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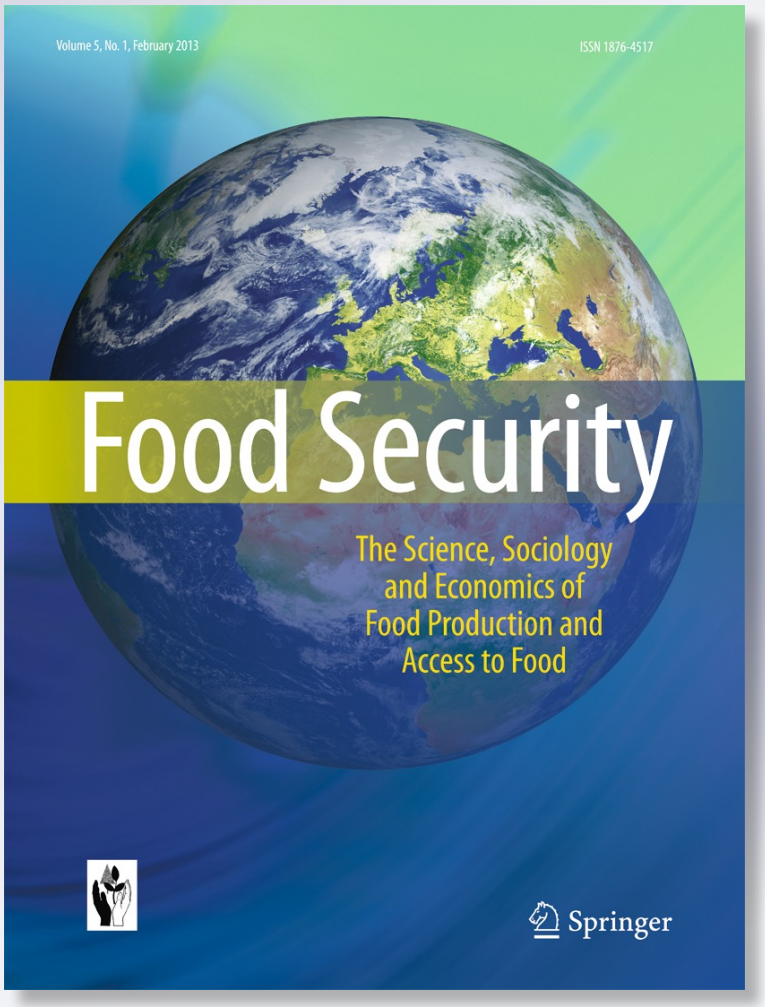

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ORIGINAL PAPER

Household food insecurity in Timor-Leste

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Abstract Timor-Leste is among the world's youngest and poorest countries. It suffers from seasonal food insecurity and has the third-highest stunting rate globally. Previously inadequately documented, this paper summarises recent advances in understanding household food security in Timor-Leste and the multifaceted approaches being used to overcome it. Information comes from the extensive annual surveys of the Seeds of Life (SoL) program in Timor-Leste. The hungry season prior to maize and rice harvests is the key issue in household food security in Timor-Leste. Farm households cope with the problem through crop diversification with tubers playing a lead role as grain stocks dwindle. Foraging for wild food resources, selling animals and other assets, and social networks are other coping strategies. To address seasonal food insecurity, the government has focused on rice importation and the improvement of agricultural productivity within a multi-dimensional program. Information on storage by households of the key staple, maize, indicates an improving trend in food security at the household level from 2006/2007 to 2010/2011 through a significant reduction in the percentage of 'at risk' households—those who grow insufficient maize for storage during the year. The current emphasis on the widespread dissemination of the new high-yielding SoL cultivars has the potential to augment these improving trends. Nevertheless this picture remains vulnerable to weather shocks—such as drought—which are anticipated to increase with climate change and it is important to build further resilience into the agricultural systems of Timor-Leste.

Keywords Household food security · Food imports · Agricultural production · Hungry season · Social networks · Wild food resources

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Introduction

Timor-Leste is a small, young country, adjacent to Indonesia and Australia that is among the poorest in Asia. The terrain of Timor-Leste comprises narrow coastal plains and dissected uplands. The climate is tropical dominated by summer rainfall varying from annual means of 600 mm in the North-West, where there is an extended dry season, up to 3,000 mm in the highlands (Barnett et al. 2007). Most of the population live in the northern drier part of the country and, in contrast, the south of the country is wetter, allowing two maize harvests per annum. Agriculturally, the particularity of Timor-Leste is the dominating importance of maize both as a staple crop and in the diet, compared to many other Asian countries where rice predominates. The rugged terrain of Timor-Leste leaves restricted areas for irrigated rice. In other SE Asian countries, maize is primarily used as animal feed or as a snack food. With Melanesia to the East, Timor-Leste has features in common such as the importance of tubers—sweet potato and cassava. In 2002 81 % of households grew maize, 68 % cassava and 44 % sweet potato (Tilman de sa Benevides 2003). A typical farming operation in Timor-Leste is unable to derive a high

level of personal income from 1 to 2 ha of land. Coffee growers (who are some of the poorest farmers in Timor-Leste) do not grow rice—they rely on maize and tubers as their main food sources (World Bank 2010) and can earn some extra income from this export crop. The country is predominantly rural with over 60 % of the population engaged in crop production (NSD 2011). A very high percentage of agriculture is subsistence rather than market oriented and there is a general lack of off-farm income in rural households. The population of Timor-Leste is 1.07 million (NSD 2011) and the country has the seventh highest rate of population growth (2005–2010) globally (UN 2009). Since independence Timor-Leste has had the 3rd highest stunting rate (percentage of chronically malnourished children) in the world (UNICEF 2011). Most farm families suffer from food insecurity, producing insufficient cereal staples of maize or rice to last a full 12 months (WFP 2006).

