Timor-Leste Agriculture Sector Review

Prepared for the
Ministry of Agriculture and Fisheries of the Democratic Republic of Timor-Leste
through the Sustainable Agriculture Productivity Improvement Project

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List of Abbreviations and Acronyms

ADB:	Asian Development Bank
ACIAR:	Australian Centre for International Agricultural Research
ASEAN:	Association of South East Asian Nations
BMI:	Body Mass index
COCOA:	Coffee and Cocoa Agribusiness Opportunities Project, cash crops program by NZ
DFAT:	Department of Foreign Affairs and Trade, Australian Government
DP:	Development Partners
DMF:	Development Market Facility, private sector support program by DFAT
EAP:	East Asia Pacific
ENSO:	El Niño Southern Oscillation
EU:	European Union
FAO:	Food and Agriculture Organization of the United Nations
FAOSTAT:	FAOs Agriculture Statistics Service
FOB:	Freight On Board
GDP:	Gross Domestic Product
GoTL:	Government of Timor-Leste
IF:	Infrastructure Fund
IPC:	Integrated Food Security Phase Classification
JICA:	Japanese International Cooperation Agency
KONSSANTIL:	*Konsellu Nasional Seguransa,Soberania Ai-han no Nutrisaun Timor-Leste* – National Council on Food Security, Sovereignty, and Nutrition
ha:	Hectare, unit of area equal to 10,000 square meters
HH:	Household
HIES:	Household Income and Expenditure Survey
MCIE:	Ministry of Commerce, Industry and Environment
MAF:	Ministry of Agriculture and Fisheries
MDF:	Market Development Facility, DFAT funded private sector development program
MoE:	Ministry of Education
MoF:	Ministry of Finance
MoH:	Ministry of Health
MoSS:	Ministry of Social Solidarity
Mt:	Metric Tone = 1,000 kg
M&E:	Monitoring and Evaluation
NGO:	Non-governmental organization
NZAid:	New Zealand Aid
PDIP:	*Planeamento de Dezenvolvimentu Integradu Distritál* – Decree Law for Integrated District Development Planning
PSAF:	Partnership for Sustainable Agro-Forestry, program by EU and GIZ
ODA:	Overseas Development Assistance
SAPIP:	Sustainable Agriculture Productivity Improvement Project, program by WB and MAF
SAR:	Special Administrative Region
SDP:	Strategic Development Plan 2011-2030
SEA:	South Eastern Asia
SEM:	Small Medium Enterprise
SEPFOPE:	Secretariat of State for Vocational Training Policy and Employment
SoL:	Seeds of Life, agriculture research program by DFAT 2000-2016
TLSLS:	Timor-Leste Living Standard Survey
TOMAK:	*To'os ba Moris Di'ak* - Farming for Prosperity, program by DFAT
UNDP:	United Nations Development Program
UNTL:	*Universidade Nasionál Timor-Loro sa'e* – National University of Timor-Leste
USAID:	United States Agency for International Development
WB:	Word Bank
WHO:	World Health Organization
WTO:	World Trade Organization
ZEESM:	*Zonas Especiais de Economia Social de Mercado* – Special Economic Zone in Oecusse

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Part 1: Introduction and Purpose

Timor-Leste has only recently emerged from a long period of colonization and occupation. Portugal controlled East Timor for centuries, until the resistance movement won independence in late 1975. Indonesia then quickly invaded and occupied. Again, the Timorese fought spiritedly, until they won independence in 1999. At least 25% of the population was killed in the process. And in the years since 2002, when the country became fully independent, several smaller conflicts have flared up, requiring United Nations peacekeepers to maintain stability. Only in the past ten years has Timor-Leste been peaceful and stable enough for its leaders to focus on improving people's lives. See below Timor-Leste´s map (Figure 1) divided in 12 Municipalities and Oecusse, a Special Administrative Region (SAR).

Figure 1 *– Map of Timor-Leste and its districts*

Source: NordNordWest, 2009.

While Timor-Leste has worked to rebuild the country, and improve life for its people, challenges remain. While agriculture can surely address food insecurity, the country's agriculture remains largely subsistence with very little access to high-value export markets. There are many reasons why agriculture growth has been stagnate including vast food insecurity and poverty; insufficient human and institutional capacity compounded with malnutrition; poor natural resources and their management fit for agriculture; high vulnerability to natural disasters and climate change; and low investment in the agriculture sector itself. Below provides a snapshot of these challenges.

- **Vast food insecurity and poverty:** The prevalence of undernourishment is on the decline in Timor-Leste: since peaking in the 1998-2000 period at 44.1%, it has decreased to 27.2% during the 2015-2017 period[1]. This figure represents approximately one-quarter of the country's population. However, for a country classified as middle-income[2], this is a very high prevalence of food insecurity. Poorer households are also more vulnerable to food insecurity[3]. Poverty remains high in the country with 41.8% of the population considered poor in 2014, and of that, 47.1% live in rural places and 28.3 % live in urban centres[4]. The human development index (HDI) of Timor-Leste is in 2018 .625, with a rank of 132 out of 189 countries, with minimal improvement in its score and rank in the last five years[5].

- **Insufficient capacity and very high malnutrition:** Stunting stands at 46.0%, a measure of chronic undernutrition among children under five years of age[6], which also serves as a proxy for overall poverty and development of countries. Stunting is significantly higher in Timor-Leste compared to some of its neighbours such as Indonesia, Cambodia and Lao PDR (36.4, 33.0, and 32.0% prevalence respectively)[7]. Wasting, a measure of acute malnutrition and often a significant risk

factor of mortality in children under five years of age, is alarmingly high (24.0%)[18]. Having high levels of malnutrition does not fare well for human capital prospects and the ability to have significant agriculture-led growth compounded with a knowledge-based economy, which is a critical avenue for Timor-Leste to undertake. In addition, demographic pressures will only make the undernutrition incapacities even more challenging. The country has one of the youngest populations in the world with almost 74% of its population under 35 years old[9]. Youth migrating to Dili and other peri-urban centres is one mechanism for the rapid urbanization of the island. Between 2010 and 2015, the urban population growth rate was 3.8% per year with 32.8% of the population living in urban areas in 2015[10]. While the agriculture sector provides direct employment to 64.2% of the employed population, this proportion has decreased, partly explained by rural-urban migration patterns[11].

- **Degraded natural resources:** While Timor-Leste benefits from its immense species and variety biodiversity, soils and the landscape make Timor-Leste difficult for agriculture. The fertile, volcanic soils of Bali and other islands of the Indonesia archipelago do not extend into Timor-Leste, and instead the soils are less fertile limestone and metamorphosed marine clays. Because Timor-Leste is mountainous, with steep slopes, soil run-off and erosion is common. Deforestation is also occurring which amplifies soil erosion. Its typical monsoon season, followed by drought-like dry seasons, can make substantive agriculture productivity inadequate. In addition to staple crops, animals and coffee, there are also several food crops endemic and/or well-suited to Timor-Leste that support food security and nutrition including leafy greens such as moringa[12, 13]. The most commonly consumed wild foods include lesser yam, elephant's foot yam, and bitter bean[14]. While biodiversity is high, particularly within marine and coastal ecosystems, there is a need for more substantive genetic conservation and sustainable use and management.

- **High vulnerability to natural disasters and climate change:** Timor-Leste is vulnerable to natural hazards because of its location in a region with seismic activity, its own topography and regional climate, and the prolonged use of poor agricultural techniques. The country has a medium exposure to natural hazards, but the absence of coping and adaptive strategies makes it a potentially disaster-prone country. It is especially prone to severe and recurrent drought (especially during El Niño years), flooding, and landslides. These natural hazards increase the country's vulnerability to agricultural challenges, food shortages, and food insecurity more broadly[15]. Though the historical record of climate conditions in the country is limited, existing records from 1950-2009 show definitive effects of climate change: regional sea surface temperatures have increased 0.15 - 0.2 degree C per decade, which is likely reflected by a similar increase in air temperatures, and sea levels have risen by 9 mm per year since 1993. The rise in sea levels is much higher than the global average increase of 2.8 - 3.6 mm per year. Coastal areas are consequently at a greater risk of flooding. Reports of climactic changes mention hotter dry seasons, extreme heat episodes, shorter and unpredictable rain seasons, more frequent extreme rainfall, and seawater intrusion[16].

- **Food imports dependency, low productivity and disincentives to commercial production:** Timor-Leste's agricultural sector consistently produces less food than is needed to feed the population[17] and overall, agriculture in Timor-Leste is primarily subsistence rather than market-oriented. This results in Timor-Leste heavily depending on food imports to meet its consumption needs, with cereal import dependency ratio ranging from 30 to 40%[18]. Coffee is the major rural export commodity, comprising 91% of all non-oil exports in 2017[19]. Though they are some of the poorest farmers, coffee growers earn some extra income from this export crop[20]. Although the country is an agrarian society with 70% of the population living in rural areas, only 30% of arable land is used for crops and grazing[21]. In addition, 70% of the population relies on rain-fed subsistence agriculture[22]. Despite Government's focus on cereals production, total output and area

[1] The anthropomtrey data from DHS 2016 should be interpreted with caution, as advised in their report (2016:180).

harvested present a downward trend while productivity is timidly improving[23]. Yields of rice and maize are low, despite averages doubling from 1.5 Mt/ha for rice and 1.1 Mt/ha for maize in 2008[24], to 3.0 and 2.2 Mt/ha in 2016[25]. These yields are far lower than those of neighbouring countries with similar agro-economies, such as Cambodia, Laos, Indonesia, Thailand and Vietnam, where maize yields average above 4 Mt/ha[26] [27]. For the most rural areas, chemical inputs such as fertilizers, pesticides, and herbicides are not available due to high cost and/or low uptake. Combined with poor-yielding local varieties, depleted soils, high weed burdens, steep slopes, and highly variable rainfall, these agricultural practices result in the low yields[28]. Livestock production is low at 6.4 kg/head of cattle compared to global average of 32.0 kg[29] and fishery production is inefficient and unsustainable. Current investments in irrigation have not been successful at stimulating increases in rice production[30], while low market prices against imports combined with social assistance transfers and the opportunity cost of farm labour disincentivise production for sale.

- **Insufficient investment in the agriculture sector:** The SDP (Strategic Development Plan for 2011-2030) recognizes the fundamental role of the agriculture sector for economic diversification, poverty alleviation and as a major driver for economic growth and employment generation. Despite the agriculture sector contributing 19.2% to the non-oil Gross Domestic Product (GDP) since 2010, Ministry of Agriculture and Fisheries (MAF) has received less than 2% of the total state budget[31]. The expenditure on agriculture continued to decrease in 2019[32], while the value of the agriculture GDP showcases an annual average growth of 5%[33]. The Forestry and Fisheries' share of the Agriculture GDP are marginal when compared to the Agriculture crops and Livestock sub-sectors, with livestock increasing its portion to 21.5% in 2015[34]. Overseas Development Assistance (ODA) comprises a significant amount of the total agriculture sector investment, more than doubling public expenditure. Decentralization of budgets and programs is transforming municipal agriculture services with allocations transferred directly to municipal authorities since 2017. The Government has focused on rehabilitating irrigation infrastructures, with a major role played by municipalities who have implemented 49% of all public expenditure in agriculture infrastructure[35]. Despite very limited reliable statistical data on agriculture performance combined with very low levels of public investment and often contradictory policies, Timor-Leste´s agriculture sector embodies huge levels of potential to ensure food security, conserve biodiversity, shared prosperity and diversified rural development.

The purpose of this Agriculture Sector Review (ASR) exercise is assist the Ministry of Agriculture and Fisheries (MAF) and its Sustainable Agriculture Productivity Improvement Project (SAPIP) on (1) identifying the key challenges and opportunities for Timor-Leste's agriculture sector through a rigorous evidence-based analysis to provide options for reform and (2) understanding the sector's contribution to reducing absolute poverty and improving food security, fostering shared growth and addressing capacity, and ensuring sustainability through better natural resource management and reducing vulnerability to climate change and natural disasters.

The initial development of the ASR did not include a fisheries section, as a separate review was commissioned to assess the fisheries sector in detail. This final January 2019 version of the ASR includes a succinct section on fisheries overviewing key data and constraints, as well as the contribution of the fisheries sector to food and nutrition security and poverty-alleviation strategies.

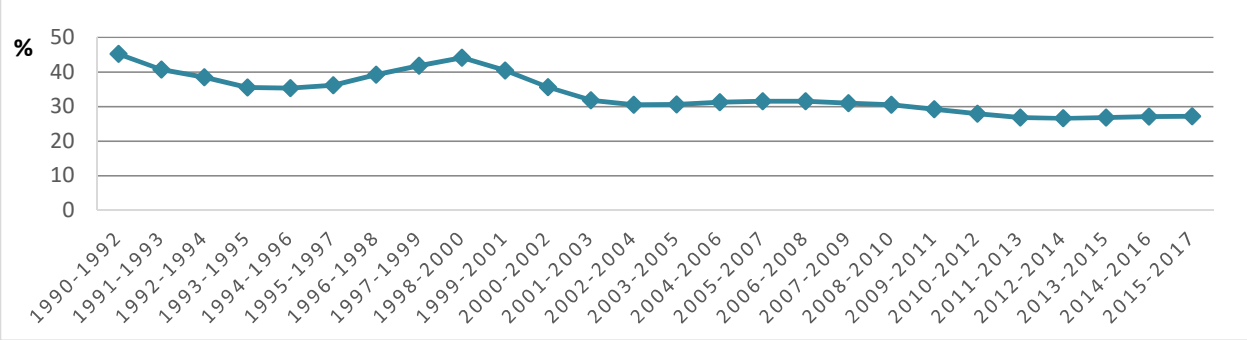
Part 2: Food Security, Poverty and Agriculture

Timor-Leste is a rural country – with agriculture[2] playing an important role for both livelihoods and food security. This section will demonstrate three things: (1) malnutrition remains high in the country with still significant undernourishment and food insecurity; (2) there is still a large swath of vulnerability and poverty in the country; and (3) agriculture while important, is still largely subsistence with little access to technology compounded with declining natural capital.

Burden of Undernourishment, Malnutrition and Food Insecurity

Since 2001, the three-year average for the number of people experiencing undernourishment in Timor-Leste has held constant at 300,000[36]. This figure represents approximately one-quarter of the country's population. As of 2017, 27.2% of the population is considered undernourished (Figure 2). Its prevalence is on the decline, peaking in the 1998-2000 period at 44.1%.

Figure 2 *– Prevalence of undernourishment in Timor-Leste, 1990-2017 (3 years average)*



Source: FAOSTAT, 2018[37]

Hunger continues to be a problem in Timor-Leste, which follows seasonal patterns. In 2011, the Seeds of Life Baseline Survey evaluated hunger both nationwide and regionally through its Household Hunger Scale Nationally, 3% of households reported severe hunger, 9% experienced moderate hunger, and 88% reported little or no hunger[38]. In 2018, an IPC analysis concluded that 21% of the population suffers from *moderate* chronic food insecurity (CFI), and 15% from *severe* rates (levels 3 and 4 respectively)[39]. These indicate how 36% of all Timorese struggle to ensure sufficient and adequate food intake throughout the year, with most affected populations in the SAR of Oecusse, Ermera and Manufahi. Major limiting factors identified include food utilization –particularly lack of access to adequate water and sanitation, high illiteracy, and very low levels of protein intake; and sustainable livelihoods –reflecting undiversified economies with dependency on unsustainable livelihoods.

One of the hangovers from the decades of upheaval and turmoil is one of the highest rates of chronic undernutrition in the world. Of the nation's 150,000 children under five years old, more than half are stunted in both bodies and brains. Stunting implies an almost irreversible disability to learn and develop. Not only are they not physically as tall, but their brains do not fully grow or function as that of a child with optimal nutrition. Poor nutrition, especially in the womb and during the first two years of life, impedes a child's ability to learn and develop to their fullest potential. One can only imagine the impact on the development and progress of a nation when almost half of the children born are stunted, and most likely

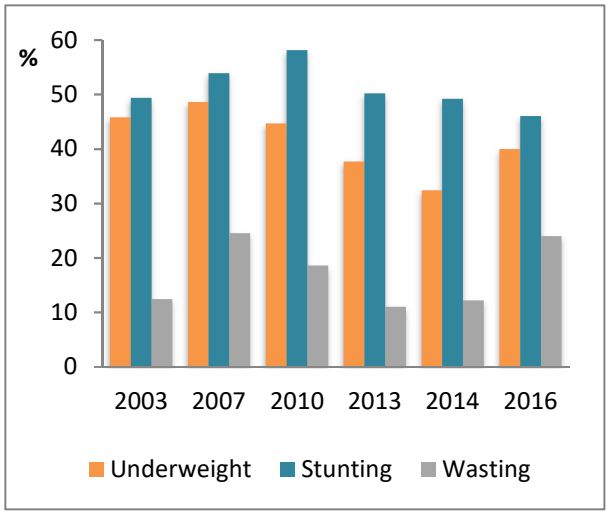
[2] Agriculture includes crops, livestock, fisheries and forestry

will also have children who are stunted. The cycle of malnutrition can have a vicious habit of perpetuating itself through generations.

Stunting is a complex indicator but it is one that reflects the persistent poverty and chronic undernourishment of a country. It also serves as proxy measure to the disruptive wars it has undergone, the inflictions of infectious disease, the poor health care access, sanitation, hygiene, and child care, as well as the lack of access to and consumption of nutrient dense foods. It is no coincidence that countries with comparable levels of stunting include Afghanistan, Yemen, and Burundi. Stunting is a depiction of a country's history. For those children who have been affected, the damage is done, and the challenges ahead to improve the nutritional status of children will be enormous.

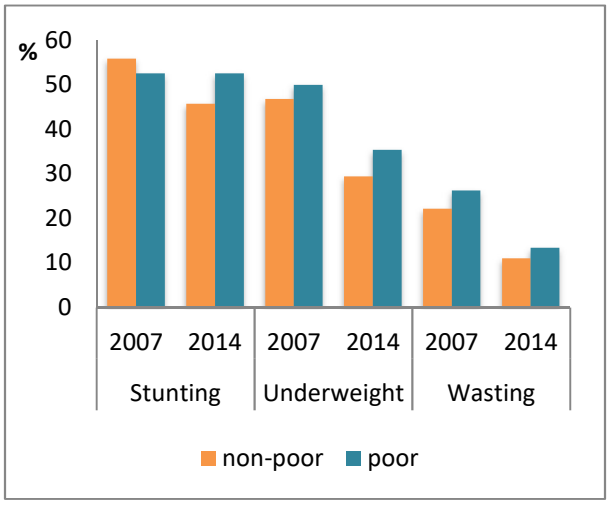
The burdens of malnutrition in Timor-Leste are high – for both stunting and wasting among children under the age of five, and particularly in poor households and in rural areas. Since 2002, there has been very slow progress in reducing stunting, with 2016 levels (46%) not far off 2003 ones (49.4%), and well under the average annual reduction rate of the world at 2.1%[40] (Figure 3). Since independence, the prevalence of stunting in children has remained *very high* as per WHO cut-off values for public health significance[41]. Between 2007 and 2014, low reductions in stunting at the national level are the result of a sharp decrease in chronic malnutrition in urban areas combined with a minor increase in rural areas. Despite stunting falling by more than 20% in urban areas, a 0.7% increase in rural areas has limited the overall reduction to 5% for the same period[42]. This is because the majority of the population is rural, which when considering that all indicators show higher prevalence amid poor households (Figure 4) indicates that malnutrition particularly affects farming households.

***Figure 3** – Prevalence of Malnutrition in Timor-Leste 2003-2016*



Source: DHS 2003, TLSLS 2007, DHS 2009/10, TLFNS 2013, TLSLS 2014, DHS 2016.

***Figure 4** - Malnutrition incidence among poor and non-poor, 2007-2014*

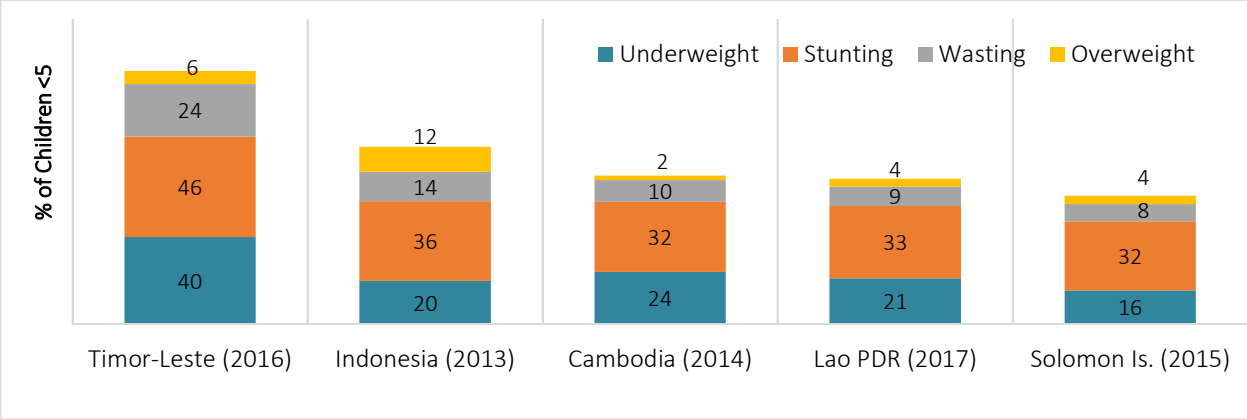


Source: WB, 2017.

Wasting also remains a serious issue particularly among Western municipalities. If 10% or more of children are classified as suffering from global acute malnutrition (GAM), there is generally considered to be a serious emergency, and with over 15% the emergency is considered critical. For Timor-Leste, prevalence has been consistently over 10%, with a worrisome prevalence of over 15% in most

municipalities[3] in 2016[43] compared to Bobonaro, Covalima and Oecusse in 2014[44]. Yet, in 2016, severe wasting concentrated in Western municipalities, which confirms the 2014 trend[45]. The bottom two quintiles experienced the sharpest reductions in wasting incidence over 2007-2014[46], which coupled with minor increases in stunting, supports the notion that nutrition amelioration is recent and probably related to improvements in food availability. The malnutrition burden in Timor-Leste is significantly higher than other Asian countries (Figure 5).

***Figure 5** – Prevalence of Malnutrition in Timor-Leste, Indonesia, Cambodia, Lao PDR, & Solomon Islands*



Source: Timor-Leste DHS; Indonesia and Lao PDR (UNICEF MICS Database); Solomon Islands WB data.

Over a quarter of women and men are underweight, with a low yet increasing prevalence of overweight and obesity. Data from 2016 shows that 27.0% of adult women were found to be underweight (BMI ≤ 18.5) compared to 26.0% of men[47]. The same study showcases that 8.0% of women were overweight (BMI ≥ 25) and 1.5% were obese (BMI ≥ 30), and for men, 5.0% of the population was overweight and 0.8% obese. The rate of overweight or obese women has increased five-fold from 2003-2014[48], while its incidence among women in Dili (15.0%) is well above the national average (10.0%)[49]. However, other studies indicated more than double the prevalence of women underweight compared to men[50]. It is important to design gender-sensitive programmes to improve the consumption of quality diets such as promoting protein, fruits and vegetables among adults, while incentivizing the required increases in their production.

Three main underlying drivers of malnutrition across Timor-Leste are inadequate dietary diversity, low rates of access to improved sanitation, and low rates of female secondary school attendance[51]. Only 13% of children 6 to 23 months[52] old meet the minimum acceptable diet (MAD)[53] – in both meal frequency and dietary diversity, while adults eat carbohydrate-based diets with very low animal source food consumption[54]. Low dietary diversity can be supported through a food-based approach combined with nutrition-sensitive agriculture priorities, such as increasing production of nutritious food, improving food processing and storage to retain nutritional value, and targeting populations that are vulnerable to malnutrition[55]. Women are not only more malnourished than men, but also less educated. In 2015, 48.8% of women living in rural areas were literate, compared to 58.8% of rural men[56]. Such low literacy levels influence the capacity of farming households to transition from subsistence to commercial agriculture and inhibit future prospects and capabilities of increasing incomes and improving livelihoods overall.

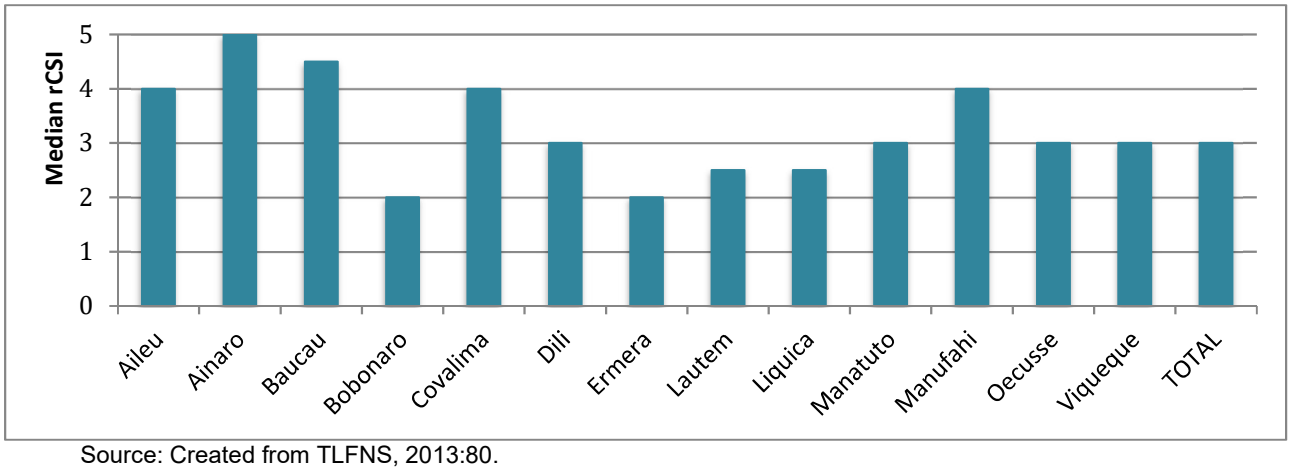
[3] However, as mentioned, DHS 2016 wasting data should be interpreted with caution, combiend with the fact that in 2016 there was an El Niño event which may have impacted on the prevalence of wasting.

Prevalence of food inadequacy and insecurity

The Food Consumption Score (FCS) survey in 2013 found that 38.7% of households did not have acceptable food consumption, a measure of household food security[57]. Nationwide, 61.3% of households met an "acceptable" FCS, a composite score based on food frequency, dietary diversity and relative nutrition importance of different food group. Yet, 10.9% of households had a "poor" FCS and 27.8% fell into "borderline" group, a vulnerable group to fall into the "poor" category when a shock hits even if the shock is mild. The highest "acceptable" prevalence was in Dili (76.8%), indicating better FCS in urban areas. Household members rarely consumed pulses, fruit, and milk across the FCS spectrum. Access to diverse and nutritious diets is affected by insufficient crop diversity, limited water for horticulture, low incomes, and low market prices resulting from low demand[58]. Moreover, the level of household income and the ability to satisfy its members' food needs are correlated, a more obvious phenomenon when income levels are assessed per individual person[59].

The overall Reduced Coping Strategy Index (rCSI) for Timor-Leste was relatively good, another a proxy indicator of household food insecurity, measuring households' resilience toward shocks[60]. The survey showed that the rCSI had a median of 3 and far from the maximum score value. Ainaro was the least resilience municipality (rCSI mean of 5), while Bobonaro and Ermera were the most resilient (rCSI mean of 2) (Figure 6). These findings are aligned with 11% of households ranking "poor" in the FCS. The kinds of coping strategies adopted by households indicate the severity of a shock or seasonal shortage in combination with the vulnerability of communities to food insecurity. Households facing difficulties in obtaining or buying food in the past week, reported borrowing food/relying from others (64.5%), eating less food (60.3%) or reducing the number of meals a day (60.0%) as coping strategies. Dili's high scores could be due to the cash-dependency of urban households to obtain foodstuff.

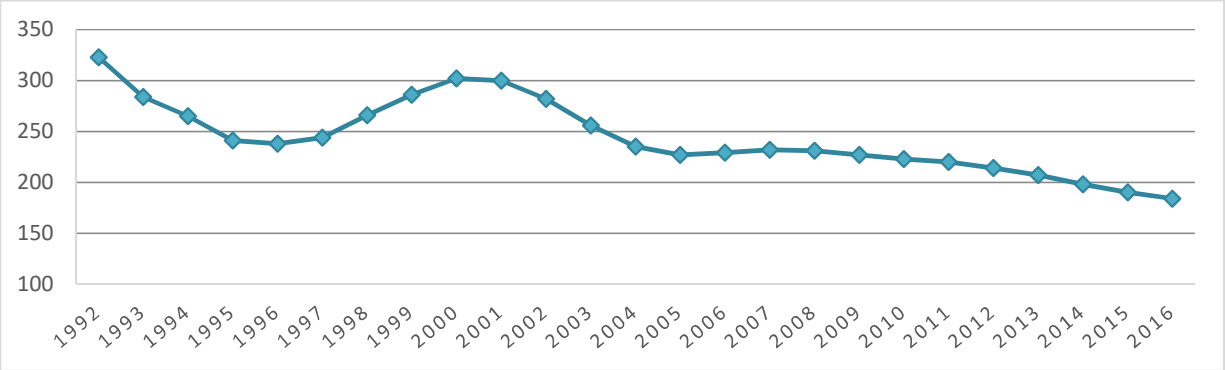
Figure 6 *– Reduced Coping Strategy Index (rCSI) by Municipality, 2013*



Source: Created from TLFNS, 2013:80.

The depth of the food deficit is on the decline, measuring 184 kilocalories per capita per day for the 2014-2016 period[61]**.** While the food deficit has improved overtime (Figure 7), its depth indicates how many calories would be needed to lift the undernourished from their status, everything else being constant. Between 2015 and 2017, the average dietary energy supply adequacy rate, a measure of the adequacy of the national food supply in terms of calories, was 102%[62]. But a large share of this dietary energy is sourced from calorie-dense staple foods that do not provide significant amounts of micronutrients or bioavailable proteins. The average protein supply was 48 grams/capita/day for 2011 to 2013, and the average supply of protein of animal origin was 17 grams/capita/day for the same period. Access to food depends on both physical availability and economic access capability.

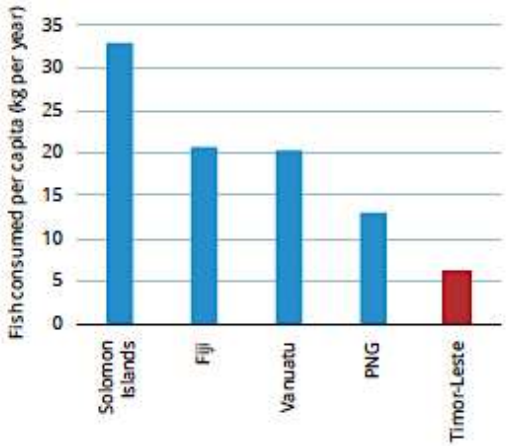
Figure 7 – Depth of the food deficit (Kcal/capita/day) 63 in Timor –Leste, 1990-2016 (3 years average)



Source: World Development Indicators, 2018 (modelled predictions of a three-year moving average).

Fish consumption in Timor-Leste is very low. The national average of fish consumption in 2011 was 6.1 kg per head[64], much below than for neighbouring South Pacific nations (Figure 8). Such average increases to 17.6 kg among coastal communities, showcasing the crucial role of fish for nutritious diets among the rural poor living close to the sea[65]. Factors influencing such low fish availability include cultural norms and a preference for land-based livelihood strategies, where in traditional narratives the sea is depicted as a space of wilderness and of the unknown, with the exception of Atauro Island[66]; as well as physical ones, since the reef area around the mainland is very small.

Figure 8 – Fish consumption in South Pacific nations and Timor-Leste



Source: WB,2018:46, based on FAO 2016 data.

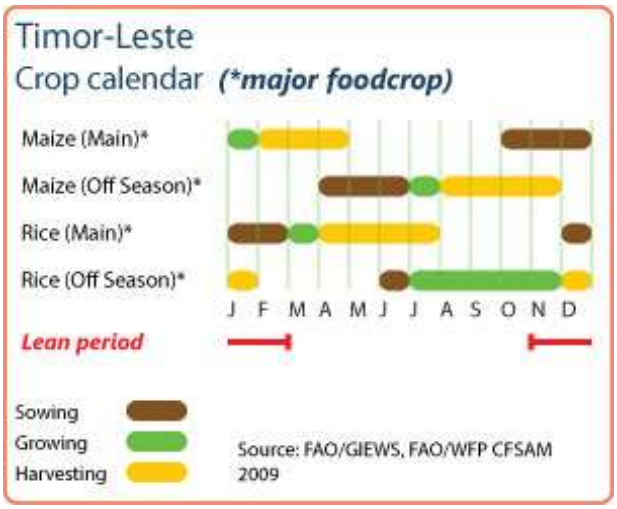
The link between the transportation infrastructure and food access is clear, as the time during which roads are inaccessible due to seasonal rains correlates with rice availability (as measured by difficulties reported by households in obtaining rice)[67]. The level of accessibility varies widely between municipalities, yet an average of 60% of all of the *aldeias* have roads that are rendered inaccessible throughout part of the year[68]. High transportation costs and stock wastage during the wet season are associated with higher food costs, with households paying an average of $2.50 more for sacks of rice in February than in August[69]. This period coincides with the annual hunger season, prior the corn harvest, when incomes are most reduced and households consume fewer meals.

