Root and Tuber Crops: Untapped Potential for Food and Nutrition Security and Rural Livelihood Development in Myanmar

RESULTS OF A SCOPING STUDY

CIP INTERNATIONAL POTATO CENTER
A CGIAR RESEARCH CENTER

CIAT
International Center for Tropical Agriculture
Since 1967 / Science to cultivate change

CGIAR RESEARCH PROGRAM ON Roots, Tubers and Bananas

IFAD
Investing in rural people

European Commission

FoodSTART +

Food Resilience Through Root and Tuber Crops in Upland and Coastal Communities of the Asia-Pacific

SCOPING STUDY

Myanmar

Moe Aung

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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADB	Asia Development Fund
CARTC	Central Agriculture Research and Training Centre
CDN	Consortium of Dutch NGOs
CDZ	Central Dry Zone
CGMTA	Cassava Growers, Millers, and Traders Association
CIAT	International Center for Tropical agriculture
CIP	International Potato Center
COFCO	China National Cereals, Oils and Foodstuffs Corporation
CSO	Central Statistical Organization
DAR	Department of Agriculture Research
DFID	Department for International Development
DOA	Department of Agriculture
ECD	Environmental Conservation Department
EFY	Elephant foot yam
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FGD	Focus group discussion
GDP	Gross Domestic Production
GIZ	German Society for International Cooperation
IFAD	International Fund for Agricultural Development
IHLCA	Integrated Household Living Conditions Assessment
INGO	International Non-Government Organization
JICA	Japan International Cooperation Agency
KII	Key informant interview
MAS	Myanmar Agricultural Services (now reformed as DOA)
MFE	Myanmar Farm Enterprise (Now reformed under DOA)
MFVP	Myanmar Fruit, Flower and Vegetable Producers and Exporters Association
MMK	Myanmar Kyat
MOAI	Ministry of Agriculture and Irrigation
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOH	Ministry of Health (under previous government)

MONREC	Ministry of Natural Resources and Environmental Conservation
NTFP	Non-Timber Forest Product
PPP	Private Public Partnership
RTC	Root and Tuber Crops
TOT	Training of Trainers
UMFCCI	Union of Myanmar Federation of Chambers of Commerce and Industry
USAID	U.S. Agency for International Development
VFRDC	Vegetable and Fruits Research and Development Center
WB	World Bank
WFP	World Food Program

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Executive Summary

The overall goal of the Food Resilience through Root and Tuber Crops in Upland and Coastal Communities of the Asia-Pacific (FoodSTART+) project is to enhance food resilience among poor households in upland and coastal communities of the Asia-Pacific region, specifically in the root and tuber crop (RTC) -producing and -consuming households in the Philippines, Indonesia, China, India, and Vietnam. This scoping study done in Myanmar offers the chance for FoodSTART+ to explore prospects for future partnerships in another important country of the region. The study was done from October 2016 to February 2017 and included visits to selected major potato and cassava production areas to meet with respective stakeholders and market actors.

Although RTC production in Myanmar has gradually increased since the late 1990s, they still lag behind the other major crops like rice. No RTCs are included in the country's list of primary important crops even though potatoes are regularly consumed in daily meals while other common RTCs like cassava, elephant foot yam and sweetpotato are consumed occasionally. RTCs primarily contribute to food security and livelihoods through the income generated from their sale, whether fresh or processed, rather than directly through consumption.

Information from farmers and other stakeholders revealed various concerns and issues affecting RTC development in the study sites. In terms of production, farmers expressed that the lack of quality seeds of improved varieties, lack of knowledge on good agricultural practices for RTC including management of pest and diseases, high inputs costs, shortage of labor, and climate change impacts result to economic losses from RTC production. In terms of marketing RTCs, particularly potato and cassava, farmers and processors claimed that they could benefit from the development of a cottage industry for RTCs, improved post-harvest and processing facilities, availability of options for diversification, and stabilized market prices.

The key action points for addressing these issues and improving the economic productivity of RTCs include research and dissemination of quality seeds and new varieties, improved cultivation technology, access to small-scale agriculture mechanization, access to postharvest technology and equipment, availability of pricing information, availability of financing, among others.

1. INTRODUCTION

1.1 Background

The overall goal of the Food Resilience through Root and Tuber Crops in Upland and Coastal Communities of the Asia-Pacific (FoodSTART+) project is to enhance food resilience among poor households in upland and coastal communities of the Asia-Pacific region, through introducing root and tuber crops (RTC) innovations, primarily within the framework of the International Fund for Agricultural Development (IFAD) investment projects. The project objective is to identify gender-responsive needs and opportunities through vulnerability assessments among food-insecure, RTC-producing and -consuming households and to design and implement innovations that enhance food resilience with partners and local stakeholders. Further, the project will develop and validate effective partnership strategies with IFAD investment projects in promoting RTCs for food security at scale.

RTC scoping studies constitute the initial activity of FoodSTART+, contributing to Output 1 wherein subnational geographic target areas combining food vulnerability with significant RTC production and use are prioritized and mapped. The scoping studies in the main target countries of India, Vietnam, Philippines, Indonesia, and China were completed in early 2016, with the results presented at the FoodSTART+ inception meeting in Manila on February 2016.

This scoping study done in Myanmar, although not directly related to target IFAD investment projects, allows FoodSTART+ to explore prospects for future partnerships in another important country of the region. While the project currently does not have sufficient funds to continue activities beyond the scoping study stage in Myanmar, it will provide evidence and justification for seeking extra funds from IFAD or other sources to expand the project in the future.

1.2 Objective of the scoping study

The objectives of the Myanmar scoping study are:

1. To collect, collate and analyse existing secondary information on RTC area, production, processing, marketing, and consumption at the national and state/district levels where (a) RTC production/consumption is most important and/or (b) where existing or pipeline IFAD investment projects are located. This will aim to locate RTCs in the context of wider livelihood systems.
2. To collect, collate and analyse relevant information on diets, food consumption habits, and nutritional status of rural and urban men, women and children in target areas.

3. To collect, collate and analyse additional information related to the development of climate change scenarios for RTCs.
4. To identify key actors and stakeholders across public, private and civil society sectors, with whom FoodSTART+ can engage in both action research and policy inputs to improve the contribution of RTCs to food security
5. To identify key problems and opportunities for attention by FoodSTART+ in the context of partnership with relevant IFAD investment projects or development-oriented projects funded by other donors, and information gaps where further assessments on specific topics are justified.

1.3 Scoping process and visited area

The study was conducted from October 2016 to February 2017. It initially focused on potato and cassava and was based on RTC statistical data from the Department of Agriculture (DOA), Ministry of Agriculture, Livestock, and Irrigation (MOALI), also referred to as the Ministry of Agriculture and Irrigation (MOAI); as well as consultations with CIP personnel. Field visit were done in major production areas in the country as shown in Table 1. However, with information received during the cassava stakeholder workshop, the scoping study was extended to include sweetpotato and additional two areas for field visit during the last week of February.

Group discussions with farmers' groups were conducted in each visited village while interviews were conducted with value chain stakeholders from Aungban, Kalaw, and Kyonepyaw. In addition, individual potato farmers were interviewed during two potato farmers' field days organized by the Potato Association at the Heho and Naungtayar villages on October 2016.

Furthermore, Elephant Foot Yam (EFY) was included in the study as it was found to be an important RTC in some areas of Myanmar during the data gathering.

Table 1. RTC production areas visited.

RTC	State & Region	Agro-ecology	Township	Village	Remark
Potato	Shan State - South	Hill and mountains	Kalaw	Heho	One season; winter crop, after paddy
				Letpanpin	Two season; summer, pre & post monsoon
			Pinlaung	Naungtayar	Three season: summer, pre & post monsoon
			Pindaya	Kyone	Three season: summer, pre & post monsoon
	Magway Region	Central dry zone	Sinphyukyune	Sinphyukyune	Winter crop, alluvial soil
Cassava	Ayeyarwaddy Region	Floodplain (riverside and delta)	Kyonepyaw	Konemezali	
				Mawhtookone	
				Ahtaung	
			Laymyethnar	Meikthalinkone	
				Khamauksu	
Additional RTC areas visited					
Cassava and Sweetpotato	Yangon Region	Floodplain	Hmawbi	Nyaung Hnit Pin	DOA cassava production farm
					Sweetpotato production area but off season
Sweetpotato	Bago Region	Floodplain	Latpatan	Tharawall	Sweetpotato harvesting period

1.4 Methodology

The RTC scoping study in Myanmar utilized data and information from literature reviews, key field visits, and stakeholder validation workshops. The first step involved collecting and reviewing available secondary data sources on the following topics:

- Socio-economic and development context in Myanmar based on the Human Development Index (HDI) from the IFAD country office and project design documents which contain relevant livelihoods, poverty, and nutrition information.
- Overlap of IFAD investment projects, as well as relevant development projects, and RTC production areas.
- Biophysical information such as soils and climate data and the provincial level land use map, which was downscaled from global GIS related sources such as the International Center for Tropical agriculture (CIAT).
- Current and historical information on RTC production, processing, marketing and consumption, with particular focus on vulnerability factors and issues. Also includes relevant industrial applications.

- RTC value chain descriptions and key industry players in the study sites.
- Dietary, consumption, and nutrition/health data relevant to RTCs especially for women and children.
- Project reports of past national and international research and development (R&D) initiatives in the target region.
- Current planning of R&D actions, including donor presence and opportunities.
- Policy environment relevant to RTCs such as crop production planning, market/industry development, and nutrition and health policy at national, provincial and local levels, as appropriate,

The second step consisted of field appraisals through key informant interviews (KIIs) and focus group discussions (FGDs) in the identified study sites where RTCS are important for livelihoods and food security. The goals of the KII with farmers and other stakeholders were to:

- Verify secondary data and fill gaps, if any.
- Understand trends, opportunities and challenges.
- Establish contacts and working relationships for later joint actions with:
    - government agencies/institutions in the agriculture R&D, natural environment, trade and industry, planning and investment and health/nutrition sectors;
    - relevant national and international non-government organizations (NGOs);
    - value chain actors, including the private sector, at all scales and stages of RTC value addition; and,
    - implementors of previous projects that worked on RTCs.

FGDs with RTC farmers, on the other hand, were done to:

- Understand RTC production, marketing, and rural processing in the context of overall agricultural production, livelihoods, and food systems and RTC's contribution to the agro-ecosystem.
- Identify issues related to environmental vulnerability, resilience capacity, role of RTCs in post-disaster situations, and extreme weather events.
- Understand perceptions of food security and insecurity, changes in household diets, and the reasons for these changes.
- Document changes in roles and norms of men and women in livelihoods and farming, including migration patterns.
- Understand perceptions of consumption and nutrition and what is "good" food or diet.
- Adaptive or organization capacity in terms of coping with extreme weather events and climate change.

The final step done to complete this scoping study was to present and validate the results with stakeholders. The stakeholder validation workshops in each study area were participated by farmers, representatives from

government institutions, members of organizations and other relevant stakeholders. The primary objectives of the workshops were to:

- Present and validate information on RTCs and the analysis of problems, opportunities and information gaps.
- Reach a consensus for the selected focus area and priority.

1.5 Local measurements

The use of traditional measurements as standard used of weight, area, and currency are still widely used in Myanmar, even in formal measurements. In this study, these local units are use while its international equivalent are provided when possible. The conversion table below can also be used as a guide for converting from local units to international units.

Table 2. Conversion table for international units and local units in Myanmar.

	International Units		Local Units	
Weight	Metric ton (MT)	1.0	Viss	625
Area	Hectare (ha)	1.0	Acre	2.47
Currency	US Dollar (USD)	1.0	Myanmar Kyat (MMK)	1,350

1.6 Limitations

The availability of statistical information on RTCs is very limited in Myanmar, due to policy makers' dominant focus on paddy rice agriculture systems since the 1970s. In fact, a specific category for RTCs do not exist, with potato and sweetpotato classified as vegetable crops, cassava as an industrial crop and EFY as a non-timber forest product (NTFP), all of which are classified as minor crops. Therefore, while efforts have been made to check the accuracy of information contained within this report, errors are possible due to the limited availability of secondary information sources. The results presented in this report are also limited by the number of persons interviewed and the time frame of assessment.

2. SITUATIONAL ANALYSIS

2.1 National context

Myanmar is an agriculture-based country with a Gross Domestic Product (GDP) reliant on agriculture. However, following the government-led introduction of an open market economy in the early 1990s which allowed Foreign Direct Investments in the oil and gas sector and the mining sector, the agriculture sector's contribution toward the national GDP has gradually declined up until today (Figure 1).

According to latest available government statistical data, the agriculture sector contributed 24.37% of the country's total export earnings in 2015-2016 (CSO, 2016). At the same time, 61.2% of the labor force is engaged in agriculture or depends, to a significant extent, on it for its income (MOAI, 2015).

