is considerable potential to improve these yields with careful planning and management. Approaches to do this are discussed below. Meanwhile, food insecurity is widespread in Timor-Leste.

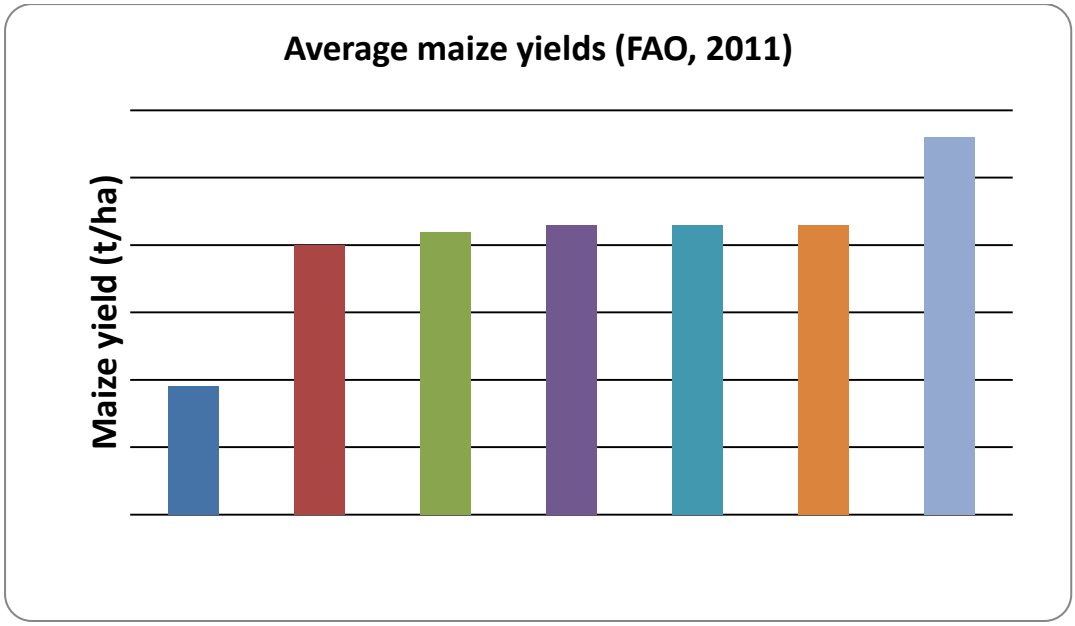

Figure 4. Average maize yields in selected SE Asian countries, 2009 (FAO, 2011).

Food security in Timor-Leste

Food security in Timor-Leste is defined in terms of three elements; availability (amount of food present in the country), access (a household's ability to acquire food) and utilisation of food (a household's use of food) (WFP 2006). For farmers, food security occurs if all members of a household are able to consistently consume three complete meals a day.

Some degree of hunger has been present in Timor-Leste since immediately after the referendum for independence in 1999 when food sources and infrastructure were either badly damaged or destroyed during the unrest. Since then, the nation has rarely been self sufficient in food production and emergency grain has been imported on an annual basis. Food shortages in the rural areas are considered to occur in two phases. The first phase is when maize and rice stocks are about to finish but there is a reasonable supply of root crops (cassava, sweet potato, taro and arrowroot) to rely on. During this period known in the local Tetun language *as tempu aihan menus*, the amount of food consumed by household members decreases. Adults access one or two meals a day, whereas children have reasonable assurance of eating two to three times a day. In worst-case scenarios, food shortages enter a second phase when all staple food is in short supply. This period is defined as the hungry season known locally as *tempu rai hamlaha*. Farmers rely heavily on harvesting wild food from the forest and the purchase or loan of food from off farm sources. Often farmers consume their seed stores and the Government needs to assist them with imported rice or maize seed to plant their next crops.

The hungry season usually occurs when crops are growing but are not ready for harvest. In the uplands, maize is harvested in March or April and the hungry months may extend from September or October through to these months. This period coincides with the labour intensive season for weeding upland crops (SoL, 2007) making it even more difficult for farmers to escape the food shortage cycle. In the lowlands, rice farmers may suffer similar food shortages prior to harvest during June/July in the north or August/September in the

south. Generally, however, upland farmers suffer the most from poor harvests from their rainfed crops.

The national annual food surplus/deficit is calculated by balancing the difference between grain production and consumption. In 2009 for example, FAO calculated that food production/consumption was reasonably balanced (Table 1) because supplementary root crops were available.