Vulnerability and Rural Poverty

Those vulnerable to hunger issues in Timor-Leste include children, women, and poor households. A regional survey found that approximately one-quarter of responding households gave meal preference to men or heads of household and roughly one-fifth gave preference to children[70]. However, this study found no difference in the amount of protein foods distributed amongst household members. Another study found that when food is limited and household members forced to eat less, children received less food approximately half the time[71]. Poorer households are also more vulnerable to food insecurity, as is discussed in greater detail throughout this section.

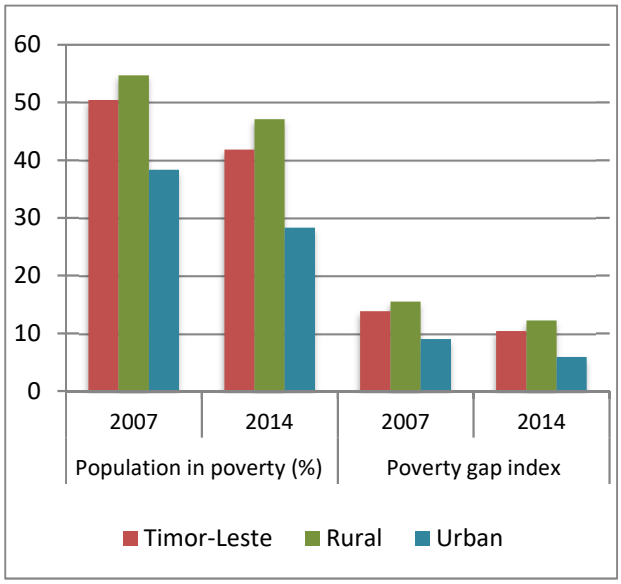
Timor-Leste also experiences annual hunger seasons that vary depending on region and time of year. Rural households typically experience a first phase of hunger when their stocks of maize and rice are almost gone but there are still reserves of root crops. In this phase, households decrease their food consumption, with adults eating once or twice each day and children eating two to three times[72]. Households often experience a more severe hunger period from approximately November until March (Figure 9). During this period, approximately eight months after the maize harvests have ended, access to all staple foods becomes more difficult for farming households as their food stores run low. January and February are the months of greatest food shortages. In one regional survey, half of respondents ate only one meal or less during February, whereas one-fifth of respondents reported eating one meal or less during the harvest season in August[73]. Food availability, access, and seasonal stability are all essential components of food security.

Figure 9 – Timor-Leste cropping calendar for major food crops and lean period or hunger season



Source: FAO, 2016 – GIEWS.

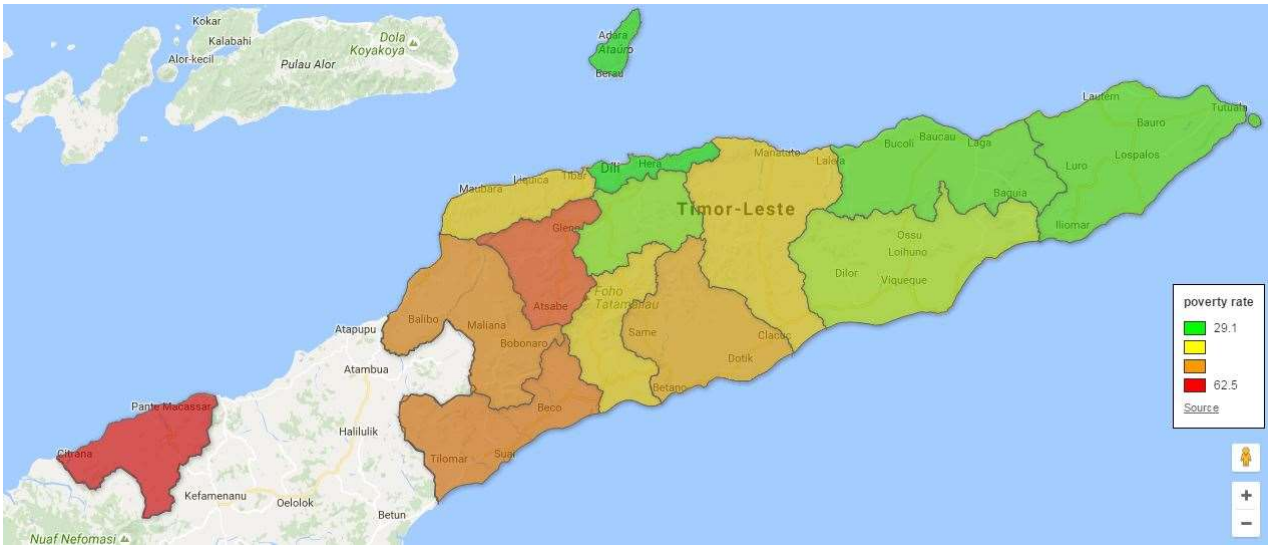
Figure 10 – Poverty prevalence in Timor-Leste and poverty index gap, 2007-2014



Source: TLSLS 2007, 2014.

One of the main reasons for food insecurity in rural areas is due to poverty, with 47.1% of rural population living below the national poverty line in 2014, compared to 54.7% in 2007[74] (Figure 10). With over a 7-percentage points improvement, it represents a significant advancement despite poverty still affecting a substantial proportion of the Timorese population. While poverty fell in both urban and rural areas, the decline was larger in urban parts. The poverty gap also had a significant reduction in the poverty gap index, suggesting that welfare was not just limited to those near the poverty line. The larger decline in the poverty gap index relative to the headcount index denotes that the average shortfall in consumption levels experienced by the poor in 2014 was smaller than that in 2007. Rural population remains high in Timor-Leste at 70.5%, a proportion that has not changed since 2010[75]. As shown, undernourishment and malnutrition are higher in rural areas and in Western municipalities, which intersect with poorer ones (Figure 11).

Figure 11 *– Poverty map of Timor-Leste*



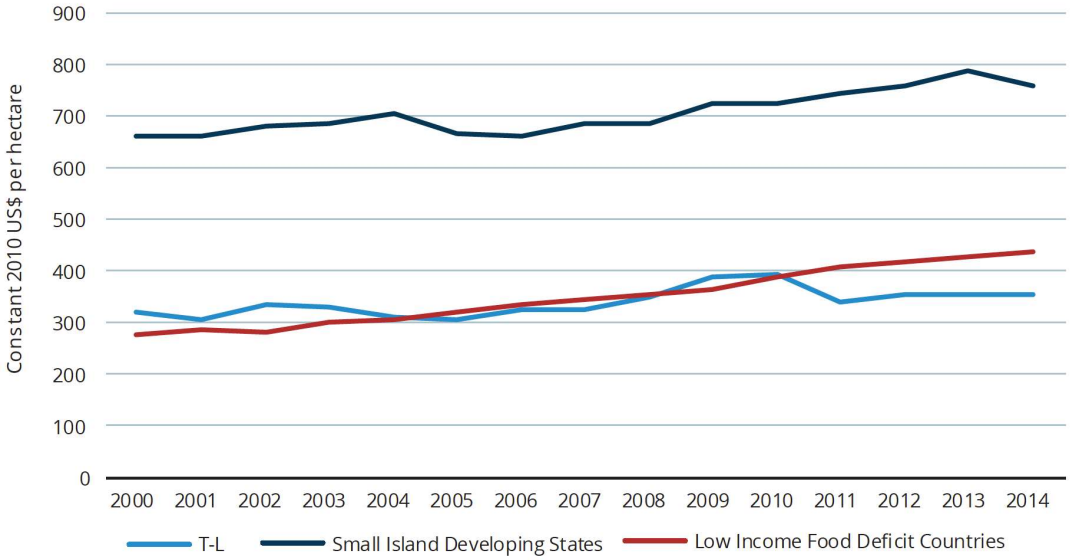
Source: TLSLS 2014.

Rural households dedicated 57% of their expenditure to food in 2014 (down from 70% in 2007), a very similar proportion and reduction trend as the share for the poorest two quintiles, 58%[76]. Nationally, the food expenditure share decreased from 65% in 2007 to 53% in 2014, above the low-income countries average of 44.5%[77]. Timorese households spent more on food per person in 2014 than in 2007, yet expenditure decreased for poor households with their mean per capita expenditure on food decreasing by 5%[78]. While a reduction in poverty reflects an increase in real purchasing power for lower-income households, there has been growth in real purchasing power overall both in rural and urban areas. The real consumption in US$ per person per month (2014 constant average national prices) shows that rural population spent US$55.5 compared to US$50.3 in 2007[79].

Importance of Agriculture and its Status

Timor-Leste's agricultural sector consistently produces less food than is needed to feed the population[80]. The agriculture productions systems in Timor-Leste remain as some of the least developed in the world– subsistence systems dominate all sub-sectors irrespective of product and most farming households are understandably risk averse[81]. Annual and perennial crop yields are far lower than those of neighbouring countries with similar agro-economies, as are animal production off-takes[82]. In Timor-Leste, the value of production per hectare is substantially lower than other small island developing states and in recent years it has fallen below the average for other low-income food deficit countries[83] (Figure 12). The fisheries sector remains almost totally undeveloped and land degradation is exacerbated by non-sustainable production systems and climate change (rainfall variation)[84]. The country imports at least one third of its food requirements.

***Figure 12** – Value of Agricultural Production per Hectare, 2000-2014*



Source: WB, 2018:44, based on FAOSTAT data.

Although the country is an agrarian society with 70% of the population living in rural areas, only 30% of arable land is used for crops and grazing[85]. In addition, 70% of the population relies on rain-fed subsistence agriculture[86]. Estimates vary, but Census data show that 38% of working age population (15-64) was involved in own-account agriculture in 2014, up from 35% in 2010[87]. This classification suggests the proportion of population that is primarily 'subsistence foodstuff producers'. However, Timor-Leste´s geography only enables 155,000 ha for arable land or 10.4% of its total land area[88], while permanent meadows and pastures account for 10.1% of total land[89].

Timor-Leste's landscapes and topography are highly diverse and recent efforts have classified the different agro-ecosystems in the country and their associated livelihoods. The seven livelihood zones cluster villages by the distinctive livelihood of its inhabitants including agricultural characteristics and topography across the country (Table 1)[90], enabling to map farming livelihoods systems as a result (Figure 13)[91]. These zones show the diversity of agro-ecosystems in Timor-Leste form a production and geographical viewpoint, identifying three irrigated rice-growing zones (33% of the population), two highland coffee-growing zones (41% of the population), and two lowland rain-fed zones (26% of the population). The livelihoods zoning typology, including crops grown and animals raised in its full assessment[92], is an effective tool to inform planning and decision-making for rural development programs.

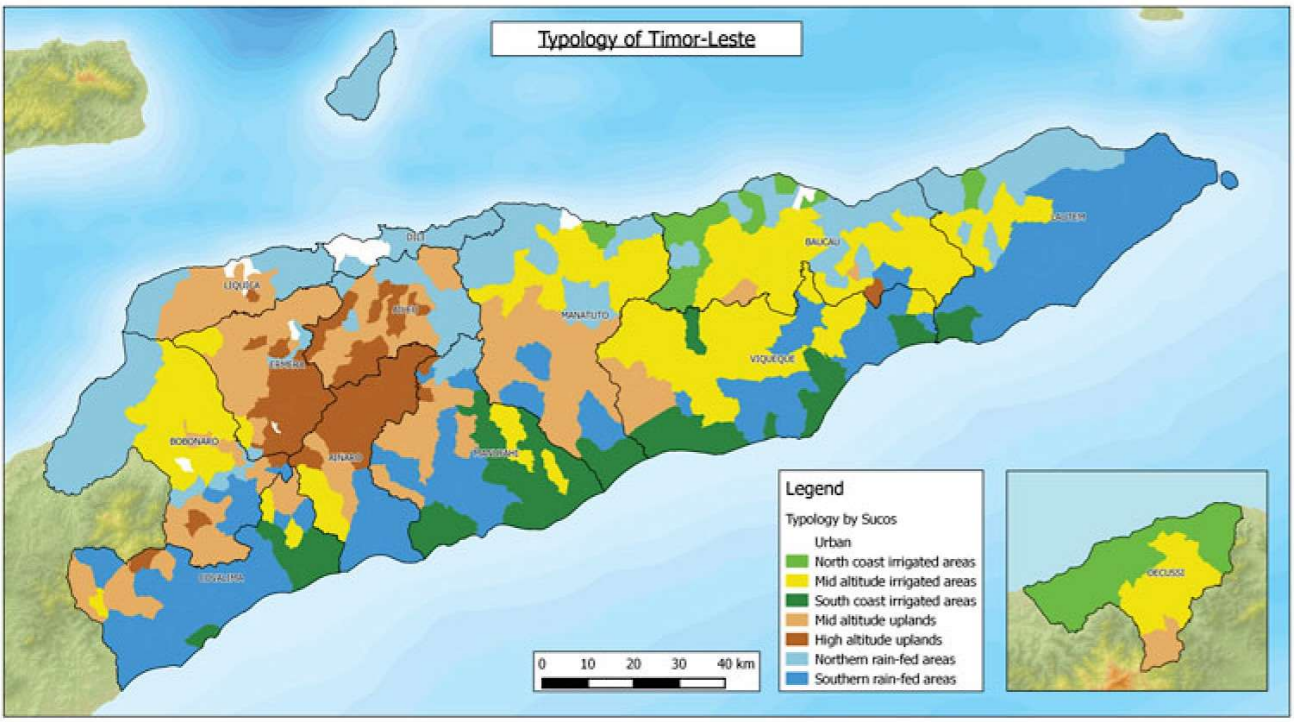
***Table 1** – Livelihood zones, crop characteristics, number of villages (suku) and population*

Livelihood zone	Primary criterion	Secondary criterion	# of villages	Population (#)	Population (%)
1. North coast irrigated areas	>35% HH grow rice	North	20	60,878	7%
2. Mid-altitude irrigated areas	>35% HH grow rice	Mid	94	184,344	20%
3. South coast irrigated areas	>35% HH grow rice	South	23	55,826	6%

4. Mid-elevation uplands	>50% HH grow coffee	Below 1100 m	128	242,751	23%
5. High-elevation uplands	>50% HH grow coffee	Above 1100 m	60	125,926	14%
6. Northern rain-fed areas	<35% grow rice and <50% grow coffee	North	42	113,714	13%
7. Southern rain-fed areas	<35% grow rice and <50% grow coffee	South (bimodal rainfall)	47	122,384	14%
		Total	**414**	**905,823**	**100%**

Source: Williams, 2017. Note: HH stands for Household. Data based on Census 2015.

Figure 13 *– Map of livelihood and agro-ecological zones of Timor-Leste with village boundaries*



Source: Williams et al, 2018. Data based on Census 2010.

I. Farming households' overview

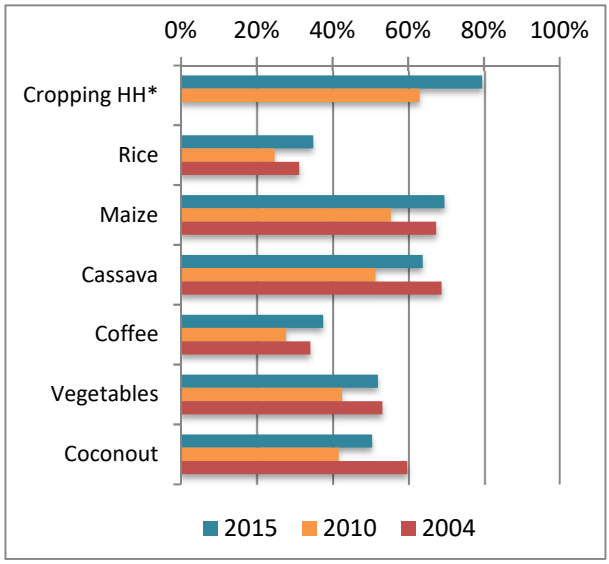
Box 1: Key crops information:

- Households grow maize (70%), cassava (64%), sweet potato (55%), rice (35%), mostly for **consumption** and key for food security
- Households grow vegetables (52%), peanuts and beans (50%), and fruits (49%), with a higher proportion using these for **sale**
- Rice and coffee are grown regionally
- Maize and cassava are grown nation-wide

Source: Census, 2015

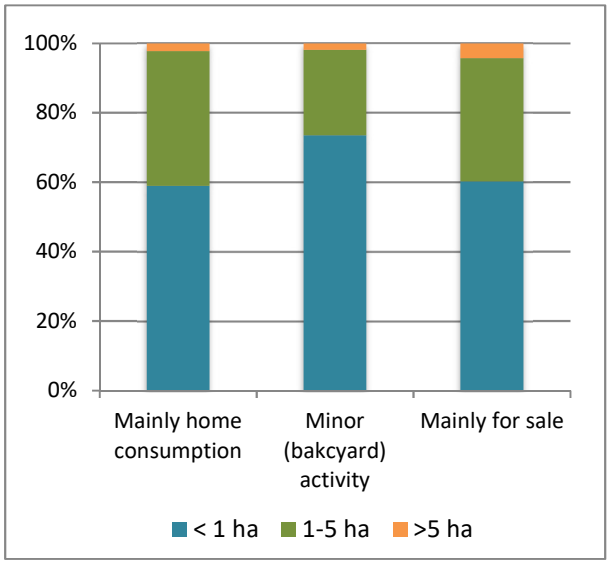
Agrarian households often manage over ten crops and four animal species in very small land holdings[93]. Cropping systems are diverse and extensive, with at least 50% of households growing maize, cassava, sweet potato, vegetables, legumes and coconut trees[94]. The four major crops produced by Mt are maize (36%), rice (25%), cassava (21%) and sweet potatoes (18%)[95], with non-rice crops accounting for at least 75% of staple food production[96]. The proportion of households growing key crops has not changed dramatically between 2004 and 2015, despite the overall decrease in 2010 (Figure 14). Farming plots are small (0.9 hectares average) due to the terrain, as rocky soil or mountains surround patches of arable land[97]. Most farming households cultivate in small plots: 66% in less than a hectare, 32% in 1 to 5 hectares, and 2% in 5 hectares[98]. Regardless of the type of agricultural activity, the majority of farmers cultivate plots under one hectare, including those that grow for sale (Figure 15). From the potentially available land for cultivation farmers are only able to utilize a fraction, due to terrain and land clearing difficulties, combined with land belonging to a family not necessarily being contiguous. Multiple smaller plots enable to mitigate crop failure and ensure food sufficiency.

Figure 14 – Percentage of Households growing selected crops among all households in 2004, 2010 and 2015



*Data unavailable for 2004
Source: Created from Census 2004, 2010 and 2015[99].

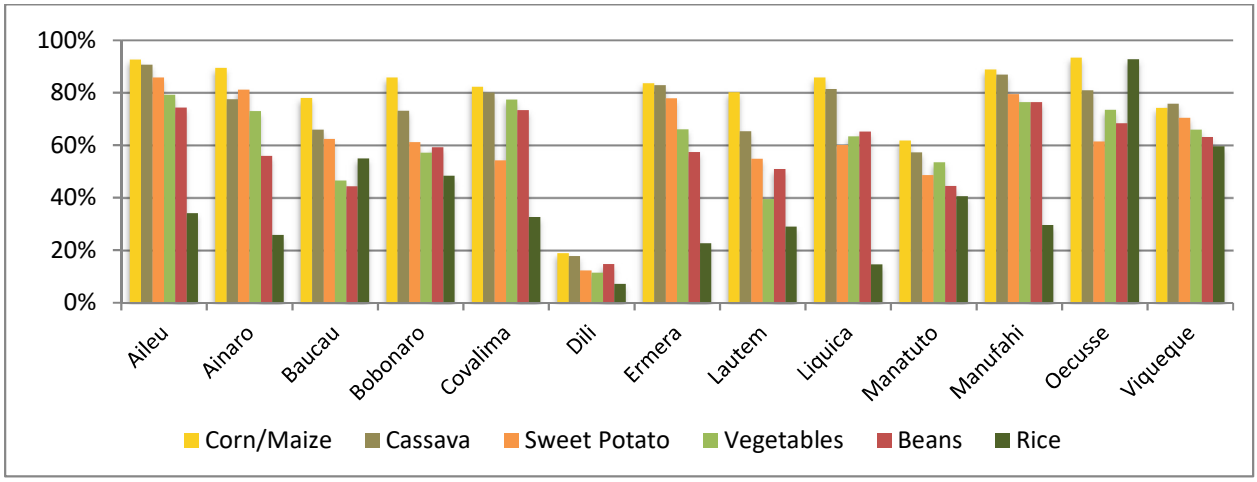
Figure 15 - Proportion of Households by Agricultural Activity and Size of Area Cultivated in 2015



Source: Created from Census 2015 Agriculture Analysis.

While type and number of crops grown vary by municipality, only 35% of farming households grow rice mostly for consumption[100]. Figure 16 shows the percentages of farmers in each municipality who grow five different main staple crops. The production of staple crops fluctuates widely by year and region. Farming households grow a variety of other crops to mitigate the risks of crop failure. These staples provide 87% of the daily caloric intake needed, but only 53% of daily protein requirements and 22% of daily fat requirements[101]. However, these calculations assume that all of crops outputs are consumed, whereas others estimate that up to one-third of all production is lost in the post-harvest storage[102, 103]. In addition to staple crops, households supplement with pumpkins, beans, taro, and a wide range of other traditionally grown species[104]. Most households also own various types of livestock in small numbers and multiple tree crops, characterizing farming systems in Timor-Leste as diversified and extensive[105].

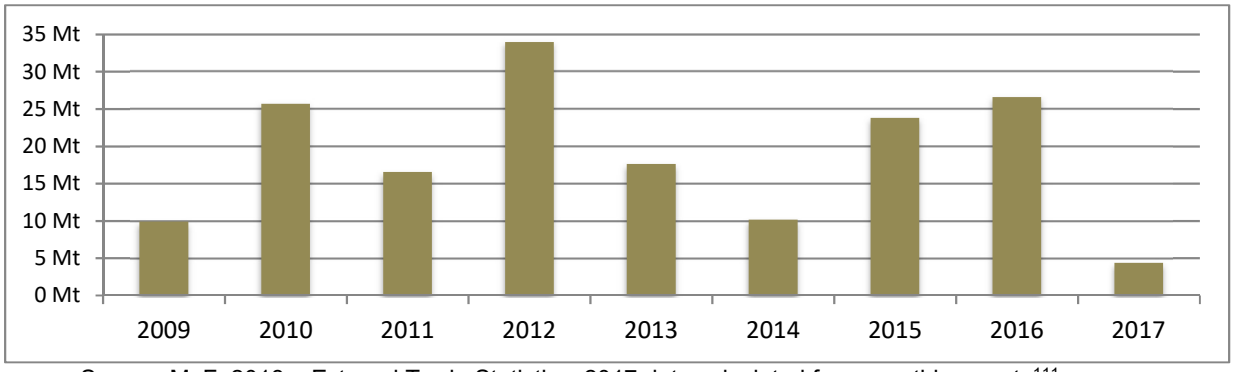
Figure 16 – Main Food Crops Grown in Timor-Leste



Source: Created from Census 2015.

While agriculture in Timor-Leste is primarily subsistence rather than market-oriented, coffee is the major rural export commodity, comprising 97% of all non-oil exports[106] (Figure 17). Though they are some of the poorest farmers, coffee producers earn some extra income from this cash crop[107], grown by 37.6% of all households or almost 77,000 families[108]. The four main coffee growing municipalities (Ermera, Aileu, Ainaro and Manufahi) are all very poor, characterized by disperse large numbers of smallholder upland subsistence farmers cultivating in less than one hectare. For example, Ermera grows around half of all coffee produced, where 56.7% of households lived below the national poverty line in 2014[109]. Supporting coffee growers to increase income through enhanced productivity is a clear strategy to reduce the incidence and severity of poverty, yet many households experience seasonal hunger due to the bulk of their income earned during harvest season in August[110].

Figure 17 – Coffee exports in Metrics tones for 2009-2017



Source: MoF, 2018 – External Trade Statistics; 2017 data calculated from monthly reports[111].

In Timor-Leste, farming suffers from important knowledge gaps paired with a low self-perception or image problem among farmers, with almost 40% displaying entrepreneurial attitudes and values[112]. A recent study assessing farmer's attitudes towards farming as a business concluded "that farmers are reasonably commercially orientated and that the most important 'mindset' challenge to development is not their low 'entrepreneurial drive' but lack of a long-term perspective partly driven by perceptions of farming as a vocation" (TOMAK and IADE, 2017:6). This unique research describes how farmers might have little understanding on the need to take risks for agriculture production to grow and making longer-term trade-offs. Most farmers have limited knowledge of costs and profitability paired with low numeracy skills, and often operate their farms on a cash flow basis[113].

II. Agricultural production by sub-sector

Timor-Leste produced an estimated 130,000 Mt of paddy rice and maize in 2017[114], close to 2016's reduced level and showcasing a 20% decline in output from the previous five-year average[115]. This amount was insufficient to supply the country with the two main staple foods, which in 2011 was estimated by the World Bank at about 245,000 Mt[116], while in 2018 at 237,000 Mt and according to the MAF[117]. The area of rice and maize harvested shows a downward trend since 2008, shrinking almost on an annual basis. In 2008, there were 46,000 ha of paddy rice harvested compared to 27,000 ha in 2016, while for maize, the area went from 79,000 ha to 53,000 over the same period[118]. These are very significant reductions of key staples for a country where most people depend on their agriculture production for consumption. A study estimates that Timor-Leste requires cultivating 76,000 ha of irrigated rice to achieve rice self-sufficiency if adopting a rice bowl approach, which maximizes rice production on existing functional irrigated areas[119]. Current rice harvested area is under a quarter of this figure. The downward staple production trend for almost a decade reinforces Timor-Leste's position as a net food importer country. In 2017/2018, cereal imports are forecasted at 190,000 Mt[120], mainly rice.

Box 2 - Agricultural data quality is limited

Low capacity and lack of adequate resources in MAF result in low quality crop monitoring and production estimates. Official estimates tend to be higher than surveyed data from development partner's programs. Maize and rice are key food security commodities, making and accurate and reliable data on their production and requirements essencial.

Available data on cereal imports and staples production are often contradictory and present a considerable limitation for effective policy and programme planning. For example, a FAO bulletin report cereal imports for 2015/2016 to be 139,000 Mt[121], composed of mostly millet rice, whereas the MAF bulletin totals 79,000 Mt of rice imports[122]. Weather events have an impact on the productivity of crops and these can be observed in the data, such as in 2011 when the area planted of maize dropped to 22,000 ha reflecting the La Niña rainfall event in 2010[123]. However, the expected impact of the 2015/2016 El Niño draught is not reflected in 2016 when the area harvested was almost 53,000 Mt[124], much higher than the 2014 levels of 37,000 Mt. In terms of the proportion of food required from imports to satisfy consumer needs, there are sources estimating to be 30-40%[125], much lower than if calculated using the 2018/2019 above data.

Rice is turning into an "opportunity crop", sufficient to provide for immediate family requirements but with no surplus for sale. Despite increases in irrigation infrastructure, provision of free inputs and extension efforts, rice farmers are not responding to such incentives and many continue to produce to supply their families' consumption needs only –exemplified through a lower adoption rate of the Nakroma improved variety in 2016[126]. Young (2016) argues that farmers who adopted improved seeds might revert to traditional paddy production systems, as these require less family labour and produce enough rice for households' utilization. This trend can be partly explained by the struggles of the irrigated rice sector lead by limited reliable water –due to land degradation in watersheds and El Niño drought in 2015/16, and by lack of markets to retail surplus paddy[127]. Other factors affecting farmer's decisions are the impact of subsidized rice on domestic market prices and of social assistance transfer payments, like pensions[128].

Roots and tubers are very important staples that ensure energy intake during the lean season particularly for food insecure farming households, with an average output of 65,000 Mt grown in almost 20,000 ha for 2014-2016[129]. For cassava and sweet potatoes, production was over 28,000 Mt and 5,000 Mt, while area harvested was above 7,000 ha and 2,000 ha respectively and over the same period.

The diverse microclimates of Timor-Leste and multiple agro-ecological zones enable growing a wide range of fruits and vegetables species. According to FAOSTAT (2014-2016 mean), the aggregated vegetable production is 29,500 Mt grown in 11,500 ha, and for fruit, annual output is close to 17,000 Mt cultivated in over 2,000 ha[130]. Fresh produce production is increasing in response to a growing demand in the main towns as urban standards of living improve and eating habits demand improved quality. Various programs are supporting the development of selected vegetables and fruits value chains including TOMAK and Avansa. Under the later, top producing vegetables in 2017 were bok choy, lettuce, tomato and broccoli, while strawberries was the highest earning crop[131]. In 2013, top crops sold in Dili markets in terms of amount

were cabbage, pumpkin, tomatoes, carrot, red beans and green papaya, in terms of amount[132]. Vegetables grow throughout the year subject to water availability, and excessive rains can be detrimental to their production, leading to lower market supply during the rainy season.

The majority of households also grow other nutritious crops like legumes, highly suitable in the southern agro-climatic conditions[133]. Production of dry beans, peanuts and soybeans, which provide high levels of plant-based protein, accounted for over 8,000 Mt, 4,000 Mt and 1,000 Mt respectively, harvested across an area of around 7,000 ha, 3,000 ha and 800 ha each[134]. Others include mung bean, the indigenous velvet beans that are used in rotation with maize as promoted by MAF and partners, and pigeon pea that is inter-planted in maturing maize crops as an important late season crop[135]. A recent regional study found mung beans to yield 1 Mt/ ha[136]. In contrast to most crops, yields of these leguminous crops are similar to the SEA average (Table 10 in Appendix).

Coffee is the most significant agriculture commodity. Production averaged over 10,500 Mt (2012-2016), yet lower than volumes recorded in 2010[137]. Over half of the 53,000 ha that grow coffee consists of overgrown plantations and aging trees[138], and adequate management is lacking. As a result, yields are very low. A 2013 regional household survey quantified an average productivity of 204 kg/ha, but for 60% of households' yields were less than 100 kg/ha[139], indicating how this cash crop is grown by very poor households. However, other sources report yields of 800 Mt/ha in 2013[140]. The 2017 coffee harvest was very low due to the detrimental impact of early and then heavy rains, associated to La Niña weather pattern[141]. This crop is particularly sensitive to land tenure issues as plantations were started during the colonial periods and have received internal labour migrations in the past.

Other forest products include high-value trees. Teak and sandalwood plantations, rooted in 10,000 ha and established by the former Indonesian government, are not adequately managed with many trees reaching maturity in the next 5 years[142]. Areas of cleared land constitute about 30% the country, and are suitable for tree crops[143], while 37.3% of households have some timber trees planted[144]. However, natural forests have been severely depleted to 46% of land area by overharvesting, land conversion and grazing[145].

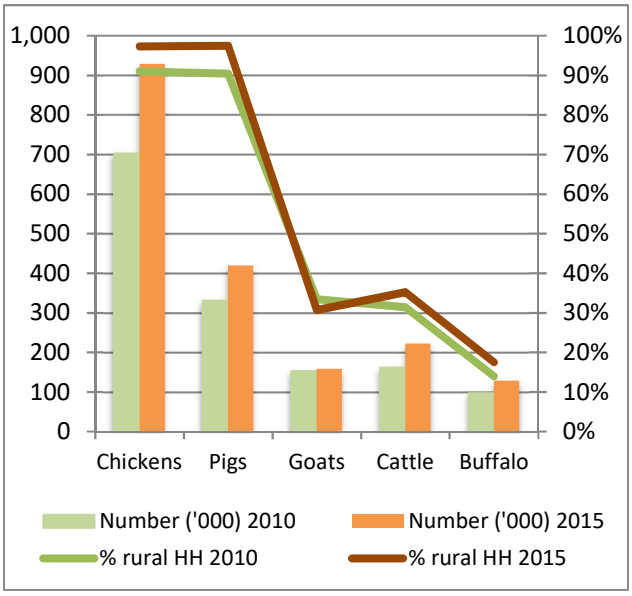
Livestock population is growing while production is stagnant except for pork, from an already low base (Figure 18 and 19; Table 9 in Appendix). Production is based on scavenging and uncontrolled grazing in public lands, with very low supplementary feeding except for pigs and poultry, sometimes fed by-products and low-quality grains. Census data shows increases in the number of ruminants (cattle, buffalo, and goats). Yet a study suggests that the national cattle herd might be reducing 5% annually[146], and MAF estimated 70,000 head of livestock dying due to El Niño drought 2015/2016, including 21,000 pigs and chickens, and over 14,000 cattle and buffaloes[147]. Ruminants free-graze in highly degraded land with very low annual pasture production[148], use un-cropped paddy land that grows weeds during the dry season and consume crop residues. For cattle, this system produces low growth rates yet reasonable returns to labour for a 12 animal herd[149], with the predominant Bali cattle species very well suited to smallholder production systems, including existing transport, marketing and processing infrastructure[150].

Box 3 - Key livestock information:

- Significant livestock numbers increase (27-37%) for chickens, pigs, cattle and buffalo since 2010
- Mainly smallholder systems with animal herd size slightly increasing for chickens and cattle
- Growth in the % of households raising livestock
- Underutilized grazing lands of 200,000 ha, with largest available areas in Lautem, Covalima, Manufahi, and Viqueque

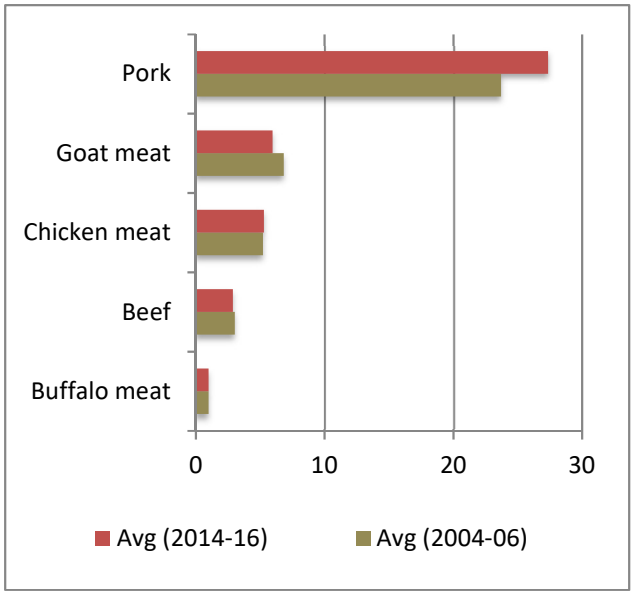
Sources: Census, 2015, ACIAR, 2017.