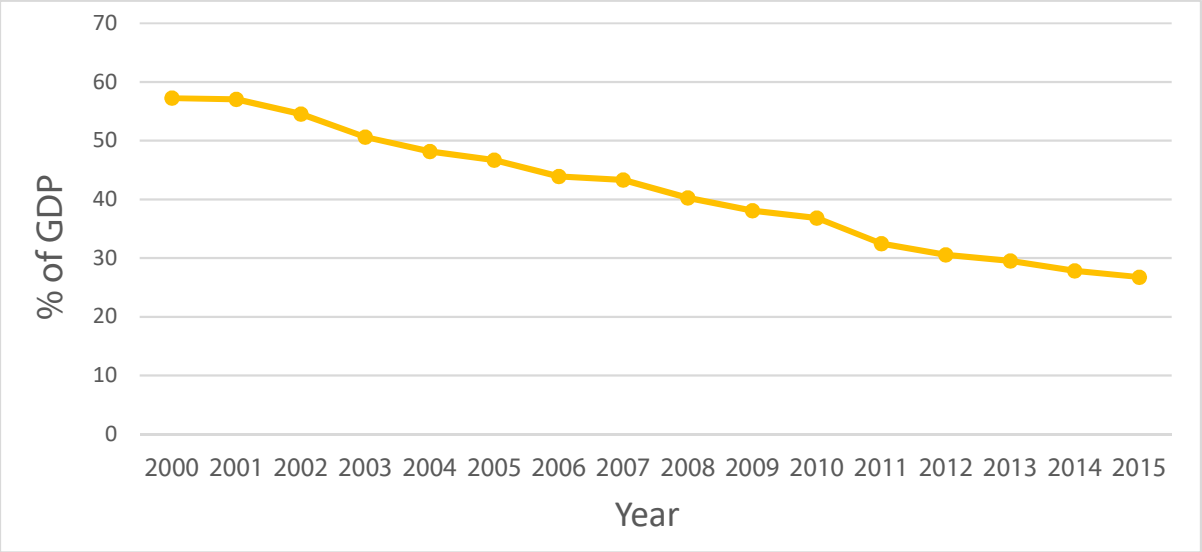

Figure 1. GDP contribution of the agriculture sector (%) from 2000-2015 (The World Bank, 2017).

Rice is the main staple food of the people of Myanmar and the agriculture policy of both past and present governments puts great emphasis on rice production. Rice also accounts for 70% of total cultivated land area and 30% of the total value of agricultural production. In recent years, rice export volume has been declining due to increased local demand from population growth and decreased supply due to a new government policy promoting beans and pulses. Since 1988, the government shifted to a market oriented economic system and the liberalization of bean and pulse trade, which led to a dramatic increase in the total sown area of beans and pulses

in Myanmar. The low production cost, short cultivation period, high rate of return of investment, reasonable profit margin even with traditional agricultural practice, and soil fertility improvement are also factors that attract farmers to expand bean and pulse crop areas.

In year 2010, 25.6% of the population in Myanmar falls under the poverty line (ADB, 2017) and despite the government's poverty reduction programs, poverty incidence only declined by 6% in 2005. Much of the poverty centers on rural areas, which account for almost 85% of the total poverty incidence. Moreover, food poverty afflicts around 5% of the population and has fallen from around 10% in 2005.

2.1.1 Climate

Myanmar has a tropical monsoon climate which is characterized by strong monsoon influences, considerable amount of solar radiation, high rainfall, and high humidity. Most of the country experience three seasons: summer season from March to mid-May, rainy season from mid-May to October, and winter season from November to February. The average annual rainfall, temperature, and humidity in each state and regions are shown Table 3.

Table 3. Climate data by state and region in Myanmar for 2014 and 2015 (CSO, 2016).

State & Region	Annual Rainfall (mm)		Temperature				Mean Relative Humidity %	
			Mean Max °C		Mean Min °C			
	2014	2015	2014	2015	2014	2015	2014	2015
Kachin State	1924	2345	30..09	30.7	20.0	19.1	76	79
Kayin State	902	1231	29.8	29.4	16.6	17.0	73	76
Kayah State	4051	4692	33.4	33.4	22.0	21.5	76	78
Chin State	1128	1578	23.9	24.2	15.4	14.7	71	69
Sagaine Region	711	774	34.9	34.8	22.1	21.5	66	68
Tanintharyi Region	5824	5627	32.7	32.2	21.5	21.8	80	81
Bago Region	3722	3366	32.9	32.6	23.2	21.7	78	81
Magway Region	605	935	35.3	34.4	21.9	20.4	69	70
Mandalay Region	624	924	35.0	34.4	23.1	22.5	67	68
Mon State	4862	5070	33.0	32.5	22.6	22.6	76	78
Rakhine State	3740	4769	31.4	30.7	20.2	20.8	85	82
Yangon Region	3136	2947	33.8	33.4	21.0	21.1	76	78
Shan - South	975	1223	29.9	29.8	16.0	15.7	72	74
Shan - North	1201	1460	25.7	25.8	14.9	15.0	69	70
Shan - East	1220	1282	30.1	29.7	17.4	17.5	68	69
Ayeyarwaddy	3091	3050	33.2	33.0	22.2	22.8	82	81

2.1.2 Soil types

There are 24 main soil types recognized in Myanmar as shown in the figure below (Figure 2).

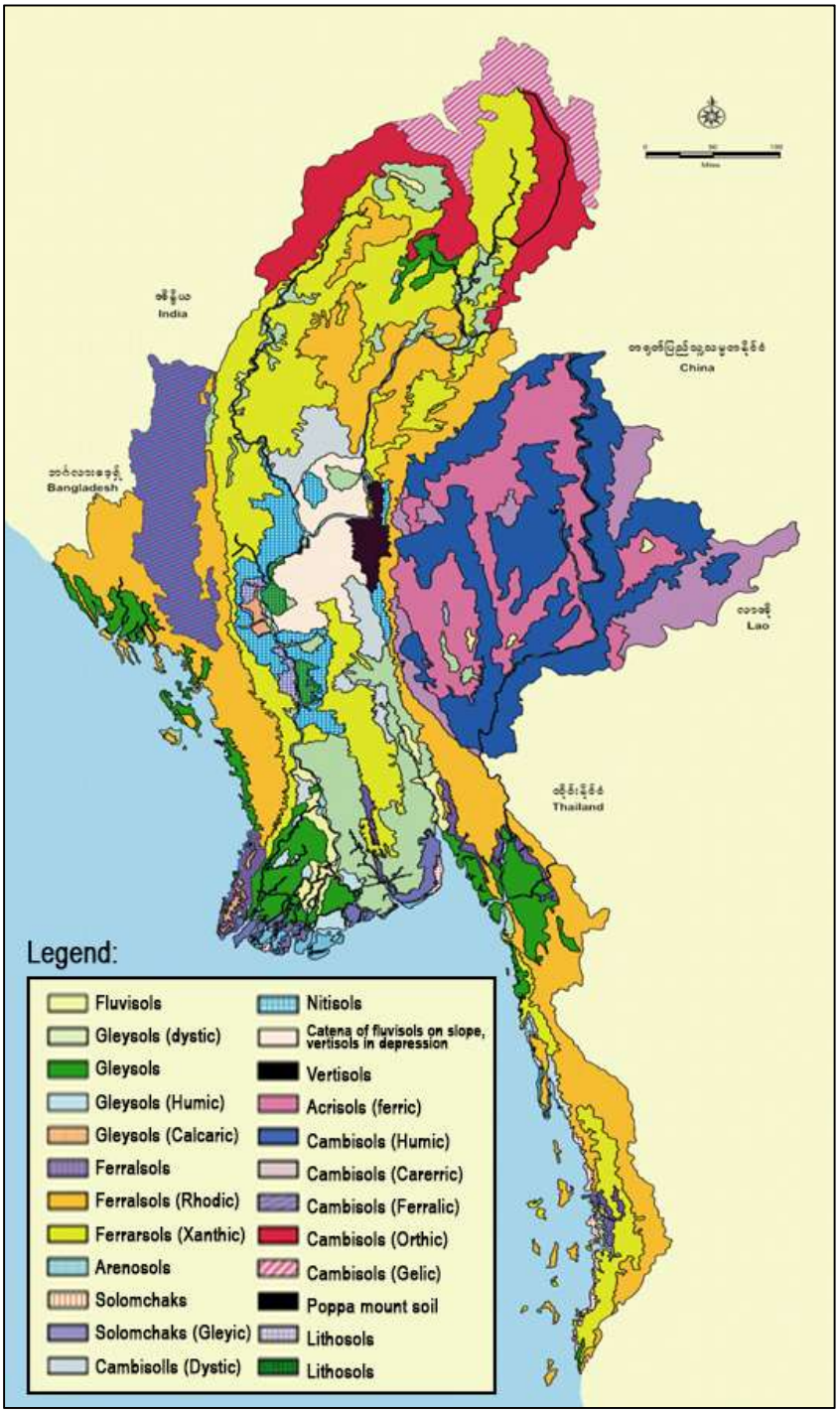

Figure 2. Soil types of Myanmar (Kyaw Yee, n.d.).

2.1.3 Agro-ecosystems

Myanmar is highly diverse in terms of its agro-ecological zones and farming systems. It has three major agro-ecologies: the delta, the central dry region, and the hill areas. These can be further divided into six agro-climatic zones as shown in Table 4.

Table 4. Major agro-climatic zones in Myanmar (FAO and WFP, 2009).

Name	Geographical Description	Administrative Area	Main Agricultural Practice
Bago, Kachin Riverside Land	Upper Delta, Kachin plain, flat plain along the Ayeyarwady and Sittaung, moderate rainfall at 1,000 to 2,500 mm.	Ayeyarwady Region, Kachin State, Sagaing, Mandalay, and Bago Regions.	Rice, pulses, oilseeds, sugarcane, tobacco, and *Kaing/Kyun* cultivation
Central Dry Zone	Flat plain, some uneven topography, less than 1,000 mm rain.	Magway, Mandalay and Sagaing Regions.	Upland crops, oilseeds, pulses, rice, cotton, irrigated agriculture, and *Kaing/Kyun* cultivation
Delta and Coastal Lowland	Delta, lowland and mouth of rivers in coastal area, heavy rainfall of more than 2,500 mm.	Ayeyarwady, Yangon, and Bago Regions, Mon and Kahyin States, Taninthayi Region and Rakhine State.	Rice, pulses, oilseeds, and nipa palm
Kachin and Coastal Upland	Mountainous, sloping land, heavy rainfall of more than 2500 mm.	Kachin and Rakhine States, Taninthayi Region, Mon, Kayin and Kayah States, Yangon and Bago Regions.	Orchards, plantation crops and upland agriculture
North, East and West Hills	Hilly, uneven topography, sloping land, moderate to heavy rainfall	Kachin, Chin, and Shan States.	Upland crops, shifting cultivation and fruit trees
Upper, Lower Myanmar and Shan Plain	Plains, plateau, upper and lower parts outside central dry zone.	Sagaing Region, Kachin and Shan States, Bago, Magway, Mandalay and Yangon Regions.	Upland crops, oilseeds, pulses, vegetable and wheat

An alternative scheme, which takes into consideration the agricultural environment formed by topography, land use, climate, sown crops, and administrative state/region divides Myanmar into four agricultural zones. These four zones are summarized in Table 5.

Table 5. Agriculture zones of Myanmar*.

	Zone I Hilly and Mountainous Area	Zone II Central Dry Zone Area	Zone III Delta Area	Zone IV Coastal Area
Administrative area	- Kachin State - Kayah State - Chin State - Shan State	- Sagaing Region - Magway Region - Mandalay Region	- Ayeyarwady Region - Yangon Region - Bago Region	- Mon State - Tanintharyi Region - Rakhine State
Climate	Rainy season: mid-May to mid-October Dry season: mid-October to mid-May Annual rainfall: 1,000 - 2,000 mm	Summer: March to May Rainy season: mid-May to October Winter: November to February Annual rainfall: 700 - 1,000 mm	Rainy season: mid-May to Mid-October Dry season: mid-October to mid-May Annual rainfall: 2,200 to 28,000 mm	Annual rainfall: 3,000 - 5,000 mm
Topography and Land Use	High mountains, range and forests Some areas high rainfall, rivers developed Crop cultivation in valley areas, shift-cultivation in hilly areas	Flat topography, semi-dry to dry condition Paddy cultivation by irrigation water. Rain-fed paddy lands are found in some areas.	Low land consists of Ayeyarwady delta and Sittaung delta Area 3.1 million ha, paddy monoculture	Cultivated areas of coastal regions of Mon, Tanintharyi, Rakhine
Major crops and potential	Rice wheat, maize, sorghum vegetables, sugarcane Soil types and topography is suitable for agro-forestry.	Rice, groundnut, sesame, pulses, oil seeds etc., various crops are sown.	Rice, pulses 60% of total rice production is produced in this zone.	Rice, rubber, oil palm oil Rice sufficiency area Potential area for development rubber, coconut and oil palm
RTC status	Major potato production (>50% share of total production) Major cassava production (about 50% share of production by one private company) EFY production can be found on forest area.	Potato production on alluvial soil during winter season	Major cassava production area (>40% share of total production with small and medium farm land holders) EFY production can be found on forest area	EFY production can be found on forest area
Issues for Agricultural Production	Forest land is degraded by shifting cultivation. Soil erosion, sediment and deficit of water resources are found. Few fertile land and low potential to manage the large scale farming.	To increase crop production depend upon the improving existing irrigation networks and maintenance canals Production of sesame depends on whether condition. Rice deficit is observed in some areas.	This zone cannot be classified as problematic one for agricultural production, but more renovation on flooding and drainage protection becomes necessary.	Flood protection and drainage improvement are required.

**Information gathered from the DOA.*

Myanmar's broad range of elevation, latitude, temperature and rainfall result to wide climatic diversity. The maximum daily temperature ranges from an average of 32 degrees Celsius (°C) in the Delta to 21 °C in the hill region. The average rainfall ranges from 5000 mm along the coast to 2,500 mm in the Delta and about 600 mm in the Dry Zone. This diversity gives rise to an enormous variety of microclimates (Figure 3).