Table 1. National food balance, Timor-Leste, 2009

	Area (ha)[a]	Yield (t/ha)[a]	Prod'n (t)[a]	Seed (t)[b]	Processed product (t)[c]	Consumption (t)[d]	Surplus/deficit (t)
Cassava	9000	4.1	37302	0	37302	37302	0
Peanuts	4141	0.9	3921	828	1856	1856	0
Maize	71340	1.9	134715	2854	107772	96671	11101
Rice	38998	3.1	120775	1950	72465	80559	-8094
Sweet potatoes	6563	3.8	24684	0	24684	24684	0

a) FAO, 2011,

b) Peanut seeded at 200kg/ha, maize at 40kg/ha, rice at 50kg/ha

c) Peanut shelled at 65%, rice at 60%, 20% of maize lost in storage and processing

d) Maize consumption assumed to be 90kg/person/year and maize at 105kg/person/year

Although national food sufficiency was reasonable in 2009/2010, those farmers who were short of food had to cut back on consumption earlier during the year compared with the previous years. One study (SoL, 2011) suggested that 16% of the surveyed farmers suffered from food shortages during the year. Of those who did suffer shortages, 40% exhausted their maize stocks in June compared with 20% in 2008/2009. These farmers must have suffered a catastrophic reduction in maize yields in the previous year.

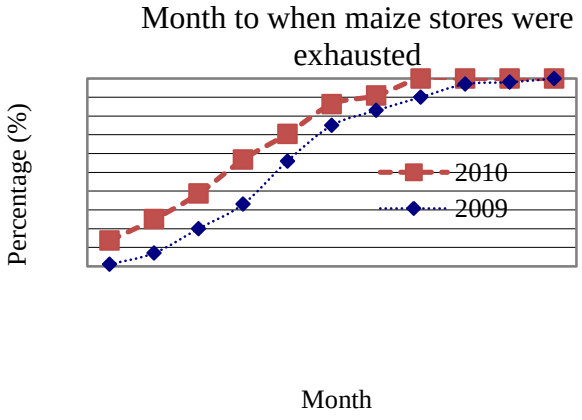

Figure 5. Maize sufficiency in farm households 2009 and 2010 (from SoL, 2011)

The wet season of 2009/2010 continued into the dry season and farmers were unable to plant their maize crops during 2010/2011. Maize production will be well below national requirements. Rice production was however, reasonable because of the consistent rainfall

and, if distributed equitably, will cover some of the dramatic food shortages to be experienced early in 2012. As shown in Table 2, overall annual food production will not cover the national requirements for 2012.

Table 2. National food balance, Timor-Leste, 2011

Staple	Gov't stocks (Oct, 2011)	Imported in 2011	Forecasted production	Total year supply	Demand/ Consumption	Balance
Rice	15,468	47,024	58,978	121,470	95,940	25,530
Maize	0	174	30,666	30,840	111,9112	-81,701

Adapted from FAO, 2011. Maize consumption assumed to be 90kg/person/year and maize at 105kg/person/year.

Farmers' strategies for tackling food insecurity.

Subsistence farmers in Timor-Leste repeatedly suffer periods of food insecurity during the year. They rely heavily on harvesting cereals including rice from the lowlands and flat areas in the mountain valleys, maize from the uplands and wheat and barley from some highland areas. They also diversify their cultivated cereal crops with sweet potato and cassava root crops, legumes (including peanuts) and potatoes (*Solanum tuberosum L.*). When stocks of these crops run short, farmers have several options to fall back upon while waiting for their next harvest. Harvesting wild food such as yams *(Dioscorea spp),* bitter beans and sago palms (*Metroxylon sagu*) are a regular strategy although this is very labour intensive. Some bitter beans need to be boiled and water changed up to ten times to eliminate the toxins before consumption and the sago palm trunk is cut into cylinders and pounded over long periods to release starch. Farmers also rely on each other during difficult times. Social networks include neighbours, relatives, and members of the working group in which the farmer is traditionally part of. There are a number of levels of support ranging from lending, borrowing, barter through to outright gifting (SoL, 2007). As a last resort, farmers sell livestock and other possessions during longer hungry periods and may eat the seed set aside for the following year's crop. As a result, farmers often rely on outside sources for seed during the following planting season. Seed may be purchased from the social group, or from the local market. The Government also imports rice and maize seed to subsidise farmers in need.

Government support to improve food security in Timor-Leste

Reducing poverty and increased agricultural production to ensure food security are essential for development in Timor-Leste. The Government of Timor-Leste acknowledges that the development of the rural areas and increased agricultural productivity will reach a high proportion of the population (GOTL, 2011). Since independence, the Government has invested in a national system for agricultural research and, more recently, in agricultural extension. The Government has also made progress to more directly addressing the constraints to agricultural production. These include the following:

Agricultural research and extension

Agricultural research within the MAF is heavily supported by bilateral, multilateral and NGO interventions. One large program within the MAF, the Seeds of Life program is involved in

varietal evaluation and release, seed production and seed distribution utilizing the informal seed sector. Other adaptive research programs are also supported by the Australian Centre for International Agricultural Research (ACIAR), the United Nations Food and Agriculture Organization (FAO), the Spanish and German governments, and Non Governmental Organizations (NGOs) such as World Vision.