Figure 18 *– Number of selected livestock (thousands) and % of rural households that raise them, in 2010 and 2015*



Source: Created from Census 2010 and 2015.

Figure 19 *- Production (Kg/head) of selected livestock in Timor-Leste, 2004-2006 and 2014-2016 averages*



Source: Created from FAOSTAT 2018.

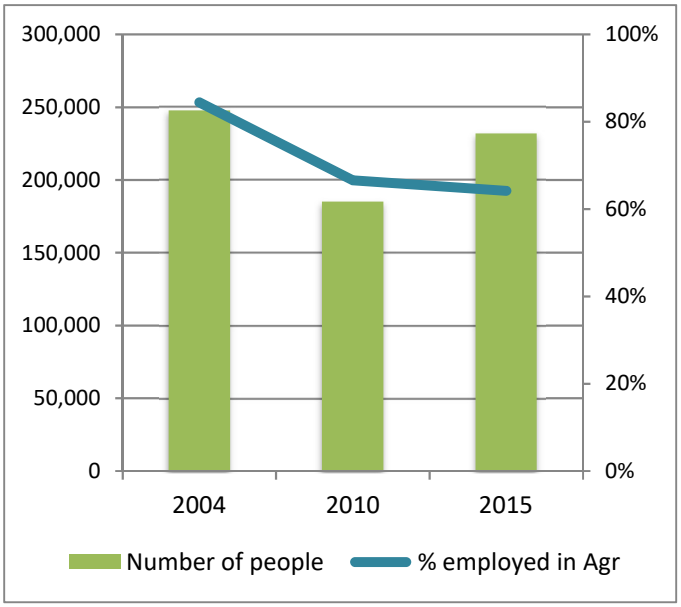
Livestock are financial and cultural assets, and support protein intake Farmers tend to consider livestock as a form of savings to mitigate financial shocks, selling these when funds are needed[151]. Livestock play an important role in maintaining social networks, distributing resources and are used extensively in rituals and ceremonies. For example, cattle are owned as an index of wealth and social status, without a necessary intention to extract any net income[152], indicating a focus on owning maximum numbers over livestock productivity. Traditions combined with customary law limit the transition to commercial systems. Observing a large number of long ceremonies and having greater number of smaller livestock species are factors that positively influence animal-source foods consumption in rural villages[153].

Small livestock support the production of animal-sourced foods, income generation and the resilience to shocks of poor households, with gender equity gains. Over 90% of rural households own chickens, with an average flock of 4.5 birds and a 32% increase in their number since 2010[154]. Chickens are managed in a low-input low-output free-range system, with farmers' knowledge of improved husbandry practices very low, and 70% of all chickens hatched lost due to predation and lack of weather protection[155]. Newcastle's Disease (ND) causes the loss of around 15% of chickens, and while considerable progress has been made by MAF to improve ND vaccination delivery, national coverage rates remain low[156]. Most poor households own pigs and chickens[157], with the later a particularly valuable source of cash income as well as food –poultry meat and eggs, despite limited knowledge regarding their nutritional value. Selling animals was the second most reported copping strategy during the El Niño 2015/2016 drought[158]. Rural households report higher decision-making of women over chickens than for larger livestock[159]. Thus, investing in healthy livestock to prevent their mortality is a crucial strategy to support farming families' livelihoods and resilience, as well as diets and women's control over assets.

Agriculture employment

Of the employed population ages 15 and over, 64.2% are employed as skilled agricultural and fishery workers in 2015, employing 76.9% of men and 77.3% of women rural areas[160]. The agriculture industry also includes forestry, hunting and fishing. The overall importance of agriculture as leading industry of employment is decreasing as shown in Figure 20. Despite agriculture continuing to be the dominant sector for the Timor-Leste workforce, the proportion of those employed in this sector has decreased from 84% in 2004 to 60% in 2015; while in absolute terms the number of people engaged in this industry increased in 2015 but not to the same levels of 2004. According to the Census, the number of households that classified themselves as farmers declined by 25% between 2004 and 2010. It is unclear how such reduction in farming households occurred and where those families went since data can´t be triangulated with internal migrations[161]. Young (2014) indicates that this could be partly explained by opportunities for off-farm work combined with a possible census error (which meant that households recorded themselves as non-rural if they were supplementing incomes with non-agriculture employment)[162].

Figure 20 *– Employed population engaged in the Agriculture, Forestry and Fishing industry, 2004-2010-2015*



Note: Population aged 15-64.
Source: Census 2010, 2015.

Employment in the agriculture industry is characterized as concentrating vulnerability, and child and elderly employment[163]. Thus, 91% of those with vulnerable employment[164] work in the agriculture sector, where both rural male and female equally vulnerable. Most workers identify as 'self-employed' or work with and for their families, probably without a salary and no job security or a guaranteed stable monthly income. Among children aged 10 to 17 that work, 89% do so in agriculture –with a higher share for boys, 58%; while 93% of the working population over 65 years did in this sector. Agriculture is a sector that concentrates low education and older heads of households, with 45.6% of those engaged in agriculture not having attended school and the same proportion over 50 years old[165].

The agriculture industry is timidly reducing its prevalence as lead occupation in rural regions for both male and female to 58 and 53% respectively in 2015, compared to 60 and 62% in 2010, suggesting positive improvements in rural employment diversification. When data are considered for sector of employment, 64% of all those employed, report being self-employed farmers, 57% male and 43% female[166], showing a higher proportion of the population engaged in agricultural work.

In 2015, 43.9% of the population 15 to 64 years was classified as economically inactive, probably underestimating the real number of actual people engaged in agriculture-related activities[167]. This is particularly important for rural women, 49% of which are classified as such compared to 30% of men living in rural areas. Much of women's work in the agriculture sector is unpaid as it is considered to be a part of their household obligations.

The Fisheries sub-sector

A small proportion of the population engages in fishing activities in Timor-Leste, despite being an island nation. The coastal fisheries sector is characterised by its small-scale nature and limited technology use, with most fishing in wooden paddle-boats around near-by reefs and gleaning from the foreshore. Only 5% of households declared finishing in the last Census[168], a much lower proportions when compared to other small-island countries of similar income level[169]. Among all households only 2% own a boat, and a fifth of these use a motorboat[170]. Commonly caught spices include sardine, garfish and mackerel, as well as reef fish such as parrotfish and soldierfish[171]. Dili and Bobonaro are the only municipalities with over 1,000 coastal finishing households[172]. Due to a lack of information of fish stocks in Timorese waters, prospects of commercial fishing are unclear[173].

Fresh-water fishing is characterised by its subsistence nature, with inland captures mostly occurring during the rainy season, and by a growing aquaculture sector. Backyard fish farming has been promoted by the MAF and Development Partners in recent years with the aim to supplement food production in rural areas to provide much needed additional animal protein. These small-scale aquaculture systems tend to grow milkfish, tilapia and carp[174].

Despite narrow reefs not enabling substantial fishing, simple technologies could sustainably increase nearshore pelagic catches and impact on income and employment opportunities for women and men working in the sub-sector[175]. Close-to-shore fish aggregating devices (FADs) are being deployed through MAF and World Fish as an effective strategy to significantly increase catch rates and decrease in species diversity, thus providing both livelihoods and conservation benefits[176]. The combination of increases in fish catch volumes and improvements in their storage, transport and/or preservation could support the increase of income for men and women employed in this sector, the former as fishermen and the later in the post-catch value chain[177].

Investing in fish storage and preservation improvements is key to support its marketing, as fish is more prone to post-catch losses than agricultural produce. In Timor-Leste, data for fish spoilt is unavailable, yet with 90% of fishing families not having access to ice and high tropical temperature year-round, fish waste is probably very high[178]. Traditionally, fish is consumed fresh, and despite fishers often preserving fish using salt, three quarters of the catch is sold fresh[179].

The major contribution of the fisheries sector is towards food and nutrition security as well as livelihoods diversification among the rural poor that live near the coast. Fishing operations are small-scale and tend to be a supplementary income stream for inhabitants of coastal communities who also engage in other livelihood activities. A recent study in Atauro Island shows that those engaged in fishing as the primary source of livelihood showcase higher levels of well-being, measured through asset ownership, income and food security[180]. Fish-based livelihoods are also less vulnerable to severe climatic events and pests that impact on crop farmers, and to animal diseases[181].

Key constraints

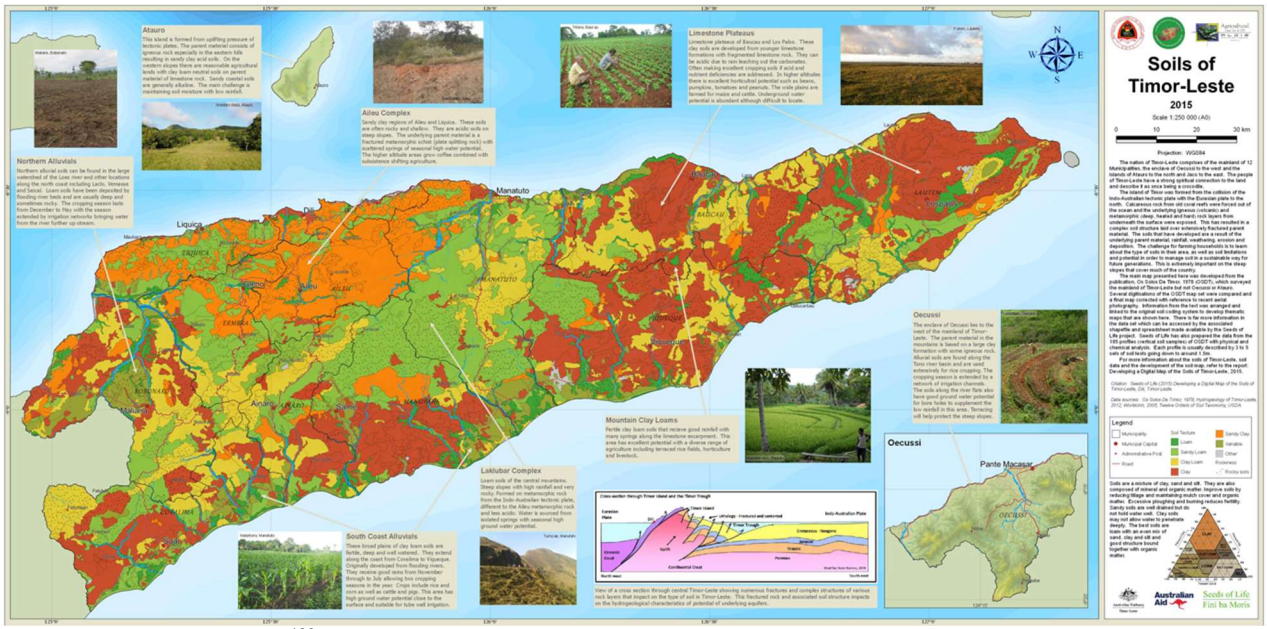
I. History of conflict and harsh geography

A history full of struggles is a leading reason to why Timor-Leste suffers from significant food insecurity, malnutrition and undeveloped agricultural systems. Timor-Leste, one of the world's youngest democracies, has suffered from conflict, violence, takeovers, and colonialists, but is still a country rich with culture and pride. The Portuguese colonized for some 400 years, followed by 24 years of Indonesian occupation. The last famine occurred in 1977-78 due to war and not to reduced rainfall as initially suggested[182]. After much bloodshed, horror, and wanton destruction, Timor-Leste became a democratic republic in 2002 after 79% of its population voted for independence in the 1999 referendum, when up to 80% of the population suffered from malnutrition[183]. Any country coming out of long-term conflict takes time to get on a path towards sustainable development.

Historians suggest that Timor-Leste has not been self-sufficient in staple production for the last three decades, when yields of key staples like corn and sweet potato were well below the Indonesian average of that time[184]. The 1999 clashes also resulted in extensive destruction of public infrastructures including roads and irrigation systems, and the combination of conflict and high numbers of internally displaced people disrupted agricultural cycles and destroyed its production base.

With a rugged mountainous landscape and poor soils, 25.6% of the overall terrain is deemed as agricultural land[185]. Timor-Leste´s geography enables 155,000 ha for arable land or 10.4% of its total land area, while permanent meadows and pastures account for 10.1% of available land[186]. Limited areas suitable for arable agriculture, particularly for irrigated rice production, constrain the potential production. Much of the terrain is steep (44% of the land has a slope of 40% or greater), with the majority only having a thin cover of productive soil[187]. The soils, especially on the slopes, tend to be shallow and impoverished and are becoming even less fertile over time through increased nutrient depletion from leaching and erosion after torrential rainfall, free grazing and over-cropping, deforestation, slash and burn agriculture and firewood collection[188]. A challenge for farming households is to know what types of soil prevail in their area, its productive limitations and potential in order to manage and nourish the soil in a sustainable manner. Figure 21 showcases soil types in Timor-Leste.

Figure 21 *– Map of soils of Timor-Leste*



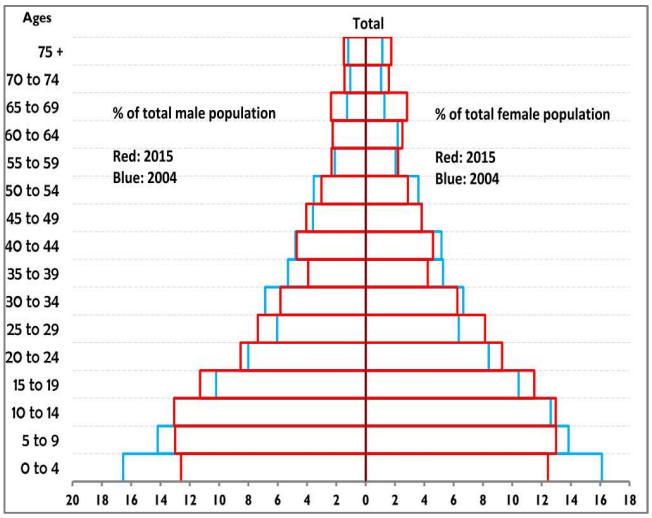
Source: SoL, 2015[189].

II. Demographic trends: population growth, employment and internal migration patterns

Timor-Leste is also undergoing a transition in its demography. While population growth is still high at 2.28% between 2010-2015, the number of children born has decreased between 2004 and 2015 while the young working age population is now larger (Figure 22). This means Timor-Leste is becoming a more developed country, with 2015 recording a maximum sex ratio of 106[190] in Dili as more males move to the capital seeking higher education and in search of employment. In the coming decades, the age structure of Timor-Leste will change substantially, mostly due to a fast decline in fertility rates, resulting in the expansion of the working-age population aged 25–59. This cohort will gradually increase from 32.0% in 2015 to 45.7% in 2050, when more people have the potential to be productive and contribute to growth of the economy, leading to a demographic dividend[191].

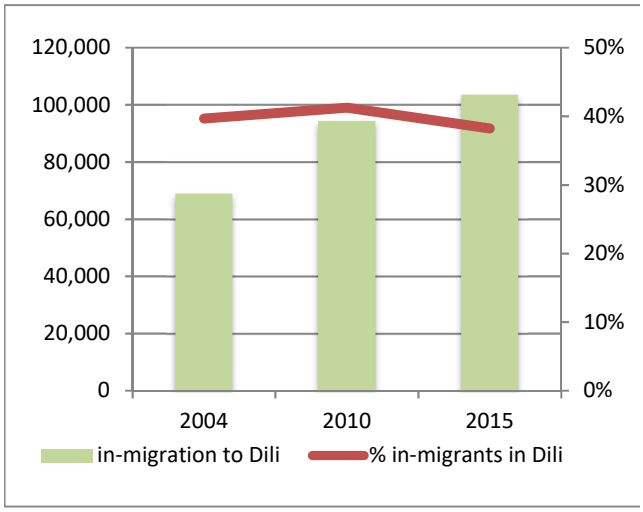
Rural-urban migration patterns and increases in employment in other sectors result in rapid urbanization due to heavy influx of population from all districts to Dili[192] (Figure 23). In 2010, most internal migrants were engaged in non-agricultural activities and were mostly young, educated up to secondary level and employed[193]. Yet, rural labour in some areas is becoming scarce and expensive due to youth reported moving to urban centres[194]. A 2012 survey found that more than 40% of rural households have at least one migrant, mostly aged 15-34[195], suggesting that farmers are an ageing group. With large family sizes and low rural incomes, this trend is likely to continue, compounded with high poverty rates among farming households that might help explaining this pattern. In 2007, households whose head was engaged in farm work had the second highest poverty prevalence (56%) only after those who were employed in household work (58%)[196].

***Figure 22** – Timor-Leste demographic pyramid, 2004-2015*



Note: Blue (Census 2004); Red (Census 2015).
Source: MoF, 2016. Launch of Census 2015.

***Figure 23** – In-migration to Dili in absolute numbers and as % of total Dili population, 2004-2010-2015*



Source: Created from DNS and UNFPA 2012, and Census 2015.

Employment opportunities in Timor-Leste are limited, and creating more employment for the population, especially youth, is perhaps its biggest challenge. The youth (aged 15-24 years) comprise almost two-thirds of the unemployed, and while constituting about one-third of the working age population, the youth make up only 14% of the labor force[197]. Unemployment youth rate is highest in Dili, 27%, and the proportion of youth not in employment, not in education or not in training (NEET) is higher for women, 27.4%, than young men, 17.1%. The solution to poverty and malnutrition depends largely in increasing purchasing power, which can be improved through expanding employment opportunities across the economy, not only agriculture. Increasing agriculture productivity might in fact reduce labor demand in the sector, while development inevitably involves urbanization, and Timor-Leste is not an exception to this trend[198]. Rural poverty issues will increasingly become large-scale urban unemployment concerns.

Engaging youth in agriculture, including young women, is essential to address the interconnected challenges of malnutrition, food insecurity and rural unemployment[199]. Successful engagement will need to address the poor image of agriculture among youth, aged 15-24, who perceive agricultural work hard and not well rewarded financially[200]. One fifth of Timorese youth are engaged in agriculture, with 21% of young women and 20% of young men[201]. Most farmers, including young ones, learn agricultural skills from families and neighbours. Despite 40% of the Agriculture Faculty students at UNTL were women in 2015, most seek professional or government employment instead of wanting agricultural work in the field[202]. Young female farmers, compared to other young women, are substantially less educated, and marry and have children at a younger age[203]. A recent study found that some entrepreneurial youth in the agriculture sector, mostly focusing at the end of the production value chain[204]. Targeted programs in rural areas should focus on literacy, agribusiness skills and mentorships.

III. Agronomic practices and access to physical productive resources

Traditional farming systems have remained much the same since the early twentieth century[205]. Shifting cultivation and bush-fallow rotations, also known as "slash and burn," are most commonly used. With this method, plots of weedy land or young forest are burned at the end of the dry season so that seeds can be directly planted. The land is then used until the weed burden increases substantially, at which time the land is abandoned for another plot. For the most part, chemical inputs are not available due to high cost and/or low uptake, with a small proportion of farming households using inorganic fertilizers (9.8%), pesticides (7.1%), and herbicides (7.4%)[206]. Combined with poor-yielding local varieties, poor soils, high weed burdens, steep slopes, and highly variable rainfall[207], these agricultural practices result in the low yields discussed previously.

The Government largely subsidizes access to seeds, fertilizers and pesticides, a required public service given the high poverty levels in rural areas, yet it can also be a disincentive to efficient production. MAF spends a large share of its budget in providing productive inputs for farmers –around US$3 million in 2014[208], using a no-cost-recovery principle and including free consultation, livestock vaccination, or extension services[209]. With private sector being absent in most municipalities, small-scale farmers highly benefit from this approach. Creating an enabling environment where farmers can access inputs from private businesses is required, while affordability might also limit their usage particularly for poor farmers. Yet, the current policy can incentivize smallholders to wait for the delivery of publicly provided inputs rather than planting on time using purchased seed and fertilizer. Alignment between fund disbursements and agricultural cycles is necessary for quality and timely public service delivery of inputs to farmers[210]. A 2013 Seeds of Life (SoL) study found that 66% of households knew their *suku* extension officer, up from 43% in 2012, suggesting that not all farming households access publicly provided inputs distributed through agriculture extensions services[211].

Ensuring inputs' access and quality, particularly seeds and Nitrogen, is key to support productivity improvements and food security gains. A great effort has been placed by MAF with support from SoL on producing national seed stock through community and Commercial Seed Producers (CSP). This approach resulted in a 75% replacement of the nation´s seed importation requirements for maize, rice and peanut in 2014-15[212], increasing to seed self-sufficiency in 2016[213]. MAF and SoL nationally released 18 improved seeds varieties between 2011 a 2016, after rigorous research trials. All varieties were suitable for use by subsistence farmers, free of intellectual property, open pollinated and non-genetically modified, with the aim to ensure seed sustainability sharing among users. In 2014, one in three farming households planted at least one improved variety, with overall estimated increases of the farm gate value for food produced of approximately US$4.4 million[214]. Yet, only 15,4% of farming households report using improved seed varieties[215], indicating the need to continue promoting these through enhanced access and distribution. A major factor limiting crop yields in Timor-Leste is low soil fertility, especially Nitrogen (N) and Phosphorous (P), as 80% of soils have low to very low levels of soil P, and very little Phosphatic fertilisers are applied[216]. Small amounts of NPK (15:15:15) have shown to increase maize yields by 30%[217], suggesting that low levels of soil N is a bigger constraint than low soil P levels[218]. As William et al (2017) conclude, sustainable increases in crop yields rely on increasing soil N supply to crops during the growing season, which could be done through the greater use of legumes, natural nitrogen-fixers, and/or of synthetic fertilizers.

A niche market is emerging for agricultural input suppliers to operate in a commercial basis. A 2018 report indicates that the quantity, quality and availability of inputs is substantially improving, and prices have dropped, indicating substantial recent improvements in their supply[219]. The sector has greatly benefited from MAF's streamlining of import approval procedures and from two key suppliers entering the wholesale inputs market; while district shop owners show a basic understanding of what chemical products are for[220]. These are promising advancements, as a previous assessment in 2015 reported the expensive sale of often old stock and a very limited number of suppliers[221]. In 2015, 9.8% of households doing agricultural activities reported using inorganic fertilizers, while 14.1% used organic ones[222], suggesting low market penetration. Particularly around Dili, an increasing number of farmers are using chemical pesticides, often

wrongly and unsafely applied due to labels being written in a foreign language; as a response, MAF and partners have drafted a Decree Law to Regulate Pesticides[223]. In 2016, the official trade balance showed annual imports of fertilizers for a value of US$150,000[224]. Market-driven models that favour private investments are a priority of the SDP, yet the free input public provision encourages businesses to wait for government orders rather than developing their own retail networks while making private enterprises reluctant to enter the market for fear of being uncompetitive[225]. Yet the Avansa and TOMAK programs are supporting the development of this market by linking input suppliers and farmers.

Lack of access to productive inputs includes small machinery, paired with lack of processing facilities and associated infrastructure. A 2009-10 MAF mechanization policy enabled the handout of thousands of free tractors at a cost of about US$16 million (in 2009 prices), yet it failed at solving the nation's staple food supply problems as it intended[226]. Reasons include lack of operational and maintenance skills and training, in a context of little market incentives for famers to increase production with the government supporting a subsidy for imported rice. The so-called "tractor legacy" has penalized MAF in future budget allocations due to its poor performance. In 2015, 19.7% of farming households reported using tractors, hand and four wheeled[227], demonstrating a low level of agricultural mechanization.

While both men and women participate in agriculture tasks, women focus more on post-harvest operations including crop processing, storage, seed selection and produce sale. In Timor-Leste, farming households are considered the production unit with each member performing a role in farm operations. A SoL study shows a balanced gender labour distribution, with men and women spending equal amounts of time performing different roles in crop production[228]. This research showcases how the gender of the head of household does not affect adoption of new varieties, with decision-making generally shared, and women playing a key role in selling farm surplus to the market. Another study found that most successful seed producer groups had a good gender balance, supporting the development of sustainable agriculture practices[229], while shellers and screens are demonstrated timesaving devices that reduce the workload of women in seed saving groups[230]. Women adopting Conservation Agriculture technologies benefit from reduced workloads as a result of less time spent weeding[231]. Since women play a leading role in household and family caring tasks, including water and fuel wood collection, gender-responsive technologies and services that generate time and effort gains are particularly important, especially when over a quarter are undernourished. Women´s leading role in produce marketing is critical to encourage a shift in agriculture from subsistence to commercial farming, yet limited by time constraints, by distance and travel cost to reach markets, and by high levels of domestic violence that permeate Timorese society[232]. A recent assessment identified women as 75-85% of rural marketplace vendors, whose priorities are increased access to clean water and toilets, better waste management and strengthened marketplace management and governance[233]. These are key to not only to support marketplaces' potential to contribute to local economies' development, but also to ensure munch needed food safety.

There is gender imbalance in terms of access to the means of production, particularly land, credit, technical advice and information, as well as Government provided inputs, impacting on nutrition outcomes. Timorese culture remains strongly patriarchal, which is a barrier for women to claim rights to land and property particularly through the customary justice system prevalent in rural areas[234]. Lack of land ownership also affects access to credit facilities due to the absence of collateral to qualify for conventional credit schemes and to micro-credit schemes tending to cater for men[235]. MAF's gender policy lacks clear targets to achieve a more balanced workforce, particularly important for extension services that enable female farmers to access technical knowledge and advice. There are approximately 10 times more male extension officers than female ones and agriculture extension activities are targeted mostly at farmer groups, in which women's participation is substantially lower[236]. Due to access to free inputs – seeds, tools, hand tractors; visits or training from extension workers depending on group membership, women are at a disadvantage. This is reflected in female members of a farming households having significantly lower access to extension services than male members[237], with women often relying on informal input sources. A 2013 study found a significant positive association between membership of a farmers' group and access to extensions services[238]. Women have consistently been found to be more prone to invest in their children's health and wellbeing than men[239] as it is the case in Timor-Leste[240]. Promoting income-generating opportunities for women and young mothers from the lowest quintiles and women´s economic earnings are

vital to support nutrition and poverty alleviation outcomes, while gender equality gains are essential to improve agricultural productivity and livelihoods of rural populations.

The Land Law approved in 2017 provides a modern legal framework that enables security of land ownership[241], however there are concerns over the low level of consultation and possible impact on rural communities. While customary rights are mentioned in the new law, there is a lack of provision on how communities' rights will be protected. Farmers are aware of their families' custodial land rights, indicating that traditional systems of land control and management persist. The law aims to formalize informal property rights through registration[242]. Several land title systems were created under both colonizers, which combined with customary systems have generated a history of competing land claims[243]. State ownership of land is particularly contentious, and insecure and unclear land ownership is a frequent driver of conflict. In the context of a fragile rural environment, there have been civil disorders related to land tenure and access[244]. It is estimated that 10% of Timor-Leste´s land remains disputed[245, 246].

The agroforestry sub-sector requires clarification on land tenure but also on other assets like tree ownership. It still is unclear how will the law create an enabling environment that would sustain agro-forestry development in the country[247]. Land ownership and tenure is of great importance to ensure farmers and producers know their rights and have the security that investments' profits will be capitalized on, as per the private sector. For agroforestry developments, it will be important to assess community-based natural resource management approaches to land tenure and identify suitable models for Timor-Leste[248], particularly since 11% of private households declared land tenure in communal lands[249].

Physical impediments due to poor infrastructure are a key constraint for farming households to market produce and access food. Land connectivity is a critical enabler for agriculture development and market integration. Yet, on average, just under half of all households in the country are accessible by compacted or sealed roads. These types of roads' coverage vary widely by municipality. For example, in Oecusse, 94% of households are accessible by compacted roads, while such roads in Bobonaro can only reach 27% of households[250]. The country's transportation system is also affected by the seasonal monsoons, with a 60% average of all *aldeias* having inaccessible roads throughout part of the year. These factors limit the movements of goods for trade as well as for consumption, as described before. Moreover, the main sources of energy for rural households' lighting are electricity (57%), solar panels (20%), and kerosene (14%)[251], illustrating high levels of energy poverty.

Water access is limited by seasonal patterns and large investments in irrigation have not yet delivered the expected results. These have been slow to improve water management, which is instrumental to farmers' resilience. Heavy tropical deluges and flooding, caused by the relatively steep and short rivers during the wet season, tend to damage infrastructure requiring repeated rehabilitation[252]. Irrigation uses 90% of the total freshwater withdrawals, mostly sourced from free or unregulated river intakes[253]. All Timor-Leste's major irrigation areas are located over water-bearing aquifers, allowing for tube well and small pumps (TWSP) usage to increase the supply of irrigation in a timely manner. Two programmes plan to investigate this under-utilized groundwater resource, SAPIP and TOMAK[254]. The current irrigation policy aims to identify new irrigation schemes, small and large dams, and the expansion of TWSP in order to achieve productivity gains[255]. Recent studies conclude that the volatility of agricultural outputs is greatly impacted by weather events, including droughts, floods and El Niño[256]. Enhanced water management is essential in order to increase agricultural productivity and reduce malnutrition. Developing more cost-effective and reliable integrated use irrigation systems or groundwater based one is an avenue to achieve improved water management[257].

Part 3: Sustainability Leading Constrains

Degradation of Natural Resources

For Timor-Leste's agriculture, natural capital remains the bedrock for its growth and sustainability. Many of the people living in Timor-Leste are dependent on cultivating the land, using forest products, and, harvesting marine life for their core livelihoods[258]. There are many issues in sustaining these resources for their livelihoods. This has significant consequences for agriculture to be a stable foundation for livelihoods among rural populations in the country. These risks to sustainability can also shock households leading to declining food security, less than ideal coping strategies, and deeper poverty traps. This section will provide an overview of the natural capital degradation, particularly land use changes, water insecurity, soil degradation and threatened coastal biodiversity -- that may impede sustainability across the agriculture sector of Timor-Leste.

There is a significant amount of topographical diversity in Timor-Leste. The features of this topography -- made of coral reefs, tropical dry and moist forests, mountains and wetlands -- are important for not only the ecosystem of Timor-Leste and potential areas of economic growth and contributions to food security and nutrition, but as a global public good[259]. At the same time, this makes for transporting commodities throughout the country incredibly difficult. Of the 6,000 kilometres of roads, half are underdeveloped[260]. For example, transport of fish from the coast to the interior mountains presents an enormous challenge due to poor road infrastructure and lack of cold chain storage increasing food safety risks.

Land degradation and use changes are factors limiting agricultural productivity, which remains stagnate[261]. Approximately 3,800 km^2 of land, about 25.5% of the country, is considered suitable for agricultural production[262], and with that, approximately 200,000 ha of public land are suitable for grazing[263]. Yet these lands are highly degraded with dense woody and herbaceous weed infestation and stunted annual pasture production. UNDP describes several causes of land degradation in Timor-Leste as shown in Table 2.

Table 2 - *Main causes of land degradation in Timor-Leste (Hunnam, 2009)*[264]

1. Deforestation
    - "Widespread deforestation during the Indonesian occupation".
    - "Unsustainable harvesting of the country's most valuable tree species, notably sandalwood, ebony and redwood."
    - Intensive cutting of trees for firewood.
2. Inappropriate agricultural practices
    - "Primarily a problem in dry land farming where vegetables are grown on steep slopes... without any soil conservation measures."
    - Shifting cultivation; slash & burn techniques; in upland areas.
3. Forest fires
    - "Recurring wildfires on grass-covered mountain slopes."
    - Many fires deliberately lit to stimulate grass growth for grazing; some lit to aid hunting.
4. Over-grazing
    - Grazing animals, especially goats, roam freely through public "rangelands", rather than being "stall fed" on collected fodder.
    - Introduction and spread of invasive weed species.
    - Destruction of vegetation, compaction of soils, loss of soil moisture and organic matter, soil erosion from wind and water run-off.
5. Demographic pressures

Source: SLM Project Document (2006) and others.

As a consequence, land degradation has several impacts on ecosystems and biodiversity. First, deforestation destroys forest habitat and its biodiversity, leading to soil erosion. This then impacts farming practices and livelihoods. Second, forest fires result in loss of habitat, loss of organic matter, reduction in soil fertility, and soil erosion; leading to sedimentation of rivers; and air pollution which in turn leads to health problems in nearby populations. Third, downstream impacts extend to flooding of settlements and destruction of infrastructure; torrential river flows causing severe siltation and destruction of coastal vegetation, beaches, mangrove forests and coral reefs; leading to loss of fisheries and the biodiversity within these ecosystems, and of potential for recreational and tourism activities[265].