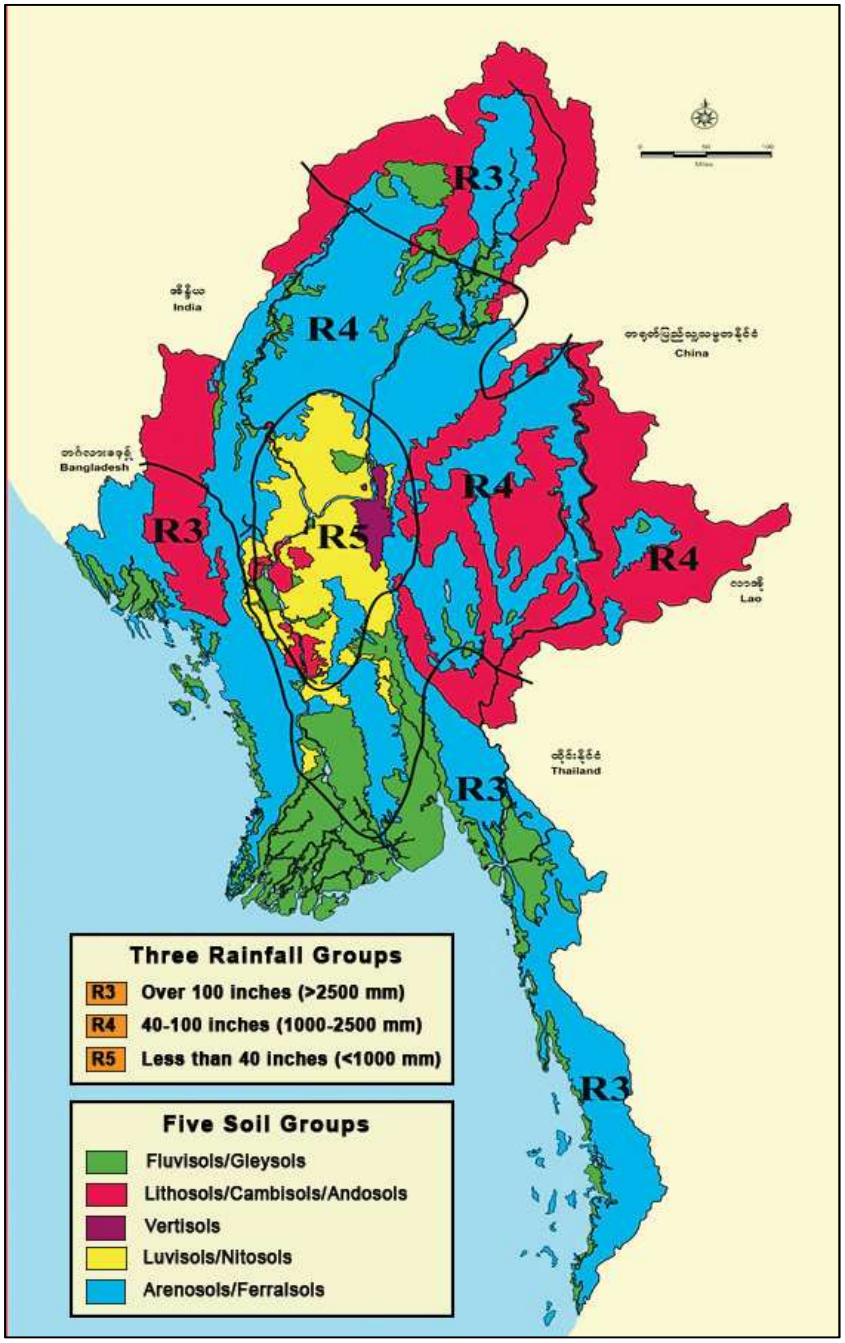

Figure 3. Agro-ecological zone of Myanmar (Myo Kywe and Kyi Toe, 2015).

2.1.4 *Land utilization*

Over 50% of land area in Myanmar is covered by forest. Land resources data indicates that 18% of the total national land comprises cultivable land including net sown area, fallow land, and cultivable waste land. Myanmar land utilization from 1995 to 2015 is shown in Table 6 below:

Table 6. Land utilization of Myanmar from 1995-2015 in '000 ha (MOAI, 2015).

	1995-96	2000-01	2010-11	2012-13	2013-14	2014-15
Net area sown	8,910	9,909	12,021	11,841	11,869	11,986
Fallow land	1,231	686	230	439	457	443
Cultivable waste land	7,971	7,205	5,396	5,361	5,285	5,267
Reserved forest	10321	12,914	17,916	18,305	18,596	18,574
Other forest area	22,079	19,786	15,630	15,207	14,842	14,734
Other land	17,147	17,159	16,467	16,506	16,611	16,656
TOTAL	67,659	67,659	67,659	67,659	67,659	69,659

It was noted that the percentage of total cultivable land area was slightly declining in the time period analyzed, as shown in the figure below. This is due to residual area expansion.

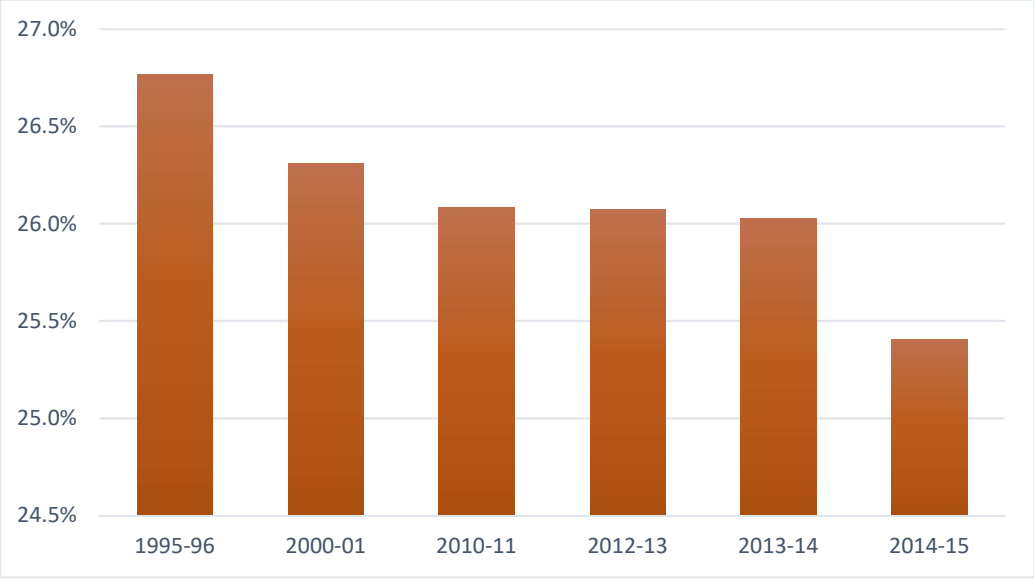

Figure 4. Percentage of total cultivable land from 1995-2015 (MOAI, 2015).

Moreover, land holding size varies considerably across regions. In 2012, 26% of households in the hilly zone and 72% in the delta/coastal zone did not own land. Among households owning land, the size of land holdings varied widely. In the delta/coastal zone, 26% of these households owned two hectares or less, while in all other regions, most of them held less than two hectares. Similarly, the average size of land holdings in the delta/coastal zone was much larger than in any other area at 6.7 ha against 1.4 ha in the hilly zone and 2.5 ha in the dry zone (LIFT, 2012).

At present, the Myanmar Government is promoting the development of agricultural land through: 1) reclamation of fallow and cultivable waste land; 2) development of farmers' embankment and paddy-fish integrated farming in deep water areas; and 3) protection of soil erosion and development of terrace farming in high-land areas. Land improvement is also being undertaken in the existing agricultural land through better drainage, irrigation, and farm roads. Apart from the traditional small-scale crop cultivation, development of modernized large scale agricultural farming by the private sector is being encouraged.

2.1.5 Land use

Multi-cropping has been practiced for decades in Myanmar. With the current cropping density at 172%, the cultivation of crops exceeds the total acreage by large margin. This is possible because of double or triple cropping being done per year, depending on the availability of irrigation water and capital investment. The status of sown area and production of different crop groups in 2014-2015 is shown in Table 7 below.

Table 7. Cultivated area and total production for various crop groups in 2015 (MOAI, 2015).

	Sown Area ('000 ha)	Production ('000 MT)	% of Total Area
Cereal Crops	9,600	34,355	30%
Oil Seed Crops	3,950	3,379	16%
Pulses	4,700	5,409	19%
Industrial Crops	1,300	10,094	5%
Culinary Crops	355	2,043	1%
Other Crops	4,126	--	21%
Total:	21.031	--	100%

2.1.6 Food security and nutritional status

Rice is the main food crop for the people of Myanmar. The annual per capita consumption is190 kilograms (kg) - the highest rate of consumption in Asia. In fiscal year (FY) 2007 (April 1 – March 31), out of a total production of

30.5 million MT, about 17 million MT of rice were consumed domestically. The self-sufficiency ratio is 179.4% (ADB, 2009).

Even though Myanmar is self-sufficient in food production at the national level, household level food insecurity is found in some areas due to low income and constraints on food production and transportation. Because of this, Myanmar is still considered food insecure, ranking 86th out of 109 countries in the 2014 Global Food Security Index (The Economist, 2014) and is among "36 high-burden countries" for global levels of stunting. In fact, despite improvements in recent years, the prevalence of under nutrition among women and children in Myanmar remains unacceptably high. According to the Myanmar Multiple Indicator Cluster Survey (MICS) in 2009-10, 22.6% of children under-five years of age are underweight, which has improved from about 30% in 2000 (MNPED & MOH, 2011 as mentioned by Cashin, 2016). One in three children are stunted and about 8% are acutely malnourished. The prevalence of stunting in rural areas (38.4%) is higher than in urban areas (27.2%), and there are substantial differences by region. The highest rates of stunting are found in Chin State (58.0%) and Rakhine State (49.9%). The 2013 Household Survey conducted by the Livelihoods and Food Security Trust Fund (LIFT) (2013) found a stunting prevalence of 31.9% in LIFT working areas and it was found to be highest in the Uplands (Chin, Kachin, Shan states) at 38.9% and lower in the Dry Zone (27.5%) and Coastal/Delta Zone (27.0%).

Moreover, micronutrient deficiencies are common among infants, young children and pregnant women. The status of micronutrient deficiencies in Myanmar are show in Table 8.

Table 8. Most recent data on indicators of micronutrient deficiencies in Myanmar (Cashin, 2016).

	Indicator	Prevalence rate (%)
Anemia	Anemia among children 6 to 23 months	>80.1
	Anemia among children under 5	64.6
	Anemia among non-pregnant women ages 15-49	45.2
	Anemia among pregnant women	71.0
	Anemia among adolescent girls	26.0
Vitamin B1/ (Beriberi)	Vitamin B1 deficiency among pregnant women	6.8
	Vitamin B1 deficiency among lactating mothers	4.4
Vitamin A	Estimated prevalence of vitamin A deficiency (low serum retinol) among children 6 to 59 months	30.1
	% of children (6-59 months) supplemented with vitamin A	55.9
Iodine	% of households consuming adequate iodized salt	68.8

The table shows that more than 80% of children 6 to 23 months of age and 70% of pregnant women are anemic (Cashin, 2016). Vitamin A deficiency, as indicated by low serum retinol, is associated with high rates of under-five mortality, diarrhea, measles, and acute respiratory infections. The prevalence of low serum retinol among children

6 to 59 months of age in Myanmar was approximately 30.1% as of 2007. By state/region, vitamin A deficiency is most widespread in Magwe (62.0%), Sagaing (55.1%), Bago (46.8%), Mandalay (33.3%), Ayeyarwaddy (32.7%), Shan-South (30.6%), Yangon (19.0%), and Mon (18.5%). By food intake, the consumption of Vitamin A below RDA was 19% across the whole country. Vitamin A deficiency in Myanmar is a severe public health problem according to World Health Organization (WHO) recommendations. Currently this issue is addressed through vitamin A fortified food programs, but this intervention requires continued funding if not accompanied by food consumption changes that introduce vitamin A rich foods into the diet (Cashin, 2016).

2.1.7 Environmental and socioeconomic vulnerability factors

Myanmar has diverse natural resources including minerals, forest, and fertile ecological zones which provided Myanmar's economic output to date. However, deforestation, large-scale mining, habitat and land degradation and diminishing water resources are all placing pressure on the environment (Ministry of Transport, 2012). The expansion of agriculture and industry, pollution, population growth, along with uncontrolled use and extraction of resources, are causing severe environmental and ecosystem degradation.

The country is highly vulnerable to climate change and extreme weather events, such as the devastating Cyclone Nargis of 2008, July drought, late monsoon with heavy rain since 2011, as well as major flooding in 2014 and 2015. Potato farmers experienced lower yield due to drought and heavy rain while cassava farmers from the delta experienced crop damage caused by flooding. Climate change and extreme weather presents heightened risks and vulnerabilities for the rural poor, particularly women and children and other vulnerable groups, a challenge for which local communities are still unprepared.

In Myanmar, the observed evidence of change over the last 60 years includes a nationwide increase in average temperatures of about 0.08°C per decade and an increase in total rainfall at 29 to 215 mm per decade. More importantly, changes in the duration of the monsoon season have been observed, as well as the recurrence and severity of extreme weather events (Ministry of Transport, 2012). These changes result to:

- An increase in the prevalence of drought events,
- An increase in intensity and frequency of cyclones/strong winds,
- Rainfall variability including erratic and record-breaking intense rainfall events,
- An increase in the occurrence of flooding and storm surges,
- An increase in extreme high temperatures, and
- Sea level rise.

Myanmar's National Adaptation Programme of Action (Ministry of Transport, 2012) categorized climate change impacts on the agriculture sector in three groups: 1) impact on productivity of the current agricultural techniques

and crops; 2) sudden destruction of cultivations by severe hazards, or lack of production because of droughts; and 3) erosion of soils in the long-term. It may also result in changes in the distribution of crop pests and diseases.

2.2 Local context

Since there is a mix of agro-ecological zones occurs throughout Myanmar, cultivation of root and tuber crops can be found in most parts of the country. But with time limitations, the scoping study team focused on three areas as follows (Table 9):

Table 9. Root and tuber crop production areas visited for the scoping study.