In recent years, the GOTL MAF has dramatically increased their capacity to support agricultural extension activities. There are now over 400 Suco (village) extension officers working with the rural community and the three agricultural secondary schools cater for about 800 students to encourage the farming communities to employ more modern agricultural techniques. The Suco extension officers work within a district based hierarchy under the National Directorate for Agricultural Community Development (NDACD) and in close collaboration with the national directorates for research, crop production and animal health.

A series of agricultural calendars were compiled as part of the planning process for research and extension. They detail cultivation practices for both the main wet season and following second crop plus describe associated weather patterns. SoL advisors, MAF staff and NGOs involved in agricultural research and extension work use the calendars to determine approximate timing and practices of a range of crops cultivated in the major agro-ecosystems (SoL, 2011).

Policy and regulation development

The MAF has submitted three laws to parliament to assist the development of agriculture in Timor-Leste. The first law to be passed concerned importation and sale of fertilizers, the second pesticides and at the end of 2011 parliament was considering a law on the management of the seed industry. Directorates in the MAF continue to work on developing policies to assist other sectors of agriculture.

Land preparation and weed control

Most upland areas are traditionally farmed using “slash and burn” methods where a young piece of forest or weedy land is burned at the end of the dry season. Maize, upland rice, sweet potato, peanuts, cassava and other crops are then planted directly into the soil using a “dibble” stick. Not all the weeds are killed using this method and the weed burden in the field is often high during the growing season, thereby causing substantial reductions in crop yield. Available labour is a constraint to keeping the weeds under control and most farm household crop area is restricted to 0.7 to 0.8 ha. The area under production could be expanded and crop yields increased with better weed control. High input costs puts the use of herbicides beyond the reach of most subsistence farmers. The GOTL does, however, support improved weed control through the preparation of flat or slightly sloping land with tractors. Tractors are particularly useful in preparing the rice paddies and maize fields on the north and south coastal areas. The MAF imported 2,491 hand tractors and 315 four wheel drive tractors between 2007 and 2009. Tractor drivers were employed by the MAF and maintenance centres were established to ensure the machinery operated effectively. In 2010 and 2011 budgetary constraints reduced the amount of available fuel to run the machines but this issue will be addressed in future budgets.

Soil fertility, fertilizers and pesticides

The mountainous spine along the island is composed of soft sediments, shales, sandstones and limestones imbedded with small areas of igneous and some metamorphic rock

(Thompson, 2011). Much of the terrain is steep. In Timor-Leste, 44% of the land has a slope of 40% or greater, a vast majority of which has only a thin covering of productive soil. The soils, particularly those on the slopes are generally thin and impoverished and are becoming even less fertile over time through increased nutrient depletion from leaching and erosion after torrential rainfall, deforestation, grazing and over-cropping. There are no volcanoes in Timor-Leste nor deep volcanic soils.

Slash and burn agriculture exacerbates the soil infertility problem as does the free grazing, seasonal bush burning and fire wood collection (UNDP, 2011). To deal with this ongoing problem, some farming communities have developed indigenous forms of soil conservation. For example, weeds are often cut and laid in the crop rows to reduce erosion and cereals may be intercropped with legumes. Subsistence farmers do not apply artificial fertilizers, few of which are available in the market place except in towns along the Indonesian border. In 2008 and 2009, the GOTL imported fertilizers to apply to hybrid rice crops grown in the irrigated areas but little of this reached the upland areas. Anecdotal evidence indicates that farmers are not in favour of applying chemical fertilizers because their use during earlier years led to lower yields in subsequent cropping years. As a result, low demand limits the amount of chemical fertilizer available in the markets.

Recent agronomic research in Timor-Leste has shown that soils can be improved and subsequent crop yields increased using "organic" techniques such as planting legumes with cereals. The results of Vidal and Williams (2011), for example, show that planting velvet bean (*Mucuna pruriens var utilise*) between maize rows is one way of increasing maize grain yields. Velvet bean improves soil fertility through its nitrogen fixation and leaf litter. It also shades out weeds during the main crops growing season, thereby reducing competition for soil nutrients and water. The bean is also edible when boiled. Farmers are slowly adopting this agronomic system in suitable parts of Timor-Leste.

High costs limit the use of herbicides and insecticides by subsistent farmers in Timor-Leste.