The rugged, erosion-prone terrain, combined with poor soils, and varying, often unpredictable rainfall make for challenging agriculture. Nearly half of the country is estimated to have a slope of 40% or more. The steep slopes and shallow soils are very susceptible to erosion. Soils are alkaline and generally poor, with low water-retention capacity, with small areas of alluvial soils in the river valleys and flat lands along the coasts that are suitable for conventional agricultural practices[266]. Furthermore, the island is made up of limestone and metamorphosed marine clays, which contribute to thin, infertile and fragile soils. The climate is tropical but dry, and precipitation comes usually from downpours, causing a high degree of surface runoff and erosion[267]. Timor-Leste's climate is tropical, but drier than that of many of the surrounding islands. The precipitation often comes in torrential downpours, which cause a high degree of surface runoff, increasing the risk of soil erosion. The deforestation mentioned above also leads to increased erosion by decreasing the amount of vegetation that anchors the soil and provides nutrients. Terracing, micro-catchments, and contour hedgerows of vegetation are all means of stabilizing crop production on slopes. Hedgerows of leguminous shrubs and grasses can facilitate soil fertility and provide food for livestock. Using crop residues and leguminous leaves for fodder has been shown to improve meat production[268].

Land suitable for rainfed agriculture is in short supply, and irrigation schemes are inadequate for agriculture growth[269]. The Government strategy to develop the irrigation sector is based on the rehabilitation of ex-transmigration irrigation systems that were constructed during the Indonesian occupation period and followed by the construction of both small and large dams and new river diversion schemes in "greenfield"[270]. Existing systems are generally non-functional due to damage to water intake channels and lack of maintenance. Their refurbishment is aimed at increasing domestic rice production, however, the current irrigation strategy has not and will not generate acceptable returns on investment in the sector[271]. Also, the supply of irrigation water in the dry season is insufficient for second crops. Many of the poor live in regions not suitable for irrigation, such as rainfed upland areas, suggesting that other poverty and food security strategies besides large irrigation need to be pursued to improve livelihoods[272].

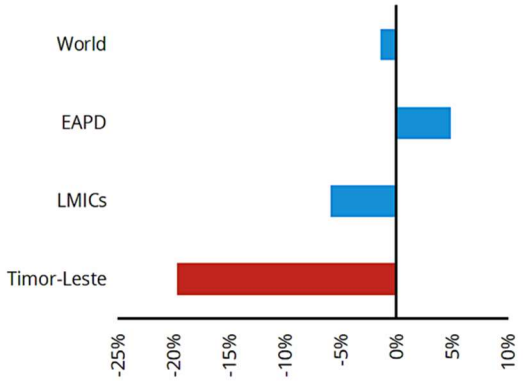
Water insecurity is a key constraint for crop production. Despite 79.8% of the Timorese population having access to an improved or safe water source (92.1% of the urban and 75.1% of the rural population) [273], water access is highly variable in rural areas particularly during the dry season when many wells and water sources dry up. This has major consequences for crop production in general, and for horticulture more specifically, since vegetables require regular watering and are less resilient than staples. Water insecurity has also implication for women and children who typically fetch household water. Also, only 53.8% have access to improved sanitation facilities (76.0% of the urban population and 45.4% of the rural)[274], with poor sanitation being a major malnutrition determinant. Both indicators are below the average for the East Pacific Region (EAP) region and closer to those reached by low-income countries. Interestingly, the water supplied to Dili comes from three rivers stemming from rural places, making the water system very vulnerable to activities like animal herding and agriculture that take place upstream and influence both the water quality and the physical integrity of the treatment system downstream[275].

Timor-Leste's coastal biodiversity is threatened, despite being a part of the "Coral Reef Triangle" initiative. The Coral Triangle is a marine biodiversity hotspot of global significance, also integrated by Indonesia, Malaysia, Papua New Guinea, the Philippines, and Solomon Islands. It contains 75% of all coral species known to science, over 3,000 species of reef fish, and the largest tuna fisheries in the world[276]. Atauro Island, hosts the highest average fish diversity globally[277]. Such rich biodiversity requires preservation measures while enabling sustainable livelihoods, with eco-tourism as a clear option. However, the total mangrove area associated with Timor-Leste´s reef systems was around 18 km^2 on 2008, a sharp decline from the 90 km^2 reported in early 20th century[278]. Many marine ecosystems have been impacted by erosion from deforestation, particularly riparian vegetation and mangrove´s forests –which continue to

be harvested for fuel and food. Further, the sea surface temperature in Timor-Leste has risen 0.16 C per decade, however, ocean acidification and sea level rises are not frequently gauged[279].

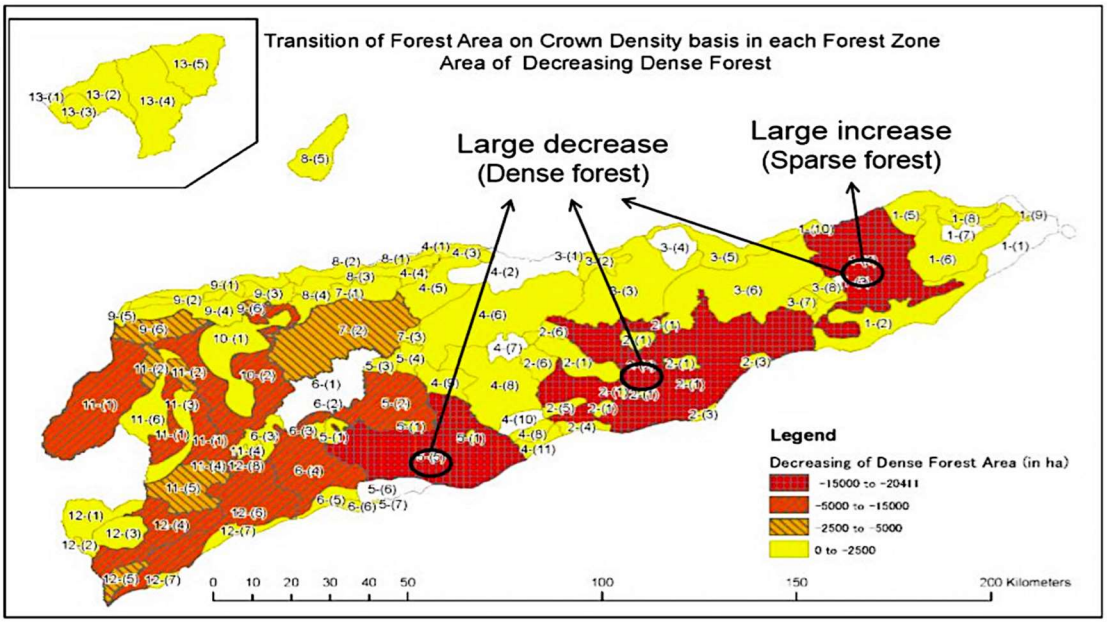
While an ecosystem asset, forests are being lost in Timor-Leste. Timor-Leste's landscape is covered by 58% or 869,000 ha of early successional forests[280], of which some of Timor-Leste's indigenous tree species are of international significance (*Santalum album*, *Eucalyptus urophylla* and *Casuarina junghuhniana*)[281]. The annual rates of loss of forested areas, which is one measure of land degradation, are estimated at 1.7%, meaning that some 14,000 ha of forests are being lost annually, one of the highest rates of loss in Asia[282]. Since the year 2000, Timor-Leste has rapidly lost 20% of its forest coverage due to slash and burn agriculture and firewood collection (Figure 24 and 25).

***Figure 24** – Change in Forest Coverage, 2000-2015*



Source: WB, 2018:53, based on WDI

***Figure 25** - Loss of forests map in Timor-Leste[283]*



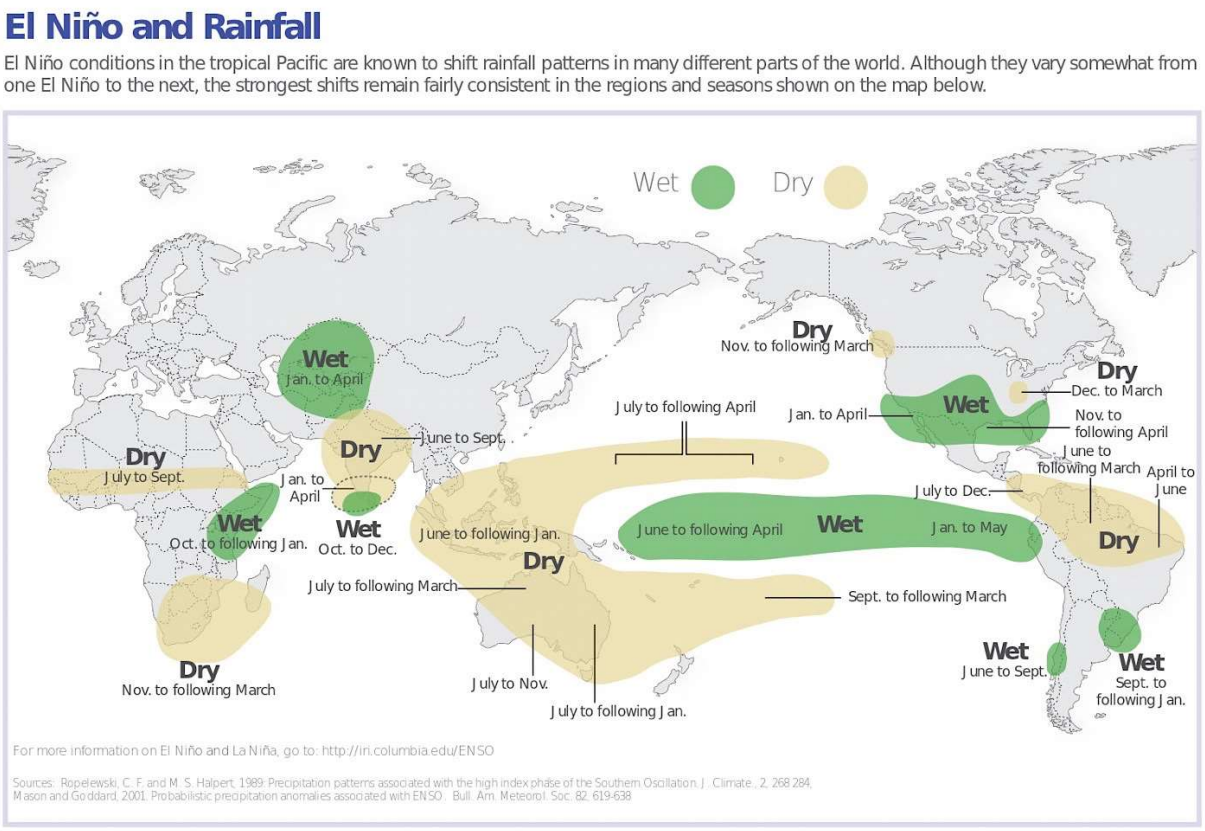
Source: JIC and NDF 2013

Most of the wood in Timor-Leste is used to build homes and for fuel, and the forestry sector contributed US$6.6 million to the economy in 2015, which is approximately only 2.3% of the agriculture GDP or 0.21% of the total GDP[284]. However, there is opportunity to cultivate forests and their products that provide both ecosystem services and support livelihoods being that so much of the landscape is covered with forests. Global demand for wood products is predicted to remain strong. Through mixed agroforestry systems that promote coffee and fruit trees with grain crops can serve as important sources of both food security and income[285]. At the same time, forests store carbon, which can be important as an important return on investment for carbon zero approaches to agroforestry.

El Niño Effects and Natural Disasters

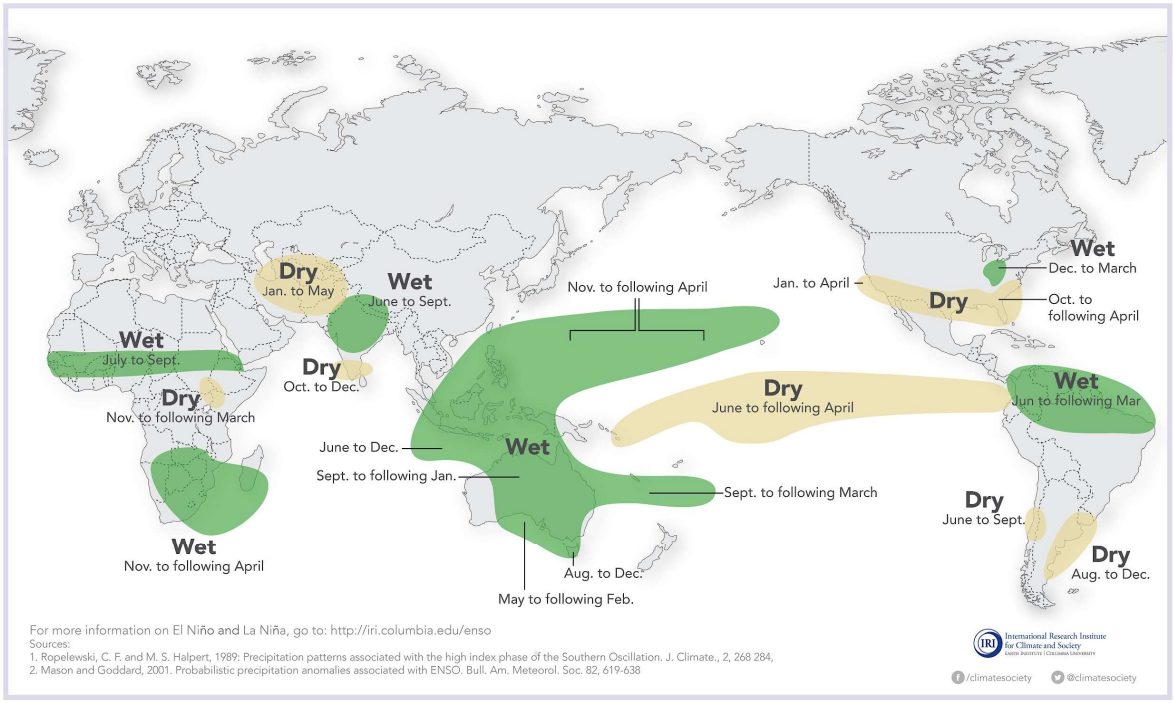
At the seasonal to inter-annual timescale, the El Niño-Southern Oscillation phenomenon (ENSO - both El Niño and La Niña) is the most significant driver of variability in the climate system. Recurring every 2–7 years, ENSO events bring predictable drought or floods to many regions of the world (Figures 26 and 27) and increase temperatures across the tropics.

Figure 26 *- El Niño and rainfall (GNR 2015)*[286]



Source: International Research Institute for Climate and Society.

***Figure 27** - La Niña and rainfall (GNR, 2015)*[287]



Source: International Research Institute for Climate and Society.

Timor-Leste's climate is highly influenced by the ENSO. The El Niño-Southern Oscillation's influence on Timor-Leste is evident in the large year-to-year variability of the rainfall totals[288]. The El Niño phenomenon changes the timing and volume of rainfall and induces prolonged drought in certain areas of the country. In general, the phenomenon delays the onset of the wet season by two to three months in addition to reducing seasonal rainfall totals, which has implications for crop planting. In El Niño years, some areas receive only 25% of the usual season rainfall. In the years following an El Niño event, rainfall amounts tend to be higher than normal and often induce severe flooding. Besides, tropical cyclone activity is lower in El Niño years and higher in La Niña years.

A strong El Niño episode marked the 2015/2016 rainy season with devastating effects for crop production, livelihoods, and food and nutrition security. Three manifestations of the weather phenomenon occurred across the country: a delay in the onset of the rainy season, overall lower rainfall volumes, and interruption of rains—all of which have significant implications for livelihoods which are primarily dependent on agricultural activities[289]. A nation-wide rapid assessment of its impact concluded that 78% of households were negatively impacted by drought, 40.6% of households experienced food shortages in December to March, and 45.9% expected food shortages from March to June[290]. As a result, crop failure for rice, maize and vegetables was reported at 6, 10 and 4.5% each, with close to 50% of these crops partially growing; while an estimated 70,000 head of livestock died[291].

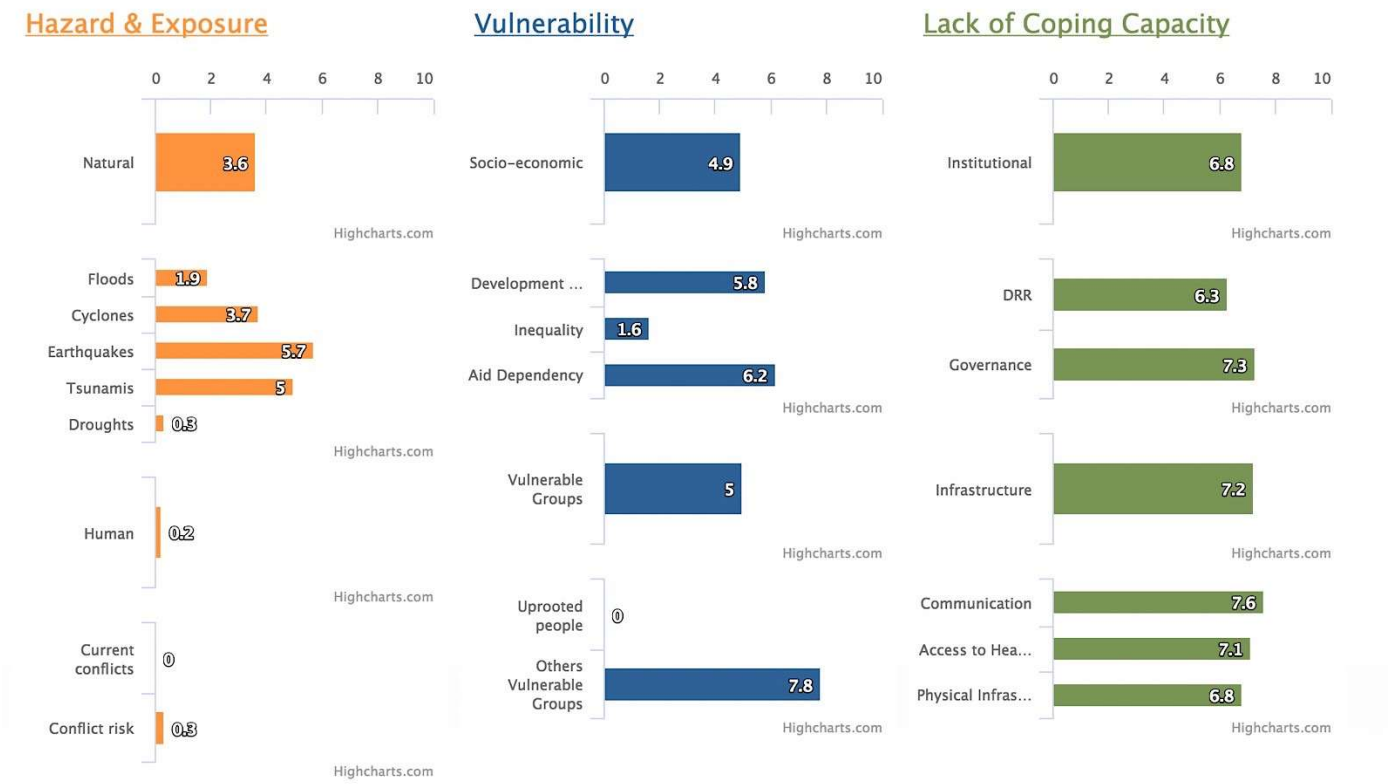
ENSO is not the only risk. There have been several risks due to natural disasters that impact farmers. Mercer et al (2014)[292] show that strong winds, floods, fires, and landslides have also contributed to hazards among the Timorese (Table 3) and suggest a strong correlation with degraded landscapes. This creates medium risks to cope as shown in Figure 28. According to Index for Risk Management (INFORM) -- which measures the risk of humanitarian crises and disasters -- Timor-Leste is ranked 69 out of 191 countries.

***Table 3** – Recorded hazards in Timor-Leste since independence, 2012-2013*[293]

Event	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Accident		2							4	1		1	**8**
Conflict	2		1		2	5		1		3	1	1	**16**
Drought		1											**1**
Epidemic										1			**1**
Fire	2	8	4				1	40	20	29	55	22	**181**
Flood	1	10			1	7	4	7	88	36	25	75	**254**
Landslide		1						4	16	12	9	6	**48**
Strong wind	3	3	5		3	3	12	32	93	47	74	33	**308**
Total	**8**	**25**	**10**	**0**	**6**	**15**	**17**	**84**	**221**	**129**	**164**	**138**	**817**

Source: Reported by Desinventar, in Mercer et al (2014).

***Figure 28** - INFORM Ranking of Timor-Leste*[294]



Source: INFORM 2017.

Climate Change Risks

Rain patterns vary according to agro-climatic zones. The country can be divided into three different climate zones, which include the northern coastal zone, the central mountain zone, and the southern coastal zone. These can be further subdivided into six distinct agro-climatic zones, three of which occur north of the central Ramelau mountain range and three that occur south of it. These include the Northern Lowlands, Northern Slopes, Northern Highlands, Southern Lowlands, Southern Slopes, and Southern Highlands. The northern and southern zones experience two diverse rainfall patterns, the monoidal pattern and the bimodal pattern, respectively.

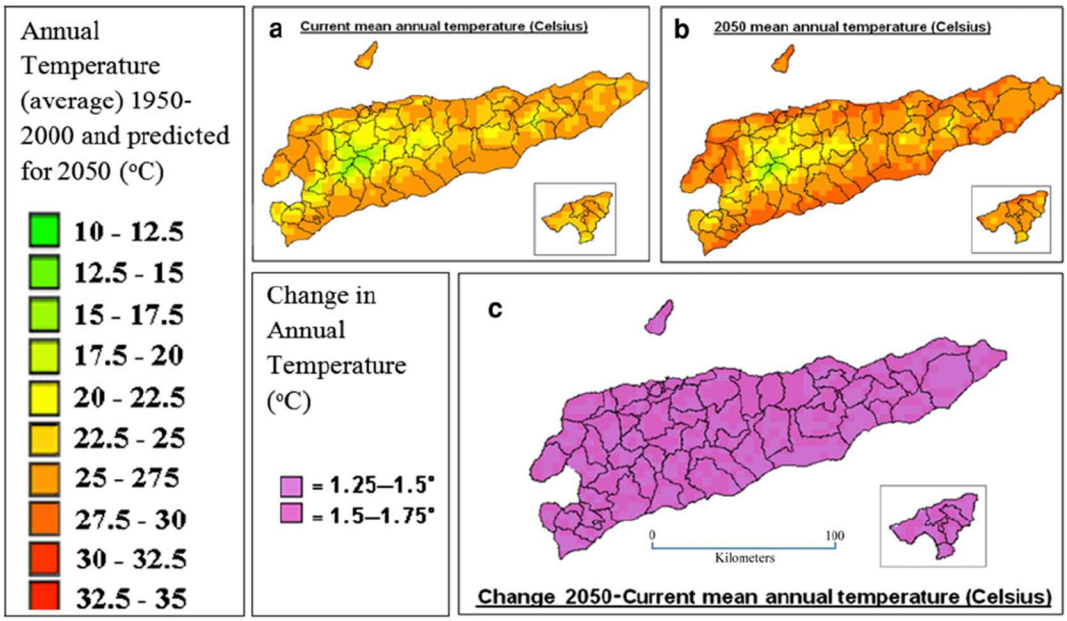
Climate models show that Timor-Leste will experience major increases in both temperature and rainfall, which could have significant implications for livelihoods and food security. Key trends under a changing climate include[295, 296].

- Large decreases in rainfall over most of the country except in Oecussi and the westernmost parts of Bobonaro leading to potentially more intense droughts and higher water stress. This trend highlights the need to identify shorter-season crops to ensure livelihood security. Projections suggest potential decreases in rainfall in the Southwester coast which may be linked to shifts in rainfall patterns during the second rainy season, potentially resulting in lower productivity of crops–primarily root crops and cash crops–grown during the second season.
- More frequent large rainfall events over the western coast and coastal Oecussi, likely associated with more severe flooding;
- Increases in maximum temperature of approximately 1 to 2 degrees Celsius, especially in the southern regions. An increased in average daily temperatures will accompany this. A combination of higher average and extreme could also affect crop health and livestock.

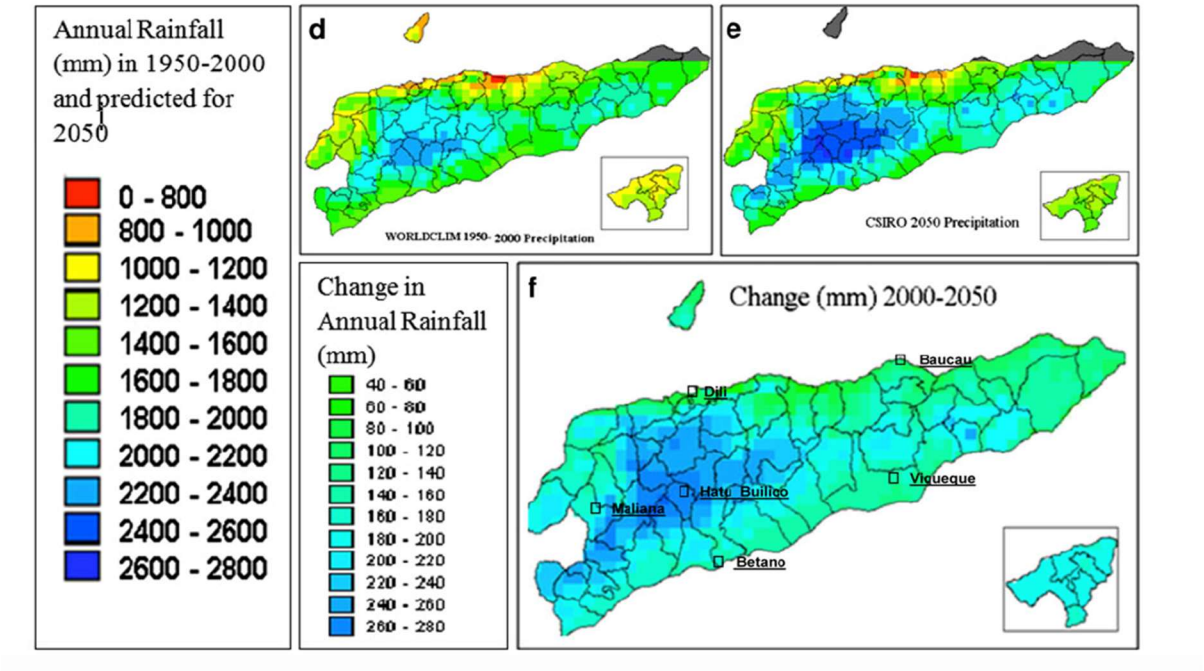
The combination of these trends will also influence the magnitude of droughts (with more intense, longer droughts) and floods (more severe floods occurring during the monsoon months). As shown in Figure 29 A and B.

__Figure 29__ - (A) Current and future (2050) annual temperature changes under climate change in Timor-Leste; and (B) Annual rainfall changes at present and in 2050 in Timor-Leste

(A)



(B)



Source: Molyneux et al., 2012.

The Climate Change in the Pacific (2014:50) report indicates that over the next 50-100 years, climate will have the following impact on Timor-Leste from very high to low confidence in future model studies[297]:

- El Niño and La Niña events will continue to occur in the future (very high confidence), yet with little consensus on whether these events will change in intensity or frequency
- Annual mean temperatures and extremely high daily temperatures will continue to rise (very high confidence)
- Ocean acidification is projected to continue (very high confidence)
- The risk of coral bleaching will increase in the future (very high confidence)
- Sea level will continue to rise (very high confidence)
- There is a range of projections of average annual rainfall, from a decrease to increase (therefore low confidence in the model average projection), but with more extreme rain events (high confidence);
- Drought frequency is projected to remain similar to the current climate (medium confidence);
- A reduction of wave period in January is projected, with no other projected (low confidence).

I. Risks to Agriculture

There is and will continue to be overall changes to productivity (mostly decreasing) due to increase in the occurrence of extreme weather events, shorter and less predictable wet seasons, extreme rainfall patterns that lead to seawater intrusion, hotter dry season, and more intense drought-causing El Niño events. When Timor-Leste faced severe drought conditions brought on by El Niño in 2015, Timor-Leste experienced erratic rainfall, resulting in diminished crop yields. One-third of the country's population has been impacted by this prolonged drought, putting them into more significant food insecurity. Soil erosion and significant deforestation make for adaptation to climate change more difficult. The northern regions will be particularly impacted because rainfall is unreliable and the area is already vulnerable to severe droughts during the dry season. Changes in temperature and rainfall will also affect the suitability of key crops—particularly rain fed paddy, coffee, maize, and cassava[298]. Maize, the main subsistence crop, is particularly vulnerable due to its reliance on regular and reliable rainfall and lack of viable irrigation infrastructure in the country. Coffee, which accounts for 97% of non-oil export revenue, is produced in the

northern and southern highlands and could be affected by rising temperatures and shifting rainfall patterns that may shift the altitude band favourable for coffee production to higher altitudes. Coffee production may be exposed to the negative impacts of climate change, with rising temperatures and less predictable rainfall potentially reducing yields and increasing risk of pests and diseases[299]. Increased levels of soil erosion because of more intense extreme rainfall events and recurrent droughts, along with vegetation clearing, could increase runoff and decrease already poor soil quality, leading to poor agriculture yields[300, 301, 302].

A recent study evaluated the impact of global warming on maize yields in Timor-Leste, concluding that yields would increase for low input smallholder farmers growing maize at maximum growing-season temperatures of < 31.8C[303]. The study modelled for no fertilizer input and for increased nitrogen (N) supply and undertaking simulations with different temperature increases and in multiple locations. Results suggest that with higher temperatures and with no added fertilizer, yields would increase in higher elevation sites while decreasing in areas closer to the coast; and with fertilizer yields would decrease or remain unchanged.

As climate change affects the phenological process of crops, it is expected that farmers will have to adapt and change their practices to continue farming in the same areas. Current varieties of crops may not continue to thrive because of changes in rainfall variability and onset of the wet seasons, as well as increases in average temperature. The type and extent of crop damage will also change as crop diseases are affected by climate change. Droughts will likely increase instances of aflatoxin contamination, while increases in rainfall may lead to more widespread groundnut rosette disease and exacerbate erosion in areas with steep slopes[304]. Conservation agriculture is an approach being promoted based on its climate adaptation and mitigation benefits but improved postharvest storage, and agro-processing technology will be key to safeguard yields[305, 306].

II. Risks to Food Security

Climate change will also intensify economic pressures on food access. Simulation models suggest that inflation-adjusted prices of the three most important staple grains in the world—wheat, rice, and maize—would increase 31–106% by 2050[307]. Most multi-country analyses suggest that higher food prices will tend to increase food insecurity and poverty not only for the urban poor, but also for rural people, most whom are net food consumers[308]. Current reviews of rice elasticities of food demand in low-income countries found that price increases are associated with sharp reductions on in all food groups consumption, indicating that higher prices are probable to diminish nutrient intake, nationally[309]. However, the impact of increases in food prices on food security will depend on the ability of farmers to adapt o volatile economic and ecological conditions[310] as well as the relative magnitude of the prices changes across foods, or in other words, the structure of the country economy[311].

III. Risks to Water Resources

Increased risk of flooding, particularly in the low-lying coastal plains on the southern side of the country, would accompany increase in the intensity and frequency of extreme weather events. There will be possible decreases in groundwater and surface water quality and quantity due to sea level rises, salt water intrusion, deforestation, river flow and run off rates[312].

Relative sea-level rise is expected to amount to 0.43 m and 0.30 m in 2100 under the A2 and B1 IPCC emission scenarios, respectively, relative to 1995[313]. Under the A2 scenario, Timor-Leste is expected to experience a 50% reduction in its wetland area by 2100, relative to 1995[314]. These sea level rise and flood-related impacts could contaminate drinking water supplies and disrupt sanitation and hygiene infrastructures[315].

IV. Risks to Coastal Areas

Climate change-induced sea level rise along with an increase in the frequency and intensity of flood-inducing, extreme precipitation events, could lead to the submergence of large quantities of low-lying lands. This could lead to a significant loss of coastal ecosystems, adverse impacts on the underdeveloped aquaculture industry, saltwater intrusion into fresh-water aquifers, salinization of agricultural areas, disruptions in the coastal agricultural industry and water supply system, destruction of established human settlements, well as population displacement. If unchecked, there will certainly be increased rates of coral reef, mangrove, and seagrass degradation resulting from rising sea surface temperatures, sea level rise, increasingly intense storms, and ocean acidification. This could lead to declines in coastal fisheries and changes in the distribution of tuna, skipjack, snapper, and prawns, all of which have a considerable potential to support economic development and sustain the population, both nutritionally and economically[316, 317, 318, 319].

Climate-smart strategies

Timor-Leste is already experiencing the effects of climate change and needs to act to increase farmer resilience and develop climate-smart agriculture to maintain and improve food production in the face of climate change. This can be achieved in several ways which need serious, scaled investment.

First, Timor-Leste has a number of national policies on development, health, nutrition, and agriculture. While some of these policies mention climate change, most do not. The Government of Timor-Leste's Strategic Development Plan 2011 to 2030 discusses climate change and the need for the country to prepare for changes in temperature and precipitation. The Zero Hunger Challenge National Action Plan and National Food and Nutrition Security Policy both mention climate change and the importance of resilient food systems. The country has a specific policy on climate change, the National Adaptation Program of Action on Climate Change. This identifies climate change as the country's biggest challenge moving forward and stresses the importance of increasing resilience. The National Adaptation Programme of Action (NAPA) developed in 2010, are cross cutting ways in which Timor-Leste should invest in across the country (Table 4)[320].Current community-based reforestation, conservation agriculture, have been critical in climate smart agriculture adaptation strategies. Timor-Leste is a member of the Alliance of Small Island States as well as one of 43 members of the Climate Vulnerable Forum. The country signed the Paris Climate Accord on 22 April 2016.