A colony of Portugal for over 400 years and under Indonesian rule for 24 years, Timor-Leste is now a democratic republic after 79 % of its population voted for independence in a referendum in 1999. The country has a long history of food insecurity. Around 1500–1600 AD, a series of stone fortresses were built across the country. The movement of the population to live within stone fortresses is presumed to be in response to reduced rainfall patterns, causing conflict over control of resources between various groups (Lape and Chin-Yung 2008). Timor has encountered famine in the past, the latest being 1977- late 1978. It has been argued by some that the famine was induced by reduced rainfall, due to El Nino conditions. Although this is possible with the late onset of rain (delayed by 70 days), a more recent analysis of the causes of famine was produced by the Timor-Leste Commission for Reception, Truth and Reconciliation (CAVR—the Portuguese acronym) which suggested the famine was not due to reduced rainfall, but war. At the time of the 1999 referendum up to 80 % of the population suffered malnutrition. The subsequent conflict also resulted in widespread destruction of infrastructure such as roads and irrigation systems. Narve Rio (1999) wrote, 'It is, nevertheless, clear that East Timor has not been self-sufficient in staple food production for the last three decades'. The yields of staple crops such as maize and sweet potato were well below Indonesian average yields.

Timor-Leste is deeply poor and has a major associated food security problem that is inadequately documented. This paper summarises recent advances in the understanding of seasonal household food insecurity in the young nation and the multifaceted approaches being used to overcome the problem. The structure of the paper is a short review of the concept of food security followed briefly by the methodology to study food security in Timor-Leste; then we cover the recent understanding of food security including rural household and cropping information, seasonality in the diet, and farmers' coping strategies; finally we address the different approaches to improving food security, highlighting food imports and increasing agricultural productivity.

Food security

The definition of food security agreed upon at the World Food Summit in 1996 is that it exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life (FAO 1996). The concept of food security is used at both the national and household levels. At the macro national level, food security is primarily used to refer to self-sufficiency, i.e. the country has enough food for its needs or that which its population demands. This addresses the supply side of the food equation and pays no attention to the distribution of the available food, which is critical (Pinstrup-Andersen 2009). A household is considered food secure if it has the ability to acquire the food needed by its members (Pinstrup-Andersen 2009). The FAO definition is on an individual basis but the measurement is typically made at the household level by interviewing a household member and measures the household's self-reported experience of food insecurity along a scale of severity. Household food insecurity scales are used to calculate official estimates of food insecurity in the United States, and are increasingly used by governments in Latin America and in other developing countries (Nord et al. 2009; Coates et al. 2010). However, household preferences may not prioritize food acquisition over the acquisition of other goods and services such as school fees and housing. Second, the intra-household allocation of the food may not be based on the needs of each individual member. Furthermore, the extent to which individual food security results in good nutrition depends on a set of non-food factors such as sanitary conditions, water quality, infectious diseases and access to primary health care. Thus, food security does not assure nutritional security (Pinstrup-Andersen 2009). A distinction is frequently made between transitory and permanent food insecurity, where the former describes periodic food insecurity as for example seasonal food insecurity, while the latter describes a long-term lack of access to sufficient food. For non-crop growing households—and even for many that do grow crops—their ability to acquire food to satisfy their nutritional needs is also closely linked to the price of food. This broad and important area will, however, not be treated in this paper.

To combat seasonal reductions in food access by poor households, policy makers typically select from among three common interventions: seasonal income transfers to poor households; seasonal food imports; and increasing agricultural productivity (Dorosh and Haggblade 1995; Dostie et al. 2002: Pinstrup-Andersen et al. 1999). The first

category of food interventions, seasonal income transfers, directly increases food demand by raising the purchasing power of poor households. Internationally, the largest seasonal interventions fall into this category, including an array of cash and food for work programs that employ millions during the lean season in India and Bangladesh (Dorosh and Haggblade 1995). In contrast, the second category of food programs, the seasonal import of food grains, addresses only food supply. They aim to reduce staple food prices through seasonal imports and stock release. Indonesia's large rice import and price control program run by the state logistics agency, BULOG, offers one classic example of this approach (Timmer 1997). The rice imports of Timor-Leste fall into this category. The third category of intervention includes public investments intended to increase agricultural productivity (Dostie et al. 2002). These investments typically focus on agricultural research, agriculture extension systems, improved input supply, and investments in rural roads. Where successful, the resulting increases in agricultural productivity affect not only the prices of basic foods but also increase income of the producing agricultural households. The Seeds of Life (SoL) program in Timor-Leste falls into this category.

Methodology

The SoL program has conducted annual surveys of 237 to 502 rural households per year in four to seven districts (Aileu, Ainaro, Baucau, Liquiça, Bobonaro, Manatuto and Manufahi) from 2006 to 2011. Details of the methods used are given in the SoL Annual Research Reports (SoL 2007, 2008, 2009, 2010, 2011, 2012a). Additionally, a consumption study of farm households was conducted by SoL between 2007 and 2010 to identify indicators of food security levels (Glazebrook et al. 2007; SoL 2007, 2008, 2009, 2010) and for the year from July 2008 to June 2009, measurements were taken in individual households in the districts of Aileu, Baucau, Liquiça and Manufahi.

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). The national annual food surplus/deficit is calculated by balancing the difference between grain production and consumption annually. For example, in 2011 as the wet season of 2009/2010 continued into the dry season, Timor-Leste farmers were unable to plant their maize crops during 2010/2011. Maize production was well below national requirements (Table 1) (FAO 2011). Rice production was, however, reasonable because of the consistent rainfall and covered some of the dramatic food shortages experienced early in 2012. As shown in Table 1, overall annual food production did not cover the national requirements for 2012.