Study Site	Agro-ecological Zone	Major RTC
Shan State	Hilly Region	Major Potato Production Area
Magway Region	Central Dry Zone	Potato production on alluvial soil
Ayeyarwaddy Region	Delta	Major cassava production area (as small farmers)

Potato production occurs in all States and Regions of Myanmar except for Yangon Region, Tainitharyi Region, Mon State and Kayah State. Majority (60%) of the total cultivation area is found in Shan State. As one of the largest States of Myanmar, Shan State is divided into three parts for administrative purposes: East, North and South. Of these, 80% of the total potato cultivation area is located in Southern Shan State or almost 50% of national production. There are 31 townships and sub-townships in the Southern State, with more than 90% of potato cultivation found in only five townships and sub-townships. In the remaining States/Regions, except for China State, potato is only a secondary crop, cultivated after harvesting the main crop which is mostly paddy rice. Most of the potato cultivated area in the Central Dry Zone (CDZ) is located on river banks and/or dry land, unlike other states and regions where potato is mostly cultivated in wet lands.

More than 85% of the total cassava cultivation area is located in two areas: in Kachin State on the northern part of Myanmar bordering China (>50%) and in the Ayeyarwaddy Region in the delta area connected to the Rakhine ridge (>35%). Almost all cassava cultivation in Kachin State is implemented by Yuzana Co., Ltd., a single large scale plantation enterprise. Cultivation there is highly mechanized, and linked to a modern cassava starch processing factory, constructed and operated since 2015. Cassava cultivation in the Ayeyarwaddy Region is, however, predominantly by smallholder farmers.

With those different situations and local contexts, the scoping study team, in consultation with FoodSTART+, proposed to focus the study on South Shan State and Magway Region for potato field visits and on the Ayeyarwaddy Region for cassava.

On the other hand, sweetpotato is cultivated in Myanmar on a very small scale, largely home gardens, and it proved very difficult to identify locations for field visits where the team could meet several sweetpotato farmers in one village. Hence, a few locations in the Yangon Region, including villages close to agriculture zone, were identified and visited to understand more about sweetpotato production.

2.2.1 Shan State

The state is mainly included in the North, East, and West Hills agro-ecological zone which is described as having uneven topography, sloping land, and moderate to heavy rainfall. Most of the Shan State is a hilly called the Shan Plateau, which, together with the higher mountains in the north and south, forms the Shan Hills system. The Thanlwin River cuts across the state. Shan State is traditionally divided into three sub-states: North Shan State, East Shan State, and South Shan State. The famous Inlay Lake is located within Shan State.

With a favorably cold climate and substantial sun, Shan State produces upland crops, fruit trees and vegetables, including potato. Cultivation in Shan State does not rely on only rain water, it also supports many irrigation systems in some areas, including the Heho Valley Irrigation Canal system, which benefits potato production.

The total population for Shan State as of March 2014 was 5,824,432. Of these, 2,910,710 were males and 2,913,722 were females. The total population of Shan State represents 11.3% of the total population of Myanmar and ranks fourth in size when compared with other States and Regions in the country. The population of Shan State has increased from 3,716,841 in the 1983 census to 5,824,432 in 2014, or a 56% increase between 1983 and 2014. The population density of Shan State in according to the 2014 census by the Ministry of Immigration and Population (MIP, 2015) was 37 persons per square kilometer (km^2) which is much lower than the Union level population density of 76 persons/km^2 and ranking 11th among other States/Regions.

Half of the population in Shan is estimated to be ethnic Shans, with the remaining divided among other smaller groups such as Pao, Palaung, Kachin, Danu, Lahu, Inthar, Wa, Kokang, and Akha ethnic minorities. A census conducted by the government in 1955 revealed that the Shan state had 52 language groups, 27 of which are geographically concentrated and the other 25 spread across the whole state (Smith, 1999).

According to the Integrated Household Living Conditions Assessment (IHLCA, 2011), about 25% of the population was estimated to be living below the poverty line in Shan South which is comparable to the national average of 26%. Higher levels of poverty were estimated for Shan North and Shan East; 37% and 46% respectively, with the latter being second only to Chin State where 73% of the population was estimated to be living below the poverty line.

Main crops produced in Shan State are paddy rice, potato, and other vegetables; grown at different seasons throughout the year based on interviews (Table 10). Two types of potato cultivation are found in Shan State, one

with potato as a major crop with two seasons of production, and another where potato is a second crop grown after paddy rice. With favorable weather conditions, a range of vegetable crops can be grown year round, either commercially on farm and/or in home gardens. As result, Shan State is a major fresh vegetable supplier for Yangon and for national fresh produce markets. According to farmers met during the field visit, almost all farmers cultivate at least two crops each season for prevention of investment loss or as a risk reduction strategy. Therefore, most potato farmers divide their land between cultivation of potato and vegetables, including root crops such as turmeric. It was noted that because of land degradation, disease prevalence and yield declines, the majority of farmers practice shifting cultivation for their potato production.

Table 10. Seasonal calendar of the main crops of Shan State*.

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Paddy (Highland)												
Paddy (Lowland)												
Potato (Pre-monsoon)												
Potato (Monsoon)												
Potato (irrigated)												
Vegetables & other crops												

**Based on interviews in the study sites.*

2.2.2 Ayeyarwaddy Region

This region includes two agro-ecological zones. First is the Delta and Coastal Lowland, which is characterized by mountainous, sloping land, and heavy rainfall of more than 2500 mm. Second is the Bago, Kachin Riverside Land located in the Upper Delta, Kachin plain; which is characterized by flat plain land along the Ayeyarwady and Sittaung rivers with moderate rainfall of 1,000 – 2,500 mm. The Ayeyarwady Region is flanked by the Rakhine Yoma (Arakan Mountains) range in the west where large areas of paddy cultivation are located. It is crisscrossed with rivers and lakes, which are also favored for paddy cultivation, leading to its preeminent position as the main rice producer in the country. In addition to rice, other crops include maize, sesame, groundnut, sunflower, beans, pulses, and jute. In addition, fishery and salt production also contribute to the economy of Ayeyarwady Region.

The total population of Ayeyarwaddy Region as of March 2014 was 6,184,829 persons. Of these, 3,009,808 were males and 3,175,021 were females. The total population of Ayeyarwaddy Region represents 12.01 % of the total population of Myanmar and ranks second in size when compared with other states and regions in the country. The population of Ayeyarwaddy Region has increased by about 23.84% between the 1983 and the 2014 censuses, from 4,994,061 in 1983 to 6,184,829 in 2014. The population density Ayeyarwaddy Region in March 2014 was 177

persons/km^2 which is higher than the Union level population density of 76 persons/km^2 and ranks third when compared to other States/Regions. (MIP, 2015)

According to the IHLCA (2011), about 32% of the population was estimated to be living below the poverty line which is somewhat higher than the poverty estimate for the country of national average of 26%.

The seasonal crop calendar in the visited area of the Ayeyarwaddy Region (Table 11) was a mixture of farmland and garden cultivation. In farmlands, aside from paddy rice, almost all farmers cultivate varieties of pulses. As for gardening, farmers divide their land for cultivating different crops. As for RTCs, cassava is mostly cultivated in garden lands in June/July and harvested in January/February. Cassava processing starts from January until March during the dry season.

Table 11. Seasonal crop calendar in Ayeyarwaddy Region*.

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Paddy												
Cassava production												
Cassava processing												
Turmeric												
Banana												
Pulses												
Papaya												
Gardening & other crop												

**Based on interviews in the study sites.*

2.2.3 Magway Region

The Magway Region is located in the Central Dry Zone agro-ecological zone which is characterized by flat plains, some uneven topography, and with less than 1,000 mm rain per year. The Magway region is famous as the major supplier of cooking oil (ground nut and sesame) in the country. It also known as a petroleum production area in Myanmar, being the area where oil was first discovered and is now extracted in large quantities. Yenangyaung Oil Field, Chauk Oil Field and Mann Oil Field in Minbu (Saku) are all major oil producing areas in the country. Apart from oilseed crops, paddy, maize, cotton, pulses, Myanmar tobacco, Virginia tobacco and potatoes are also grown in Magway Region.

The total population of the Magway Region as of March 2014 was 3,917,055 persons. Of these, 1,813,974 were males and 2,103,081 were females. The total population of Magway Region represents 7.6% of the total population

of Myanmar and ranks seventh in size when compared with other states and regions in the country. The population of Magway Region has increased from 2,634,757 in the 1973 census to 3,243,166 in the 1983 census and to 3,917,055 in 2014. This means the population of Magway Region has increased by about 20.78% between the 1983 and the 2014 censuses. The population density of Magway Region in March 2014 was 87 persons per km^2 which is higher than the Union level population density of 76 persons per km^2 and ranking fifth when compared to other States/Regions. (MIP, 2015)

According to the IHLCA (2011), about 27% of the population was estimated to be living below the poverty line which is comparable to the national average of 26%.

The seasonal cropping calendar (Table 12) of the area visited in the CDZ depends on land type. There are four different land type: 1) farmland (*le Myay*) which is mainly irrigated area, 2) farmland (*Yar Myar*) not accessible by the irrigation system, 3) alluvial soil located by the river side, and 4) backyard garden. Paddy is cultivated on farmland accessible by the irrigation system. Non-irrigated farmland is cultivated with bean, pulses, ground nut and maize. Potato is cultivated in alluvial soils and/or farmland which has soil type suited to potato cultivation. Chili, onion, and garlic are also cultivated in alluvial soil.

Table 11. Seasonal crop calendar in Magway Region*.

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bean and pulses												
Groundnut												
Potato												
Paddy												
Maize												
Vegetable												
Onion & garlic												
Chili												

**Based on interviews in the study sites.*

2.3 General information on RTCs in Myanmar

No RTC are listed as major agriculture products as defined by the DOA - MOALI. Among RTCs, only statistical data for potato were included in the yearly agriculture statistical data published by MOALI. It was noted that root and tuber crops are listed in different categories. Potato and sweetpotato are listed as vegetable crops, cassava is listed as an industrial crop and elephant foot yam (EFY) is listed as a Non-Timber Forest Product (NTFP). The total cultivated area of major root and tuber crops in Myanmar are mentioned in Table 13 below.

Since rice is the main staple food for people in Myanmar, paddy is the government's top priority in the agriculture sector. As a result of market liberalization and the short duration of the rice crop season, pulses are also a major interest as a cash crop for many smallholder farmers in the country. In addition, with good international market demand and the interest of policy makers in previous governments, sugarcane and rubber are also major industrial crops. Unfortunately, no RTCs are included in the list of primary important crops even though potato is a main culinary crop for most Myanmar families.

For these and other reasons, RTCs still lag behind other major crops including rice. Although RTC production in Myanmar has gradually increased, especially since the late 1990s, as shown in Figures 5 to 7.

Table 12. Root and tuber crops cultivated area in Myanmar 2014-2015*.

State & Region	Potato	Cassava	Sweetpotato	EFY
Nay Pyi Taw	1,668			
Kachin State	4,869	44,877	1,477	543
Kayin State	1,620		274	112
Kayah State		2,129	1,748	2,325
Chin State	4,131	219	1,815	6,788
Sagaine Region	7,852	4,630	3,853	470
Tanintharyi Region		1,678	1,061	
Bago Region	635	140	1,010	134
Magway Region	5,298		3,357	580
Mandalay Region	2,018	100	932	
Mon State		735	2,082	459
Rakhine State	8,074	791	2,351	94
Yangon Region		1,378	1,729	
Shan				
Shan South	43,217		908	
Shan North	7,283	461	2,245	451
Shan East	3,492	568	771	
Ayeyarwaddy	25	31,830	4,820	
Total:	90,032	89,536	30,433	11,956

**Based on information gathered from the DOA.*

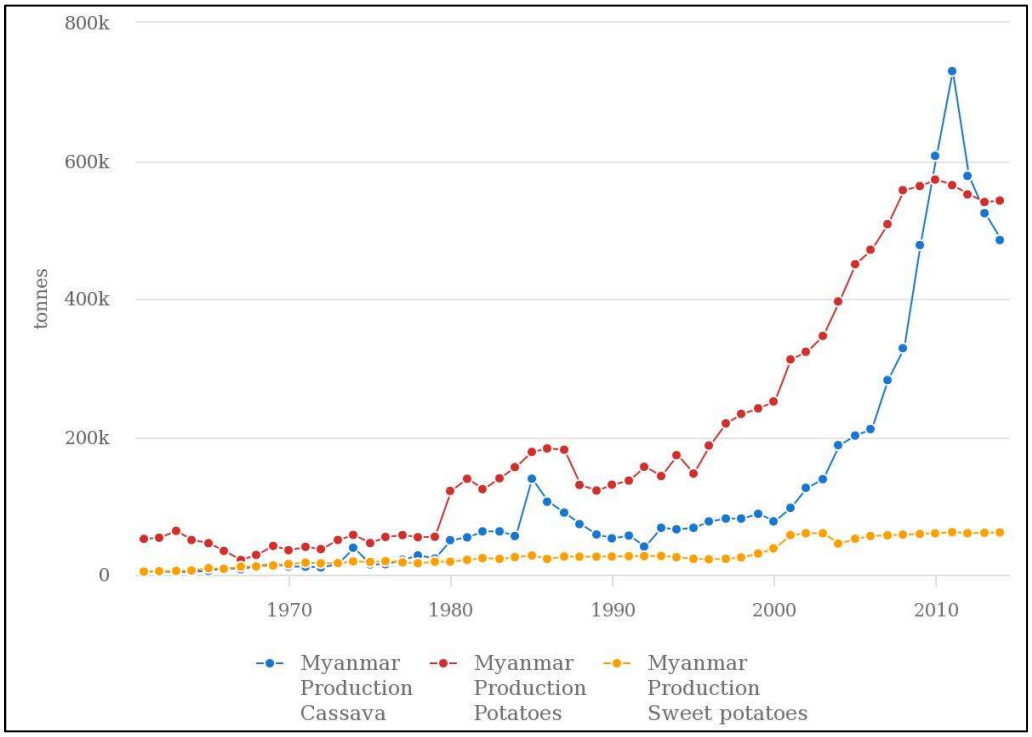

Figure 5. RTC production in Myanmar (FAO, 2017).