***Table 4** - Adaptation Strategies from the NAPA*

Rank	Adaptation options	Activities
1.	Food security	• Integrated agro-forestry and watershed management. • Integrated sustainable land management. • Reforestation of degraded land. • Improvement of physical infrastructure, civil engineering and natural vegetation methods to prevent landslides. • Education and awareness raising on sustainable agriculture and forest management.
2.	Water resources	• Building of infrastructure to protect water sources. • Enhancement of government and community strategies on drought response. • Creation and enhancement of the water harvesting model and distribution system. • Control of the quantity of water used by industry and water pollution.
3.	Human health	• Strengthening of integrated community health services. • Strengthening of the integrated early warning system at the community level. • Review of existing guidance and standards issued by the Ministry of Health on respiratory, airborne and vector diseases.
4.	Natural disasters	• Establishment of early warning systems. • Integration of climate risk information into traditional DRR and disaster risk management.
5.	Forests, biodiversity and coastal ecosystems resilience	• Maintenance of mangrove plantations and awareness raising to protect coastal ecosystems. • Inclusion of ecosystem management in national planning.
6.	Livestock production	• Improvement of planning and the legal framework to promote sustainable and balanced food for livestock production.
7.	Physical infrastructure	• Review of existing laws, regulations and standards to enhance resilience of critical infrastructure. • Passing of new legislation to strengthen and guarantee national development through improved regulations.
8.	Oil and gas sector	• Protection of offshore infrastructure against strong wave damage that could affect the distribution of gas and oil, and a reduction of accidents and destruction of offshore oil and gas infrastructure.
9.	National institutional capacity development for climate change	• Strengthening of the mandate of the cross-sectoral national climate change team to improve coordination and engagement. • Establishment of the Climate Change Unit. • Capacity development support for key non-governmental institutions. • Development of a national climate change strategy and action plan. • Promotion of sub-national capacity development for improved adaptation planning and implementation. • Strengthening of the hydro-meteorological department in the NDMG to collect, compile, analyse and disseminate climate-related data.

Source: Mead et al, 2014[321]

Second, climate-smart strategies such as low or no-till farming, conserving biodiversity, selecting higher yielding cultivars, terracing, using contour planting of perennial trees and grasses, crop rotation, and technologies such as irrigation will be essential in the context of climate change[322]. For the Timorese context, these climate-smart strategies work for smallholder farmers when they directly influence local climate risks and empower local communities. Adaptation interventions are knowledge-intensive processes and require technical skillsets, finance and capacities of farmers. Thus, with the low capacity and skill set level of many rural Timorese, adaptation measures may be limited if investments do not include knowledge and ownership building. MAF, FAO and other partners have been promoting Conservation Agriculture

technologies since 2013 with the aim to increase productivity of maize, improve household food and nutrition security and reduce disaster risks associated with climate change[323].

Biodiversity and conservation resources

The preservation of biodiversity and genetic diversity is of greatest relevance for Timor-Leste. In the 2014 Draft National Seed Policy, the MAF outlined its plan to establish a national gene bank, of primary importance to preserve genetic resources[324]. Local varieties might present climate-resilient traits that could be crucial to ensure future crop adaptation. There are also a number of endemic and/or well-suited crops to Timor-Leste´s climate and soils that support nutrition, some of which are cultivated while others are found growing in the wild[325]. Moringa is a pantropical tree species that contains high levels of vitamin A, vitamin C, potassium, and protein; and has been used to address malnutrition among infant and mothers [326, 327]. In Timor-Leste moringa is often found in the wild and promoted by multiple programs to improve nutrition by incorporating its leaves into foods as well as into animal feed.

Wild foods play an important role for food and nutrition security, particularly among resource-poor households. There are traditional leafy vegetables and ferns that have ten times the nutritional value of comparable imported crops[328]. Rural households often rely on the collection and consumption of wild foods during the seasonal lean season, including lesser yam, elephant's foot yam and bitter bean as some of the most commonly consumed[329]. Despite their harvest no necessarily reliable and often time and energy-intensive, the foraging of wild foods provides an important safety net for households in times of lower crops availability[330]. Some of these foods are very labour-intensive to prepare, relying on women´s work for their processing, such as for sago and bitter beans.

The majority of the Timorese population relies on natural ecosystem services to support agriculture, forestry, fisheries and hunting. Most livelihoods depend directly on the assets provided by the environment and natural resources, and their sustainability is paramount to ensure future livelihoods based on agriculture productivity improvements and tourism developments[331]. The natural environment also provides a wide range of essential services that enable and support resilience to disaster and climate change. Preserving such natural assets embeds multiple gains for food and nutrition security, livelihoods and climate resilience.

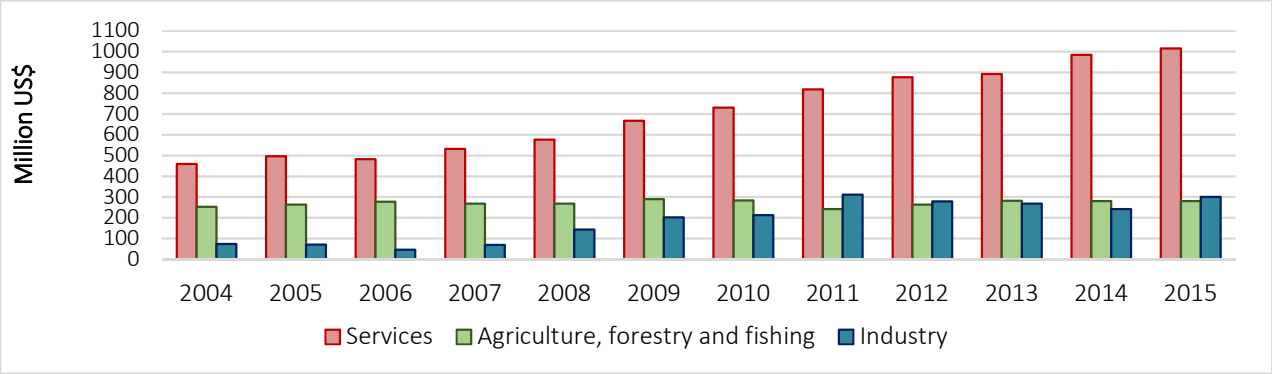
Timor-Leste is part of the Coral Triangle and hosts highly biodiverse and important seascapes that can support both livelihoods and marine tourism. Atauro Island has been found to host the highest average fish diversity in the world in a recent survey, with an average of 253 reef fish species among 10 sites studied[332]. Marine mega fauna also inhabits Timorese waters, including whales, whale sharks, dolphins and manta rays, which have potential to develop into whale-watching and diving ecotourism niche sectors. Threats to this fragile ecosystem include solid waste pollution derived from land-based activities, and non-traditional fishing practices such as shark fishing or dynamite fishing hat have damaged other marine resources in the region[333].

Part 4: Shared Prosperity and Inclusive Growth

Agriculture contributions to GDP

Timor-Leste´s double-digit economic growth during 2007-2011, with an annual average of 11.4% and followed by a 5% from 2012 onwards, does not reflect contributions made by the agriculture sector[334]. This growth has been led by substantial increases in Government´s expenditure sourced from petroleum revenue and subsequent demand for services, with limited contributions from productive sectors outputs such as agriculture or manufacturing[335] (Figure 30).

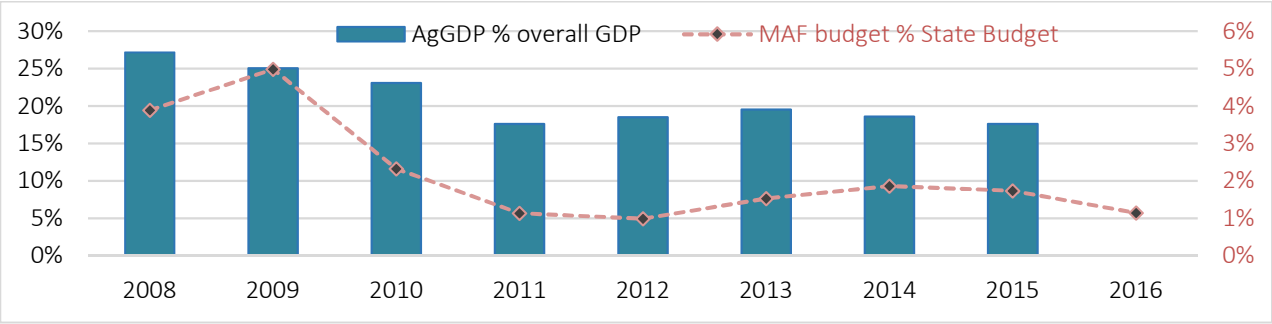
Figure 30 *- Non-oil GDP per Industry - 2004-2015 (constant price 2015)*



Source: A-PEA, 2017:14.

The agriculture sector contributes to 20% of non-oil GDP[336], decreasing from 27.2% in 2008 to 17.6% in 2015[337] as a result of the decline in agricultural production per capita in mean value from 2000 to 2013[338]. The agriculture GDP is largely dependent on crop outputs, with highly volatile volumes that are particularly sensitive to weather conditions (including droughts, floods, El Niño/La Niña cycles) and influenced by public investments. Forestry and fisheries contribute marginally to non-oil GDP, while livestock has been progressively increasing its share (from an estimated 12% to 17% of the Agriculture GDP)[339]. Despite the sector providing direct employment to 64.2% of employed population[340], MAF's ratio of the Government's budget has also diminished overtime, from 3.9% in 2008 to 1.1% in 2016 (Figure 31). For 2019, the proportion of the total State budget allocated to MAF is 0.7%[341]

Figure 31 *- Agriculture sector contribution to non-oil GDP vs. MAF's share of Government's expenditures*



Source: A-PEA, 2017:14.

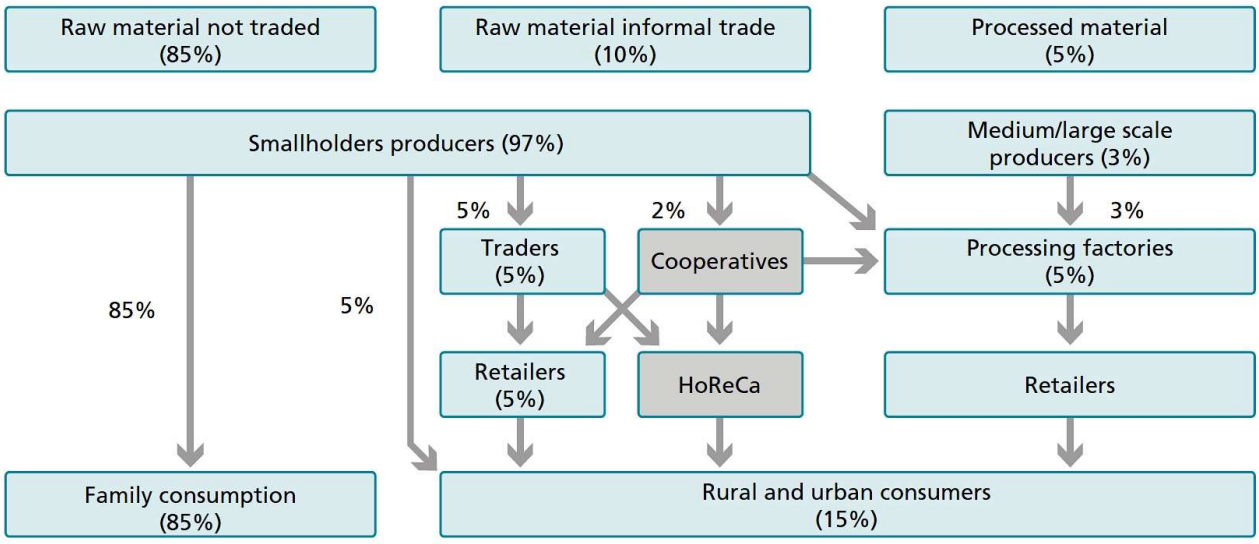
The level of public investment in the agriculture sector in Timor-Leste is very low given its relative importance for the economy and share of national employment. When assessing contributions of the Agriculture sector to the GDP Timor-Leste, with 20%, is close to the Pacific average of 22%[342]; however, MAF´s share of the government expenditure, 3%, is the second lowest among selected Pacific nations[343].

Agri-food value chains characterization

The GoTL[344] and DPs use Value Chain Analysis (VCA) to identify areas where policy and programmatic interventions could have positive impacts on agriculture productivity. Despite previously described difficulties to obtain reliable data at each step of the value chain[345], recent VCA for various commodities are available for several crops and livestock, applying a domestic and export markets focus –see note for specific list of commodities and literature[346]. These demonstrate valuable advances at producing up-to-date market-oriented analyses for selected commodities in Timor-Leste.

The structure of most commodities value chain is short and simple, with stages generally including farm production, negligent on-farm post-harvest handling, sale from farmer to local buyer, processor and/or exporter, and domestic wholesaler, retailer and/or export, and consumption[347]. Value chain operators usually include producers –often poor subsistence farmers, and farmer groups; municipal stakeholders such as rural collectors, truck drivers and small-scale traders that act as agents for processors and exporters; and Dili-based actors such as traders and companies, NGO projects, and export-oriented companies –particularly for coffee. See note for detailed private sector involvement in selected value chains[348]. A recent study exemplifies actors and products flow for rice production[349] (Figure 32).

Figure 32 *- National production information for the rice subsector: actors and product flow*



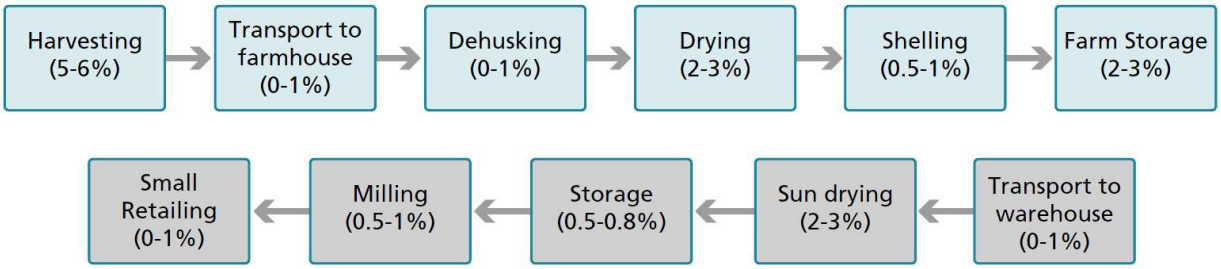
Source: FAO, 2018b:2.

Value chain bottlenecks vary by each commodity, yet leading ones include, for Producers: traditional farming practices and non-commercial mindsets, insufficient seed supply of improved varieties, inadequate extension services, and lack of support from the private sector to farmers due to potential free rider issues (coffee); and for Traders: high transport costs, with in-season high truck rentals and expensive petrol prices compared to Indonesia where fuel is subsidized, putting Timor-Leste in a competitive disadvantage[350]. There is a distinct lack of Processors as these are generally the producers.

Postharvest management and processing are generally very poor, with traditional systems widely used to store harvests[351]. This results in high post-harvest losses, estimated at 32% for maize[352] and sometimes as high as 50%[353] and 30% for rice, which result in annual cereal losses of about 6,420 Mt and valued at about US$4.82 million[354]. With already low productivity at household level, such losses have a tremendous impact on subsistence farmers' food sufficiency. For an average farmer growing 1 Mt of maize and consuming regularly throughout the year, harvest losses are due to weevils (19%), rats (9%), mould (3%) and chickens (1%)[355]. The resulting substantial losses require better storage methods such as airtight metal drums[356]. When these are used, the critical loss point occurs during the manual

harvest, at 5-6% (Figure 33)[357]. Ensuring food safety is important, as a study found that 10.5% of maize and 6.25% of groundnuts in Timor-Leste were contaminated with aflatoxins, which impact on child growth[358].

***Figure 33** - Estimated average losses along the maize supply chain –among farmers who mostly use IFAD drums*



Source: FAO, 2018c:18.

Improving processing and handling practices through the value chain from farmers to final consumers is crucial, while very little value-adding is done to commodities impacting on lower prices. The coffee industry would benefit from improvements on harvesting techniques, picking times, and cherry grading along with processing techniques to ensure more value remains with producers. Coffee for the export market is sold as green beans. Developing value-adding roasting facilities in country would support increasing export value with the same production levels. For other cash crops, low product quality due to poor postharvest handling is an impediment for candlenut export increases[359] or results in low copra trading prices[360]. Generating jobs in postharvest management and processing is a gender-sensitive approach, since women are particularly active in postharvest operations including crop processing, storage and seed selection[361].

Box 4 - Remarks on the coffee value chain:

- Very poor upland subsistence farmers sell coffee cherry and parchment (50% each of all production)
- For cherry, some processing occurs in districts – pulping, washing; and some in Dili –drying, hulling, storage, shipment and transport
- For parchment, all processing is Dili-based
- Four companies account for 90% of coffee exports
- CCT leads approaches to increase processing quality, first at obtaining certification for Organic and Fair Trade – with a premium difference in FOB price of US$0.10/kg green bean exported

Source: WB, 2011; ADB, 2015.

Rural market system distribution in Timor-Leste is highly fragmented, with trading characterized by small volumes, high transaction costs and *ad hoc* trading[362]. Markets have become disconnected from producers, and a lack of farm-gate traders and district level aggregators results in the distance between producers and potential markets to be too wide to traverse. Traders are opportunistic due to not knowing which products are available where and when, and have a low investment capacity. Producers are 22km from their closest market on average[363]. Despite a relatively intensive road network, poor road conditions and common disruptions lead to very low volumes of traffic in the districts, limiting both supply and demand market access. This results in most sales being localized at retail in sub-district or *suku* markets. Farmer's try to sell surplus, yet small volumes and high transaction costs combined with low yields and high labour costs result in small margins.

Financial and economic analysis of key commodities

Detailed financial analysis of key commodities with reasonable potential to develop into commercial ventures enable to compare local subsistence systems (no inputs) with systems that use an intermediate or high level of technology proven in Timor-Leste. Various summary gross margin analyses are available for multiple corps and livestock, see note for references[364]. For example, improved coffee systems that apply organic inputs combined with systematic pruning and weeding can almost triple yields and increase cash gross margin from US$412 /ha to US$1,105 /ha, while requiring more than double of the labour days compared to unimproved management (Table 5). Thus, the gross margin per work/day remains almost unchanged, from US$6.49 to US$6.61[365].

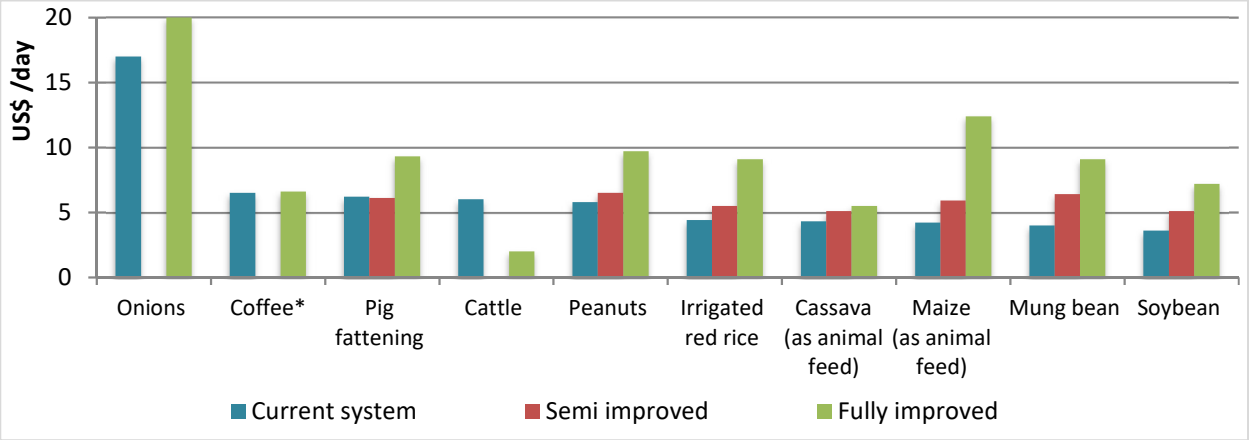
Table 5 *- Gross margins per hectare and per Labour Day for coffee (unimproved and improved)*

	Gross Margin / Hectare / Labour Day US$	
Model	**Unimproved**	**Improved**
Trees per hectare	1,479	2,000
% of trees replaced annually	0%	3%
Yield per tree (kg)	0.7	1.65
Yield cherry per ha (kg)	1,036	3,003
Yield of green bean per ha (kg)	179	519
Gross income $/ha	$412	$1,195
Cash input costs	$0	$90
Cash gross margin $/ha	$412	$1,105
Total family labor days (FLD)	64	167
Gross Margin per FLD	**$6.49**	**$6.61**

Source: Adapted from USAID, 2013b:31.

The gross margin per labour/day, elaborated by TOMAK in 2016 (Figure 34), is presented as a useful tool to review commercial investment options through the analysis of potential gains for farming families after improved practices. Gross margin analyses combine information on inputs, outputs, productivity and labour required for each commodity, and assessed against a range of scenarios based on use of improved varieties and agronomy to increase yields, combined with labour saving technologies. For example, fully improved cropping for legumes such as mung beans or soybean can at least double gross margin per labour/day by introducing new varieties and a moderate use of fertilizer. Pigs also present a good opportunity to increase labour profitability, particularly for women –since pigs are their customary responsibility, through a more intensive system using improved breeds, formulated feed containing cheaper imported soybean meal, and vaccination services. This analysis enables to assess potential commercial gains from select crops, while it does not present the levels of nutrition that these commodities can provide to support subsistence diets effectively.

Figure 34 - Gross margin per labour per day for selected commodities [366]



Source: Created from TOMAK, 2016:6; * USAID, 2013b:31.

The return to labour is calculated for paid/unpaid work and pooled together, and represents the effective return to total labour required. Multiple agriculture reports argue that commodities returns need to compete with the prevailing rural labour rates of around US$5 /day[367], suggesting how with current practices it is uneconomical for farmers to grow most crops for sale as their return is below the opportunity cost –except for onions, coffee, livestock or peanuts (Figure 34). However, the amount of rural paid employment, despite having increased in recent times, remains small relative to the groups of inactive adults and agricultural workers.

Relative importance of food exports and imports

In Timor-Leste imports largely surpass exports in value, reflected in a trade deficit exceeding US$500 million a year. Indonesia and Singapore, both ASEAN nations, supply more than 50% of total imports and followed by China and Australia, while Germany, USA and Portugal are the leading export trading partners with an 80% share of all exports[368]. The value of food imports over total merchandise exports increased from 48% in 2003-05 to 343% in 2010-13[369], indicating potential food security vulnerability when oil revenues and foreign exchange dwindle. Agricultural products represent 20% of all imports, while the leading export commodity is coffee (over 30% of all exports in value, including re-exports)[370] and accounting for 91% of non-oil merchandise exports in 2017. Such limited export basket and negative trade balance are signs of lack of economic diversification. Annual exports averaged US$17.5 million/year from 2010 to 2017 (Table 6), while revenues from coffee exports have a tendency to oscillate with a 2016 peak.

Table 6 - Trends in Agriculture Commodity Exports in Timor-Leste, 2010-2017 (US$ million)

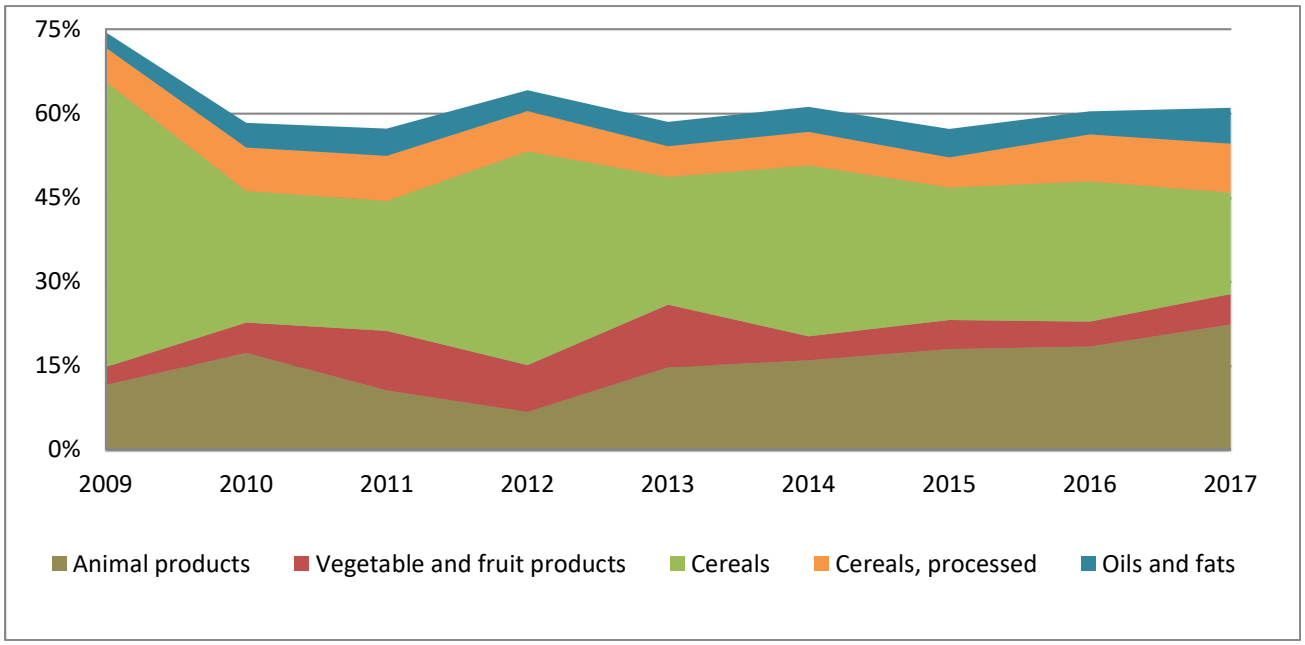
Agricultural Commodities Exports ($)	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Coffee	15,987	11,919	18,813	15,181	13,773	10,731	23,963	13,558
Teak wood / *Ai Teka*	312	85	11	17				
Candlenut / *Kami'i*	60	40	125	143	84	258	97	
Sandal Wood / *Ai Kameli*		398	834					
TOTAL exports (Re-exports not included)	**16,395**	**13,202**	**30,793**	**16,049**	**13,868**	**11,074**	**24,030**	**14,867**
% Coffee over TOTAL exports	97.5%	90.3%	61.1%	94.6%	99.3%	96.9%	99.7%	91.2%

Source: MoF, 2018 – External Trade Statistics; 2017 data calculated from monthly reports.

Timor-Leste is a net food importer country, heavily dependent on imports to meet its consumption needs. Food imports in value constitute a 21.2% average (2009-2017) of total merchandise imports (see Table 8 in Appendix). Rice imports were 190,000 Mt in 2016/17 to satisfy local demand and fill the domestic production gap[371], with a cereal import dependency ratio ranging from 30 to 40% according to MAF[372]. It is estimated that for 2017/18 marketing year, total cereal imports will remain close to the already high previous year, reflecting reduced cereal production and more than doubling the average amount imported during 2009-2013. The value of cereal imports, mainly rice, represented 28.1% of total food imports[373] or almost US$32 million for 2017[374]. Fischer (2016) estimates that the total available food (in milled rice equivalents) is barely adequate to support population needs on an energy basis.

To illustrate food imports expenditure trend, Figure 35 presents the value of types of foods over the total value of food merchandise imports[375] (see Table 9 for disaggregated list). Cereal needs in 2012 spiked due to a sharp decrease in maize and paddy production in 2011 and contracted in 2013 after a record high level of rice output in 2012[376]. While cereals have been the dominant food category in terms of imports value, in 2017 animal-source foods were the highest (22.4% with a noticeable growing trend. Yet if cereals and processed cereals (including instant noodles) are aggregated, their combined weight is higher, 26.8%. While the chart presents value and not amount of imported food groups, it is indicative of the increase in demand for protein-rich products and rising incomes for some sectors of Timorese society. The imports value share of vegetables and fruits has contracted since 2014, perhaps due to developing horticulture value chains, while for oils and fats has been stable overtime at around 4-5%, and processed cereals have increased their share since 2013 to 8.8% in 2017.

Figure 35 *– Value of selected food imports by group as % of total value of food imports in Timor-Leste, 2009-2017*



Source: Created from MoF, 2018 – External Trade Statistics.

By 2025, the projected real price of all key commodities for Timor-Leste is no greater than in 2006 except for commodities in high demand as income grows, such as, maize and palm oil with higher prices, and sugar with lower ones (Table 7)[377]. Timor-Leste food imports focus not only on rice but also on meat, wheat, sugar products, and vegetable oil. However, a low import parity price (world price adjusted for exchange rate and tariffs and port costs) for food poses challenges for Timorese producers that sale food surplus. These are important considerations for low-income farming households, as an ADB (2011) study estimated that a 10% rise in food prices in Timor-Leste could increase poverty incidence by 2.25[378].

Table 7 - Real and projected world prices for commodities of importance for Timor-Leste

Commodity	Unit	Real price (2010 US$ per unit)				
		2006	2008	2012	2015	2025
Rice, Thai 5%	tonne	339	632	523	365	329
Maize	tonne	136	217	277	161	176
Coffee, Arabica	kg	2.80	3.00	3.82	3.34	2.81
Sugar	kg	0.36	0.27	0.44	0.28	0.30
Palm oil	tonne	532	922	929	589	642
Chicken meat	kg	1.70	1.81	1.93	2.39	1.76
Wheat US HRW	tonne	214	317	291	192	217
Crude oil, average	barrel	71.50	94.32	97.60	48.0	66.3

Note: WB used inflation indices of 105.7 and 124.7 (2025) relative to 100 (2010) to link real and nominal prices.
Source: WB, 2016 (in Fischer, 2016:26).

Agriculture international commodity markets

Timor-Leste has the potential to commercially develop a range of agricultural products for the domestic and export markets[379] provided it addresses the key constraints identified in this paper. Exportable commodities are coffee, followed by other forestry products such as high-value hard woods, candlenuts and coconut, spices, live cattle, and other cash crops such as legumes[380]. Undeveloped opportunities exist to increase cross-border trade with Indonesia and continue historical trading patterns of selling internal surplus reflected in informal export arrangements[381]. These are conditional to a favorable Rupiah exchange rate and enactment of trade agreements, while requiring increases of quality control across the value-chain and significant investment, for example in slaughter facilities.

Coffee is the top agricultural commodity, with latent potential to increase from its low base to estimated annual export sales of about US$45 million[382], and impact on poverty. The SDP frames Timor-Leste as the largest single source of organic coffee in the world[383] and well placed to capitalize on the strong foreign import demand for such high-grade coffee. Differentiated specialty markers pay premium prices for quality, origin, production processes and environmental sustainability, offering the possibility to develop a market for niche coffee with geographical identification as added value and promote the Timor Hybrid unique variety, recognized as high quality in the international market[384]. The recent Timor-Leste Coffee Association and its growing Timor Coffee Festival is an advancement to improve coordination of private sector stakeholders and linkages with international markets[385].

Timor-Leste´s topography is suited to develop agroforestry products, including teak and sandalwood that have been exported in the recent years (Table 6). Global demand for wood products is predicted to remain strong, which is expected to grow by about 300% over the next 35 years, from 500 million m^3 in 2013 to 1,500 million m^3 in 2050[386]. Asia's economic growth has driven regional timber demand growth of over 20% CAGR (Compound Annual Growth Rate) between 1980 and 2008[387]. An expanding regional demand for timber and wood products, led by countries with rapid growing economies, has been based on growth in both export-oriented processing and manufacturing industries and domestic consumption[388].

Candlenut is a non-timber forest product with an export value of $US258,000 in 2015, exported to West-Timor, Singapore and Australia[389] while some production with organic certification is processed into oil and traded to Hawaii[390]. Local companies report capacity to sell greater production volumes yet low quality is an impediment, as it is for copra –in high demand in the region, which is sold for a low price to West-Timor as a result[391]. While coconut productivity is only 11% of the SEA (South East Asia) mean (Table 10 in the Appendix) it is grown by 51% of households[392] particularly in Eastern municipalities, including

Viqueque that used to have a viable coconut industry now not very productive[393]. Past virgin coconut oil production initiatives have been unable to reach competitive market prices[394], while other argue that there are economic opportunities when certified organic[395]. There is also conceivable scope to manufacture small household products from its wood[396].

A TOMAK value chain study concludes that cloves, black pepper and vanilla offer the best potential for further spice development in Timor-Leste, with an estimated annual production of 40 Mt, 20 Mt and 8 Mt respectively[397]. Despite global demand for spices is increasing, prices show a downward trend due to increasing and intensified production by counties like Vietnam or China, in a market mostly supplied by smallholders. The global consumption of spices is concentrated in the Asia-Pacific region, accounting for 70% by volume, while in Western markets there is an increasing consumer demand for quality and sustainability certified spice products[398]. Traditionally, small amounts of different spices have been grown wild in Timor-Leste. Recent increases in spice production have been made possible through access to export markets liked to coffee exporters, and over the past 3 years USAID-funded projects have distributed cloves, pepper and vanilla seedlings to farmers. When accounting for these at maturity, the industry has an estimated export value of almost US$10 million, half of which would go directly to 6,000 spice farmers[399]. Vanilla (fresh bean) is showing substantial farm gate increases from US$7/kg in 2015 to US$57/kg in 2018[400]. Spices are an excellent opportunity as prices are still higher compared to most corps, and support farmers' income diversification and livelihood risks reduction.