As indicated earlier, a degree of hunger has been present in Timor for some decades. Since the 1999 referendum for independence when food sources and, more importantly, the civil infrastructure were badly damaged or destroyed during the unrest, the nation has rarely been self-sufficient in food production and emergency grain has been imported on an annual basis rising in 2000 from 27,000 t to 63,000 t in 2009 (FAO 2012). A World Bank survey (2003) highlighted the seasonal pattern of food security in the rural areas of Timor-Leste. Food shortages in the rural areas are considered to occur in two phases. The first phase is when maize and rice household stocks are about to finish but there remains a reasonable supply of root crops (cassava, sweet potato, taro and arrowroot). During this period, known in 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 as *tempu rai hamlaha*. Farmers rely heavily on harvesting wild food from the forest (Glazebrook et al. 2007) 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 (Lopes and Nesbitt 2012).

The hungry season 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/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 in the north during June/July and in the south in August/September. Generally, however, upland farmers suffer the most from poor harvests from their rainfed crops.

What is a household in Timor-Leste and what do they grow?

Surveys of rural households indicate that most farm households comprise between five and nine members (SoL 2007, 2008, 2009, 2010, 2011, 2012a). Such households operate as production units with the workload distributed among household members, although the head of household is considered as the most senior person in house. While usually male, 30 % and 26 % of the surveyed households were headed

Table 1 National food balance (tonnes), 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	111,911	−81,701

Adapted from FAO (2011). Rice consumption assumed to be 90 kg/person/year and maize at 105 kg/person/year

by women during 2008/2009 and 2009/2010, respectively (SoL 2009 and 2010).

A list of food crops cultivated by farmers in Timor-Leste conducting on-farm trials in 2010/2011 is given in Table 2 (data for other years are available in SoL reports). Farmers grow a wide range of crops in order to spread the risk of failure in one or more of them. The extent to which households grow combinations of five staples on one or more plots during a year is shown in Fig. 1. The most frequently encountered combination was farmers growing maize, cassava and sweet potato (SoL 2012b). The risk of crop failure is also reduced through intercropping. Maize is the most important crop. After maize, tuber crops are prominent among the staples of farm households. Household consumption of maize, sweet potato, cassava and rice was supplemented with pumpkins, beans, peanuts, taro and a wide range of other traditionally grown species. Approximately 29 % of 1,799 farmers reported planting irrigated rice which is consistent with other surveys in Timor-Leste and reflects the greater emphasis on upland rainfed food cropping among the majority of Timorese farming households.

Table 2 Food crops planted in house gardens or bush gardens (Sol 2011)

Crops planted	Total # respondents	% of total respondents
Long-season maize (*Zea mays* L.)	194	83 %
Cassava (*Manihot esculenta* Crantz)	192	82 %
Pumpkin (*Cucurbita spp.*)	173	74 %
Sweet potato (*Ipomea batatas* L.)	172	74 %
Short-season maize (*Zea mays* L.)	157	67 %
Cowpea (*Vigna unguiculata subsp. sesquipedalis* (L.) Verdc)	142	61 %
Taro (*Colocasia esculenta* (L.) Schott)	126	54 %
Peanut (*Arachis hypogaea* L.)	114	49 %
Cucumber (*Cucumis sativus* L.)	106	45 %
Wild yam (*Dioscorea spp.*)	94	40 %
Arrowroot (*Maranta arundinacea* L.)	79	34 %
Irrigated rice (*Oryza sativa* L.)	68	29 %
Yam bean (*Pachyrhizus erosus* L.)	65	28 %
Bitter bean (*Phaseolus lunatus* L.)	54	23 %
Elephant's foot yam (*Amorphophallus paeoniifolius* (Denst.) Nicolson)	46	20 %
Mung bean (*Vigna radiata* (L.) Wilczek)	36	15 %
Sorghum (*Sorghum bicolor* L.)	35	15 %
Upland rice (*Oryza sativa* L.)	24	10 %
Common bean (*Phaseolus vulgaris* L.)	23	10 %
Potato (*Solanum tuberosum* L.)	11	5 %
Papaya (*Carica papaya* L.)	9	4 %
Banana (*Musa spp*)	2	1 %
Tomato (*Solanum lycopersicum* L.)	2	1 %
Foxtail millet (*Panicum italicum* L.)	1	0.4 %
Egg plant (*Solanum melongena* L.)	1	0.4 %

N=234

Long season maize is 110–150 (mean 130) days from planting to maturity and short season maize is 90–95 days. Short-season maize helps households to relieve food shortages—especially for the children in the households—at the end of the hungry season

Seasonal food insecurity

Annual SoL surveys showed that approximately one third (16–38 %) of households harvest insufficient maize for the year, and run out of maize during the year (Fig. 2) (SoL 2007, 2008, 2009, 2010, 2011, 2012a). Over the years food security is improving in the farming community with a significant ($P<0.05$) decline of −5.4 % each year of 'at risk' households. Overall, simple proxies to indicate relative household wealth/poverty associated with house construction types and ownerships have been used in annual surveys and they show clearly that rural household wealth has increased over the same period. This is evidenced from increased levels of ownership of mobile phones and motorbikes (Fig. 3). Turning to focus on the 'at risk' households with insufficient maize for the year, the month at which stocks are exhausted varies over years (Fig. 4). Typically (2008 and 2009) by June only 20 % of 'at risk' households had empty maize stores; but in 2010 by the month of June 40 % of the 'at risk' households had exhausted their maize stocks. The year 2010 saw poor maize harvests and when growers were asked in 2010 about factors reducing yield, 46 % responded that lack of rain was responsible. Other factors such as problems with storage are widely recognized (SoL 2011) – see below.