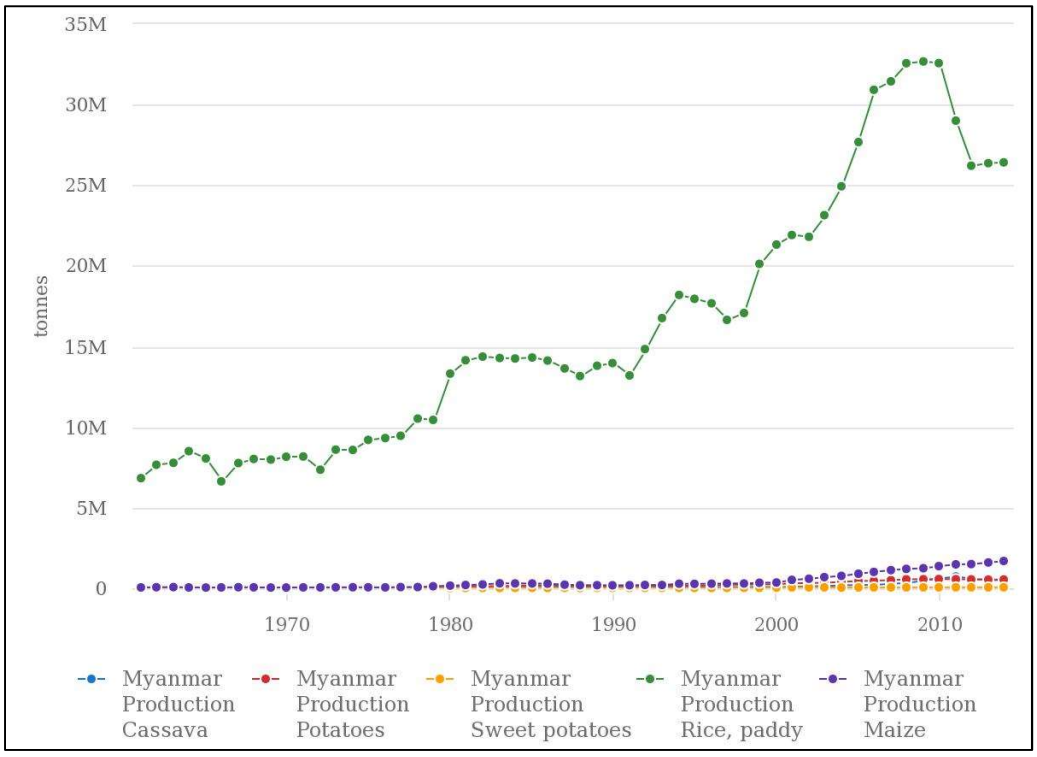

Figure 6. Comparison between rice, maize and RTCs (FAO, 2017).

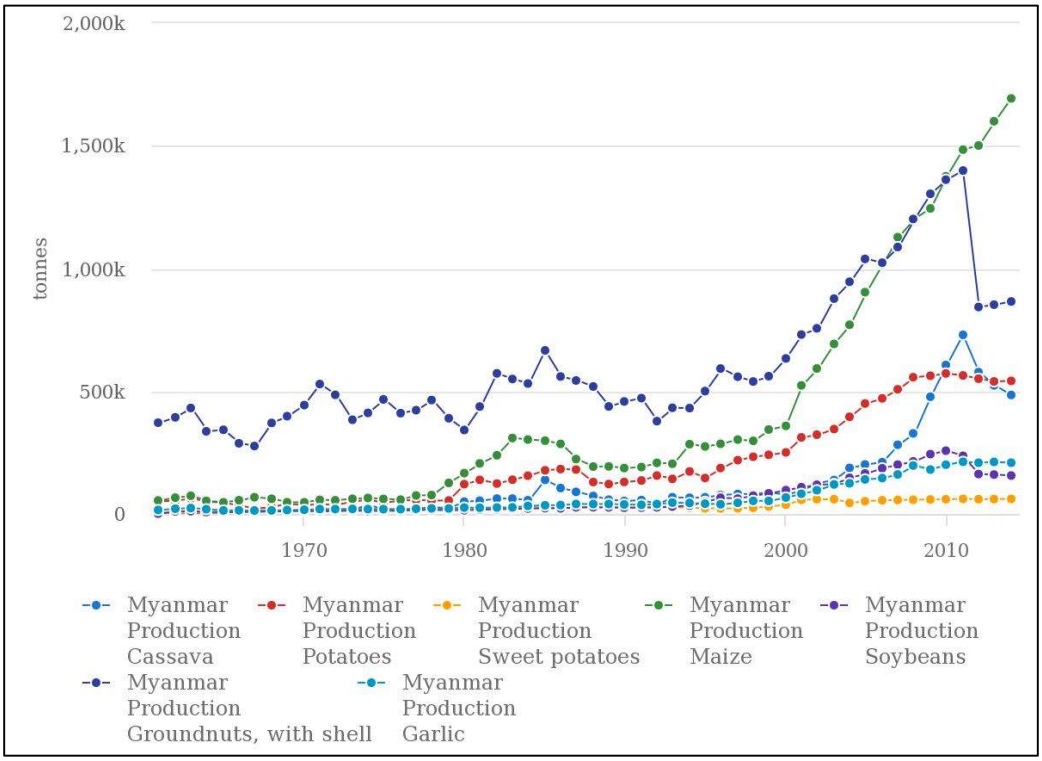

Figure 7. Comparison between RTCs and other crops (FAO, 2017).

2.3.1 Overview of potato

The potato is a very popular vegetable crop and one of the main culinary crops in Myanmar's households. Potatoes are grown almost the year round in Myanmar. According to the Myanmar Agricultural Services (MAS, 1990). Potatoes were being grown using seed tubers imported from Britain since 1882. By 1892, production has spread using two varieties introduced from India: kidney potato and the Bengal potato. In 1915, a new variety called "Up-to-Date", locally known as '*Sitbo'* meaning army officer, was introduced and quickly became the most popular potato variety. During the 1950s to 1970s, several other potato varieties were introduced in Myanmar by different means. For instance, some representatives from Agriculture Universities and Ministry bring back potato samples from their visits to other countries for trial in Myanmar, but "Up-to-Date" remained the country's major variety until 2000s.

With different agro-ecological zones and climate conditions, potato in Myanmar is cultivated in four seasons as summer, pre monsoon, post/late monsoon, and winter crops. Except as winter crop, the remaining three season

cultivation practice is found in Shan State only. The potato cultivation seasonal calendar in Myanmar is shown in Table 14 below.

Table 13. Potato seasonal calendar*.

Season	From	To	Area/Location
Summer Season Crop	January-February	April-May	Irrigated area after monsoon crop harvested, mainly in Shan State, Chin State, and Mandalay Region
Pre Monsoon Crop	April-May	August-September	Hilly side of Shan State, mainly on Pinlaung and Pindaya Township
Post (Late) Monsoon Crop	August-September	December-January	
Winter Season Crop	October-November	January- February	Mostly alluvial land (Central Dry Zone)

**Based on interviews in the study sites and literature review.*

DOA statistics includes only two potato cultivation seasons referred to as rainy and winter, with a total cultivated are of 46,158 acre and 44,486 acre, respectively (Table 15). Out of fourteen states and regions, the DOA notes that only 10 are listed as potato growing areas, with 60% of total cultivation located in Shan State.

Table 14. Potato cultivation in Myanmar per state/region in 2015 (DOA, 2015).

State/ Region	Cultivated/Harvested Area (acre)			Average Yield (Viss)	Total Production (Viss)
	Winter Season	Rainy Season	Total		
Nay Pyi Taw	1,668		1,668	5,700	9,507,600
Kachin State	4,649	220	4,869	2,732.8	1,2488,924
Kayah State	1,110	510	1,620	1,865.31	2,084,860
Chin State	356	3,775	4,131	1,298.76	5,365,175
Sagaine Region	7490	362	7,852	4,615.46	36,240,626
Bago Region	635		635	3,279.95	2,082,769
Magway Region	5,298		5,298	6,079.73	32,210,433
Mandalay Region	812	1,206	2,018	2,565.37	2,218,295
Rakhine State	8,074		8,074	2,038.54	16,459,147
Shan	16,041	38,413	54,454	3,965.28	58,868,180
Shan South	8,588	34,629	43,217	4,335.93	41,707,336
Shan North	5,875	1,870	7,745	2,450.61	13,251,720
Shan East	1,578	1,914	3,492	2,537.21	3,909,124
Ayeyarwaddy	25		25	3,570	89,250
Union Total	46,158	44,486	90,644	3,744.71	337,143,452
Data from FAO (2014)			36,682 ha	6.1 MT	549,541 MT
Data from DOA (2015)			36,000 ha		542,300 MT

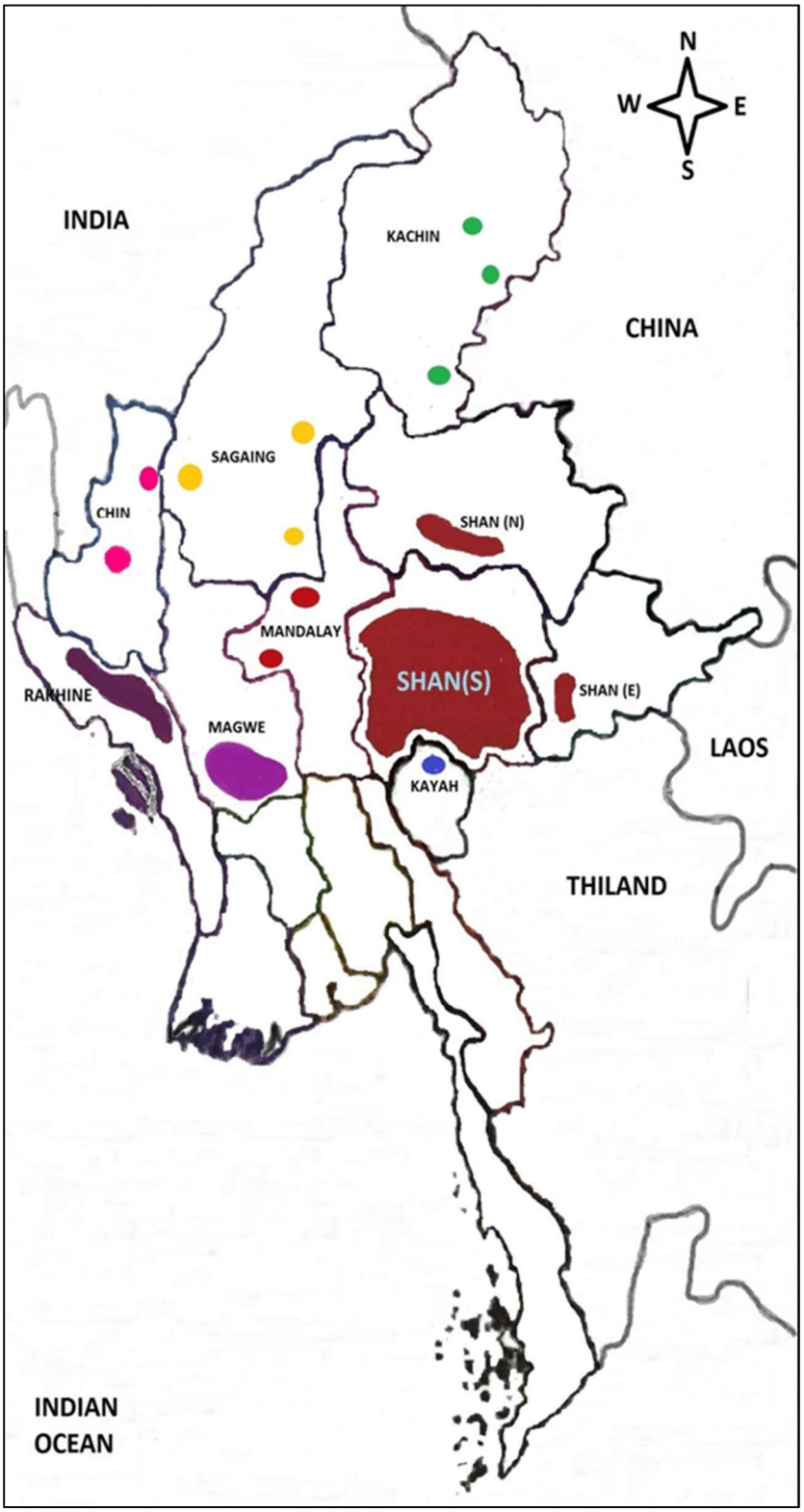

Figure 8. Potato cultivation area in Myanmar (Source: Prof. Dr. Maung Maung Myint).

In terms of seed potato, there is no existing industry in Myanmar and small tubers are traded by and between farmers as seed. This informal seed system provides virtually all seeds to farmers. The rainy season crop from the Shan Hills provides the majority of seed tubers to potato producers in different states and regions, except for the Rakhine State and Chin Hills area which, due to its inaccessibility, is apparently self-reliant in seed (MAS, 1990).

There are several potato varieties growing in Myanmar introduced informally through employees from the DOA Department of Agriculture Research, and Yazin Agriculture University (YAU). Because of the lack of enough quality tuber seed of preferred varieties and the existing seed law of Myanmar prohibiting such, varieties from China are being illegally imported across the border by local traders to respond to demand from farmers. Apart from Cooperation 88, these varieties carry no specific name but are referred to as China variety. Based on interviews from potato farmers from Sin Phyu Kyun, the team estimated that more than 800 MT of China fresh potato used as seed were imported every year for Sin Phyu Kyun alone. Some farmers estimated that 50% of the 1600 to 1700 acres planted to potato in Sin Phyu Kyun used the imported china variety with a rate of 600 viss/acre.