The cattle export industry is geared for Indonesia and focusing on male live bulls. Indonesia´s demand for beef is estimated to be growing 6-8% per year, with imports likely to supply 38% by 2010[401]. It is estimated that 10,000 head/year sold through illegal border trade with a total value of around US$7.3 million/year[402]. Unofficial exports have reduced in recent years since Indonesian traders prefer fix princes in Rupiah, which has reduced its value by 30%, resulting in Timorese producers lowers US$ gains[403]. In Indonesia, there is strong demand for the Bali cattle raised in Timor-Leste, with a lower meat fat content compared with the Australian-breed cattle. Its potential to grow is dependent on increases on herd size and animal weight through improved feeding, performance of Australian live exports, and importantly, formalization of official trade channels by improving phytosanitary and quarantine regulations that would demand substantial financing. A detailed cost-benefit analysis to meet international protocols is a practical cost-effective measure that the Government could undertake to assess live cattle exports feasibility while also regulating and increasing trade with its neighbour[404].

Mung beans are the pulses with highest prospects for increased export earnings, mainly to Indonesia. In pre-Independence mung bean production was much higher than current levels, 4,000 Mt[405] compared to 1,295 Mt in 2006 and concentrated in three municipalities[406]. Limited volumes are exported to West Timor, estimated at 100-125 Mt, with attractive seasonal market price differences between peak and off-peak seasons in Kupang[407]. While export market for legumes is strong, farmers are not able to take advantage of these opportunities due to production related constrains[408].

Quality vegetables and fruits embed export possibilities because crops are labour intensive, can contribute to income generation and employment in rural areas. Selected horticultural crops suitable for off-season production can grow in pockets of micro-climates in Timor-Leste, such as snow peas[409].

Agriculture domestic commodity markets

Rice production in Timor-Leste, around 65,000 Mt in 2017, is insufficient to supply the national demand and requiring rice imports of around 190,000 Mt[410]. The current irrigated rice policy and MAF large public investments in irrigation, totalling US$60.9 million (2008-2018)[411], have been unsuccessful at meeting the domestic production gap, partly because the strategy is uneconomic[412]. The current importation policy, with imported rice almost half the price of local production, also leads to negative incentives for farmers to grow over their household consumption requirements. The lack of profitability associated with irrigated rice production presents opportunities to shift irrigated cropping systems to include non-paddy crops, such as cash crops like legumes grown in rotation with rice and replacement for intensive fodder or feed grain production for livestock[413]. Timor-Leste's irrigation sector strategy had absorbed US$82 million by 2015, while generating very low level of returns on the sunk costs already invested[414].

Box 5 - The rice paradox in Timor-Leste

- Rice is the preferred staple for consumption
- Prior Indonesia´s colonization, main staples were corn, roots and tubers
- MAF subsidizes inputs: irrigation, seed, machinery; yet large areas of paddy land are grazed by ruminants, rather than cropped
- Many major irrigation schemes produce negative economic rates of return, including limited water flows in the dry season resulting in low cropping intensities (1.2 maximum) and absorb resources
- National rice purchasing schemes are limited
- Reversion to traditional rice production systems due to lack of domestic marketing opportunities
- It is far more expensive for Timor-Leste to grow rather than to import rice
- Given the high import dependency on rice, Timor-Leste could develop regional rice trade cooperation agreements, including via ASEAN, to ensure future low price supply and rice security
- The "concentrated rice bowl" approach is recommended, maximizing rice cultivation on existing and functional irrigated areas

Source: MoF and WB, 2015; Young, 2013 and 2014.

Maize demand opportunities are stratified in two segments, for human consumption in processed form and for non-ruminant livestock feed. The first segment included until recently a fortified product part of the School Feeding Program and developed by Timor Global, composed of 80% maize. If the 2016 pilot is scaled up nation-wide, it would require 4,300 Mt of aflatoxins-free maize on an annual basis[415] –an equivalent of 6.6% of 2015 Timor-Leste´s maize production. However, production was discontinued in 2017. The second segment focuses on the growing market for processed livestock feeds for intensive poultry and pig productions[416]. The demand for locally produced chicken and pork is growing fast with prices for the later same as for beef, while it is expected that through maize surpluses from productivity improvements and transition to rice-based diets, residual maize production will be fed to backyard pigs and poultry[417]. Such value adding to maize crops is a common trend in countries that have succeeded at satisfying staple foods demand, which in Timor-Leste is due to rice imports and not increased domestic production[418].

There is a growing domestic demand for beef and other meats due to increasing consumption and tourism, **despite most Timorese households raising livestock in order to fulfil their social obligations.** ACIAR (2017) calculations suggest annual cattle turnoff, or the quantity of fattened livestock distributed to market, to be almost double the official figure[419]. The study quantified the cattle marketing system to service the ceremonial market, municipalities slaughter, Dili slaughters, and live exports (with 5,000 heads each) and to higher value markets in Dili (with 1,000 animals to the Dili abattoir and butchers). The study estimates Dili to consume as much beef as in all municipalities combined, with 806 and 801 Mt each, while the live export market consumes a 750 Mt equivalent (yet trade was disrupted again in 2014 to present). There is potential to substitute some of the beef imports with local cattle, 160 Mt or 1,000 cattle equivalent, which requires increasing production rather than sheer number by improving forages and husbandry practices[420]. A recent TOMAK study concluded that the major restraints to efficient smallholder pig production are the lack of cost-effective supplementary diets and the lack of an efficient and stable fresh pork market; to which the analysis suggests a cut-off for a cost-effective diet below US$0.40/kg.[421].

In the legume spectrum, soy is an important crop with strong domestic demand that production has not been able to meet. Consumption of soybean products in the form of tempeh and tofu are increasingly popular and valuable sources of protein and oils. Production levels have decreased since 1997 from 1,400 ha to 900 ha over the last five years, while competition for farmers is difficult due to cheap imports –with an estimated annual volume of 300 Mt for soy and mung beans or US$1.5 million[422].

Fresh vegetables' supply and demand has been growing paired with increasing incomes, population and economic growth. A study estimated outdoor markets annual vegetable sales in Dili of over 6,000 Mt, 88% produced domestically, with a total value of US$7.8 million[423], while the HIES 2011 survey shows purchases of 7,649 Mt[424]. Extrapolated national figures indicate an estimate of around 40-50,000 Mt of vegetables produced annually, and of around 80-100,000 Mt when including those for self-consumption[425]. Domestic production remains limited and seasonal, resulting in higher prices than neighbouring Indonesia. USAID, through Avansa, is leading the development of horticulture value chains, supporting vertical integration approaches including inputs provision (especially high-quality seed) to growers by wholesalers to ensure the right types and vegetable volumes[426]. In 2017, the National Agriculture Association (ASHORTL) was formalized with the aim to improve the horticulture value chain[427]. Imported fresh vegetables were 4,758 Mt in 2011 sold in outdoor markets[428], supermarkets or restaurants; while in 2015 vegetable imports totalled US$4.37 millions[429], a clear opportunity for import substitution.

In the oils and fats sector, Timor-Leste imports palm oil from Indonesia for the majority of its needs[430], with opportunities to process coconut oil and replace annual imports of approximately US$2 million worth of this edible oil[431], which would require an extraction mill and a refinery to produce food-grade coconut oil.

Improved prosperity has also stimulated increased house building, with an expanding yet unquantified domestic demand for building poles and sawn wood for furniture and construction. There is opportunity to invest in domestically grown trees for local uses and export[432] with a clear role for the private sector. Indonesia supplies the market demand for processed wood products, which, including plywood was worth US$2.35 million, followed by furniture US$5 million and prefabricated buildings US$4 million in 2012, as well as timber products worth US$2 million[433]. A EU (2015) study found demand is being met through unsustainable harvest from declining teak plantations or illegal harvest from remnant native forests and imports of sawn wood from Indonesia. In Suai alone, it was estimated that 2,100 m^3 of rough sawn teak wood was traded annually directly from growers and sold in Dili for about US$500/$m^3$, a volume sufficient to provide full-time employment for about 320 people in wood processing industries[434]. In 2007, fuelwood consumed annually in Timor-Leste was monetized to be worth US$220 million[435], the primary source of cooking fuel for 88% of households[436].

Opportunities from changes in consumption patterns

Staple consumption patterns seem to be changing rapidly in Timor-Leste due to availability of cheap subsidized rice, social assistance transfers impact on household´s expenditure[437], reflected in much lower consumption of tubers in urban than in rural areas (0.61 vs 1.44 kg/per person per week) and a similar proportion for cereals (2.11 urban vs 2.25 kg/per person per week rural)[438]. Marketing, retail and convenience are also shaping food choices, as reflected in an increasing ratio of processed cereals packaged products imports – including high sodium, processed instant noodles, over cereal imports – mainly rice (Figure 35). For example, instant noodles are becoming more attractive than other traditional, less processed foods[439], and while recent in rural market, their popularity has rapidly grown due to taste, ease of preparation and transport – with minimal cooking fuel requirements yet make little contribution to improving nutrition[440].

The demand for meat products, and fresh produce is increasing rapidly in main urban centres as some sectors of society improve their living standards, and these changes have major implications for where sectoral investments in agriculture might be focused[441]. A growing demand for fruit and vegetables in Dili is partly being met by DP (Development Partners) support and integration with supermarkets[442], and opportunities to increase non-ruminants feed by value-adding maize surplus to meet the growing demand for meat products. However, the appetite for fresh pork and beef in Dili has resulted in higher food price inflation that consumer price inflation (2011-2013)[443]. Importantly, real income per capita is a driver of the amount and composition of food demanded, and this is increasing globally[444], as well as in Timor-Leste.

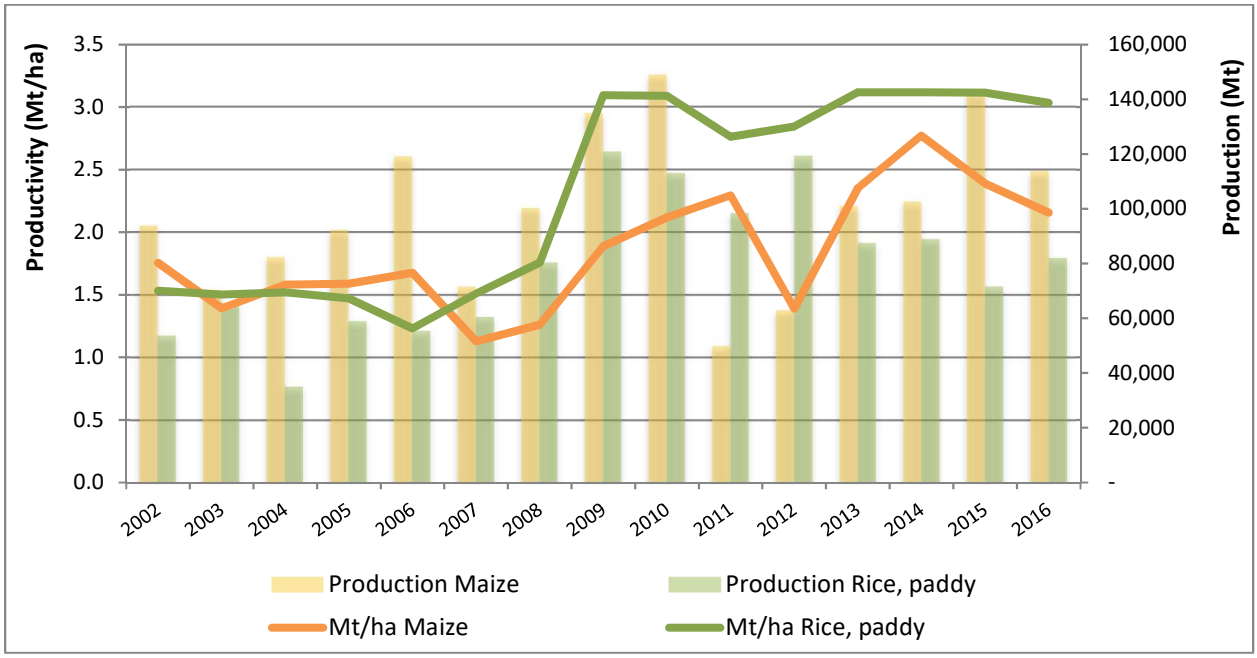
Timorese diets generally lack diversity with low consumption of meat, fish, legumes, fruits and vegetables, which would more likely improve by increasing the availability and variety of micro-nutrient-rich fruit and vegetables available in markets. Besides urban areas, there is little demand for animal-source foods and vegetable protein outside the ceremonial context. The Timorese are known as low consumers of fish and seafood compared to the rest of the region, due to a low prevalence of fishing resulting from a combination of limited know-how and technologies to fish further than the reef and cultural norms[445]. A MDF (2013) study estimated that the gap between demand and recommended consumption of legumes (soybeans, mung beans and peanuts) exceeded 50% and 10% for fresh produce[446].

Key constraints

I. Low productivity and farming practices

Timor-Leste is a predominantly agricultural country, where increased agricultural productivity (yields or Mt/ha) is an obvious potential engine for economic development and poverty alleviation, as it has been throughout Asia[447], with further gains in food security and nutrition outcomes. Yields for maize and rice, the most valued staples, have been increasing since 2012[448] while production is generally decreasing (Figure 36), despite government and development partner efforts. Data from 2016 shows rice productivity at 3.0 Mt/ha and maize yields of 2.2 Mt/ha[449]. As discussed, area harvested (ha) of both staples has consistently declined since 2008[450, 451].

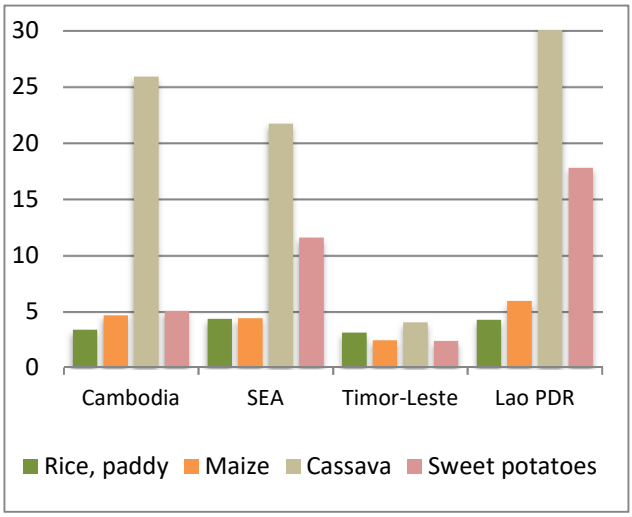
Figure 36 - Production (Mt) and productivity (Mt/ha) of key staples in Timor-Leste, 2002-2016



Source: Created from FAOSTAT 2018

Productivity of staples in Timor-Leste is substantially lower than world and regional standards, with SEA countries reporting average yields much higher for maize, cassava and sweet potatoes. For example, when comparing average staples productivity between Cambodia and Timor-Leste in 2014-2106, the later yields were 3.3, 4.6, 25.9 and 5.0 (Mt/ha) for rice, maize, cassava and sweet potatoes respectively, while for Timor-Leste these were 3.1, 2.4, 4.0 and 2.3, respectively (Table 10 in Appendix; Figure 37). Except for rice, all other yield levels are far superior in Cambodia, a reasonable country for comparison. Roots and tubers are of paramount importance for rural farmers and impoverished households as they supply food reserves during the lean season, with their current production based on broad estimates founded on area of maize grown[452].

Figure 37 - Productivity (Mt/ha) of key staple crops and selected SEA countries, average 2014-2016



Source: Created from FAOSTAT 2018.

Trials and modelling suggest[453] that the potential yield[454] for Timor-Leste is more than double than the farm yield of smallholder farmers – currently at 2-3 Mt/ha for maize and rice, reflected in a yield gap of over 100%[455]. The maize yield gap is estimated to be due to low fertility (42%), use of unimproved varieties (19%), weeds (13%), drought (10%) and intercropping (6%), indicating that improvements in soil fertility would incur highest returns[456]. The inclusion of legumes in rainfed and irrigated cropping systems as rotational crops is lacking, resulting in cereal crops not benefiting from residual nitrogen from legume crops and their weed-smothering ability[457]. As discussed, the SoL programme has released 18 improved varieties of staples and legumes crops suitable for use by subsistence farmers and free of intellectual property since 2000[458]. In 2016, it was estimated that 30% of farmers nationwide were using an improved maize variety developed by SoL[459], a crop mostly used for consumption with as little as 7% estimated to be traded[460]. Access to improved planting material and varieties farmers can increase their average return to labour by 35%, from an estimated US$4.6 to US$6.2 /day[461].

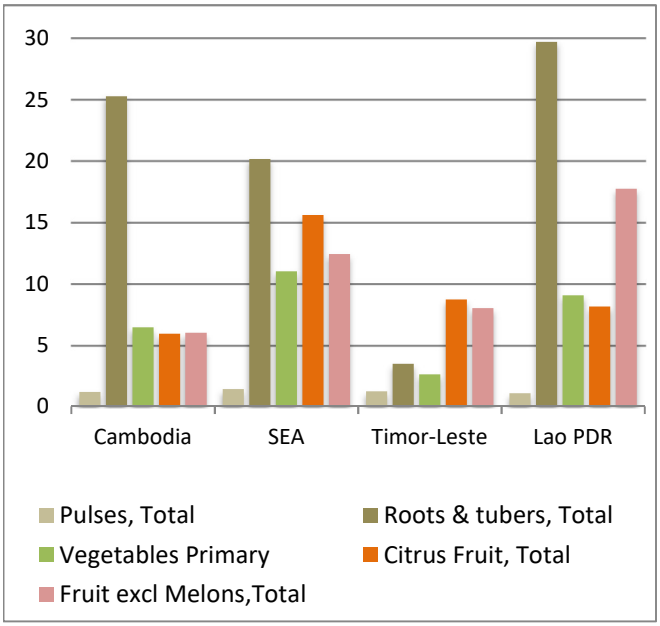
Box 6 - Conservation agriculture is characterized by three interlinking *principles*: (i) continuous no or minimal soil disturbance (i.e. direct sowing or broadcasting of crop seeds and direct placing of plant material in the soil; (ii) permanent organic matter soil cover, especially by crop residues and cover crops; and (iii) diversified crop rotations in the case of annual crops or plant associations in the case of perennial crops, including legumes.

Conservation agriculture has multiple *benefits*: (a) provides and maintains an optimum environment in the root zone to a maximum possible depth; (b) favours beneficial biological activity in the soil to rebuild soil structure and levels of soil organic matter and contribute to capture, retention and slow release of plant nutrients and water; and (c) avoids physical or chemical damage to roots that disrupts their effective functioning or limits their maximum potential for nutrient uptake. (FAO, 2017)

Bridging the maize and rice yield gaps can be achieved by improving technology, such as fertilizers, legume cover crops, simple zero-till drills and herbicides, as well access to microcredit, and applied agricultural research and extension. For example, results from a current conservation agriculture project by FAO[462] showcase substantial increases in maize yields, averaging 3.0 with traditional methods and 5.4 (Mt/ha) in maize cobs (not comparable with yields otherwise presented)[463] with conservation agriculture technologies and practices, an 80% improvement that present even higher differentials when including yields form flat lands only. Conservation agriculture adoption has also demonstrated up to 50% reduction in labour and more efficient production of maize and legumes that are better adapted to weather variability, particularly reduced rainfall and dry spells[464].

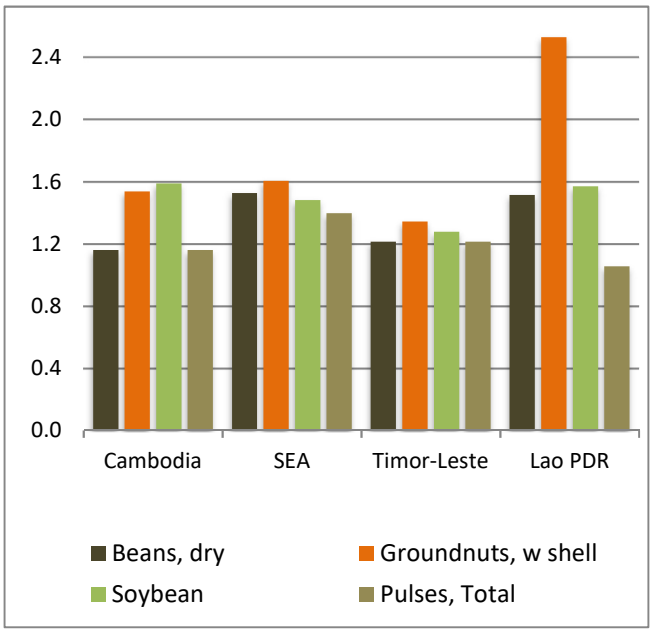
Productivity for aggregated nutritious crops in Timor-Leste, SEA countries and the regional average (2014-2016) show similar productivity for legumes and an opportunity for further production (Table 10 in Appendix). Figure 38 shows how Timor-Leste productivity for roots, and tubers and vegetables, is much lower than the SEA mean, and lower for both fruit groups while higher than in Cambodia. However, pulses productivity in Timor-Leste is 87% of the SEA average, with higher or equal productivity than the Cambodia and Laos for pulses (Figure 39)[465], indicating a potential competitive advantage worth strengthening and develop the local and the export markets, and support livestock consumption.

Figure 38 *- Productivity (Mt/ha) of aggregated nutritious crops and selected SEA countries, average 2014-2016*



Source: Created from FAOSTAT 2018.

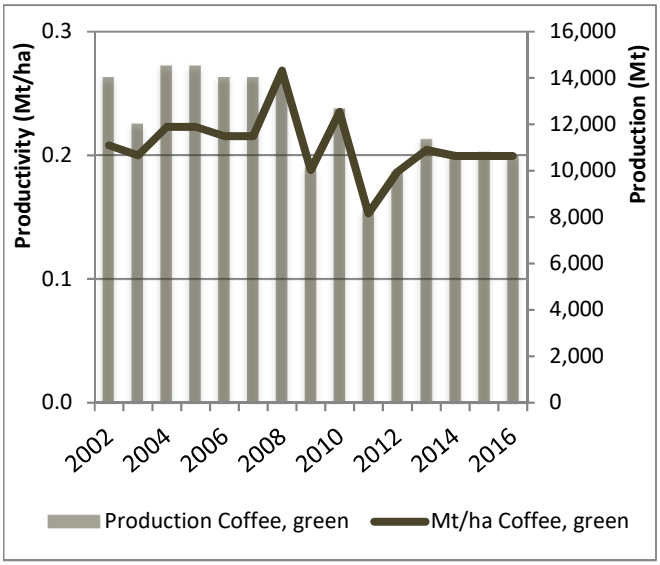
Figure 39 *- Productivity (Mt/ha) of selected legume crops and SEA countries, average 2014-2016*



Source: Created from FAOSTAT 2018.

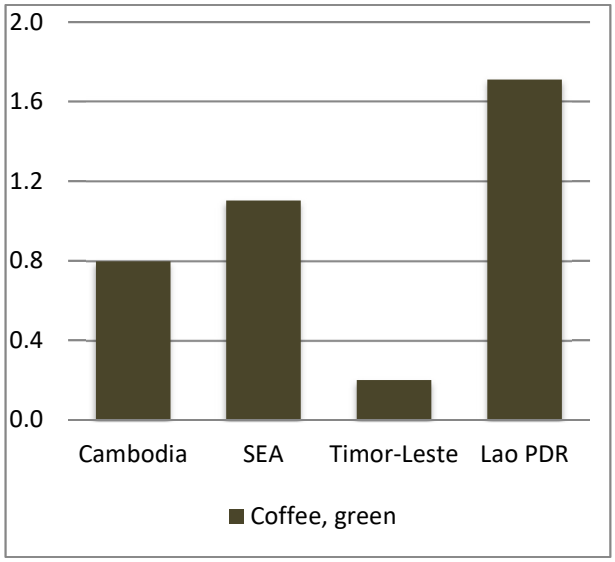
Coffee presents the lowest yields in SEA, yet all coffee grown in Timor-Leste is organic "by default". Organic coffee seems to incur at least 20% productivity reductions[466], while studies in tropical Uganda found a 75% increase in net coffee revenues by enabling farmers to access guaranteed price premiums for "certified" organic coffee. The average productivity between 2014-2016 in Timor-Leste was only 19% of the average in other coffee producing South Asian nations (Figures 40 and 41) and 10% of the yield achieved by productive plantations[467]. Applying relatively simple technologies, such as replanting, pruning and improved farmed management, have demonstrated to triple the yield per unit area and raise household´s income derived from coffee by a factor or 2.7 in Timor-Leste for a certified organic and fair trade scheme[468].

Figure 40 *- Productivity and production of coffee in Timor-Leste, 2002-2016*



Source: FAOSTAT 2018.

Figure 41 *- Coffee productivity (Mt/ha) in selected SEA countries, average 2014-2016*



Source: Created from FAOSTAT 2018.

Livestock productivity in Timor-Leste is 18-43% the SEA average, with beef and buffalo among the lowest mean with 18 and 21% respectively (Table 10 in Appendix). The main reasons for low cattle productivity per animal, less than half of what is achievable, are undernutrition caused by lack of adequate feed and water, combined with almost not management[469]. Simple interventions in the livestock sector[470], including controlled bull mating and weaning are demonstrated to double annual live weight production per kg of live animal and the profitability of beef production, may increase farmers´ income through domestic sales and increase the available protein for human consumption.

Rice and maize show the highest productivity gains since 2007, with 119% and 49% yield improvements, followed with more timid growth for pork (Table 11 in Appendix). However, productivity of other crops and livestock has slightly decreased since 2007, especially for some key food security crops like sweet potatoes or coffee which productivity has been stagnant, an important cash crop for many poor households. To ensure shared prosperity and wellbeing advances in Timor-Leste, productivity needs to further improve and rapidly.

II. Access to services and markets

Fundamental constraints to agricultural development in Timor-Leste are a small market size, young institutions paired with a weak private sector and lack of agriculture infrastructure. Following crosscutting issues comprise poor quality of extension system paired with limited rural services and resources to stimulate the agriculture sector growth, like scarce formal/informal credit. The nascent private sector is too small and with inadequate capacity to supply agriculturalist across Timor-Leste, and consequently many farmers rely on a publicly extension systems and subsidized inputs provided by MAF and DP. Producers experience market access difficulties due to insufficient rural traders, challenging road conditions particularly during the rainy season and high transport costs (as already discussed), and a general lack of market information and coordination at horizontal and vertical levels, particularly important given the large number of small producers. Other constraints involve inconsistency of quality driven by farmers' poor understanding on quality matters; poor postharvest practices, processing and marketing; and not yet systematized formation of farmers to strengthen bargaining power.

The capacity and resourcing of agricultural extension services to serve rural farming communities to disseminate improved agricultural innovations and management systems and improve national food security is limited. In 2015, 542 *extensionistas*[471] were tasked to support an average of 1,500 individuals or 277 rural households each[472] with limited operational resources. Current extension staff numbers, 342, are lower than total *suku* 422, entailing low levels of service delivery[473] and not fulfilling the "one *suku* one extension officer" policy[474]. During the Indonesian occupation, there were 700 PPL or village extension agents, double the 2017 number[475] and indicating that the current human resources allocation is meagre. If fuel consumption is devised as a proxy for public service delivery in rural communities, limited investment in maintenance and low fuel consumption have resulted in fewer services to farmers[476]. Between 2012-2015, demonstration of good agricultural practices[477] on 3,141 plots were undertaken to improve the capacity of extension staff, and more than 56,000 farmers were trained by the extension service[478]. However, with a system and staff cadre fresh from 2008[479], little resources available including transport and a sparse population in rugged terrain, the level of advice and support farmers' access is basic, if any. Nonetheless, in 2018 the MAF launched a much-needed nutrition-sensitive agriculture curriculum for extension workers focusing on the links between agriculture and nutrition, 90 of which have already been trained[480].

Delays in procurement or budget releases of key agricultural goods can have serious consequences and important impacts on agriculture services and programmes[481]. MAF offers other forms of technical assistance to farmers, including animal health services provided by the Directorate of Livestock and Veterinary, including free-of-charge vaccination for poultry´s Newcastle Disease through a network of community vaccinators. However, if vaccine supplies are delayed, it can leave livestock unprotected and result in death since these provide immunity for limited period and require periodic renewals. Timely budget execution is critical for activities targeting farmers.

Despite limited access to credit, an expanding network of 323 village-level savings and loan groups (UBSPs) supplies 7,800 members first-time savers, mostly concentrated in Oecusse[482], and with a combined loan portfolio of US$460,000 among 3,200 borrowers[483]. Subsistence smallholders' participation accounts for US$185,000 of savings and 1,180 loans averaging US$100 in value, of which probably 200 may be used for agricultural purposes, or US$20,000[484]. Credit is mainly used for consumption (school and funeral expenses, occasionally food) and as means of insurance, while a small proportion of loans is used to purchase of goods from Dili for re-sale through kiosk outlets in rural areas. Nearly a third of Timor-Leste's population does not have access to banking services, and given mobile phones' widespread use, financial inclusion strategies are focusing on alternative means of "branchless banking"[485]. Many households prefer to purchase rice or livestock from sales revenues as an alternative means of saving.

An assessment on financial services for agribusinesses and rural farmers found a credit demand of US$2.9 million, met from US$2.2 million by financial service providers and US$0.7 million attributed to value chain financing[486]. Medium-term increases in agribusiness credit demand are projected to grow, conservatively, to US$9.5 million or approximately three times the current level over the next five years[487]. When smaller scale SME agriculture enterprise suppliers, traders or processors require higher levels of debt finance they will normally be expected by banks to show equity leverage on about a 1:1 basis, which can become a constraint on business expansion[488].

While adopting the US Dollar as its official currency has anchored Timor-Leste´s economy to monetary policy in the US and helped to control inflation, it places challenges to improving international costs competitiveness. This is due to a dollarized economy and depreciating Indonesian Rupiah against the US dollar, resulting in cheap imports and less competitive exports. Commercial demand for products exists both through substitution of existing imports and/or potential demand from international markets, yet to capitalize on these opportunities multiple crosscutting issues require addressing, as stated above. Value chains tend to be short and poorly developed, with weak marketing channels and limited value-added activities such as drying, storage, processing and packaging[489]. The agriculture sector in Timor-Leste has good near-term opportunities for export growth and diversification, with far-reaching potential to impact on economic growth and rural poverty amelioration.

III. Labour structure and opportunity cost

Labour supply is a limiting factor for most households, since many youth move to urban centres for education and employment opportunities, while farming returns also compete with a US$5 opportunity cost, plus meals, to surpass the current daily wage for informal employment on labour-based construction projects in rural areas[490]. Most gross margin analyses undertaken in Timor-Leste consider the gross margin per family labour day to calculate the financial and economic returns to labour for a given crop, as already discussed. Some also do not account for the division between family and paid labour to assess real profitability[491]. However, further assessment of the labour rural market impact on agriculture labour supply could be undertaken to fully understand its real implications as farming disincentives.

Rice farmers are not responding to increased supplies of water from rehabilitated irrigation systems because of demonstrated limited financial incentives to do so[492]. The gross margins and returns on family labour from growing paddy rice in Timor-Leste are estimated at US$6.21 for improved systems and no input subsidies, with a meagre financial margin of US$1.21 over the US$5.50 per day with current rural labour daily wage[493]. Such margin combined with the risks associated with adopting novel technologies and practices are insufficient to entice rice farmers to maximize production.

Farmers see greater advantage to seek off-farm employment, or seek employment that, with a minimum wage of US$115 for 13 months, averages to US$4 per day[494]. Farming is arduous work and when returns for a day´s labour are just marginally above the "opportunity cost" salary, it seems rational for farmers to only grow their immediate families´ subsistence food requirements[495]. And when these pay differentials are assessed in the context of households receiving social transfers that enable farmers to purchase cheap imported rice, the economics of commercial farming become simply unattractive.

A range of negative incentives for farming households seems to be deterring commercial agricultural production, including access to social protection programs, the expanding cash-for-work government program (SEPFOPE) and other rural development initiatives, or the distribution of subsidized imported rice by MCIE (Ministry of Commerce, Industry and Environment)[496]. Despite showcasing a downward trend over the years, the agriculture sector is still the leading employer in Timor-Lest, as already discussed, while farmers report less labour resources in their communities and many young people seem to leave rural villages to move to urban centres.

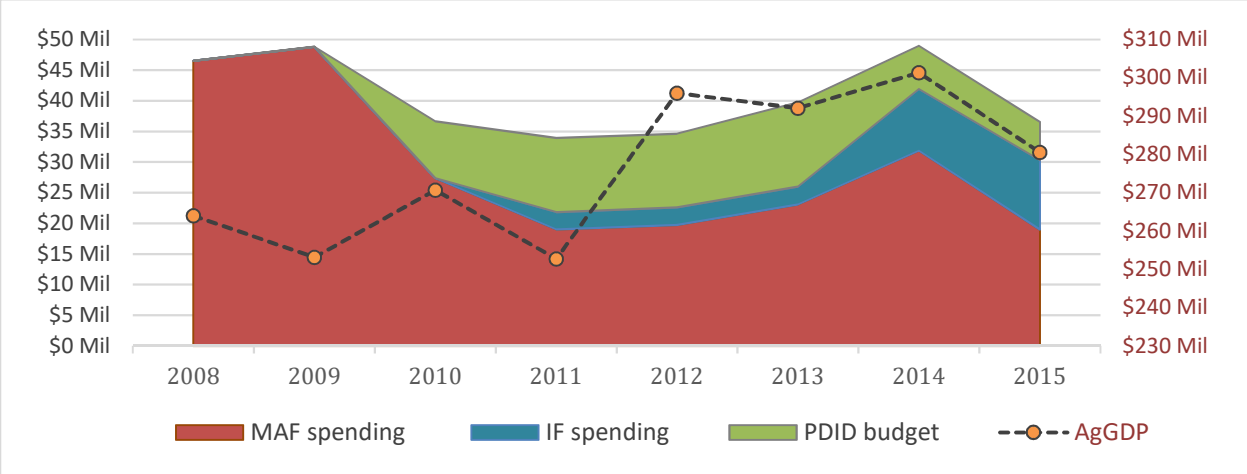
Part 5: Institutional landscape

Level of agriculture spending

Agriculture expenditure is a key government instrument to promote economic growth and poverty alleviation in rural areas. The agriculture sector is based on farmers accessing state support through input subsidies and agriculture output purchasing programs, and an emergent private sector that is struggling to develop. With 70.5% of the population living in rural areas that mostly depend on agriculture-based livelihoods, agriculture investments are also crucial to ensure food and nutrition security. The composition of government's allocation and spending reflect, or so it should, the government priorities.