A SoL consumption study of farm households identified some indicators of food security levels as food availability ebbed and flowed over the annual cultivation cycle (Glazebrook et al. 2007; SoL 2007, 2008, 2009, 2010). These studies identified such issues as first the change in consumption of staple during the year depending on the timing of

Fig. 1 Crop combinations grown by maize growers in Timor-Leste (SoL 2012b)

Number of farmers	Maize	Cassava	Rice	Sweet Potato	Peanut
345	■	■		■	
274	■	■			
174	■	■	■	■	
150	■	■		■	■
141	■	■	■	■	■
125	■	■	■		
68	■		■		
68	■				
55	■	■			■
37	■	■	■		■
29	■			■	
10	■		■		■
4	■				■
3	■			■	■
1	■		■	■	
1	■		■	■	■

harvest, second a reliance on wild food when crop supply was reduced and third the effect of imported rice on the pattern of household food consumption. There was a notable shift from predominantly maize consumption to consumption of tubers and roots as the supply of maize thinned over the course of the year. Figure 5a shows daily consumption of a single household from Baucau on the North coast with maize harvest in February and increasing use of cassava, rice and sweet potato as this runs out. By contrast, an individual southern (Manufahi) household's consumption pattern is dominated by the two maize harvests in April and September (Fig. 5b) with other crops, particularly rice consumed in the interim. Also, during those months when crop consumption is low, household needs may be met through foraging for wild foods and/or through gifting of food through social networks (not shown in Fig. 5). Compared to cereal crops, tubers such as sweet potato and cassava have the advantage of storability in the ground and may be harvested further into the dry season providing valuable supplements/replacements to cereals

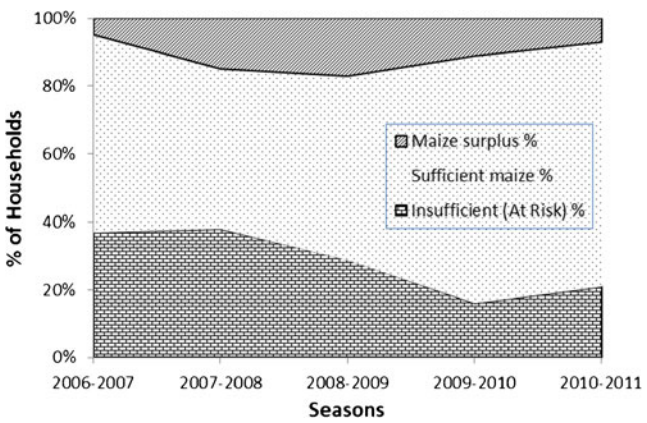

Fig. 2 Percentage perceived maize grain sufficiency for the year among households (Classes: 1. Household with surplus maize to yearly requirements; 2. Households with sufficient maize for the year; 3. 'At risk' households with insufficient maize stored to last the year) (SoL 2007, 2008, 2009, 2010, 2011)

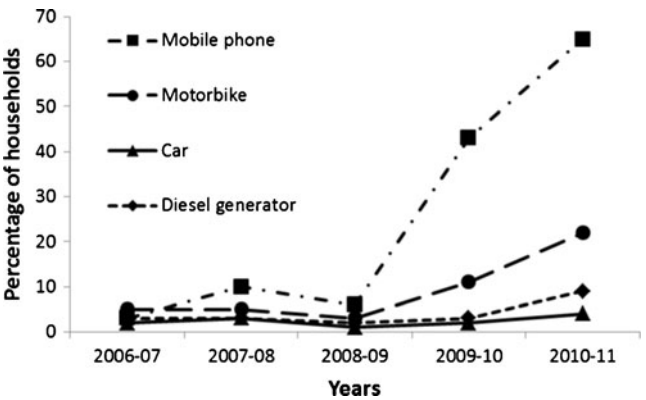

Fig. 3 Household wealth measures across years as percentage of respondents (n=from 237 to 502 households per year) assessed by proxy indicators associated with ownership (SoL 2011)

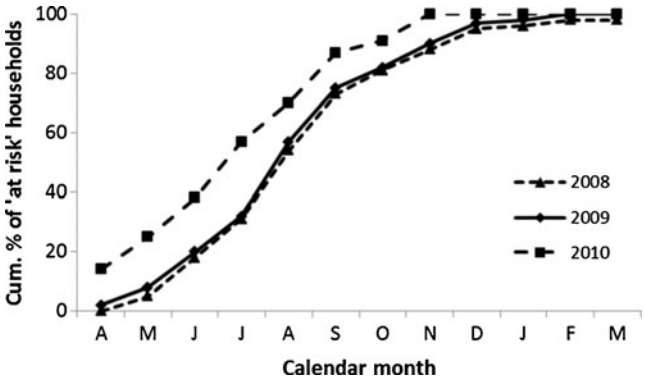

Fig. 4 Month when grain store is exhausted expressed as cumulative percentage of 'at risk' households (those with insufficient maize stored to last the year) (SoL 2011)

during lean times. Since independence, the government has imported rice and sold it at a subsidized price to the population. Seven of the ten households surveyed in 2009–2010 relied on rice rather than the traditional maize crops. Household rice consumption is high when reserves of maize are exhausted, and farmer households are forced to buy imported rice at the market illustrating the importance of rice as a back-up food to maize and the vulnerability of poorer farmer households to fluctuations in the market price. When maize reserves are exhausted, farmers are more likely to purchase rice rather than maize due to factors of distribution, cost, and labour. Subsistence farmers' reliance on imported rice as a reserve food during the wet season, and especially the hungry season, means that the government must ensure distribution and affordability of rice particularly during these periods.