Through the Consortium of Dutch NGOs (CDN) potato project, which aimed to introduce healthy, brown rot free seed of late blight resistant varieties, the Heho seed farm conducted rapid multiplication of CIP L 11 variety and distributed to farmers under the name of *Shwe Heho*. Upon distribution to farmers, farmers came to prefer Shwe Heho because of fewer pesticide applications required and reasonable yields result. But the yield of Shwe heho dramatically dropped after three years due to disease problems with bacterial wilt. The rapid multiplication was stopped at the Heho Farm because of the bacterial wilt problem in 2014.

Also with the financial support of CDN, a research report from the Wageningen University and Research (WUR) (Holdinga et al., 2014) identified the cause of the problem with the Shwe heho variety as hygiene errors. They posited that "the numerical examples are mainly meant to illustrate the potential of the technique once perfected and carried out on routine base: producing plantlets in-vitro -> mini-tubers from these in a screen house in sterile soil -> G1 in first field generation and so on. Due to two crucial hygiene errors (mini-tubers not produced in sterile soil and seed cut without disinfecting the knives) seed of a late blight resistant variety (L121) distributed to growers in 2013 was heavily infected with brown rot."

With the objective of preparing a Myanmar - Netherlands Public Private Partnership (PPP) Programme which aims at building a strong, sustainable and competitive potato sector in Myanmar, a fact finding mission of four members of the Agro Food Cluster, a member of the Netherlands farmers' organization LTO/Agriterra and two members of the knowledge institutions (Aeres Groep and WUR) visited Myanmar in March 2015. The mission identified the potato seed situation as "no or low availability of seed of proper variety, health status, and sprouted at time of planting". Also as part of PPP program preparation, a baseline survey on potato production in Myanmar has been carried out by two experts from WUR and 2 students of the Aeres Group Dronten, together with various

stakeholders in the potato sector in Myanmar In August 2015 to April 2016. Moreover, with support from the Netherlands Embassy, farmers from key potato clusters visited the Netherlands as a study tour.

Because of these, the potato sector in Myanmar have established a good network with Dutch potato seed providers. At the same time, through collaboration with International NGOs, potato seed suppliers from the Netherlands, and the Potato Association, new varieties of potato seed from Netherlands are already being tested since 2015. The table (Table 16) below presents the most commonly used potato varieties used in Myanmar from Heho seed farm, group by the year there were introduced. During the second field visit to Naung Ta Yar in February 2017, team also noted on-going on-farm trials of many varieties, eight new varieties and three existing varieties, some of which are shown in Figure 9.

Table 15. Potato varieties in Myanmar*.

Year Introduced	Variety
1914	Up-to-date (Sitbo)
	Allay (Mahamate)
1995-1996	4 Tissue culture varieties: "LKP"
	8 Pakistan varieties: Latona, Asterix, Baraka, Canbate, Caesar, Symfonia, Mona Lisa, Florissant
1990s	Kufri Jyoti
	CIP 24
2010	CIP L 11
	CIP L 15
2013-2014	China varieties: Corporation 88, Heho 1, Heho 2
2014	Atlantic,
	Arsenal
2015	Carolus, Markies

**Based on information from U Nyi Nyi Aung, Manager, Heho Seed Farm, DOA, MOALI.*

Figure 9. Some of the potato varieties in trial plots at Naung Ta Yar.

During the interviews and desk research, four commonly used potato seed sources and flows were identified for each planting season. Firstly, seed for the early monsoon crop is purchased from wholesale dealers who keep and store fresh potato for seed. Meanwhile, seed for the late or post monsoon crop is kept from farmers' own paddy fields which were harvested in April. Seed for the January planting is saved from the early monsoon August harvest or purchased from higher upland production locations. Lastly, seed for winter crop is purchased from wholesale dealers. These informal seed flor is illustrated in Figure 10.

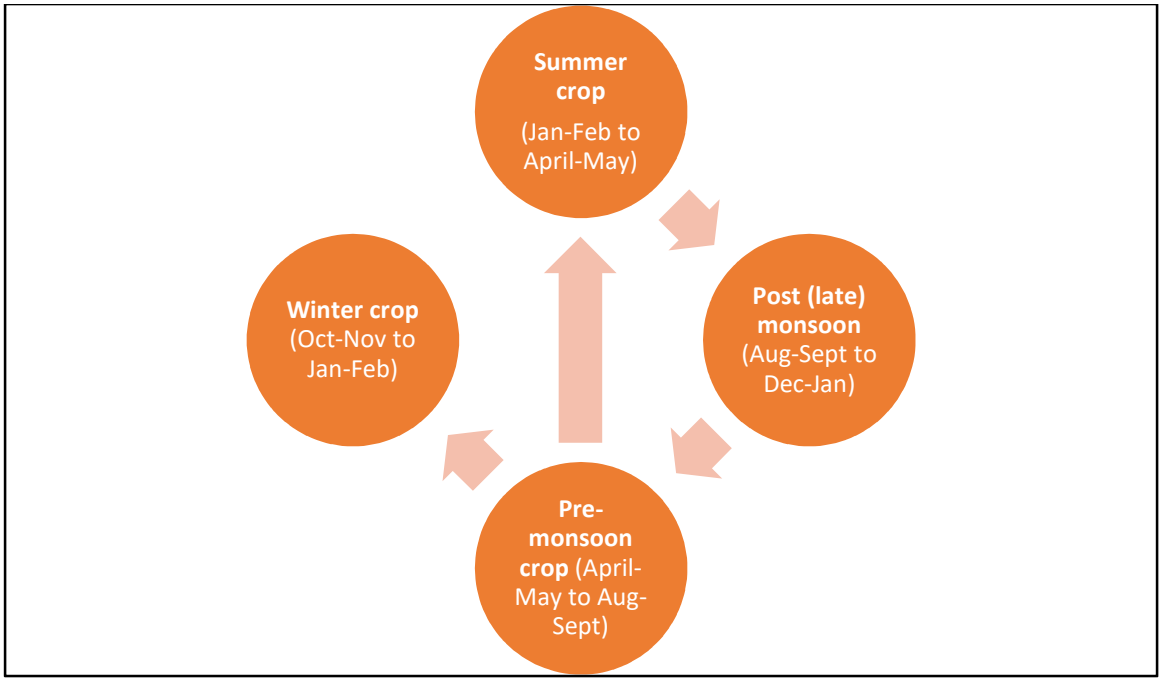

Figure 10. Informal seed (small tuber fresh potato) flow.

Farmers sell small tubers from harvests in October to November at 350 MMK/viss (1 viss ≈ 1.63 kg or equivalent to 16 USD per100 kg). On the other hand, bigger tubers are sold for 550 MMK/viss (equivalent to 25 USD 100kg). In January, the small sprouted "seeds" are then sold for 600 MMK/viss (equivalent to 27 USD per 100kg) and are often more expensive than ware potatoes. (Holdinga et al., 2014)

Holdinga et al. (2014) also noted several quality issues in seed potato in Myanmar:

- Bacterial wilt (BW) caused by bacteria *Ralstonia solanacearum*.
- Root knot nematode.
- Virus degeneration was not mentioned, probably not known/recognized as problem.

- When bought quality and origin are uncertain.
- Old and young seed is often mixed.
- Mixture of varieties (example, Up-to-Date and Kufri Joti)

A rapid multiplication in-vitro laboratory was set up by two Korean volunteers in 2004-2006 in the Heho Research Farm under the Department of Agriculture Research. There was, however, no adequate transfer of technology. Nevertheless, through national capacity in 2009 rapid multiplication was restarted with the then available varieties L11 of CIP and Up-to-Date. Emphasis was on L11 as that variety yielded higher due to late blight resistance. Despite this, until today the rapid multiplication system is not functioning at its best performance despite a training programme (Holdinga et al. 2014).

The average yield of potatoes in Myanmar is approximately 15 MT fresh weight/ha but the average yield in Southern Shan State is approximately 25% higher than the national average at 18 - 19 MT/ha (Thun et al. 2006). However, these actual yields may still be lower than attainable yields. In practice, the economically attainable yield is approximately two-thirds of the modelled attainable yield (pers. comm. A.J. Haverkort, as mentioned by Holdinga et al. 2014). At this point, costs for additional inputs are balanced with profits due to the increased yields. The multiplication rate of seed potatoes in the visited area ranged from 5 - 10 depending on individual plant treatment.

The average cost of potato cultivation and profit in four locations in South Shan state is shown in Table 17, noting that potato is a labor intensive crop. Despite the large profit margin of potato production being attractive to farmers, some marginal farmers cannot grow potato due to the high initial capital needed to cover the cost of input supply. In this regard, some farmers (including landless farmers) rent farmland for potato cultivation. It was noted that the rent price for one potato season was 300,000 to 500,000 MMK/acre or 550 to 915 USD/hectare.

With interest of an international investor, contract farming for potato production was introduced to Myanmar by PepsiCo in 2013. It was noted that the partner company of PepsiCo imported the Atlantic variety and distributed to farmers both input and technology support. They buy back potato at the prevailing market prices, which is beneficial to farmers because of its good yield. Despite the positive farmer interest, contract farming of potato is still limited due to the relatively small scale of international demand to date.

As mentioned earlier, potato production is labor intensive and majority of farmers still use traditional practices. They lack awareness on the need for proper seed selection considering various criteria such as disease, dormancy period, quality, among others; as well as proper crop management such as timely, efficient input use. Because of this, potato yield in Myanmar is lower than in neighboring countries, while production costs are higher. With the lack of economic benefit from agriculture and potential employment opportunities, the potato sector faces labor shortages. Some well-off farmers are starting to mechanize production, but most marginal farmers do not have

access to these technologies. In addition, lack of storage facilities and traditional practices also result in high postharvest losses.

Participants of the potato stakeholder workshop agreed that despite progress in crop management and technical knowledge support, many areas crucial to potato sector developing are still lagging behind other countries, including access to quality seed, small scale agriculture mechanization to address the labor shortage, and access to market information.

Table 16. Average cost of potato production various locations in South Shan state*.

Average Cost	Heho	Naungtayar	Kyone	Sinphyukyune
Land preparation	137,000	56,750	55,000	11,1000
Seed	700,000	350,000	200,000	480,000
Organic fertilizer	298,000	9,2500	160,000	8,000
Fertilizer	197,500	369,500	130,000	183,840
Pesticide	72,000	7,4800	7,200	214,415
Water pumping	96,000			48,000
Labor	260,000	210,000	134,000	288,500
Transportation (farm to home)	10,000	42,000	60,000	24,000
Total Cost (MMK/acre)	1,770,500	1,195,550	746,200	1,357,755
Total Cost (USD/Ha)	3,239	2,187	1,366	2,484
Average Profit	**Heho**	**Naungtayar**	**Kyone**	**Sinphyukyune**
Average yield (viss/acre)	6,000	4,500	3,000	5,000
Average yield (MT/ha)	24.21	18.16	12.11	20.18
Average price (MMK/viss)	600	500	550	600
Average income (MMK/acre)	3,600,000	2,250,000	1,650,000	3,000,000
Average income (USD/ha)	6,586	4,116	3,019	5,488
Average profit (MMK/acre)	1,829,500	1,054,450	903,800	1,642,245
Average profit (USD/ha)	3,347	1,929	1,653	3,004

**Based on FGDs with potato farmers in the study sites*

2.3.2 Overview of cassava

Cassava was introduced to Myanmar in the middle of the 19th century and was first grown in the coastal and river delta regions of the country, where it still grows widely today. The cassava varieties traditionally grown in the region are known to be native ones. Cassava is mainly used for producing starch by small private factories and also used as a snack food, flavoring agent (MSG) and as animal feed (Thun Than, 1992).

Production and area increases in the 1980s were due to the demand for raw material from the Daike Oo MSG factory which started to operate in 1982. To meet the growing demand, the government expanded the cassava cultivation area in Daike Oo Township and introduced new varieties from Thailand. These new cassava varieties spread out to Ayeyarwaddy Region through some migrant workers from the delta who worked at the cassava farms in the Daike Oo area. Cassava cultivation also dramatically increased after the government allowed alcohol factories to operate in the region in the 1990s. With the expansion of cassava production in the Ayeyarwaddy Region, processing has also progressed from manual to semi-manual processing.

After the fuel crisis, the government of Myanmar encouraged alternative energy development and biofuel emerged as one of the options. The government of Myanmar allocated plots of land to private investors interested in biofuel production. In this regard, the government granted Yuzana Company over 400,000 acres (1,600 km^2) of land from Kachin State for cassava and sugarcane production in 2006. Land concessions were granted to establish an agricultural development zone in the Kachin State's Hukawng Valley in Tanai and Hpakant Townships, much of which is within the Hukawng Valley Tiger Reserve. In November 2010, Yuzana Company opened a 20,000 square feet (1,900 m^2) tapioca powder factory in Kachin State, near the company's plantations in the Hukawng Valley. The factory is reported to be the largest in Southeast Asia (Thae Thae Htwe, 2010).

According to statistical data from the DOA, almost 50% of the country's cassava cultivation area is located in Kachin State (Table 18). Majority of this is owned by Yuzana Company, but a company representative interviewed for this study claimed that only less than 25% of the allocated land is under cassava production at the moment. Other farmers consulted during the study also mentioned changing to more profitable crops, due to fluctuations in cassava prices. For these, and other reasons, cassava production has declined since 2013.

On the other hand, 35% of national cassava cultivation is located in the Ayeyarwaddy Region, mostly by smallholder farmers. To expand cassava cultivation, the Cassava Growers, Millers, and Traders Association (CGMTA) in the Ayeyarwaddy Region applied for and has received hundreds of additional acres within the region.