Storage

Post harvest losses of the major food crops in Timor-Leste are significant. It is estimated that maize grain losses may average a high 30% due to weevil and rat infestations using conventional storage techniques (DOF, 2011). In one study (SoL, 2008, 2009), weevil damage was as high as 63% when stored as cobs in the sheath for 9 months. Weevils, rats moulds also destroy other stored grains, tuber and root crops. In an attempt to address this issue, the GOTL assisted the provision of over 5000 air tight silos to farmers groups between 2007 and 2011. Air tight containers such as silos, drums and plastic bags have proven to reduce weevil and eliminate rat damage. The NGOs CARE (Timor-Leste) and 'Drums on Farms' have also been involved with the distribution of drums which are able to store 180kg of maize grain. The savings from food losses are estimated to provide the farmers with an extra 20 days of food for each drum. The International Fund for Agricultural Development (IFAD) (IFAD, 2011) has plans of funding the distribution of 43,000 drums over a three year period commencing in 2012. These will go a long way to providing the 600,000 drums required to store all harvested maize in Timor-Leste.

Water security

Farmers in all districts raised concerns about the need for water security during the consultation for developing the national Strategic Development Plan in 2010. Improving the area of crop under irrigation has the potential of doubling rice yields. Of the 71,000 ha of

land developed for irrigation, only 34,000 ha is currently operating effectively. Heavy tropical deluges and flooding of the short relatively steep rivers during the wet season results in extensive damage to the infrastructure, requiring repeated rehabilitation work. The Government dedicates part of its budget to re-construction of the irrigation network and has plans of installing an extra 9,000 ha during the 2012-2015 period (MAF *pers comm*.) and have 70,000 ha of rice under irrigation by 2020 (GOTL, 2011) in an effort to increase productivity. There is also potential for improving water security using water harvesting techniques and an individual or communal level. Some NGOs have been involved in such a program.

Roads, markets, reliable power, farm finance and communications.

Farmers recognize the need to be located next to good infrastructure to access markets and modern services. They are particularly excited about being connected to the national electricity grid due for completion in 2012. The Government is also repairing many of the roads which have deteriorated over recent years. Micro-finance remains an issue in Timor-Leste. Small amount of funds are being released by NGOs and the NACD for suco level activities but little is available for subsistence farmers to purchase farm inputs. It is envisaged that level of microfinancing will improve for these purposes as the infrastructure expands into the rural areas.

Improved cultivars and agronomy for food security

Traditional Timor-Leste maize land races are extremely low yielding. As shown in Figure 4, average national maize grain yields are less than half of those in neighbouring Indonesia. Yields of most other commonly grown crops are similarly low in comparison (FAO, 2011). As discussed by Sperling *et al*. (*2008*) and Erskine and Nesbitt (*2009)* the ensured availability and continued supply of improved seed of food crops has successfully improved food security in post conflict situations in other parts of the world. During Indonesian rule (1975-1999), some HYVs were introduced to Timor-Leste but these did not prove to be popular and were not adopted by any but the best farmers. For example, the Indonesian yellow maize variety, Arjuna, is known to yield higher than the local varieties but is extremely susceptible to weevil damage when stored as whole cobs in the traditional manner. Farmers possessing modern on-farm storage facilities planted Arjuna but relied on Government support for annual seed requirements. Many of the introduced lowland rice varieties were also considered to be of lower quality compared with traditionally grown land races. The new Government (2000 – present) continues to import improved maize and rice seed to cater for farmers who were able to take advantage of HYVs. This is an expensive process with the Government spending over $1million per annum on importing seed for a small proportion of the nation's farmers. This is not sustainable and a program was commenced to a) identify higher yielding food crop varieties of acceptable quality, and b) establish a seed production program to ensure a majority of farmers were able to source high quality seed. The Seeds of Life program within the Timor-Leste Ministry of Agriculture and Fisheries (MAF) took a lead role in developing the capacity of the nation to manage the appropriate research and seed system.

Seeds of Life (SoL) is funded by the Governments of Australia and Timor-Leste. Australian funding is through the Australian Agency for International Development (AusAID) plus the Australian Centre for International Agricultural Research (ACIAR) and is managed by ACIAR. The Centre for Legumes in Mediterranean Agriculture (CLIMA) within The University of Western Australia (UWA) coordinates the Australian funded activities. The goal of SoL is to

'improve food security through increased productivity of major food crops" It commenced in 2000 and in the initial years SoL imported potential material from similar environments in other parts of the world through the Consultative Group on International Agricultural Research (CGIAR) centres. CIMMYT (International Maize and Wheat Improvement Centre) supplied suitable maize varieties, IRRI (International Rice Research Institute) rice, CIP (International Potato Centre) potatoes, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) peanuts and CIAT (International Centre for Topical Agriculture) for cassava. In later years, these centres also assisted source improved germplasm from other organizations in the region and Africa.