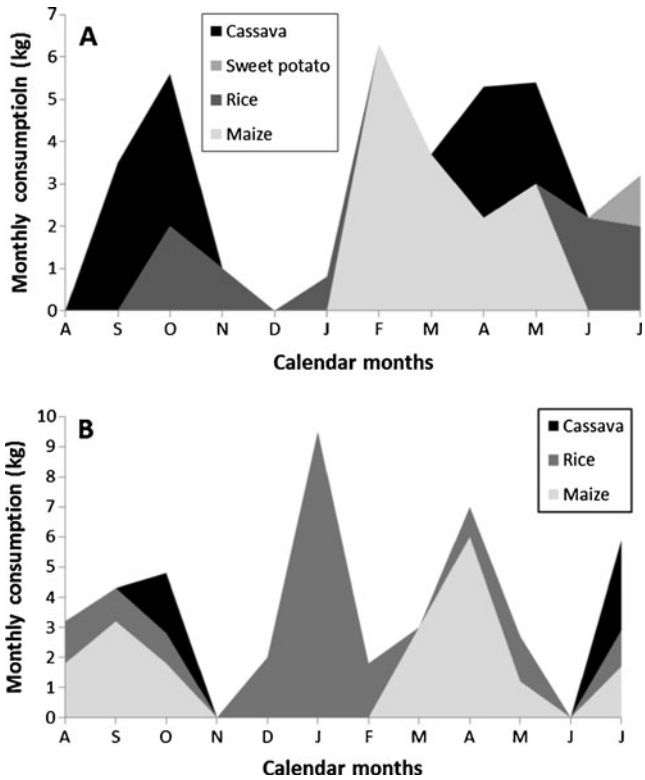

Fig. 5 Examples of carbohydrate consumption (kg) of individual households by month from Lari, Baucau (**a**) and Selihasan, Manufahi (**b**) (SoL 2009). Note: Household food needs may also be met through foraging for wild foods, and/or through gifting of food through social networks. Such contributions to the household food basket are not included in the above graphs

Farmers' coping strategies

To cope with repeated periods of food insecurity during the year, subsistence farmers in Timor-Leste have several options to fall back upon while waiting for their next harvest—in addition to crop diversification. Harvesting wild food such as yams, bitter beans and sago palms are a regular strategy although processing wild beans by repeated boiling to remove bitterness and processing sago palms to release starch are very labour intensive particularly for women (Glazebrook et al. 2007). Wild yams are harvested opportunistically as products from surrounding forests. The sago palm trunk (*Metroxylon sagu* Rottb) is cut into cylinders and pounded over long periods to release the starch. Farmers also rely upon each other for support during difficult times. Social networks include neighbours, relatives, and members of the working group to which the farmer traditionally belongs. There are a number of levels of support ranging from lending, borrowing and barter through to outright gifting (SoL 2007). The gifting of food between neighbours and members of extended families may be characterized as 'delayed reciprocity' whereby the gift is returned at a later date when the household that has received the gift has a surplus and/or its members 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. 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.

In summary, household food insecurity in Timor-Leste is seasonal with the hungry season prior to maize and rice harvests. Farm households cope with the problem through crop diversification with tubers playing a lead role as grain stocks dwindle. Foraging for wild food resources, selling animals and other assets, and social networks are other key coping strategies.

Addressing food insecurity in Timor-Leste

As discussed, policy makers usually select among three common interventions to combat seasonal reductions in

food access by poor households: seasonal income transfers to poor households; seasonal food imports; and increasing agricultural productivity. The Government of Timor-Leste has focused on the latter two options, which are discussed below, but is also organizing rural road construction, road rehabilitation, the installation of the national electricity network and other forms of rural labour. These provide valuable sources of cash for subsistence farming households and may be regarded as seasonal income transfers to poor households.

Seasonal food imports

Since independence the government has imported rice in order to supplement indigenous food supply. The household consumption study has highlighted how, over time, the nation has become increasingly reliant on this imported staple. The study has also provided information which will be important for the development of indicators of levels of food security. Such indicators may be useful for identifying both positive and negative changes. In relation to negative changes, one of the challenges for the government and development partners is knowing when food security drops to a critical point and food assistance is required. In relation to positive changes, in the context of the SoL program, it was hoped that indicators could be developed that would reflect positive trends associated with the adoption of SoL varieties and their impact on food security. Such indicators might include:

- increases in levels of cereals consumed, particularly maize
- reduction in purchases of rice and/or a shift from consumption of imported rice to local rice
- increases in the amount of produce being bought and sold in the markets
- increased investment in assets such as livestock, consumer items or productive assets for on-farm or off-farm enterprises

Increasing agricultural productivity

Reducing poverty and increasing agricultural production in order to ensure food security are essential for development in Timor-Leste. The government claims that the development of the rural areas and increased agricultural productivity will reach a high proportion of the population (GOTL 2011). Since 2002, the government has invested in a national system of agricultural research and, more recently, in agricultural extension. The government has also made progress in addressing other constraints to agricultural production more directly, including policy and regulation development; land preparation and weed control; soil fertility, fertilizers and pesticides; water security; roads, markets, reliable power, farm finance and communications; improved cultivars and agronomy; and food storage (Lopes and Nesbitt 2012).

Agricultural research and extension

Agricultural research within the Ministry of Agriculture and Fisheries (MAF) is heavily supported by bilateral and multilateral interventions. One large program within the MAF, the SoL program, has a goal of 'Improved food security through increased productivity of major food crops' and is involved in varietal evaluation and release, seed production and seed distribution utilizing the informal seed sector (Borges et al. 2009). In recent years, the MAF has dramatically increased its capacity to support agricultural extension activities. There are now over 400 village (*suco*) extension officers working with the rural community and the three agricultural secondary schools, catering for about 800 students, encourage farming communities to employ more modern agricultural techniques.