Less than 2.5% of total Government expenditure was allocated to the agriculture sector, despite its critical role on the economy with 20% contributions to the non-oil GDP. This trend has led to a decrease in agriculture expenditure per unit of agricultural output, reflected in the per capita expenditure reducing from US$21 to US$15 between 2010 and 2015[497].The value of the Agriculture GDP fluctuates with yields performance –extremely sensitive to weather variability, and crop market prices, with an annual average growth of 4.7% during the same period[498]. Public investment in agriculture is comprised of MAF budget, Infrastructure Fund (IF) and sub-national programs (PDID) (Figure 42).

Figure 42 *– Government expenditure in Agriculture vs. Agriculture GDP value*

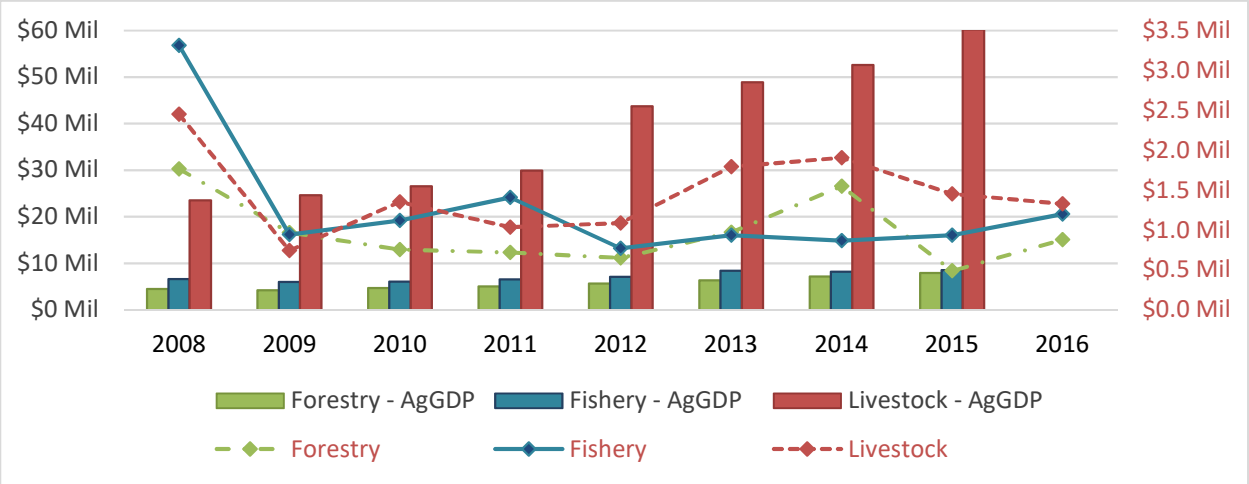


Source: Based on A-PEA, 2017:16.

The agriculture budget for 2017 was 6.7% lower than in 2016, totalling US$20.9 million –with almost a quarter managed by municipalities and US$16.2 million by MAF, in the context of contracting total state budget[499]. The 2018 duodecimal budget harshly reduced MAF's allocation to an all-time low of $7.0 million, while for 2019 MAF's budget increased to $US14.7 million –yet much lower than the average of US$21.6 for 2010-2017[500]. Goods and services constitute the largest share of MAF´s budget, representing 48 to 55% between 2013-2016 and dedicated mainly to operational expenses, up to 66% in 2019[501]. Such relatively high proportion reflects the considerable role MAF has in delivering goods and services to farmers who require public services and in an environment where there are not many alternatives.

The sub-sectoral expenditure for Livestock, Forests and Fishery is relatively a la par, while their respective contribution to the Agriculture GDP differs substantially (Figure 43). These are mostly funded through MAF´s largest programme, the Agriculture Production and Productivity[502]. The sub-sector budget average distribution for 2008-2015 was: Agriculture –crops (58%), Livestock (11.4%) and Fishery (10.1%) as well as Irrigation and Water use (15%), and Research (5%). The average ministry spending on livestock has increased to near 15% between 2014-2016, aligned with increases in its share of the Agriculture GDP.

Figure 43 - Agriculture Production and Productivity programme - sub-sector investments vs. contribution to Agriculture GDP

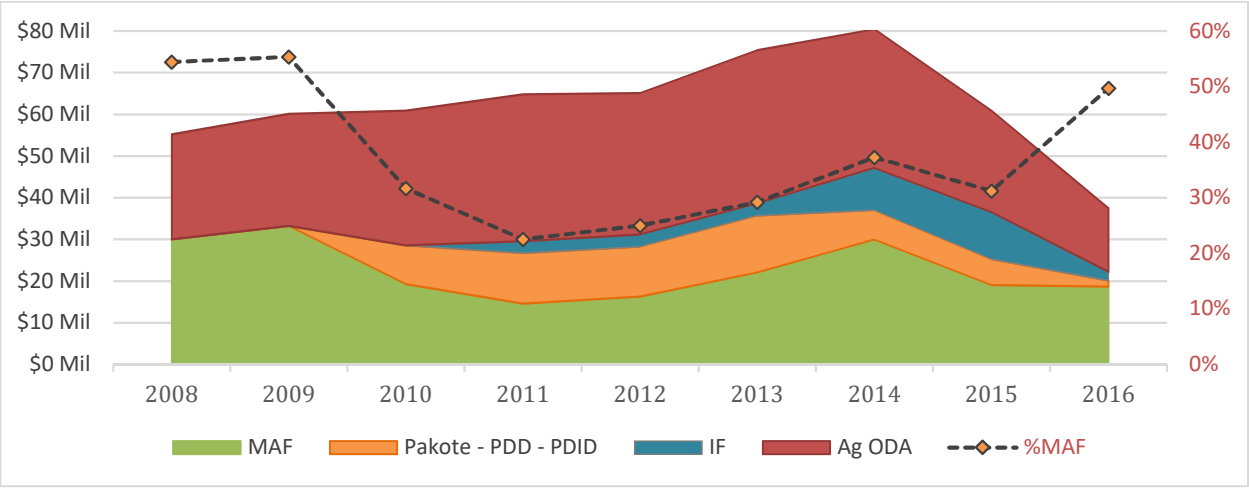


Source: A-PEA, 2017:52.

Between 2011 and 2015, US$126.2 million have been spent on agriculture related infrastructures through different budget holders[503], which is equivalent to almost 6 years of MAF's annual budget[504]. The Government has progressively increased infrastructure spending managed through the IF (Infrastructure Fund), as aimed in the SDP[505]. Agriculture represents a modest share of the IF total budget, used to rehabilitate and expand existing irrigation schemes and aimed at staple crops self-sufficient by increasing their production and productivity. However, more than 50% of planned agriculture projects have not been implemented[506].

Since 2010, ODA has systematically exceeded the agriculture sector public investment (Figure 44). Yet by ODA allocation (including loans), agriculture was the fourth highest funded sector after infrastructure, health and education[507]. For 2015-2016, the agriculture ODA reflects transition years for major DP programs with lower disbursements[508], indicating that the level of investment is expected to rise in the coming years. The agriculture donor envelope for 2017-2019 remains fairly constant at US$20.1 million average[509]. Total ODA has been reducing since 2014 and it is expected to continue this trend, particularly lead by Australia´s decreases, the largest donor, and agriculture has followed the same downward trend.

Figure 44 - Public spending in Agriculture 2008-2016, including ODA, and MAF´s share



Source: A-PEA, 2017:2.

Decentralization process and the SAR of Oecusse

MAF started to incrementally deconcentrate agriculture services in 2008, and from 2017, allocation to the municipal agriculture services is channelled directly to the municipality authorities through the Ministry of State Administration. Of the US$42 million that the 2017 State budget allocates for the first time to 8 Municipal Administrations and 4 Municipal Authorities (Baucau, Bobonaro, Dili, Ermera), US$4.7 million are for agriculture, the second largest budget after Education[510]. The agriculture budget transferred is mostly dedicated at salaries and wages (73%), followed by goods and services.

Since 2009, multiple infrastructure decentralization programmes have regionalized power and authority to accelerate operations while stimulating the economy in municipalities, access to basic infrastructure and job creation, and mitigate the potential for conflict in the short term[511]. The PDID (Decree Law for Integrated District Development Planning) represented 49% of all Government spending in Agriculture related infrastructure during the 2011-2016 period, with 65% all budgeted investments dedicated to irrigation and water management, 14% to agriculture (green houses, agriculture center, rice terracing, warehouses), 6% to livestock and 5% to training schools[512].

The Oecusse Agriculture Regional Secretariat is totally independent from the central government in terms of priority, strategy, policy and processes. This is due to the SAR of Oecusse Ambeno becoming an autonomous administrative zone in 2015, when ZEESM (Special Economic Zone in Oecusse) started managing its own investments directly. Budget is allocated to Oecusse through a public transfer. The IF program introduced in 2014 for the development of irrigation infrastructure has been also transferred to the autonomous zone, and DP support is negotiated directly at ZESSM's level. Oecusse is in a unique position to pilot innovative approaches to public service delivery with substantially more resources than the rest of mainland municipalities.

Current policy approaches

The SDP establishes the country's priorities for 2030 and emphasizes the fundamental role of the agriculture sector for poverty alleviation, economic diversification, and as a key driver for employment and economic growth[513]. To deliver the SDP commitments, MAF developed in 2012 its own Strategic Plan 2014-2020 articulated through four mutually-reinforcing objectives: 1. Improve rural incomes, livelihoods, and reduce poverty; 2. Improve household food and nutrition security; 3. Support the transition from subsistence farming to commercial farming; and 4. Promote environmental sustainability and conservation of natural resources. These are operationalized into five large programmes[514].

MAF prioritizes the strategic objectives and resources allocation intended for the agriculture sector with costs exceeding sectorial resources, through the Medium-term Operational Plan (MTOP) and Medium-term Investment Plan (MTIP) for 2014-2018. The MTOP develops each strategic sub-objective by providing detailed project and activities descriptions, while the MTIP specifies their costs estimation[515]. MTOP´s and MTIP´s anticipated role as planning and budgeting tools for the MAF is not occurring yet[516]. A renewed MAF investment strategy tailored to the next quinquennial plan is necessary.

In 2015-2017, four major DP agriculture programmes started with a combined total investment of approximately US$79 million, covering sustainable agriculture, horticulture, forestry and value chains for agricultural livelihoods[517]. There has been a positive level of coordination among leading donors to cover different sub-sectors, while the geographically is not as equitable with some municipalities hosting two programs (Aileu, Ainaro, Baucau, Bobonaro, Lautem, Viqueque) and others none (Manufahi).

Most projects link agriculture value chain economic development with nutrition and livelihood outcomes while addressing sustainability considerations. USAID's Avansa Agrikultura focuses on increased productivity and profitability of the horticulture value chain, while promoting nutrition and climate-smart agriculture, with a US$19.2 million investment over 2015-2020. DFAT´s TOMAK aims to improve agricultural livelihoods through profitable agricultural markets and support food and nutrition security, with an AU$25 million budget during 2016-2021. World Bank´s administered SAPIP is implemented by MAF and

will assist to modernize and reform its system of providing agricultural and environmental support services to increase smallholder agriculture production and marketability, worth US$21 million over 2016-2022. EU-GIZ´s PSAF component 1 focuses on promoting sustainable, market oriented, competitive and prosperous agroforestry systems to increase employment and income in rural areas, valued at US$20.5 million over 2017-2021. Other large DP initiatives include NZAid´s CACAO a US$10.5 million project in the coffee and cocoa sectors over 2015-2020; and JICA´s rice production strengthening, worth US$8 million during 2016-2021[518].

Regional integration and cooperation

Timor-Leste is seeking to enter ASEAN and achieve full membership, which would provide direct benefits by developing closer trade, investment and labour market linkages with neighbouring SEA countries. Complying with binding ASEAN legal agreements requires improved legal and regulatory frameworks for private investment, production, and trade. A 3-year USAID funded project started in 2017 aimed to reform and streamline customs operations, which would enable Timor-Leste to meet global standards, a pre-condition for ASEAN and WTO accessions[519]. Some food manufacturers are already tapping into opportunities like *Be´e Mor* that exports 30% of its mineral water to Singapore and it has the ASEAN Water Certification at a competitive price[520]. Taking advantage of Timor-Leste´s natural features suitable for a deep-sea port could enable the promotion of logistics connectivity with ASEAN nations. The Asian Development Bank (ADB) is supporting Timor-Leste in preparing ASEAN accession by 2020[521].

ASEAN´s Integrated Food Security Program provides a menu of policies for reducing and managing the chances of excessive rice price volatility. This programme was a novel response to the 2007–2008 rice crisis and has become a regional public good that may provide solutions to reducing high price volatility[522]. Through its implementation mechanism, the Strategic Action Plan on Food Security, it has focused on preventing or mitigating extreme rice price volatility through collective action by establishing regional and national food reserves, expanding food trade, strengthening market information, and increasing food productivity[523]. The last ASEAN Rice Trade Forum was held in Jakarta in 2013[524]. As an ASEAN member, Timor-Leste would highly benefit from this initiative to ensure being able to access affordable rice in the future irrespective of price fluctuations. Yet, rice prices are predicted to remain stable (see Table 7). Since production levels for rice in Timor-Leste are not able to satisfy local demand, the country relies on rice imports to supply its most desired staple. Developing cooperative measures with key rice exporters like Vietnam and Thailand, both ASEAN members, seems an adequate strategy to ensure rice security and its affordability now and in the future.

Key constraints

I. Knowledge gaps and data limitations

MAF´s current monitoring and evaluation (M&E) system is under-resourced and largely ineffective. The National Directorate responsible for centralizing information across MAF´s directorates do little in terms of data collection and analysis, despite setting the agriculture indicators standards[525]. Monitoring activities are decentralized to each directorate and result in variable data quality, and levels of completion and timeliness. With an average 2.4% of MAF´s budget, the Directorate´s allocation has been decreasing in terms of amount and share of the ministry´s budget over the past 6 years[526]. A high-quality M&E system is critical, requiring the allocation of sufficient financial and human resources to its successful operation, an endeavour that SAPIP is currently supporting. Effective monitoring also facilitates resource mobilization.

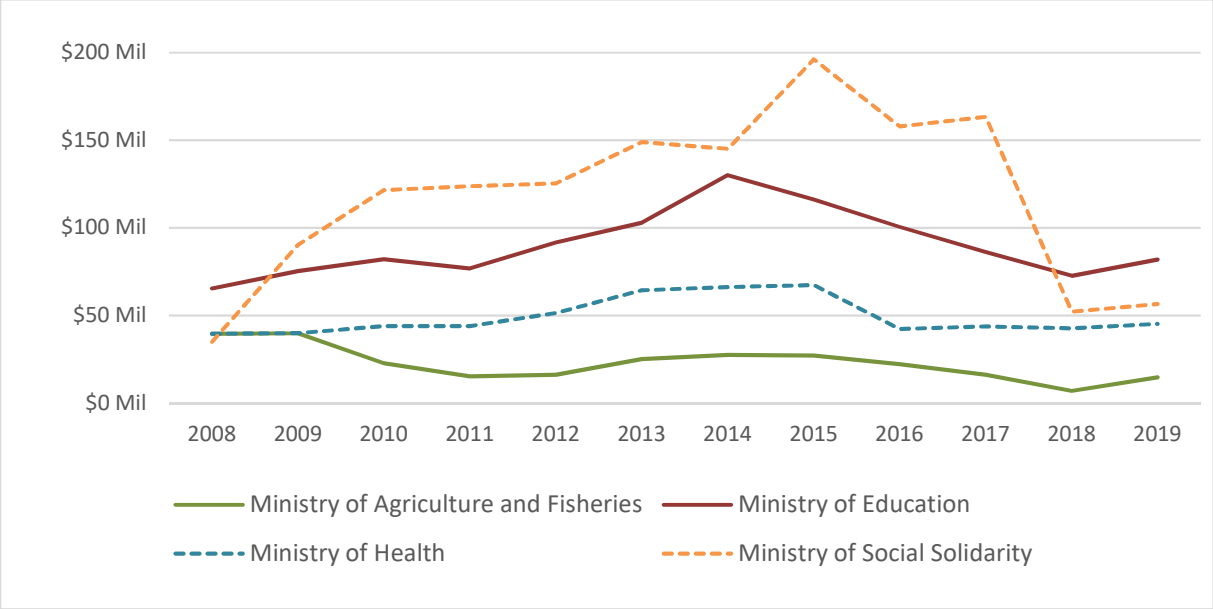
Lack of reliable and accurate information is a major constraint for effective analysis, and therefore planning, for the agriculture sector. Trustworthy and consistent data on all sub-sectors and areas are simply not available, impacting hugely on planning processes and feasibility assessments. Production, productivity and cultivated areas are estimated for key staples, while figures for other crops are grossly "guesstimated"[527]. An agriculture census would meet these needs while providing information on spatial

planning to protect productive lands and depleting natural resources from alternative uses. An Agriculture Census pilot program covering 30 *suku* is due to start in November 2018 under FAO´s patronage[528], an operation already postponed in 2011. There are also several data issues with the reliability of Timor-Leste's recorded trade figures[529].

II. Government investment, capacity and coordination

Since the political crisis of 2017-18 when the Government operated in a duodecimal budgetary environment, key ministers have faced budgetary reductions, not only MSS, but also MAF which has operated in a US$7 million budget in 2018 (Figure 45). Despite the planned increase to almost US$15 million for MAF in 2019, this level of resourcing is simply insufficient to support the livelihoods' development of over 60% of the population and the vast majority of the poor. Public investments in agriculture are not aligned with successive Governments' statements and policies where agriculture is framed as a priority sector and key to the diversification and growth of the economy. With the current level of investment, it will be extremely difficult for MAF to deliver quality results and meet the ambitious goals set by the SDP and agriculture sectoral policies. DP´s substantial contribution to agriculture is not conducive for MAF´s successful advocacy to increase annual allocations during state budget negotiations. For 2019, planned disbursements from ODA grants in Agriculture or off-budget ODA account for US$20.4 million equal to 138.8% of MAF´s line budget of US$14.7 million[530].

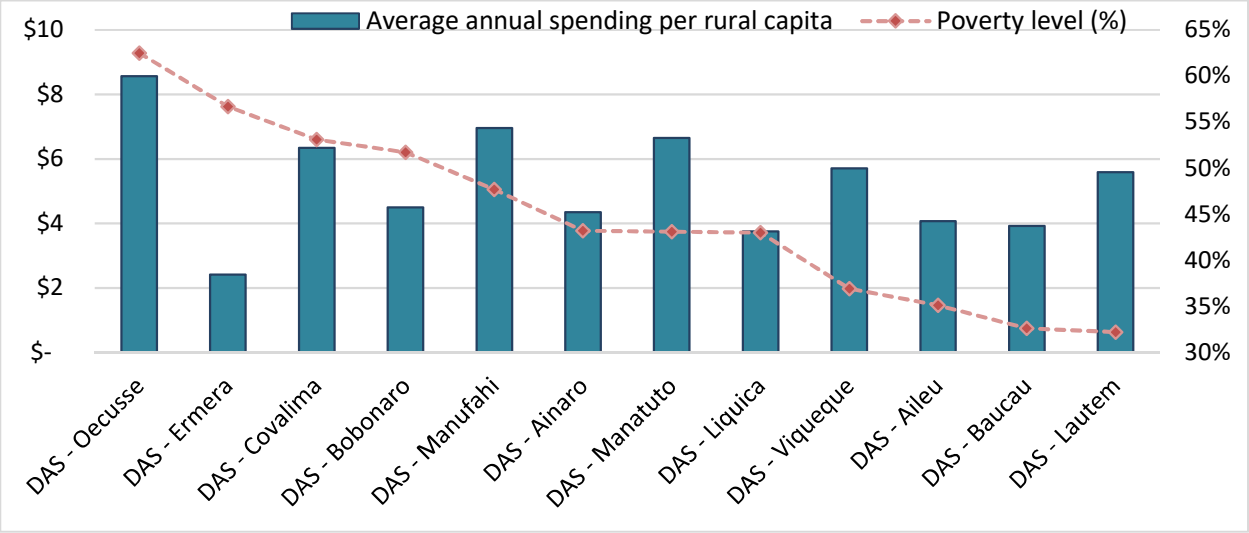
***Figure 45** - Budget trends for key line ministries 2008-2019*



Source: State Budget Book 2, 2008-2019 - Transparency Portal.

MAF´s expenditure allocations at municipal level over the last ten years do not align with poverty or population needs considerations (Figure 46), nor do for Municipal infrastructure[531]. For example, Ermera is the second poorest municipality and receives the lowest MAF investment per capita; while for PDID infrastructure, Ermera received US$20 per capita compared to US$78 in Baucau with a relatively low poverty rate. Budget allocation to municipalities should reflect different levels of needs, including population size, poverty levels area covered, and staffing. Also, municipal level vehicle maintenance budget and planned activities seem to be disjointed[532].

Figure 46 - Municipal services per capita allocation vs. poverty



Note: Average municipal budget 2008-2015, Rural population –Census 2015, and Poverty -TLSLS 2014
Source: A-PEA, 2017:61.

Public investment in the coffee sector, the leading agricultural export, is insufficient. In 2017, MAF dedicates US$712.000 to coffee plantations rehabilitation and intensification, 5.6% of the total budget for key priority programmes[533]. Coffee can also be included in part of the agribusiness portfolio of the Access to Market and Value Chain program –which receives the second lowest MAF´s budget share. While agribusiness has more than doubled its budget since 2013 to almost US$1 million in 2016 and accounting for 4.4% of MAF´s budget[534]. These levels of investment do not reflect the trade importance of this crop nor the large number of impoverished households that cultivate it. Ermera is the leading coffee producing municipality and second most populated, explaining such low per capita level of investment (Figure 46).

While MAF is allocated little resources to accomplish its mandate, the ministry´s capacity to scaling up the coverage, adherence, impact, and sustainability of agriculture programs is limited. Despite some progress, there is a shortage of skills and leadership capacity of the agricultural workforce. Among its 2,196 employees, the third largest public workforce (nearly 6%) in 2015[535], only 20% have an educational level above diploma with most (56%) being secondary school graduates[536]. Several DP projects rely on MAF´s human resources, particularly extension staff, which might increase their technical capacity through training at the cost of limiting their ability to execute their own programme and budget. There are sizeable discrepancies between planned and actual budget execution[537].

The lack of coordination and expertise between ministries is a challenge to achieving a supportive environment. Different levels of government must cooperate to tackle food insecurity, hunger, and malnutrition through agreed upon legal frameworks, technical capacities, and incentives to transfer resources and share information for accountability[538]. The objectives of agriculture growth, poverty alleviation and nutrition are intrinsically related and often mutually reinforcing. For example, given the importance of adequate nutrition on the economic productivity of the population, there is a strong economic justification for using fiscal, trade, and regulatory instruments to support the production and consumption of nutritious foods[539]. KONSSANTIL is the inter-ministerial body aimed at coordinating activities across food security, sovereignty, and nutrition, led by MAF with very modest effectiveness.

III. Contradictory policies and trade regulatory framework

Conflicting sectoral priorities and Government programs undermine the agriculture sector in Timor-Leste. Government policies in agriculture production and trade tend to conflict. MAF has the double mandate to distribute free-of-charge seeds, fertilizers and equipment whilst also promoting the development of a private market for agronomic inputs. While MAF aims to increase rice production and productivity by heavily investing in irrigation infrastructures through the Ministry of Planning and Strategic Investments (MPSI)[540], MCIE imports and subsidizes the sale of rice. This results in a double-subsidy, where the Government, using scarce resources in an inefficient manner, finances both rice demand and rice supply. Cheap rice imports also result in negative incentives for commercial rice growers. National social protection transfers and cash-for-work programs in rural areas, including SEPFOPE, further dis-incentivize the agricultural workforce. While developing an export-oriented market sector opposes focusing on poverty alleviation in rural areas that depend on subsistence agriculture. Reconciling priorities and policies should be considered.

Achieving Sanitary and Phytosanitary (SPS) standards is the most critical market access issue for Timor-Leste´s exports of agricultural products and livestock[541]. Meeting SPS standards of importing countries is a key constraint for trade, with very limited SPS capacity in Timor-Leste. Currently, coffee and candlenut exports receive the SPS certification in Singapore before they are shipped to their export destinations. To continue exporting agricultural products to Indonesia, particularly livestock, will require considerable investments to issue health certificates compliant with WTO-SPS Agreement, and integration with domestic vaccination and animal health programs[542]. Main challenges to develop and implement an SPS system include the technical and financial resourcing of the National Directorate of Quarantine and Biosecurity[543]. The current tax regime sets considerably lower taxes than in many other comparable countries in the EAP region, including a flat 2.5% customs duty tax[544].

Part 6: Conclusion and Recommendations

Summary of Challenges for Agriculture in Timor-Leste

In a country where over two-thirds of the population live in rural areas and approximately 70% of all households are engaged in agriculture, major constraints to the development of the agriculture, livestock, fisheries and forestry sectors remain embedded and difficult to address and overcome.

Vast food insecurity and poverty

- With 47.1% of the rural population living under the poverty line, and almost all of those employed in agriculture concentrated in rural areas, farming and poor households are more vulnerable to seasonal food insecurity. The hungry season occurs when food reserves finish, happening during the wet season when roads are also inaccessible for most *aldeias*, resulting in higher food and transportation costs.
- Some food security indicators portray Timorese households' resilience toward shocks as relatively good, while other consumption-based measures indicate that over a third do not access an acceptable diet, with particularly low intake levels of protein-rich foods, such as animal source foods.
- Traditional farming systems and limited access to productive resources and services result in low household production, with water availability constraining outputs and crops diversity. Despite a decreasing food deficit, Timor-Leste needs to increase productivity to meet the population needs.

Insufficient capacity and very high malnutrition

- With over a quarter of the population malnourished, particularly women and children, the nutrition situation of Timor-Leste reflects a long history of conflict and food insecurity. The resulting sub-optimal nutrition impacts on the future capacity of farming households.
- The prevalence of children with chronic undernutrition is one of the highest in the world, paired with emergency levels of acute malnutrition. Despite improvements in urban centres, stunting is concentrated in rural areas and more common among poorer households, with the Western region of the country showcasing very serious levels of both stunting and wasting.

Degraded natural resources and high vulnerability to natural disasters and climate change

- The geographic characteristics of Timor-Leste are very different from near-by Bali, with poor topsoil and almost half of the country´s terrain displaying very steep slopes. Only a quarter of the land is suitable for agriculture, with arable areas comprising a tenth of total landmass. Land degradation, soil erosion, and changes in land uses hinder agriculture productivity.
- Timor-Leste´s climate is highly influenced by El Niño weather variations that have a huge impact on farming households particularly with droughts, who are also at medium risk to cope with natural disasters.
- Models predict that climate change will significantly raise temperatures and rainfalls, including longer droughts and flood events, with major implications for food security and those whose livelihoods rely on natural resources, biodiversity and ecosystem services, particularly subsistence farmers.

Agriculture labour, low agriculture productivity and food imports dependency

- Agriculture provides employment to most the employed population, and although figures are probably higher, its role as main industry of occupation is decreasing. Rural-urban migration patterns are led by young males, probably driven by high poverty levels in rural areas, and impacting on the number and age of the human resources available in farming households.
- Many farmers, and specifically rice producers, seem to be increasingly growing for family consumption needs only. This is probably due to low market prices and productivity, in a context where social assistance transfers and access to subsidized rice for consumption support households' economies, incentivizing farmers to abandon production for sale. Small gross margin gains and relatively high earnings associated with rural labour might contribute to this pattern.

- Improvements in productivity have focused on maize and rice, and while these have more than doubled since 2008, the area cultivated and total output are following a downward trend. Lack of attention and investment on other more nutritious crops, such as legumes –that have similar yields to the SEA average, and vegetables, limit potential nutrition gains derived from food-based approaches as well as export trade opportunities. However, reliable agricultural data and statistics are largely unavailable, which hampers strategic planning and savvy expenditure options.
- Rice imports have almost doubled in recent years, partly due to poor harvests resulting from unfavourable weather conditions, but also to a general trend where total rice production is decreasing. The share of animal food imports is increasing, reflecting changes in local demand and increasing purchasing power of some societal segments, while presenting opportunities for the import-substitution market.

Insufficient investment in the agriculture sector

- Levels of public investment in agriculture are very low compared to the sectoral contribution towards non-oil GDP; while the allocation of expenditure at the municipal level, where technical and inputs support are essential for subsistence farmers, is not undertaken according to population density nor poverty prevalence considerations.
- There is a mismatch between public resources allocated to the agriculture sector and its policy expectations. High malnutrition rates and food insecurity are linked to low agriculture productivity, and higher investments in the sector are necessary to support poverty alleviation outcomes.
- Coffee is the most important cash crop and export commodity, grown by a significant proportion of the population who are mostly poor, and with extremely low productivity outputs; yet public investments in the industry´s development are negligent.
- The Government focus on irrigation infrastructure rehabilitation to increase rice production has absorbed large amounts of expenditure in recent years and yielded very poor results; at the same time, policies across multiple ministries result in double-subsidies where both demand and supply are subsidized, also generating negative incentives for farmers to produce commercially.

Pathways and Opportunities to Improve Agriculture and Food Security

1. **Address extreme poverty and the multiple burdens of malnutrition through agriculture by:**
   - Ensuring the national social protection programmes including *Bolsa da Mãe*, Social Safety Nets and Disaster Relief programmes are meeting the needs of the vulnerable and are more nutrition sensitive by improving the food transfer, which could include fortified rice, legumes or other protein sources such as tempeh or tofu, and vitamin A fortified cooking oil into the Food Security Program.
   - Increasing the availability and access (through both production and local markets) of nutritious crops/ trees/ animals that contribute to a positive diversification of the diet (fruits, vegetables, pulses, nuts, indigenous crops, seafood/ fish, small animals*)*, considering the interests of small-scale, female, young and marginalized farmers.
   - Low levels of protein consumption present an opportunity to inform agriculture investment in livestock, legumes and fisheries. Increasing the availability of protein-rich foods can support dietary quality outcomes.
   - Improving agriculture public services delivery to support the most vulnerable populations and poor farmers to increase their crop productivity and diversity in order to advance food security and nutrition.
   - Identifying leverage points (i.e. through women's empowerment and self-agency, targeted female youth programmes) for developing effective intervention strategies to promote food utilization, and specifically address individual factors, behavioural factors, and social norms and values that may constrain or reinforce healthful eating.

2. **Invest in natural resource management, biodiversity and ecosystem services by:**
   - Promoting agroforestry as a source of cash crops to export, natural resource restoration, and climate resilience. Timor-Leste needs to improve wood processing efficiency and encourage the private sector to invest and become actively involved in establishing, harvesting, processing and

processing domestically-grown forest trees for local use and for export in a sustainable way. There will also be a need to think about conservation of biodiversity of forests and their products and the potential ecosystem benefits of agroforestry (pollination, carbon sink, food and sustainable export of timber products).

- Protecting the biodiversity of coastal ecosystems through protected marine areas and through better formulation, management and enforcement of appropriate fishing practices and regulations.
- Supporting smallholder farmers to increase access to water and water infrastructure and irrigation, particularly for more rural and remote upland communities that are more vulnerable to natural disasters and food insecurity.

3. **Support a climate-smart portfolio of activities for agriculture by:**
   - Protecting against near-term seasonal variations, natural disasters, and El Niño like effects by improving early warning systems and surveillance linked to seasonal changes, natural disasters, and episodes of conflict/ social unrest.
   - Increasing stocks of soil organic carbon to improve crop yields and sequester carbon, carry out soil conservation and rehabilitation through soil erosion mitigation plans, and build resilience to drought and flooding through better watershed management strategies.
   - Diversifying farming system and crop- livestock- tree integration to increase farm scale efficiency, reduce emissions intensity and raise productivity. There should be a significant focus on reforestation, forest conservation, watershed management for small-scale irrigation and sustainable agro-forestry. Integrated agriculture is a sound strategy for such diversification.
   - Enhancing animal productivity through better animal feeding, animal health and herd structure management.
   - Investing in climate-smart agriculture strategies such as low- or no-till farming, biodiversity conservation and ecosystem services, use of companion planting, crop rotation, cover crop, terracing, perennial trees and grasses along slopes, and high yield cultivars. There are technologies such as tractors, seeders, and irrigation that can also increase yields and decrease labour. There is also insurance to provide farmers with a safety net when these methods fail and they lose crops in the face of droughts or floods.