The first five years of trials were conducted under research station conditions (SoL 2008, SoL, 2009, SoL, 2010, SoL, 2011, Fontes *et al* 2009). They commenced in the wet season of 2000-2001 during the development of the new Government structure. Several Non-Governmental Organisations (NGOs) including World Vision International (WVI) and Catholic Relief Services (CRS) offered assistance with establishing and managing trials. Research supervision duties were assumed by Government officials and by 2006 varieties of maize, sweet potato, rice and peanuts were identified which showed considerable promise. Yield increases from some introduced test entries were impressive with yield advantages over locals ranging from 20% to 180% for rice and sweet potato respectively. Consumption tests by farmers were also encouraging. However the test entries still required to be evaluated on farmers' fields under farmers growing conditions. A series of small trials were established across the nation's agro-ecosystems ranging from low rainfall, flat landscape to steep slopes with high rainfall. An example of the distribution of these "on-farm demonstration trials" (OFDTs) is presented in Figure 6. Field days were also held in each of the subdistricts to gauge the farmer's appreciation of the test entries. Approximately 20-30 field days were held each year to see if the potential varieties were acceptable by farmers and whether they would plant them. The OFDTs also provided a small amount of seed or planting material for the farmers to try in other parts of their farms or share with family and neighbours.

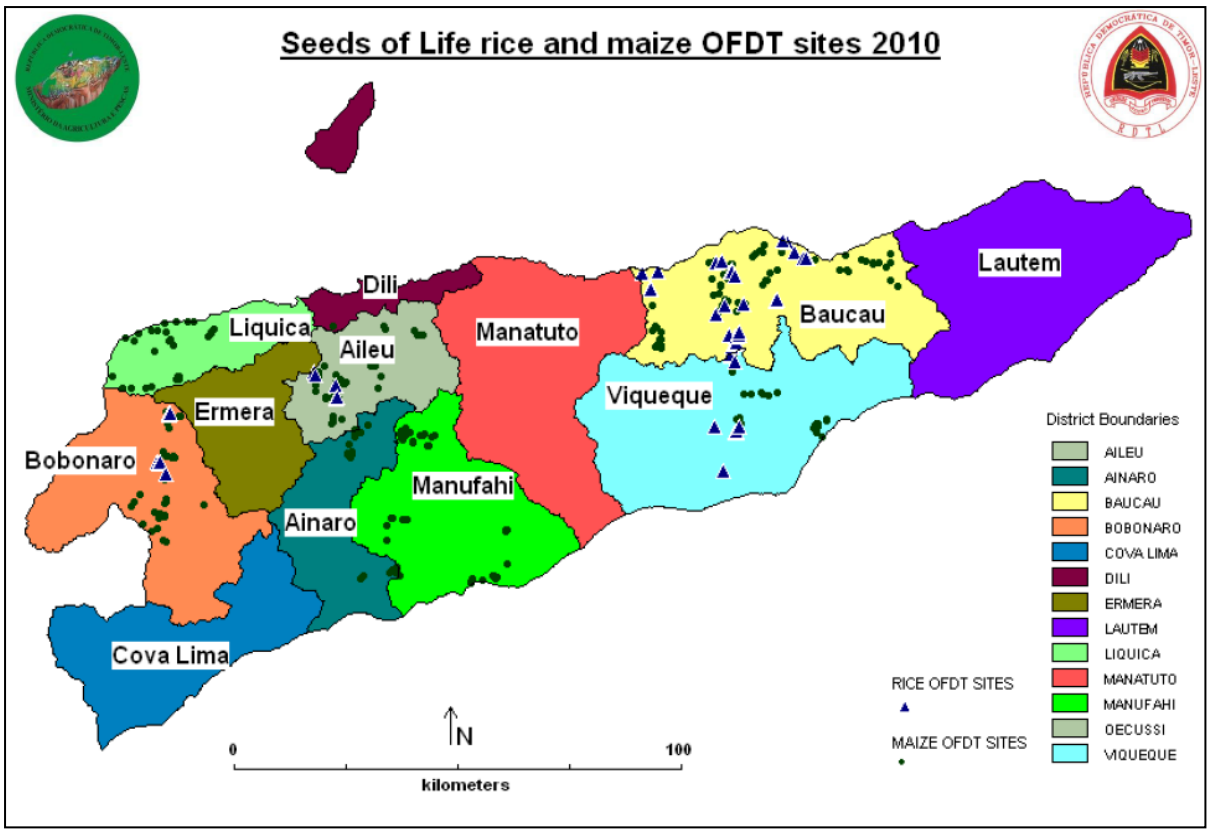

Figure 6. Map of Timor-Leste (Oecussi excluded) showing rice and maize on-farm trial sites

By 2007 there was sufficient evidence for the MAF to establish a Varietal Release Committee to consider seven new cultivars for release to the farming community (SoL 2009). Yellow maize, peanut, rice and sweet potato cultivars were named by the Timor-Leste parliament members and seed and planting material multiplied for distribution. In 2009, two cassava cultivars and in 2011 a white maize variety was released making a total of 10 improved varieties being released by the program to date. All varieties performed extremely well on research stations and on farmers' fields. The yield advantages of select varieties evaluated on farmers' fields over a number of years are presented in Table 3.