Land preparation and weed control

Most upland areas are traditionally farmed using slash and burn agriculture whereby a young piece of forest or weedy piece of land is burned at the end of the dry season. Maize, pigeon pea, sweet potato, peanuts, cassava and other crops are then planted directly into the soil using a dibble stick. There is very little weed burden in the first year after clearing a forest area, and crops are successfully grown with little weeding. As the cleared land is planted in succeeding years, the weed burden increases until it is decided to leave that plot for a new area. As the weed burden increases, substantial reductions in crop yield result. Weed control is constrained by lack of labour availability and consequently the cropped area of most farm households is restricted to 0.8 to 1.0 ha. The area under production could be expanded and crop yields increased with improved weed management. High cost puts the use of herbicides out of the reach of most subsistence farmers. The government does, however, support an increase in the cropping area through the cultivation of flat or slightly sloping land with tractors. In some situations tillage can reduce the weed burden. For example, Siam weed (*Chromolaema odorata* (L.) R. King and H. Robinson), an invasive species, can be controlled by a combination of the gall fly (*Cecidochares connexa*), a biocontrol agent which kills the mother plant, and cultivation. Deep ploughing that inverts the soil can control *Imperata cylindrica* (L.) Raeuschel, one of the most dominant weeds throughout Timor-Leste. Tractors are particularly useful in coastal and inland plains in preparing rice paddies and maize fields. The MAF imported 2,491 hand tractors and 315 four-

wheel drive tractors between 2007 and 2009, which are available with drivers for farmers to utilize.

Soil fertility, fertilizers and pesticides

The island of Timor is the result of geological uplift due to a locked continental collision between the Indo-Australian and Eurasian geological plates (Thompson 2011). Much of the terrain is steep (44 % of the land has a slope of 40 % or greater), and the vast majority has only a thin covering of productive soil. The soils, particularly on the slopes, are generally shallow and impoverished and are becoming even less fertile over time through increased nutrient depletion from leaching and erosion after torrential rainfall, deforestation, free grazing and over-cropping, slash and burn agriculture 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, where stones are abundant they are laid along contours, 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. During 2008 and 2009 the government imported fertilizers to apply to hybrid rice crops grown in irrigated areas but little of this reached the uplands. Anecdotal evidence indicates that farmers are not in favour of applying chemical fertilizers because of their previous negative experiences which led to lower yields in subsequent cropping years. As a result, low demand limits the availability of chemical fertilizer in the markets. High costs limit the use of herbicides and insecticides by subsistence farmers in Timor-Leste.

Recent agronomic research in Timor-Leste has shown the benefits of an indigenous technology, velvet beans. Velvet beans (*Mucuna pruriens* (L.) DC. var. *utilis* (Wall. ex Wight) Baker ex Burck) have been used in small parts of the island as a weed suppressant and as a soil improver. However in most of the country, velvet bean is only grown as a source of food, often sown at the base of a tree or fence, while its other benefits, when grown as a mulch crop, are largely unknown. Ongoing research shows that soils can be improved and subsequent crop yields increased using "organic" techniques such as relay sowing legumes with cereals. The results of Vidal and Williams (2011), for example, show that sowing velvet bean between maize rows is one way to increase the yield of maize. Velvet bean improves soil fertility through nitrogen fixation and leaf litter. It also shades out weeds during the main cropping season, thereby reducing competition for soil nutrients and water. Although the seeds contain the psychoactive drug L-dopa, the bean is also edible when boiled (Wulijarni-Soetjipto and Maligalig 1997). Farmers are re-adopting this agronomic system in appropriate parts of Timor-Leste.

Water security

Farmers in all districts raised concerns about the need for water security during the consultation in 2010 to develop the national Strategic Development Plan. Improving the area of crop under irrigation has the potential to double 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 result in a ravaged infrastructure, requiring repeated rehabilitation. The government dedicates part of its budget to the re-construction of the irrigation network and has plans to irrigate an extra 9,000 ha during the period 2012–2015 (MAF *pers. comm.*) and to have 70,000 ha of rice under irrigation by 2020 (GOTL 2011). There is also potential to improve water security using water harvesting techniques at an individual or communal level. Several NGOs have been involved in such programs.

Improved cultivars and agronomy for food security

As already mentioned, maize is the primary staple crop in the country, but maize yields averaged only 2.0 t/ha in 2009 and 2010 (FAO 2012). This productivity level is far below yields in neighbouring countries with similar agro-ecologies such as Cambodia, Indonesia, Laos, Thailand and Vietnam, all of which have mean maize yields above 4 t/ha.

Borges et al. (2009) reported staple crop improvement in Timor-Leste which started in 2000 with the introduction of germplasm of staple crops (maize, peanut, rice, cassava and sweet potato). Replicated trials confirmed by extensive evaluation in participatory farmer-managed trials revealed significant yield advantages over the local cultivar in maize of 53 % (Williams et al. 2012a), peanut 31 % (Williams et al. 2012b), rice 23 % and sweet potato 80 %, accompanied by improvements in size and eating quality. Cultivars of maize (2), peanut (1), rice (1) and sweet potato (3) were released in 2007 (Borges et al. 2009) and of cassava (2) in 2009 (SoL 2009). Initial adoption by the farmers who had been involved in on-farm trials was high (over 80 % 1 year after the trials). Importantly, as participatory evaluation was done under farmer management without fertilizer or pesticide application, the new cultivars do not require additional inputs. Three years on, although there were significant areas of the new varieties managed by adopters and planting material had been widely shared, crop failures (particularly from climatic hazards and animal damage) and the loss of planting material were common, reducing diffusion (Lacoste et al. 2012). To ensure long-term adoption and broad diffusion, Lacoste et al. (2012) recommended combining participatory evaluation with

comprehensive, flexible and reliable planting material sources. The SoL program is now linking the formal and existing farmers' seed systems at the community level to ensure widespread seed availability to the farmers of Timor-Leste.