The outlook for cassava production remain positive, with foreign interest in processed cassava, both dry chip and starch, growing in recent years. According to a source from Yangon, a Yangon based company called the Tint Tint Myanmar Company, a large company involved in various businesses, has started to invest in agriculture in 2016 and already has a market link with Australia for exporting dry cassava chips. The company has been granted thousands of cultivable waste and fallow land by the Yangon Regional Government, and are already cultivating a total of 700 acre (280 ha) of SC 205 variety of cassava in Twantay Township last year. With the support of the Nyaung Hnit Pin farm, the company had already begun contract farming with farmers from Nyaung Hnit Pin agriculture zone area.

Table 17. Cassava production in Myanmar in 2013 and 2015.

Sr.	State & Region	Cultivated Area (ha)		Production (MT)	
		2013-2014[1]	2015[2]	2013-2014[1]	2015[2]
1	Kachin State	22,022	18,161	289,099	215,697
2	Kayin State	490		3,598	
3	Kayah State		862		10,169
4	Chin State	107	89	474	368
5	Sagaine Region	1,953	1,874	13,831	12,693
6	Tanintharyi Region	686	679	1,683	8,472
7	Bago Region	1,039	57	9,599	1,388
8	Magway Region				
9	Mandalay Region		40	2	439
10	Mon State	336	297	5,111	4,268
11	Rakhine State	278	320	1862	1,936
12	Yangon Region	823	558	16,273	9,991
13	Shan	1482	417	17540	4,254
14	Ayeyarwaddy	14,547	12,881	242,298	183,572
Union Total		90,032	89,536	603,383	455,262

[1]*Maung Aye, 2015*
[2]*DOA, 2015*

Meanwhile, one major constraint for increasing cassava yield in the country is the lack of good planting material. During the field visits, the research team observed that many farmers were not aware which cassava variety were better, and they only relied on planting material from their own or nearby farms. There appear to be no practice of marketing quality cassava planting material in the study area.

To address this, CIAT conducted preliminary cassava variety assessments in different regions in Myanmar, including the Dry Zone from 2009 to 2011. This research was conducted in collaboration with DAR and local field staff based in the network of research stations. The evaluations of cassava varieties included those suited mainly for direct human consumption, industrial application (feed, starch, biofuel) and for dual purposes. More than 45 improved cassava varieties have been released by national cassava breeding programs and CIAT throughout Asia (Howeler and Maung Aye, 2014). Among these, there may be many promising cassava varieties suitable for conditions in Myanmar (Maung Aye *et al*., 2011)

In 2007, the Ministry of Agriculture and Irrigation (MOAI, former name of MOALI) and China National Cereals, Oils and Foodstuffs Corporation (COFCO) reached an agreement to establish a cassava plantation in Myanmar for biofuel production. This pilot project meant to find a suitable cassava variety for mass production in Myanmar and COFCO funded the development of 100 acres or about 40 ha of cassava cultivation, including farm trials seven new cassava varieties and technical support. The 100 acre land was divided to four locations: 1) Nyaung Hnit Pin

farm previously under the Myanmar Farm Enterprise (MFE), MOAI and now under the Industrial Crop Division, DOA-MOALI; 2) Nyaung Hnit Pin farm under the Myanmar Agriculture Service (MAS), MOAI; 3) Hlegu vegetable & horticulture research farm under MAS; and 4) Shwe Pyi Thar farm under private institution of the Vegetable and Horticulture Association. After completion of variety selection, COFCO extended mass plantation and established a biofuel factory in Myanmar. Unfortunately, In May 2008, cyclone Nargis severely damaged the new cassava varieties at all locations except the MFE farm, causing COFCO to waive the project after reviewing progress one year later.

Despite this, the farm manager from MFE continued cultivation of the seven new varieties after receiving a positive market response. Based on consumer feedbacks, the farm has decided to continue cultivation of three varieties, namely SC 205, SC 124, and RG 891. According to the farm manager, SC 205 (Figure 11) was preferred by bakeries for making a traditional Myanmar pudding locally called "*san win ma kinn*" which use fresh cassava. On the other hand, RG 891 was the preferred variety for boiled cassava. The farm manager also revealed that the average yield of SC 205 was over 12,000 viss/acre (approximately 50 MT/ha). This estimation is based on 4,000 plants with 3 viss tuber per plant in average. However, maximum trial yield was over 140 MT/ha, which was achieved by ridge planting 4,840 plants per acre and harvesting about 3 to 6 viss (5kg to 10 kg) tuber per plant.

Figure 11. SC 205 during growth stage (left) and during regrowth following stem cutting for planting material three months earlier (right).

Cassava production in Nyaung Hnit Pin farm has been successful since 2010, but other stakeholders from the cassava sector, including people from Horticulture Department under the Department of Agriculture Research (DAR) and the Myanmar CGPTA were not aware of its success, and only found out in late 2016. The farm had since

changed roles from production to extension, research, and seed production and although there has been no official distribution of planting material of SC 205 from the farm before, it had planned on distributing planting materials in 2017. Good characteristics of SC 205 include small distance between nodes, early root bulking, higher dry matter, thin skin, and lower fiber content. It also has lower hydrocyanic acid content which was confirmed through laboratory testing.

In terms of planting practices, cassava farmers in Ayeyarwaddy uses the mound method, instead of the ridge method. A farmer claimed that they changed from ridge to mound a long time ago so they can easily calculate or measure for labor costs, especially for hired workers. For instance, land preparation labor cost is 30-35 MMK/mound. Local measurements also often use a standard 1,000 mounds/acre. While there are local cassava varieties available, farmers in the visited area mainly use varieties widely known as "Singapore", "Malaysia", and "Japan" which are identified by the skin color of their cassava roots. Researchers also found out that the CGMTA are cultivating trial plots with different varieties imported from Thailand and supported by CIAT.

Cassava is planted in July and harvested in January to February. Harvested cassava roots are sent to local processing factories within one day of harvest for immediate processing. This harvesting and processing period last up to a maximum of two and a half months. In the study sites, almost all cassava farms practice mono-cropping, with no other crops cultivated during the cassava off-season in April to June.

The majority of cassava farmers use credit or loans as initial investment, often from traders and processors, and use part of their income to pay back the loans, thereby decreasing potential profits from cassava. Meanwhile, farmers who self-finance cassava production may change to other crops if they think cassava production will be less profitable, but it was noted that none of them would stop cassava cultivation completely. The costs and benefit of cassava production and processing is shown in Tables 19 and 20.

The cost was calculated using the standard fertilizer application provided by well-off farmers, however, majority of marginal cassava farmers apply less fertilizer and never apply pesticides. They also usually use their own family labor for land refilling and weeding rather than pay for hired labor. It should also be noted that the yield of cassava from marginal farmers varied from 2000 viss/acre (8 MT/ha) to 3500 viss/acre (14 MT/ha) but farmers agreed to an average yield of 3000 viss/acre (equivalent to 12 MT/ha).

It was noted that there is no practice of measuring or estimating starch content of root cassava during the trading process. There was also no specific moisture content required but it was understood that average moisture content of dry starch is 12% to 13%, although this may sometimes reach 15% to 17%. The average starch content of fresh roots mentioned by processors is approximately 30%. It was also observed that processor usually get a weight advantage when they buy fresh root cassava from farmers.

Table 18. Cost-benefit analysis for one season of cassava production*.

Average Cost	Quantity	Frequency	Price per unit (MMK)	Total Cost (MMK)
Land preparation	1,000 mounds	1	50	50,000
Planting	1,000 pcs	1	10	10,000
Weeding	Lump sum	5	12	60,000
Land refilling after fertilizer added	Lump sum	5	25	125,000
Fertilizer (five times for urea + NPK)	Lump sum	1	205,000	205,000
Labor for fertilizer & pesticide	Lump sum	5	3,000	15,000
Labor for pesticide	Lump sum	1	5,000	5,000
Pesticide	Lump sum	1	15,000	15,000
Labor for harvesting (10 MMK/viss)	3,000 viss	1	10	30,000
Transportation (10 MMK/viss)	3,000 viss	1	10	30,000
			TOTAL COST:	**545,000**

Average Profit	Local Units	International Equivalent
Average yield	3,500 – 4,000 viss/acre	14 – 16 MT/ha
Average price	150 – 200 MMK/viss	
Average income I	525,000 - 600,000 MMK/acre	960 – 1100
Average income II	700,000 -800,000 MMK/acre	1,280 – 1,460 USD/ha
Average profit with low price	25,000 - 55,000 MMK/acre	45 - 100 USD/ha
Average profit with high price	155,000 - 255,000 MMK/acre	280 - 460 USD/ha
Equivalent profit (lowest to highest)		**100 - 460 USD/ha**

**Based on FGDs with cassava farmers on the study site.*

In most cases, fresh cassava roots are sold by farmers to local processors but in some, traders buy fresh cassava roots from farmers by an estimated lump sum price before harvest and process the roots at processing units that provides this as a service. In those cases, processors charge up to 5500 MMK 100 viss of fresh cassava roots as a service fee and return 30 viss dry starch as finished processed product. There are also a few specialized grinding millers who buy rough dry starch from processors and mill this to a finer grade starch or powder before selling.

During the stakeholder workshop, participants noted that the cassava market in Ayeyarwaddy is monopolized by one large trader who can buy large volumes of dry starch at any time. Cassava prices are also directly influenced by dry starch price. For instance, in 2017, the dry starch price at the start of harvesting season was at 850 MMK/viss and one month later, the price dropped to 650 MMK/viss. As result, the price of fresh root cassava also dropped from 200 MMK/viss in early January to 150 MMK/viss in early February.

Table 19.Cost analysis for a small scale cassava starch processor with a processing capacity of 4,000 viss or 6.5 MT of fresh roots per day*.

Average Cost (Quantity)		Amount in MMK	Amount in USD
Initial investment for processing machine		4,600,000	3400
35-hp Engine		700,000	520
Machine for removing skin		600,000	445
Machine for crushing/milling		1,000,000	740
Separation tank		600,000	445
Pulley wheels, axels, belts and other accessories		1,500,000	1,100
Pump set		200,000	150
Initial investment for operation		1,100,000	670
Tarpaulin sheet for temporary tank		200,000	150
Bamboo map for drying		500,000	370
Bamboo for structure construction		400,000	300
Capital for purchasing fresh roots		2,000,000 – 3,000,000	1,450 – 2,200
Raw cassava (4000 viss x 150-200 MMK/viss)		600000 – 800,000	
Labor - men (6 pax x 5,000 MMK/pax)		30000	
Labor – women (10 pax x 4000 MMK/pax)		40000	
Diesel (4 gal x 4,000 MMK/gal)		16000	
Average Cost		**686,000 – 886,000**	
Average Output	**Quantity**	**Unit Value**	**Total Value in MMK**
Dry Starch	1200 viss	650 – 850 MMK	780,000 – 1020,000
Pulp	40 baskets	900 MMK	36,000
Average Profit		**Amount in MMK**	**Amount in USD**
Gross income per day		816,000 – 1,056,000	600 – 780
Average profit per day		130,000 – 188,000	96 – 140
Average interest for a 2,500,000 MMK loan with a 5% interest rate for purchasing raw		4200	
Cost for poly bag (40 bags x 120 MMK)		4800	
Net profit for one day (4000 viss operation)		121,000 – 179,000	
Net profit for one day (6.4 MT operation)		90 -133	
Net profit for one season - 75 days operation		9,075,000 – 13,425,000	6720 - 9950
Equivalent MT/USD (one day 6400 kg approximate)			15.0 – 20.8
Equivalent MT/USD (one day 4800 kg approximate)			11.7 – 16.3
Equivalent USD for one day operation (4800 kg capacity)			56.2 – 78.4

**Based on interview with processors at the study site.*

The processors met during the field visit mentioned that they received complaints from neighboring families about the smell of waste water, which is discharged directly into the streams or allowed to accumulate in ponds close to the processing units. All processing units are located beside creeks or streams, originally well away from

residential areas, however, with population increases and construction of new houses, the processing locations are now close to residential areas. It was noted that only a few processors build drainage systems for waste water flow in order to reduce odors nor practice any other treatment or mitigation to address this problem.

Apart from access to good planting material, lack of knowledge about improved cultivation techniques and reliance on traditional cultivation practices is a major constraint for yield improvement. Like potato, cassava production and processing is labor intensive work and now faces a labor shortage problem. Promoting the adoption of modern cultivation practices among farmers may increase yields, even though simple methods such as changing from mound to ridge planting system, which permit more plants per area without the need for mechanization.

2.3.3 Overview of elephant foot yam (EFY)

EFY, locally called *Wa-u* or *phyan-u,* thrives in natural forests and is identified as an NTFP. They are found in many areas of Myanmar especially evergreen forests in Kachin state, Chin state, Rakhine state, Shan state, Mon state, Tanintharyi Region, Bago Region, and Yangon Region. However, over-extracting from forests has resulted in production declines between late 2000 and early 2010. It was usually harvested or extracted from the forest, processed and transported in a traditional manner, but as demand grew, more people took advantage by harvesting without replanting. As a consequence, production of EFY from natural forests has gradually declined in terms of quality (i.e. tuber size) and quantity (i.e. total volume).

Today, EFY is now largely cultivated as a cash crop to avoid over-extraction from forests and to meet higher market demand. For instance in Chin State, CARE Myanmar has encouraged the community to cultivate EFY in their own backyards by providing seed, small tubers, basic tools, and training through farmer field schools and demonstration plots. Through this, more EFY cultivation in home gardens and farmland has been observed in Chin State in recent years, although extraction from forests still exist. Apart from Chin State, EFY cultivation is now also found in some areas of Yangon, Bago, and Mandalay Regions. It is worth noting that EFY cultivation in the Yangon Region was established under shade trees in the late 1990s.

The demand for EFY is dominated by the Chinese and Japanese export markets for dried chips. The Chinese market was the first to develop through traders from Mandalay who were main link between China and Myanmar, while the Japanese market only emerged in 2006, based on a zero tax exemption quota, through traders from Yangon.