Table 3. Yield advantage of MAF Seeds of Life varieties over traditional varieties

Crop	Released variety name	Yield advantage over local variety	Number of on-farm trials
Maize:	Sele	47%	1100 trials over five years
Peanut	Utamua	47%	779 trials over five years
Rice	Nakroma	24%	297 trials over five years
Sweet Potato	Hohrae 1	66%	198 trials over two years
	Hohrae 2	80%	198 trials over two years
	Hohrae 3	159%	383 trials over four years

From SoL, 2011a

Other characteristics often play a more important role during cultivar evaluation. High yield is not always a top priority for farmers. The product must be of good eating quality and produce size may also be a preference regarding sweet potatoes, maize cobs and peanuts.

The most important selection criteria for the newly released sweet potato varieties, Hohrae 1, Hohrae 2 and Hohrae 3 are presented in Table 4. For this crop, farmers considered root size to be more important than other characteristics, although eating quality and speed to maturation were also important. Farmers often also like to see an even height crop and fragrance in rice (Table 5). Grain colour is often an important characteristic in maize (SoL, 2011). For these reasons, the SoL program placed considerable effort on market acceptability before releasing any new varieties. Seed of all the currently released varieties are being multiplied for distribution to farmers.

Table 4. Farmers' opinions (% of 115 respondents) of new sweet potato cultivars

Reason for liking this cultivar	Hohrae 1	Hohrae 2	Hohrae 3	Local
Big Tubers	26.5	31.6	29.2	0
Good to eat	21.1	18.4	17.7	22.4
Fast growing	12.2	10.9	12.2	0
Total % respondents giving positive comment	*66*	*65.3*	*70.7*	*29.3*

Source, SoL, 2009.

Table 5. Farmers' preferences for Nakroma rice

Farmer's name	Village	Identified preferences
Fernando Kolimau	Sarin	Large, fragrant grain, even height crop
Antonio Hornai	Betano	High yields, fragrant, oily, even height crop
Ernesto da Costa Freitas	Buruma	Large, fragrant grain, similar height plants
Regina Amaral	Uma nai iku	Produce many tillers, high yields
Domingos	Sarin	Similar height, fragrant
Augusto Da Silva	Sarin	High yields
Maria da Costa	Sarin	White colour seed, high yields

Source, SoL/ Reaping the benefits, 2009a.

Farmers adopting improved agronomic practices increase the effectiveness the new varieties. SoL research has shown that planting a bean between the maize hills reduces the weed burden and increases soil fertility (Vidal and Williams, 2011). The bean locally known and velvet bean or *Lehe* in Tetun language (*Mucuna pruriens var utilise)* acts as a ground cover smothering the weeds and because it is a legume increases soil fertility directly from nitrogen fixation and from leaf litter. Other weed control and soil improvement practices are also being researched.

Seed production

The MAF assumes responsibility for the production and distribution of improved seed for food crops in Timor-Leste. The industry is too small for private enterprise to take an interest in any but seed for high value crops such as vegetables and horticulture. Until recently, FAO supported the importation of rice and maize seed from Indonesia and the Government also sponsored on-farm seed production for distribution to farmers in need. SoL, within the MAF, has established a three tier seed production system to promote the program released varieties. The purest breeder and foundation seed is produced on MAF research stations.

Foundation seed is multiplied on farmer's fields for sale to Government, NGOs and direct to other farmers. Seed multiplication on farmers' fields under direct Government supervision is classified as "formal seed". Some of this seed also goes to community seed production groups (CSPGs). The CSPGs multiply seed for their own needs, sale or gift to relatives and neighbours or for sale at local markets. This system, known as "informal seed" not only allows good quality seed to reach a large number of farmers, it is sustainably reliable with minimal support from Government research stations. Stimulating community-based seed businesses as local rural enterprises contributes to markets and rural development as well as food security (Fontes, *et al*. 2009).

Impact of improved varieties on food security

Yield increases on farmers fields

The yield advantages of the new improved varieties over traditional varieties presented in Table 3 clearly indicate that farmers adopting these new varieties will benefit from increased yields. If all farmers adopted the new maize variety Sele without changing any of their other farming practices, national maize production would increase by 47%. Farmers are, however, advised to cultivate a number of maize varieties to reduce risk and increase harvest date diversity. High yields are also expected from the other released varieties if the farmers are able to access planting material.