Food storage

Post-harvest losses of the major food crops in Timor-Leste are significant. It is estimated that maize grain losses may average as high as 30 % due to weevil and rat infestations using conventional storage techniques (DOF 2011). In one study weevil damage was as high as 63 % when stored as cobs in the sheath for 9 months (SoL 2008, 2009). Weevils, rats, and moulds also destroy other stored grains, tuber and root crops. In an attempt to address this issue, the government assisted the provision of over 5000 silos to farmers' groups between 2007 and 2011. Air-tight containers such as silos, drums and plastic bags have been proved to reduce weevil and eliminate rat damage but metal containers which are not airtight were of no value for storing maize (Tefera et al. 2011). They can, however, be used very successfully to store rice and peanuts because these crops are not prone to weevil damage. The NGOs Drums on Farms and CARE (Timor-Leste) have also been involved with the distribution of drums which are able to store 180 kg of maize grain. The savings from food losses are estimated to provide the farmers with an extra 20 days of food per drum. The International Fund for Agricultural Development (IFAD 2011) has plans to fund the distribution of 43,000 drums over a 3 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.

Returning to the three interventions (seasonal income transfers to poor households; seasonal food imports; and increasing agricultural productivity) most commonly used by governments world-wide to address seasonal food insecurity, Timor-Leste has focused on rice importation and the improvement of agricultural productivity within a multi-dimensional program. Information on storage by households of the key staple, maize, indicates an improving trend in food security at the household level from 2006/2007 to 2010/2011 through a significant reduction in the percentage of 'at risk' households—those who grow insufficient maize for storage for the year (Fig. 2). Among all the different approaches for overcoming food insecurity it is not possible to make separate attributions. It is to be hoped that with the current emphasis on the widespread dissemination of the new high-yielding cultivars within the on-going SoL program that these improving trends will be further augmented. Nevertheless, this ameliorating picture remains vulnerable to weather shocks such as drought (Fig. 4) or excess rainfall. Such climatic anomalies are expected to increase with climate change (Molyneux et al. 2012) and it is important to build the necessary resilience into the agricultural systems in Timor-Leste.

Food security implies the availability to individuals of sufficient calories to provide their energy requirements but malnutrition is more complex than just fulfilling calorie deficiencies. A lack of essential vitamins and minerals often results in 'hidden hunger' where the signs of undernutrition and hunger are less obvious. A person may have access to sufficient calories but lack adequate micronutrients (Burchi et al. 2011). Chronic micronutrient deficiencies—hidden hunger—affect over two billion people worldwide (Burchi et al. 2011). In Timor-Leste, in addition to chronic calorie malnutrition, vitamin A deficiency and anaemia from iron deficiency are major nutritional problems (NSD 2010). In this regard dietary diversity is essential for food and nutritional security. The SoL program is examining opportunities to address not only insufficient calories but also vitamin A and iron deficiencies through biofortification—the breeding of bio-fortified crops with improved yield. Achieving food and nutritional goals simultaneously is a distinct possibility in Timor-Leste because current yield levels are so low, leaving considerable room for improvement.

Conclusions

Household food security in Timor-Leste is seasonal with the hungry season prior to maize and rice harvests. Farm households cope with the problem through crop diversification with tubers playing a lead role as grain stocks dwindle.

Foraging for wild food resources, selling animals and other assets, and social networks are other key coping strategies.

To address seasonal food insecurity, the government has focused on rice importation and the improvement of agricultural productivity within a multi-dimensional program.

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The current emphasis on the widespread dissemination of the new high-yielding cultivars has the potential to augment these improving trends. Nevertheless, this ameliorating picture remains vulnerable to weather shocks such as drought or excess rainfall. Such climatic anomalies are expected to increase with climate change and it is important to improve resilience in the agricultural systems of Timor-Leste.

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References

Barnett, J., Dessai, S., & Jones, R. N. (2007). Vulnerability to climate variability and change in East Timor. *Ambio, 36*, 372–377.

Borges, L. F., AdR, F., Da Silva, D., Williams, R., Andersen, R., Dalley, A., Monaghan, B., Nesbitt, H., & Erskine, W. (2009). Improving food security through agricultural research and development in Timor-Leste: a country emerging from conflict. *Food Sec, 1*, 403–412.

Burchi, F., Fanzo, J., & Frison, E. (2011). The role of food and nutrition system approaches in tackling hidden hunger. *International Journal of Environmental Research and Public Health, 8*, 358–373.

Coates, J. C., Webb, P., Houser, R. F., Rogers, B. L., & Wilde, P. (2010). "He said, she said": who should speak for households about experiences of food insecurity in Bangladesh? *Food Sec, 2*, 81–95.

DOF (Drums on Farms). (2011). Drums on farms program http://www.drumsonfarms.org/

Dorosh, P., & Haggblade, S. (1995). Filling the gaps: consolidating evidence on the design of alternative targeted food programmes in Bangladesh. *Bangladesh Dev Studies, 23*, 47–80.

Dostie, B., Haggblade, S., & Randriamamonjy, J. (2002). Seasonal poverty in Madagascar: magnitude and solutions. *Food Pol, 27*, 493–518.

FAO (Food and Agriculture Organization). (1996). *Declaration on World Food Security*. Rome: World Food Summit, FAO.

FAO (Food and Agriculture Organization). (2011). *Inter-ministerial task force on food and nutrition security. Situation assessment report*. Timor-Leste: Dili.

FAO (Food and Agriculture Organization). (2012). FAOSTAT Statistical database of the United Nations Food and Agriculture Organization (FAO), Rome, Italy

Glazebrook, D., Lopes, M., da Costa, M. d. J., & Ximenes, A. (2007). *Stocks and flows of household food supplies during the wet and dry seasons and food shortage period: a longitudinal case study among subsistence farmers in Aileu, Baucau* (p. 50). Timor Leste: Liquica and Manufahi districts.

GOTL (Government of Timor-Leste). (2011). Government of Timor-Leste strategic development plan 2011–2030. 232 pp.