4. **Promote agriculture-led growth through strategic "commodities" by:**
   - Investing in agribusiness development is key to increase incomes of farming households. Higher incomes are likely to translate into diets of higher quality.
   - Improving the agricultural productivity and incomes of small-scale food producers women and smallholder farmers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment. Five core crops/ animal commodities recommended are:
     - *Coffee:* Improve cultivation of coffee by rehabilitating coffee plantations, promoting integrated pest management (IMP) to maintain/ achieve organic certification, improving product quality and production processes, and strengthening value chains for high-end export markets. Establish place of origin value and promote Timor-Leste as a brand in the international coffee market.
     - *Pulses:* Increase investment in pulse crops by improving seed varieties, pest management and post-harvest processing, supporting initiatives in the South coast, and promoting legumes rotation/ inter-planting with staple crops to benefit from their nitrogen-fixing properties in soils.
     - *Livestock:* Invest in the livestock sector by improving veterinary services, medicines and disease control, expanding intensive production of meat (cow and pig) in rural areas, and of eggs and poultry in rural and peri-urban areas, strengthening their value chains, and promoting local fodder and grains value-adding to produce quality supplementary feed.
     - *Forests:* Promote agroforestry by focusing on high-value tree crops such as sandalwood, mahogany and teak, which can be intercropped with shorter-term non-timber products such as coffee, cacao and spices, to not only benefit poor farmers but also increase climate change resilience and restore ecosystem services.

- *Spices:* Expand spices plantations of vanilla, cloves and black pepper, particularly as a secondary crop for coffee or forest farmers, by strengthening this emergent sector through training to farmers to achieve high quality products and organic certification.

- Applying the livelihood typology approach to inform and plan strategic opportunities and investments that are adapted to the local context and reflect a bottom up approach.
- Concentrating rice production in areas with presently operational irrigation systems and implementing a "concentrated rice bowl" approach, which requires sufficient investment to achieve high yields and cropping intensities. Such financing could be sourced from redirecting current expenditure in public infrastructure irrigation rehabilitation schemes that cover the whole country. Implementing alternative strategies that supply auxiliary irrigation water to rice farmers through access to aquifers underlying paddy land, such as using Tube Wells and Small Pumps (TWSP).
- Increasing access of smallholder farmers to both local and export markets by supporting roads developments and their maintenance to enable adequate connectivity between producers and markets all year round. Promoting mechanisms, platforms and schemes where producers are linked with traders, which would facilitate produce to reach the market while generating a demand for higher quality and consistent production.
- Supporting MAF to use, apply and scale-up findings from extensive research by SoL, UNTL (National University of Timor-Leste) and FAO programs on improved varieties and agronomy, and conservation agriculture. Strategies should support not only productivity but also each step along the value chain from postharvest storage and processing to market access. Mitigation against aflatoxin using low-resource technologies such as drums and afla-safe[4] have important potential for the Timor-Leste context.

5. Facilitate transparent fiscal and trade environments, public services (infrastructure) and sector facilitation by:

- Advocating for the Government to increase its investment in agriculture, climate resiliency and natural resource management. The current level of investment in agriculture is not sufficient to achieve the goals established by the Government in its SDP.
- Investing in capacity within the MAF to scale up the coverage, adherence, impact, and sustainability of agriculture programmes. DP have an opportunity to support MAF by investing in on-budget financing to build its institutional and human resources capacity.
- Achieving the Sanitary and Phytosanitary (SPS) certification and comply with internationally recognized SPS requirements to enable current and future agricultural exports. To build SPS capacity and systems the National Directorate of Livestock with technical and financial assistance from DP should develop a SPS strategy, undertake a cost-benefit analysis of short-term options that might involve off-shore inspection capabilities, while aiming to establish Phytosanitary Inspection Certificates through the National Directorate of Quarantine and Biosecurity and to develop plans for each quarantine compound inspection exit points for imports and exports[545].
- Participating in regulations of the current trade environment and treaties set out by ASEAN and COP[5].

[4] http://www.aflasafe.com/aflasafe

[5] The Conference of the Parties (COP) is the supreme decision-making body of the United Nations Framework Convention on Climate Change.

Appendix

Table 8 *- Trends in Food Imports in Timor-Leste, 2009-2017 (US$ million)*

	Description Value (US$'000)								
Description	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Animals; live	18	52	25	16	69	43	85	40	1
Meat & edible meat of offal	3,919	5,116	2,042	2,600	7,594	8,120	9,951	14,053	22,704
Fish & Crustaceans, molluscs	443	662	153	402	1,135	1,853	1,375	1,191	3,475
Dairy produce; birds' eggs; natural honey	2,662	3,320	853	1,192	3,881	4,398	5,290	7,779	8,923
Animal originated products	10	24	5	7	14	13	7	20	40
Trees & other live plants, bulbs, roots	29	9	1	3	6	25	37	31	11
Vegetables & certain roots, tubers	806	1,284	591	336	1299	1,954	2,621	2,394	4,002
Fruit & nuts	587	811	299	418	695	982	1,053	1,346	1,959
Coffee, tea, mate & spices	594	873	431	598	1,484	1,148	1,746	1,666	1,899
Cereals	35,169	14,123	9,182	31,066	22,525	32,215	24,696	35,365	31,914
Products of the milling industry	1,320	1,870	1,368	2,455	3,224	2,151	2,123	3,008	6,232
Oils seeds & oleaginous fruits;	738	637	173	492	257	440	828	821	468
Lac; gums, resins, other vegetable saps	7	18	6	11	35	10	9	26	37
Vegetable plaiting materials	34	5	8	30	34	14	14	58	39
Animal/vegetable fats & oil	1,170	2,000	1,743	2,515	4,012	4,267	4,455	4,972	10,841
Meat, fish or crustaceans preparations	929	1,255	1,128	1,316	1,890	2,455	2,102	2,991	4,367
Sugars & sugar confectionery	1,580	2,079	1,831	3,121	4,026	4,399	3,924	6,455	6,250
Cocoa and preparations	18	160	174	167	96	156	158	204	365
Preparations of cereals, flour, or milk	4,223	4,694	3,156	5,854	5,423	6,377	5,648	11,870	15,473
Preparations of vegetables, fruit, nuts	830	1,174	3,287	5,987	9,088	1,617	1,756	2,538	3,605
Miscellaneous edible preparations	3,679	4,066	859	1,401	1,727	2,137	2,027	4,466	4,434
Beverages, spirits & vinega	7,793	12,197	9,275	15,725	22,210	21,162	23,087	28,448	34,891
Food industries, prepared animal fodder	64	247	313	460	553	610	618	757	971
Tobacco & tobacco substitutes	2,479	3,533	2,589	5,238	7,599	9,214	10,890	10,884	13,785
TOTAL Food Imports	**69,101**	**60,209**	**39,492**	**81,410**	**98,876**	**105,760**	**104,500**	**141,383**	**176,686**
% Cereals imported (mainly rice grain, not paddy)	50.9%	23.5%	23.3%	38.2%	22.8%	30.5%	23.6%	25.0%	18.1%
% Food imports over total merchandise imported	24.5%	20.2%	11.8%	12.2%	18.7%	19.1%	21.3%	27.9%	34.9%
TOTAL Merchandise Imports	**282,594**	**298,758**	**334,787**	**667,876**	**528,822**	**553,659**	**491,273**	**506,089**	**506,089**

Mt imported cereal (mainly rice)*	86,758	60,745	30,854	98,614	89,616			
Value of cereals imports (US$ million)	$35,132	$14,119	$9,148	$31,039	$22,510	$32,215	$24,696	$35,365
Value (US$ / Mt)	$247	$430	$337	$318	$398			

Source: MoF, 2017 – External trade statistics; *Young, 2014.

Table 9 *– Livestock (thousands), proportion of rural households keeping and ratio, 2010-2015*

Livestock	Chickens	Pigs	Goats	Cattle	Buffalo
Number ('000) 2015	929	419	158	222	128
Number ('000) 2010	702	330	152	162	96
% increase 2010-15	32%	27%	4%	37%	33%
% rural HH 2015	97%	97%	31%	35%	18%
% rural HH 2010	91%	90%	33%	31%	14%
Animals / HH 2015	6.4	2.9	3.4	4.2	4.9
Animals / HH 2010	5.6	2.7	3.3	3.8	5.0

Source: Created from Census 2010 and 2015.

Table 10 *– Productivity (Mt/ha) of selected crops and production of livestock (kg/head) in selected SEA countries (average 2014-2016) and Timor-Leste % of SEA mean*

Crop type	Crop	Cambodia	Laos PDR	SEA	Timor-Leste	TL % of SEA Avg
Staple crops	Rice, paddy	3.3	4.2	4.3	3.1	72%
	Maize	4.6	5.9	4.4	2.4	55%
	Cassava	25.9	30.8	21.7	4.0	18%
	Sweet potatoes	5.0	17.8	11.6	2.3	20%
Nutritious crops (aggregated)	Roots & tubers, Total	25.3	29.7	20.2	3.5	17%
	Pulses, Total	1.2	1.1	1.4	1.2	87%
	Vegetables Primary	6.4	9.1	11.0	2.6	24%
	Citrus Fruit, Total	5.9	8.1	15.6	8.7	56%
	Fruit excl Melons,Total	6.0	17.7	12.4	8.0	65%
Legume crops	Beans, dry	1.2	1.5	1.5	1.2	80%
	Groundnuts, with shel	1.5	2.5	1.6	1.3	84%
	Soybean	1.6	1.6	1.5	1.3	86%
Cash crops	Coffee, green	0.8	1.7	1.1	0.2	18%
	Coconuts	5.3	-	5.0	0.6	13%
	Cocoa, beans	-	-	0.4	0.1	26%
Livestock*	Buffalo meat	12.3	17.4	25.2	5.3	21%

Beef	19.7	17.3	32.7	6.0	18%
Chicken meat	1.3	0.8	2.6	1.0	38%
Goat meat	-	4.0	6.6	2.9	43%
Pork	50.9	22.3	98.8	27.4	28%

* Productivity (kg product per head)
Source: Created from FAOSTAT 2018.

Table 11 *– Productivity (Mt/ha) of selected crops and production of livestock (kg/head) in Timor-Leste, 2004-2006 and 2014-2016 averages*

Crop type	Crop	Average 2004-06	Average 2014-16	Difference
Staple crops	Rice, paddy	1.4	3.1	119%
	Maize	1.6	2.4	49%
	Cassava	4.0	4.0	1%
	Sweet potatoes	3.9	2.3	-41%
Cash crop	Coffee, green	0.2	0.2	0%
Livestock*	Buffalo meat	5.2	5.3	1%
	Beef	6.8	6.0	-13%
	Chicken meat	1.0	1.0	-1%
	Goat meat	3.0	2.9	-5%
	Pork	23.7	27.4	15%

* Productivity (kg product per head)
Source: Created from FAOSTAT 2018.

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[357] FAO, 2018c. Food loss analysis: causes and solutions - Case study on the maize value chain in the Democratic Republic of Timor-Leste. Rome: Food and Agriculture Organization of the United Nations.
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[364] Gross margin analyses: TOMAK, 2017d. Aggregator Study, for mung beans, red rice, peanuts, red onions, red beans; TOMAK, 2016. Farm level productivity improvement –for commodities included in this report; TOMAK, 2016b. Market analysis for selected agriculture products, for rice, maize, legumes, vegetables, non-ruminant and ruminant; MoF and WB, 2015. Timor-Leste Public Expenditure Review Infrastructure: roads, irrigation and electricity, for irrigated rice; USAID. 2013b. Mid-term evaluation of the Timor-Leste Consolidating Cooperative and Agribusiness Recovery Project for Coffee; and WB, 2012. GFRP: Technical Assistance to Timor-Leste "With" and "Without" Project Production and Financial Models, for multiple staples, cash cops, legumes, and livestock.
[365] USAID, 2013b:31.
[366] "Gross margin analyses have been conducted to combine information on inputs, outputs, productivity and labor required for each commodity. Given that labor supply is the critical limiting factor for most households (HHs), the key measurement used to report the analyses is gross margin per day of labor required (i.e. return to labor). In the analyses, there is no division between family and paid labor, all labor (whether paid or unpaid) is pooled. Gross margin per labor day therefore represents the effective return to total labor (paid and unpaid) for the enterprise. Note that these returns need to compete with an opportunity cost of around US$5 per day, plus meals, equal to the prevailing rural wage labor rate." TOMAK, 2016:6.
[367] TOMAK, 2016; Young, 2014; Denning, 2013.
[368] MoF, 2018 – External Trade Statistics.

[369] An indicator of shocks vulnerability measured as adequacy of foreign exchange reserves to pay for food imports, with implications for national food security depending on production and trade patterns; expressed as a 3 years average. FAOSTAT, 2018.
[370] MoF, External trade annual report 2008-2015, in A-PEA 2017:4.
[371] FAO, 2018.
[372] MAF, 2016:5.
[373] Total food imports include the value of “Beverages, spirits and vinegar” and “Tobacco and tobacco substitutes”, accounting for 27.5% in 2017, which down size the proportion of cereals over actual food imported .
[374] The increase in amount spent on cereals in 2016 does not necessarily reflect cereal insufficiency, but it could also be attributed to an increase in stocking the national rice reserves by the Centre for National Logistics (MCIE).
[375] The following categories from the Merchandise Imports (HS2) (MoF, External trade statistics) have been aggregated/included: Animal products or HS 2-5,16 (Meat and edible meat of offal; Fish and Crustaceans, molluscs and other aquatic invertebrates; Dairy produce; birds' eggs; natural honey; edible products of animal origin; Animal originated products; Meat, fish or crustaceans, molluscs or other aquatic invertebrates; preparations thereof); Vegetable and fruits or HS 7-8,10 (Vegetables and certain roots and tubers; edible; Fruit and nuts, edible; peel of citrus fruit or melons; Preparations of vegetables, fruit, nuts or other parts of plants); Oils and fats or HS 12,15 (Oils seeds and oleaginous fruits, industrial or medicinal plants; Animal or vegetable fats and oils and their cleavage products; prepared animal fats). Cereal HS 10 and Cereals, processed or HS 19 (Preparations of cereals, flour, starch or milk; pastry cooks' products) are included on their own.
[376] A-PEA, 2017:16.
[377] WB, 2016. http://www.worldbank.org/en/research/commodity-markets (accessed 27 January 2016), quoted in Fischer, 2016. Global food security and Timor-Leste; in ACIAR, 2016.
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[379] WB, 2011. Vol I.
[380] The selection of commodities is based on existing market demand for surplus production and an identifiable market chain, an existing strong production base, and agro-ecological potential to increase productivity.
[381] WB, 2011. Vol I.
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[400] See TOMAK, 2018c for an in-depth analysis of the spices value chain and detailed opportunities for farmers.
[401] WB, 2011. Vol I.
[402] Also, since 2011 the official export trade to West Timor declined, when the Indonesian Government required approval by the Directorate of Livestock in Jakarta, a complicate and lengthy compliance process that has resulted in casement of official exports. TOMAK, 2016.
[403] TOMAK, 2016.
[404] ACIAR, 2017.
[405] WB, 2011. Vol I.
[406] Covalima, Manatuto and Bobonaro. 2006 is latest data available. MAF National Directorate of Agriculture, Horticulture and Extension, in TOMAK, 2016.
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[408] Not many farmers in Timor-Leste seem prepared to accept the prices offered because of high production costs (especially hired labor) and low crop productivity. TOMAK, 2016b.
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[410] FAO, 2017 and FAO, 2017.
[411] MoF and WB, 2015. Review Of The Quality Of Infrastructure Spending In Timor-Leste, Focusing On Roads, Irrigation And Electricity, p15.

[412] MoF and WB, 2015.
[413] TOMAK, 2016b.
[414] MoF and WB, 2015. Timor-Leste Public Review of Infrastructure: roads, irrigation and electricity.
[415] The introduction of aflatoxin tests by Timor Global with assistance from MDF is a major advance for Timor-Leste, but the real challenge will be avoiding contamination in the first place. TOMAK, 2016b.
[416] There is an increasing number of small-scale pig fattening operations using rations based on maize, fish-meal, rice bran – plus locally-available feedstuffs (at least in Baucau where GIZ supported the industry and MAF distributed free pigs). TOMAK, 2016b:19.
[417] Young, 2014.
[418] TOMAK, 2016b.
[419] Census 2010-based official statistics record an annual turnoff of about 12,000 cattle, but calculations in the ACIAR (2017) report suggest a turnoff of about 21,000 in 2013 and 2014 (similar numbers in both years).
[420] ACIAR, 2017. Final report: Enhancing smallholder cattle production in East Timor.
[421] TOMAK, 2017c. Assessment of Smallholder Pig Production Development Opportunities. Dili: *To'os ba Moris Di'ak.*
[422] TOMAK, 2016b.
[423] USAID, 2013. The Fresh Vegetable Value Chain In Timor-Leste.
[424] HEIS, 2011.
[425] USAID, 2013.
[426] USAID, 2015.
[427] Avansa, 2017.
[428] The study estimated that 24% of the fresh produce sold in outdoor markets is imported, primarily potatoes, onions, and garlic. USAID, 2013:6.
[429]Observatory of Economic complexity, MIT atlas, 2015. Consulted June 2017. http://atlas.media.mit.edu/en/visualize/tree_map/hs92/import/tls/all/show/2015/
[430] Young, 2014.
[431] USAID, 2015.
[432] EU, 2015.
[433] Observatory of Economic complexity, MIT atlas, 2012. https://atlas.media.mit.edu/en/explore/tree_map/hs/import/tls/all/show/2012
[434] EU, 2015. Agroforestry.
[435] WB, 2007b. Timor-Leste: Issues and options in the household energy sector: A scoping Study. Transport, Energy and Mining Sector, Sustainable Development Department, East Asia and the Pacific Region. June 2007.
[436] TL LSMS 2014.
[437] Denning, 2013.
[438] HIES, 2011:30.
[439] Castro, A. 2013. An Approach to the Food Habits of Three Communities in Timor-Leste: Final Report. CARE International Timor-Leste, December 2013.
[440] Provo et al, 2017.
[441] Denning, 2013.
[442] USAID is leaving the horticulture sector development with the successful programme "Developing Agricultural Communities (*Desenvolve Agrikultura Comunitaria* - DAC)", and now expanded through "Avansa Agrikultura".
[443] Figure from FNSTF Quarterly Report, Issue No. 3, January – March, 2013, in Denning, 2013:23.
[444] Values up to 2050 are 1-2% per annum per capita in OECD countries yet 2-5% in other nations. Such growth is translated into increases in food demand multiplied by the income elasticity of food demand (increases in demand relative to increases in income), which generally lies between 0 and 0.5, with higher values for processed foods than staple as well as for developing countries than developed ones (Fischer, 2016:16, in ACICAR, 2016).
[445] WB, 2018.
[446] MDF, 2013.
[447] See Hazell et al. 2007 as an example.
Hazell P., Poulton C., Wiggins S. and Dorward A. 2007. *The future of small farms for poverty reduction and growth*. 2020 Vision Policy Brief 75. Washington, DC: International Food Policy Research Institute.
[448] Productivity data from 2015 does not seem reliable since it shows substantial increases in rice yields while decreasing for maize (and it is calculated from two different sources as indicated in the chart). After consulting with different MAF personnel, the 2014 productivity figure has been deemed as more reliable.
[449] FAOSTAT, 2018. Consulted in November 2018.
[450] FAOSTAT, 2018.
[451] De Almeida et al, 2017.
[452] For example, MoF's 2010 HIES reports national consumption of about 73,401 Mt of cassava and sweet potato, whereas MAF's official production figure for these two crops is about 29,110 Mt (MTOP tables); and there are no imports of these staple foods (in Denning, 2013:55).
[453] Bacon S.A., Mau R., Neto F.M., Williams R.L. and Turner N.C. 2016. The effect of climate warming on maize production in Timor-Leste—interaction with nitrogen supply. *Crop and Pasture Science* 67, 156–166.

[454] Potential yield is defined as the crop yield that could be reached in optimally managed experiments with the best varieties under full control of biotic and nutrient stresses, but otherwise experiencing the environment of the region of interest (e.g. soil type, weather including temperature and radiation, and rainfall if water-limited). (Fischer, 2016:13, in ACIAR, 2016).
[455] The yield gap is the difference between potential yield (PY) and farm yield (FY), and expressed as a % of FY.
[456] If the fertility component of the gap was simply due to N deficiency, an application of around 50kg N/ha would meet crop needs at current levels of management. However, other significant additional issues related to soil fertility (e.g. deficiencies of B, Cu, Zn etc.) are likely to reduce the N response. SoL, 2011. Timor-Leste Seeds of Life (Phase 3), Technical Advisory Group Report, p.19-20.
[457] Denning, 2013:55.
[458] See Williams et at (2016) for detailed data on adoption rates and productivity gains. In ACIAR, 2016.
[459] Young, 2016.
[460] TOMAK, 2016:7.
[461] TOMAK, 2016:8.
[462] The "Enhancing Food and Nutrition Security and Reducing Disaster Risk through the Promotion of Conservation Agriculture" Project (USAID funded) is operational in Aileu, Baucau, Ermera, Manatuto and Manufahi, while Atauro Island (Dili) data is from the "Conservation Agriculture, Permaculture and Sustainable Fisheries Management: Enhancing Food and Nutrition Security and Reducing Disaster Risk in Timor-Leste" (IBSA funded). In both projects trials compare productivity of plots by the same farmer groups using traditional/conventional methods vs conservation agriculture technologies and practices. Results include data from November 2016 to April 2017 (FAO staff personal communication).
[463] Yields are from "wet maize cobs", which are *not* comparable with maize yields otherwise presented, as the later are calculated after the maize has been dried, with lower moisture content. However, these data illustrate how by using conservation agriculture maize productivity can be substantially increased in the Timor-Leste context.
[464] Flamarique-Urdín, 2016. Conservation agriculture in Timor-Leste: experiences and opportunities. In ACIAR, 2016.
[465] FAOSTAT, 2018. Williams et al, 2017.
[466] "In a pairwise farm comparison, Lyngbaek, et al. (2001) found mean yield drops of 22 percent on shaded organic coffee farms, compared to conventional shaded coffee farms. Pülschen and Lutzeyer (1993) found mean yield reductions of 28 percent on an organic shaded coffee farm compared to a neighbouring conventional shaded coffee farm in Mexico. Yield reductions were attributed to problems in replacing inorganic nitrogen (N) fertilizers by organic N sources (van der Vossen, 2005)."
FAO, 2007. Organic Agriculture And Food Availability. International Conference on Organic Agriculture and Food Security. 3-5 May 2007, FAO Italy, p.6
[467] WB. 2011. Vol I.
[468] Mendez, England & Associates. 2013. Performance Evaluation of the USAID/Timor-Leste Consolidating Cooperative and Agribusiness Recovery Project. Dili.
[469] ACIAR, 2017.
[470] See ACIAR 2017 for cattle, TOMAK 2016 for pig.
[471] da Cruz, 2016. In ACIAR, 2016.
[472] Using Census 2015 data with a total of 838,961 rural population and 150,208 households living in rural areas.
[473] MAF´s Food Security information Unit stated that currently there are 342 ***extensionistas***, personal communication, June 2017.
[474] MAF, 2008. Policy Extension Framework Timor-Leste.
[475] During the period of Indonesian occupation (1975-1999), Timor-Leste had an extensive network of locally based extension officers, with over 700 PPL (village based extension worker under the Indonesian extension system) servicing all villages with technical advice, promotion of national programs and the provision of a range of input and market support services. MAF, 2008:11.
[476] A-PEA, 2017.
[477] PAD or *Praktika Agrikultura Diak* is a MAF program that has published detailed manuals in Tetun on how to improve productivity of 4 key crops and general good agronomy that extension agents can use. Training of farmers occurred in EU´s RDP IV working areas. Langen, 2016. Agricultural extension in Timor-Leste: experiences of the Fourth Rural Development Program (RDP IV), in ACIAR 2016.
[478] From 2012-2015, the EU funded another rural development program (RDP IV) to strengthen the agricultural extension service, following the policy framework for agricultural extension formulated by the Government of Timor-Leste. The program consisted of: agricultural education, capacity building, improvements to extension management to facilitate the interaction of extension staff with the farming community, and the implementation of agricultural campaigns. Langen, 2016. in ACIAR 2016.
[479] MAF developed a framework for agricultural extension in 2008 (MAF, 2008. Policy Extension Framework Timor-Leste)

[480] TOMAK, 2018d. New training package targets the role of agriculture in reducing malnutrition in Timor-Leste – Media release, 26 July 2018. http://tomak.org/wp-content/uploads/2018/07/Media_release_NSA-training-curriculum-launch.pdf
[481] A-PEA, 2017.

[482] INFUSE, 2014. “Saving and Credit Groups/Associations” (UBSPs) in Timor-Leste,” spread sheet as of March 2014 showing 323 groups and 7,799 members, by NGO support entity, Timor-Leste partner entity, and district location.
[483] FHI 360, 2014. USAID FIELD Brief 20: Assessment of Financial Services for Agribusiness and Rural Farmers in Timor-Leste, June 2014. Washington D.C.: FHI 360-managed FIELD-Support LWA. (cited as USAID, 2014)
[484] USAID, 2014.
[485] USAID, 2014.
[486] Demand Stakeholders: non-commercial (“subsistence”) farm households, small-scale commercial farmers, producer groups/cooperatives, input suppliers, small-scale traders/collectors, end buyers (wholesalers, processors, exporters), and domestic retail outlets. Supply Stakeholders, by Financial Service Providers: village-level savings and loan groups/associations (UBSPs), financial cooperatives (credit unions), MFIs, and the government-owned commercial bank (BNCTL); and by “value chain finance”: buyer or supplier credit provided within agribusiness chains, most commonly by lead firms/buyers to small-scale commercial farmers linked in supply chains. USAID, 2014.
[487] USAID, 2014.
[488] The analysis also reviews the Timor-Leste financial system as a whole, including financial sector policies, laws and regulations, the core institution (Central Bank Timor-Leste), the deposit and loan portfolios of the existing financial service providers (commercial banks, MFIs, financial cooperatives, and other entities), “branchless banking” as a financial inclusion solution, and the need for more detailed disaggregation of credit data. USAID, 2014..
[489] WB, 2011. Vol I.
[490] TOMAK, 2016.
[491] TOMAK, 2016.
[492] See the financial models described in Table 13. MoF and WB, 2015.
[493] MoF and WB, 2015.
[494] See the financial models described in Table 13. MoF and WB, 2015.
[495] Denning, 2013.
[496] Denning, 2013.
[497] A-PEA, 2017:18.
[498] See A-PEA, 2017:16-17 for a detailed explanation of crop outputs, weather events and market prices.
[499] The state budget for 2017 contracted by 29% compared to the 2016 rectified budget or 11% less than the original 2016 budget, totaling US$1,386,826.
MAF, 2017. Agriculture State Budget 2017, DP Agriculture working group. Power Point presentation.
[500] Ministry of Finance. 2018. State Budgets 2017-2019 Books 1 and 2.
[501] Goods and Services are largely dominated by operational expenses (Operational material & supplies, Operational Expenses, Vehicle Operation Fuel, Vehicle Maintenance, and Local Travel), which account for 75% of the Goods and Services’ budget and 72.5% of the actual expenditures. A-PEA, 2017:29. Data for 2019 from MoF, 2018b. State Budget 2019 Book 2.
[502] MAF´s is structured in 5 programmes and the Agriculture Production and Productivity receives 50% of allocations (2008-2015), and including most productive sub-sectors. See further details in A-PEA, 2017:46-48.
[503] IF – Infrastructure Fund; PDD - Programa de Dezenvolvimentu Desentralizadu, or Decentralized Development Program; PDID Planeamento de Dezenvolvimentu Integradu Distritál, or the Decree Law for Integrated; District Development Planning; PDL - Programa Dezenvolvimentu Lokal, or Local Development Program; PR - Pakote Referendum, or Referendum Package; PDIM - Planeamento de Dezenvolvimentu Integradu Municipál; PNDS - Programa Nacional do Dezenvolvimentu do Suco, or National Suco Development Program.
[504] Composed of US$ 32.1 million in Capital Development by the MAF; US$ 32.2 million spent on irrigation through the IF; US$ 61.9 million budgeted through the PDID and previous iterations of the subnational infrastructure investment program. A-PEA, 2017:39.
[505] The IF was established in 2011 and includes all multi-year infrastructure projects with a value of more than US$1 million, with more than 80% of expenditures spent in electricity and transport (roads, bridges, airports and ports). A-PEA, 2017.
[506] Since 2011, the following infrastructures have been planned to be funded under the IF - Agriculture programme: 12 Irrigations scheme and extensions in Tono, Casameta, Bebui Uatulari, Raibere phase I and phase II, Maukola, Beikala, Oebaba phase I and phase II, Buluto, Galata, Larisula, Dardau, Carau-Ulun phase I and phase II; one fishing port in Metinaro; Feasibility studies and construction of 10 new dam sites; and the new building of the ministry of Agriculture. See A-PEA, 2017:39-42 for detailed information.
[507] DPMU-ATP. In A-PEA, 2017:68.
[508] In 2015-2016, 4 major partners have initiated a new cycle of their support to the agriculture sector, namely USAID’s AVANSA, DFAT’s TOMAK, EU-GIZ´s PSAF and the World Bank’s SAPIP.
[509] Ministry of Finance. 2018. State Budgets 2017-2019 Book 5.
[510] MAF, 2017. Development Partners Program Mapping 2017, Power Point presentation”. Both provided by the MAF´s Strategic Agriculture Policy Advisor.

[511] The *Pakote Referendum*, 2009, was refined through successive iterations, from the *Programa Dezenvolvementu Decentralizado* (PDD - District Development Program), including the *Planeamento de Dezenvolvimentu Integradu Distritál* (PDID) or the Decree Law for Integrated District Development Planning, and leading to today’s ‘PDIM

projects'. The PDIM (former PDID) is a semi-centralized program which targets investments at sub-district and district level and can provide funding for infrastructure up to USD 500,000. A-PEA, 2017.
[512] A-PEA, 2017:43.
[513] GoTL, 2010.
[514] MAF´s strategic objectives covers a large spectrum of agriculture sub-sector and are articulated around 5 large programs representing key areas of opportunity: (i) enhancing production and productivity; (ii) improving market access and value addition; (iii) creating an enabling environment; (iv) organizational strengthening; and (v) sustainable resource management. MAF, 2014. Ministry of Agriculture and Fisheries Strategic Plan 2014-2020.
[515] MAF, 2014b. MTOP - Agriculture Sector Development Medium Term Operational Plan 2014 – 2018; MAF, 2014c. MTIP - Agriculture Sector Development Medium Term Investment Plan (2014 – 2018).
[516] See further detailed information on MAF´s policy and institutional framework in the agriculture sector in A-PEA, 2017.
[517] Calculated from project documents of each DP programme, and "MAF, 2017. Agriculture donor mapping 2017 spread sheet, updated June 2017". For further information on DP programs by municipality and sub-sector, see "MAF, 2017. Development Partners Program Mapping 2017, Power Point presentation". Both provided by the MAF´s Strategic Agriculture Policy Advisor.
[518] EU´s Rural Development Program V (RVP V) is a €57 million project, of which €27 million were assigned for PSAF –which has two components Agroforestry (€13M) and rural road rehabilitation (€11M), and evaluation (€3M), while GIZ co-financing €5M. Information sourced from project documents of each DP programme, and MAF, 2017. Agriculture donor mapping 2017 spread sheet, updated June 2017; provided by the MAF´s Strategic Agriculture Policy Advisor.
[519] Avansa, 2017. Usaid/Timor-Leste Signs Agreement To Assist With Reforms Of Timor-Leste's Customs Operations. Press Release 11 June 2017.
[520] JICA, 2014. Industrial Development for Timor-Leste.
[521] ADB, 2016. Country Partnership Strategy.
[522] ADB, 2013. Rice Trade and Price Volatility: Implications on ASEAN and Global Food Security.
[523] ADB, 2013:24-25.
[524] See ASEAN news, 12 June 2013. http://asean.org/asean-rice-trade-forum-to-promote-regional-cooperation-on-rice-trade-and-self-sufficiency/
[525] The National Directorate of Planning, Monitoring, Policy Development and Legal Affairs. In A-PEA, 2017:57.
[526] A-PEA, 2017.
[527] Denning, 2013.
[528] MoF, 2018c. Web news, 14 November 2018. https://www.mof.gov.tl/programa-pilotu-sensu-agrikula-ba-timor-leste-sei-hahuu-semana-oin/?lang=tl
[529] WB, 2011. Vol I.
[530] MoF, 2018b. State Budget 2019, Books 2 and 5.
[531] See A-PEA, 2017:43, 59-65.
[532] A-PEA, 2017.
[533] MAF, 2017. Presentation of MAF priorities to DP meeting; provided by the MAF´s Strategic Agriculture Policy Advisor.
[534] Calculated from charts in A-PEA, 2017:18, 59.
[535] Behind Education (49.5%) and Health (12.6%). A-PEA, 2017:24.
[536] Wickramsinghe, 2014. In ACIAR, 2016.
[537] A-PEA, 2017:22.
[538] Acosta, A. and Fanzo, J. 2012. Fighting Maternal and Child Malnutrition: Analyzing the Political and Institutional Determinants of Delivering a National Multi-Sectoral Response in Six Countries. A Synthesis Paper.
[539] Fanzo et al, 2017.
[540] The role of this new ministry is to supervise and coordinate major infrastructure investments (include irrigation scheme and public buildings), including assessing the economic impact and viability of development projects and supervising physical project execution funded from the Infrastructure Fund (IF). Coordinate and Implement the PDID and PNDS programs.
[541] See WB, 2011. Vol I, chapter 6 for a detailed account on SPS certification.
[542] ACIAR, 2017.
[543] WB, 2011. Vol I.
[544] Timor-Leste uses a uniform ad valorem tax rate of 2.5% (except for selective items, to which an excise tax is applied) that has been in force since 2008. ADB, 2015:52-53.
[545] See WB, 2011. Vol I, Chapter 6, for more detailed assessment on how to approach SPS certification.