Number of farmers accessing improved varieties

Distribution of seed multiplied under supervision of MAF/SoL personnel (formal seed) reached an increasing percentage of the East Timorese population between 2008 and 2011 (Table 6). Seed was distributed a) directly by MAF/SoL to farmers conducting OFDTs, b) through the MAF (and FAO sponsored) seed distribution system and c) by NGOs.

Table 6. Estimated number of farmers receiving SoL/MAF seed

Est. number of HH received seed and cuttings*	2008/2009	2009/2010	2010/2011	Total
Rice (Nakroma)				
via MAF	979	4,635	4,700	10,314
via NGO	293	457	79	829
via MAF-SoL	382	176	248	806
Total households	1,654	5,268	5,027	11,949
Maize (Sele)				
via MAF	220	645	2,407	3,272
via NGO	8,077	13,263	2,129	23,469
via MAF-SoL	516	366	290	1,172
Total households	8,813	14,274	4,826	27,913
Peanuts (Utamua)				
via MAF	0	0	637	637
via NGO	321	710	135	1,166
via MAF-SoL	168	341	99	608
Total households	489	1,051	871	2,411
Sweet potato (Hohrae 1, 2 and 3)				
via MAF	1,280	90	35	1,405
via NGO	147	344	0	491
via MAF-SoL	978	434	451	1,864
Total households	2,406	869	486	3,760
Cassava (Ai-Luka 2 and Ai-Luka 4)				
via MAF	0	10	9	19
via NGO	20	41	270	331
via MAF-SoL	3	546	121	670
Total households	23	597	400	1,020
Total no. HH receiving seed +cuttings	*10,979*	*21,190*	*11,124*	*43,293*

* Estimates based on distributing 10kg of seed to rice and maize farmers, 20kg to peanut farmers and 50 cuttings per household for cassava and sweet potatoes. From SoL, 2011a

Economic impacts

On-farm trial data indicate that the potential yield improvement of the MAF released varieties over traditional land races range from 24% to 159% based on two and four years of data and over 2900 harvested trials (Table 3).

SoL released varieties are highly acceptable to many farmers for reasons ranging from eating quality to cob size. An example of why farmers like Hohrae sweet potatoes is presented in Table 7.

Table 7. Farmers opinions of new sweet potato varieties

Reason for liking this variety	Hohrae 1	Hohrae 2	Hohrae 3	Local
Big tubers	26.5	31.6	29.2	0
Good to eat	21.1	18.4	17.7	22.4
Fast growing	12.2	10.9	12.2	0
Total % respondents giving positive comment	*66*	*65.3*	*70.7*	*29.3*

From SoL, 2009

Preference for the newly released varieties is illustrated through the high adoption of the varieties by farmers performing OFDTs. Farmers often cultivated the test varieties after conducting an OFDT (Table 8) with approximately 70% of farmers continuing to grow Sele maize four years later. Farmers cultivating the new varieties tended to grow larger areas than the "test" plots of the OFDTs and often sold surplus at the market or on the roadside (Table 9).

Table 8. Proportion of households replanting at least one test variety from one year to another after the initial 2005/06 on-farm trials

Crop (number of households)	% households which kept replanting from: Initial trial to 1st year after*	1st to 2nd year after	2nd to 3rd year after	3rd to 4th years after (anticipated)	Means	St.dev.
Maize (42)	83	66	70	69	72	8
Sweet potato (37)	61	64	67	68	65	3
Peanuts (40)	60	50	40	77	57	16
Rice (12)	77	73	88	90	82	8
Means	70	63	66	76	69	6
St.dev.	12	10	20	10	6	

From SoL, 2010

Table 9. Expanded cultivation of modern varieties after completing OFDTs

Crop		Maize	Sweet potato	Peanut	Rice
Number of households still re-planting in 2009/10		19	12	6	7
Areas (m²) planted per households	*in 2006/07 (on-farm trials*)*	50	75	50	25
	in 2009/10 at time of survey	4,200	230	315	7,215

* Each variety was planted in 5×5m plots. From SoL, 2010

Some farmers now produce surplus product providing valuable cash income which previously did not exist. Farmers report selling their surplus and that it is of high value when sold in local markets. One farmer is quoted as saying . "My experience with Hohrae sweet potato is a story that can be remembered by our children when I pass away" indicating that

having money in the household was a life changing experience. That particular farmer used the surplus to buy household goods. Others buy food with the proceeds, educate their children, use funds for clothes etc (Table 10).