IFAD (International Fund for Agricultural Development) (2011) Timor-Leste maize storage project. Project design report, pp 210

Lacoste, M., Williams, R., Erskine, W., Nesbitt, H., Pereira, L., & Marçal, A. (2012). Varietal diffusion in marginal seed systems: participatory trials initiate change in East Timor. *J Crop Improvement*. doi:10.1080/15427528.2011.651775.

Lape, P., Chin-Yung, C. (2008). Fortification as a human response to late Holocene climate change in East Timor Archaeol Oceania 43:11–21

Lopes, M., Nesbitt, H. (2012). Improving food security in Timor-Leste with higher yielding crop varieties. Paper presented at Australian Agricultural and Resource Economics Society Mini Symposium "Food security in our own back-yard", Fremantle 8–10 February, 2012.

Molyneux, N., Rangel da Cruz, G., Williams, R., Andersen, R., & Turner, N. C. (2012). Climate change and population growth in East Timor: implications for food security. *Ambio*. doi:10.1007/s13280-012-0287-0.

NSD (National Statistics Directorate). (2010). Timor-Leste demographic and health survey 2009–10. Dili, Timor-Leste: NSD [Timor-Leste] and ICF Macro. pp 395.

NSD (National Statistics Directorate). (2011). *Population and housing census 2010: Population distribution by Administrative Areas, Volume 2* (p. 292). Timor-Leste: Dili.

Nord, M., Andrews, M., Carlson, S. (2009). Household food security in the United States, 2008. Economic Research Report No. ERR-83, US Department of Agriculture, Washington.

Pinstrup-Andersen, P. (2009). Food security: definition and measurement. *Food Sec, 1*, 5–7.

Pinstrup-Andersen, P., Pandya-Lorch, R., & Rosegrant, M. (1999). *World food prospects: Critical issues for the early twenty-first century*. Washington DC: International Food Policy Research Institute.

Rio, N. (1999). *The status of the East Timor agricultural sector. WP, 2001: 7 Columbia University* (p. 32). New York: International Conflict Resolution Program.

SoL (Seeds of Life). (2007). *Annual research report, 2006*. Timor-Leste: Ministry of Agriculture and Fisheries.

SoL (Seeds of Life). (2008). *Annual research report, 2007*. Timor-Leste: Ministry of Agriculture and Fisheries.

SoL (Seeds of Life). (2009). *Annual research report, 2008*. Timor-Leste: Ministry of Agriculture and Fisheries.

SoL (Seeds of Life). (2010). *Annual research report, 2009*. Timor-Leste: Ministry of Agriculture and Fisheries.

SoL (Seeds of Life). (2011). *Annual research report, 2010*. Timor-Leste: Ministry of Agriculture and Fisheries.

SoL (Seeds of Life). (2012a). *Annual research report, 2011*. Timor-Leste: Ministry of Agriculture and Fisheries.

SoL (Seeds of Life). (2012b). *Seeds of Life 3 Baseline Survey*. Timor-Leste: Ministry of Agriculture and Fisheries.

Tefera, T., Kanampiu, F., De Groote, H., Hellin, J., Mugo, S., Kimenju, S., Beyene, Y., Boddupalli, P. M., Shiferaw, B., & Banziger, M. (2011). The metal silo: an effective grain storage technology for reducing post-harvest insect and pathogen losses in maize while improving smallholder farmers' food security in developing countries. *Crop Protection, 30*, 240–245.

Thompson, S. (2011). Geology and soils in Timor-Leste. Seeds of life program report, p 39

Tilman de sa Benevides, F. (2003). Cropping systems in East Timor. Pages 17–19 in Agriculture: New directions for a new nation—East Timor (Timor-Leste). Proceedings of workshop 1–3 October 2002, Dili, East Timor. ACIAR Proceedings No. 113.

Timmer, C. P. (1997). Building efficiency in agricultural marketing: the long-run role of BULOG in the Indonesian food economy. *J Int Devel, 9*, 133–145.

UN (United Nations). (2009). *Total Population by Sex in 2009 and Sex Ratio by Country in 2009 (Medium Variant). Population Division of the Department of Economic and Social Affairs of the UN*. New York: Secretariat.

UNDP (United Nations Development Program). (2011). National Human Development Report, UNDP, 120p http://www.undp.east-timor.org/undp/focus_areas/energy_environment.html

UNICEF (United Nations Children's Fund). (2011). State of the World's Children Report. United Nations Children's Fund (UNICEF)

Vidal, M.C., Williams, R.L. (2011). Moris—*Lehe bele hasae produsaun batar iha Timor-Leste.* 'Knowledge, Attitudes and Skills for Timor-Leste's Development: an Opportunity for Dialogue' 4 July 2011.

World Bank. (2003). Timor-Leste poverty assessment—poverty in a new nation: Analysis for action. Volume II: Technical Report. Report No. 25662-TP 215 pp.

World Bank. (2010). Timor-Leste raising agricultural productivity: Issues and options. Report number: 50276-TP 27 pp.

WFP (World Food Program). (2006). Comprehensive food security and vulnerability analysis of Timor-Leste. p 40.

Williams, R., Borges, L. F., Lacoste, M., Andersen, R., Nesbitt, H., & Johansen, C. (2012). On-farm evaluation of introduced maize

varieties and their yield determining factors in East Timor. *Field Crops Res, 137*, 170–177.

Williams, R., Andersen, R., Marçal, A., Pereira, L., Almeida, L., & Erskine, W. (2012). Exploratory agronomy within participatory varietal selection: the case of peanut in East Timor. *Experimental Agriculture, 48*, 272–282.

Wulijarni-Soetjipto, N., Maligalig, R.F. (1997). *Mucuna pruriens* (L.) DC. cv. group Utilis [Internet] Record from Proseabase. Faridah Hanum, I & van der Maesen, L.J.G. (Editors). PROSEA (Plant Resources of South-East Asia) Foundation, Bogor, Indonesia. http://www.proseanet.org. Accessed from Internet: 16-May-2012.

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