Table 10. Use of cash earned from selling *Nakroma* rice

Farmer's name	Village (Baucau)	Cash received (US$)	Purchases for the household
Fernando Kolimau	Sarin	35.0	One pig and one chicken
Antonio Hornai	Betano	25.0	Paid children school fees and paid labour for planting, harvest and threshing
Ernesto da Costa Freitas	Buruma	-	Shared the yields with group member
Regina Amaral	Uma nai iku	305.2	Coconut grater machine
Antonio Hornai	Betano	21.0	Children's school fees
Domingos	Sarin	17.5	Cheaper rice
Augusto Da Silva	Sarin	23.8	Children's clothes
Maria da Costa	Sarin	18.0	Other types of food

Source: SoL, 2009

Social impacts

There is some indication that food security is improving in the farming community installing OFDTs. Farmers appear to have improving food sufficiency over the three years from 2007 to 2010 (Table 11) and ownership of mobile phones in these households is increasing rapidly (Table 12). Initial studies of non-maize crops (sweet potatoes and rice) indicate that farmers use their increased yields to supplement household food sources directly and by selling the higher value product to purchase other (cheaper) food (Table 10). Funds generated from produce sales is also improving access to medical facilities.

Table 11. Maize sufficiency in OFDT households over years.

Year	Insufficient (%)	Sufficient (%)	Surplus (%)	No. respondents
2006/2007	37	58	5	340
2007/2008	38	47	15	502
2008/2009	29	54	17	362
2009/2010	16	73	11	354

Social science researchers regularly report on the significant role rituals play in crop production. Rituals are performed in response to the plant reaching the threshold of another stage. Some new crop varieties will impact on the timing of these rituals.

Table 12. Farmer wealth measures across years

Description	*2006-07*	*2007-08*	*2008-09*	*2009-10*	*2010-11*
	%	*%*	*%*	*%*	*%*

Tin/board roof	na	76	69	79	70
Full block wall	na	19	17	24	24
Half block wall	na	22	10	13	13
Cement / floor tiles	na	34	22	35	30
Mobile phone	3	10	6	43	65
Motorbike	5	5	3	11	22
Car	2	3	1	2	4
Diesel generator	3	3	2	3	9
Total # of respondents	340	502	362	354	237

Source: SoL, 2011

Discussion

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). To be food secure means that food is available, food is affordable and food is utilized. In Timor-Leste, most farmers live in a subsistence agriculture environment with little cash flowing through the household. They grow most of their food and secure the remainder through several means including trading (most commonly palm wine, cassava and leafy greens, and chickens and pigs) in order to buy other forms of food (most commonly rice, salt, oil and sugar). Farmers also gift food through village networks (SoL, 2007). The gifting of food between neighbours and members of extended family can be characterized as 'delayed reciprocity' whereby the gift is returned at a later date when the household that has received the gift has surplus of their own, and/or they are aware that the other household has a shortage. Food items that are the subject of gifting are predominantly cassava, maize, hulled rice, and leafy greens. The practice of reciprocal gifting of food underlines the inter-dependency of Timorese households on extended family ties and the resources that may be mobilized and re-distributed through these networks.

The identification, multiplication and distribution of new higher yielding varieties with improved nutrition value have been identified as being an effective method of improving food security in Timor-Leste. Gifting and receiving of seed facilitates the spread of new cultivars but the existence of strong social networks are currently the most important means of spreading new higher yielding varieties in the farming community. SoL/MAF is strengthening these networks through the implementation of both formal and informal seed production systems. The GOTL supports these activities through the development of new policies and regulations to promote as well as control the quality of agricultural inputs. In addition, the Government supports agricultural research and extension, subsidises land preparation through the provision of tractors, is increasing the area under reliable irrigation and improving roads, markets, rural power, communications and micro-finance. Once suitable higher yielding varieties are available within the farming community, the promotion of soil improvement techniques, including the use of fertilizers will enhance the effectiveness of the HYVs further.

The potential impact of the farmers adopting the new varieties released by SoL/MAF on food security is considerable both on-farm and nationally. For example, for some farmers are able to quadruple their sweet potato production. The new sweet potatoes, Hohrae 1, Hohrae 2 and Hohrae 3, double the yield of traditional varieties in half the time. Therefore it is possible for farmers in particular environments to grow two crops each year. Potential maize yields may be 47% higher, peanut 47% and rice 24% higher than those currently grown. Supplying seed to farmers is recognized as being a constraint to the adoption of these improved varieties but this is being addressed by SoL/MAF. Surplus to farmers needs is traded through both social networks and at local markets. Some is also fed to animals which, in turn, are sold for cash or slaughtered for local consumption. Cash income from the sale of produce at local markets has already revolutionised the thinking of some farmers resulting in the production of "cash crops" for sale.

The number of farmers cultivating crops for surplus is on the increase. Farmers are now able to purchase much needed household goods, pay for school and medical fees and purchase other food. In areas where SoL/MAF varieties are grown, the number of farmers self sufficient in food appears to be on the increase as are their "wealth indicators" of communication and transportation ownership. It is envisaged that these impacts will expand rapidly over the next five years.

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