There are two specific methods for the drying EFY: sun drying or grilling using firewood. Farmers often prefer the sun drying method, but lack of sunshine and presence of frost during the winter season cause farmers to use firewood instead. In some cases, farmers would use sulfate (locally called *kant*) to reduce drying times and to

obtain whiter colored chips. The use of sulfate was widely practiced in Myanmar and was not a problem for the China market in the past, but has been a major obstacle for expanding the export market to Japan.

Three varieties of EFY are found in Myanmar, which can identified by color: white, yellow, or red/pink. The quality of EFY is defined by its glucomannan ratio and according to research carried out by traders, the red/pink EFY variety which can only be found in Chin State had the highest glucomannan ratio of above 60%. In this regard, EFY from Chin State are more attractive to traders, especially those who export to Japan.

Without consideration of plant treatment including weeding, fertilizer, and pesticide usage, the average income from one acre of EFY cultivation is shown in Table 21 below.

Table 20. Cost and benefit analysis for one acre of EFY cultivation*.

Average Cost	Local Units	International Equivalent
Seed (550 viss x 2500 MMK/viss)	1,375,000 MMK	
Labor cost for cultivation (100 man days x 2500 MMK/day)	250,000 MMK	
Average cultivation cost	1,625,000 MMK	2,975 USD
Labor cost for processing (100 man days x 2500 MMK/day	250,000 MMK	
Average Yield	**Local Units**	**International Equivalent**
Fresh tuber	5,000 viss/acre	19.8 MT/ha
Processed/dried chips (1:6)	833 viss/acre	
Average buying price of fresh tubers	600 MMK/viss	
Average buying price of dried chips	4200 MMK/viss	
Average Profit	**Local Units**	**International Equivalent**
Net profit from tubers	1,375,000 MMK/acre	2,515 USD/ha
Net profit from dried chips	1,625,000 MMK/acre	2,975 USD/ha
Extra income for processing	250,000 MMK/acre	460 USD/ha

**Based on data from cluster level meeting at Mindat, Chin State*

2.3.4 Overview of sweetpotato

Sweetpotato is widely consumed as a traditional snack in Myanmar and almost all sweetpotato production is backyard home gardening by small farmers. Field visits in South Shan and Ayeyarwaddy did not yield positive results in terms of identifying commercial sweetpotato production areas, even after consultation with local DOA officials. However, during the stakeholder consultation workshop for cassava, the team was advised of some small scale commercially oriented sweetpotato production area in the Hmawbi Township, Yangon Region. Moreover, after further consultation with Chris Wheatley of CIP-FoodSTART+, the scoping study extended to the

Thiyimingalar wholesale vegetable market in Yangon, where sweetpotato is traded throughout the year (Figure 12).

Figure 12. Sweetpotato being sold at the Thiyimingalar wholesale vegetable market.

According to wholesalers in Thiyimingalar, the sweetpotato comes from different production locations depending on the season. Most of it come from the Ayeyarwaddy Region (Maubin), CDZ (Myingyan, Pakokku, and Yamething), Yangon Region (Hmawbi), and Bago Region (Phayagyi and Latpadan). Three types of sweetpotato that can be found in the market throughout the year are:

1. Red skinned with white flesh,
2. Red skinned with violet flesh, and
3. White skinned with orange/yellow flesh.

DAR reportedly maintains a collection of about 15 local sweetpotato varieties, including orange and yellow fleshed varieties, but otherwise has no active R&D program related to this crop. Most people prefer the variety with red colored skin with violet flesh locally called *Nga Chaik*. All three types are local varieties, except for the orange fleshed sweetpotato which appears to be imported from Thailand but are being grown in Myanmar. At the time of the field visit to Thiyimingalar market the sweetpotatoes being sold were from the Latpadan Town in Bago Region, which were harvested from mid-February until the end of April. Although the traders noted that sweetpotato from the Hmawbi area receives the highest price because they harvest in the rainy season during the months of August and September.

The Hmawbi area produces both Thailand and local varieties of orange-fleshed sweetpotato, as well as the violet ones. Most farmers here produce their own planting material. They would leave sweetpotato plants in fences and/or boundary of their farm after harvesting sweetpotato roots. One month before cultivation, farmers would cut the sprouting part from the raw sweetpotato plants and grow those sprouts in a nursery to produce seedlings

(Figure 13). Farmers would sometimes sell seedlings to other farmers at 2.5 to 3 MMK per seedling or 1.85 to 2.22 USD per 1000 seedlings. However, other farmers during the FGD claimed that farmers from Hmawbi in Yangon Region, and also Yemathing area in Mandalay Region – CDZ, purchase sweetpotato vine cuttings during the harvesting period for multiplication as planting material in their area for 1.5 MMK per cutting.

Cultivation of sweetpotato in Hmawbi Area uses the mound system, similar to cassava production. According to farmers, the average spacing is 1000 mounds per acre with about 25 to 30 cuttings planted in one mound which is around 3-4 ft in diameter. Total plant population was 25,000 to 30,000 plants per acre. Farmers also reported an average yield of 1 to 2 viss per mound or 3.9-7.9 MT/ha, however, the Nyaung Hnit Pin farm manager provided lower estimates of yield at 0.8 to 1 viss per mound (3.2 to 3.9 MT/ha) due to the low quality of the planting material used in in the area, as well as the prevalence of traditional cultivation systems.

Figure 13. Sweetpotato seedlings at a nursery in Hmawbi.

Similarly, sweetpotato farmers in Latpadan produce the orange/yellow and violet fleshed varieties (Figure 14). The yellow variety is harvested 3.5 - 4 months after planting, or even as early as three months for some, while the violet variety has a longer period for tuber maturity at 4 - 4.5 months after planting. Some farmers even extend this up to 5 months. Cultivation of sweetpotato in Latpadan is usually in alluvial soil from the river side. Farmers here cultivate sweetpotato as a winter crop after the water level drops.

Figure 14. Sweetpotato farm at Latpadan.

Unlike in Hmawbi, farmers in Latpadan do not practice planting material production in nurseries, and would purchase cuttings from other areas including Hmawbi, Yemathin, and Kwinkauk in Ayeyarwaddy Region. The cost of planting material was 3500 MMK per 1000 cuttings equivalent to 2.6 USD per 1000 cuttings including transportation. The wholesalers mentioned that the buying price of sweetpotato is 400 to 500 MMK/viss (0.18 to 0.23 USD/Kg) and resold to retail after sorting into 3 or 4 grades.

Different from Hmawbi, the farmers from Latpadan area cultivated sweetpotato by ridge. Each row of ridge is spaced at 18 inches. The yield was 2500 to 3000 viss/acre (10 to 12 MT/ha) maximum, if no extreme event occurs. It was noted that some farmers rent farmland at 200,000 to 250,000 MMK/acre (equivalent to 366 to 457 USD/hectare).

Like other crops, access to finance is one of the key constraints for sweetpotato farmers. They borrow initial investment for production with 5% to 10% monthly interest rate, which affects their potential income come harvest time. The cost and benefit analysis of sweetpotato production is shown in Table 22 below.

Table 21. Cost and benefit analysis of sweetpotato production[1].

Average Cost	Unit Cost	Local Units	International Equivalent
Land preparation by machine	5 days x 12,000 MMK/day	60000	
Land preparation by cow	2 cows x 5,000 MMK/cow	10000	
Cuttings	30,000 pcs x 3.5 MMK/pcs	105000	
labor for planting	20 man days x 2,500 MMK/day	50000	
Fertilizer (Compound NPK) 1	1 bag x 25,000 MMK/bag	25000	
Fertilizer (Compound NPK) 2	1 bag x 28,000 MMK/bag	28000	
labor harvesting	6 man days x 2,500 MMK/day	15000	
Cow for harvesting	2 cows x 5,000 MMK/cow	10000	
TOTAL COST		303,000 MMK/acre	554 USD/ha
Average Yield		**Local Units**	**International Equivalent**
Average Yield		2,500 viss/acre	10 – 12 MT/ha
Average Price		400 MMK/viss	
Average Profit		**Local Units**	**International Equivalent**
Average income		1,000,000 MMK/acre	1,830 USD/ha
Net profit		697,000 MMK/acre	1,275 USD/ha
Average Profit with Land Rent Fee		**Local Units**	**International Equivalent**
Land rent fee		250,000 MMK/acre	263 USD/ha
Total cost with rent		553,000 MMK/acre	
Net profit with land rent fee		447,000 MMK/acre	818 USD/ha
Average Profit in 2016[2]		**Local Units**	**International Equivalent**
Average price in 2016		150 MMK/viss	
Average income in 2016		375,000 MMK/acre	686 USD/ha
Net profit in 2016		72,000 MMK/acre	132 USD/ha

[1]*Based on FGDs with cassava farmers on the study site.*
[2]*Prices dropped in 2016 due to oversupply.*

2.4 RTC for food security, nutrition, and livelihoods

RTCs such as cassava, EFY, and sweetpotato are not often consumed daily, and except potato which is part of many everyday meals. Potato is consumed as curry food and as a snack while sweetpotato is consumed as a snack, but cassava and EFY is not consumed directly as a household food at all. Cassava is processed as starch and used by the food industry for producing noodle and snack, while dried EFY chips is sold to China and Japan. At present, RTCs as an alternative staple food is not practiced, and rice remains the major staple food in Myanmar. It was

noted, however, that people from some food insecure areas such as upland communities consume maize and/or mix maize and rice as a staple their food.

RTCs, especially potato, cassava, and EFY primarily contribute to food security and livelihoods through the income generated from their sale, whether fresh or processed, rather than directly through consumption. The exception to this may be sweetpotato, on a small scale in some communities, although there is no hard data to support this.

RTCs, specifically sweetpotato, may have a greater role in addressing nutrition issues in Myanmar in the future. In a round table discussion on "Realizing Nutrition Outcomes in Myanmar" held in Yangon on 26 September 2016 and organized by the International Institute of Rural Reconstruction (IIRR), CIP contributed a presentation on the role of RTCs in nutrition. This highlighted the experience of Bangladesh in realizing the potential of orange-fleshed sweetpotato in mitigating dietary vitamin A deficiency among vulnerable children and women. The participants in this meeting expressed great interest in exploring the possibility of a similar approach in Myanmar, given that sweetpotato was not a major component of the diet in Bangladesh either, when the project was initiated. An exploration of the potential for such an effort will require more detailed and thorough research given the almost complete absence of secondary data and institutional attention to this crop in Myanmar.

3.0 Value Chain of Selected Root and Tuber Crops

3.1 Potato value chain

The potato value chain in Shan State was found to be relatively straightforward (Figure 15), with not many steps or actors involved. It was noted that the potato value chain from Sin Phyu Kyune also involved the same actors, and that the same actors and flow could be typical in other locations in Myanmar.

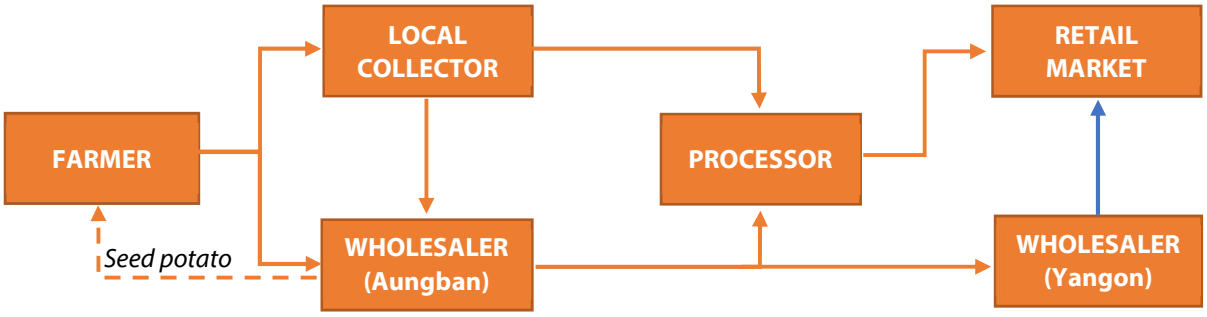

Figure 15. Typical potato value chain in Shan State.

Fresh potato is sold for home culinary use through retail markets. Farmers simply sell fresh potato right after harvest to local collectors, wholesalers, or traders who then sell in wholesale markets in Yangon and Mandalay for redistribution to retail markets around the country. In some remote areas, farmers sell fresh potato directly at retail markets. Approximately over 80% of fresh potato are consumed by rural and urban households.

Fried potato chips are processed by small scale local processors and large scale processors or snack food factories from Yangon and Mandalay. These processors buy fresh potato from local collectors as well as wholesalers.

Seed potato, usually medium sized (40-60mm) fresh potato, is mostly distributed by local wholesalers to farmers, as illustrated by the broken lines in the figure. Presently, there are no specific potato seed production areas or growers in Myanmar. Some farmers store fresh potato from their own harvest to use as seeds, but majority of potato farmers purchase fresh potato from wholesalers to use as seeds when planting season starts. There are no recommended record system or specific storage period for potato farmers in the country. As a result, some farmers face a problem with potato seed dormancy periods. While there are many factors that determine the length of the dormancy period, the short period between harvesting and planting time is often not sufficient to break dormancy.

Potato grades in the market are defined and named by the size of potato tubers. While there are seven different grades with different local names only three are commonly known in local markets: OK, A1 and Swel Thee (Table 23). There is also a grade called S, meaning special, which are larger than grade OK size, there are also two different grades under S. Additionally, there are grades smaller than Swel Thee known as Lone Latt and Gawli. Gawli is about 1 inch in length. Farmers would often use size comparison with other items to identify grades. For instance, OK is equivalent to a standard sized chicken egg while Swel Thee size is equivalent to the size of a large plum, which is a Thailand variety and is even locally called Thailand plum. A1 is defined as the size between OK and Swel Thee.

Table 22. Average sizes of common potato grades in Myanmar.

Grade	Size
OK	2.5 inches to 3 inches (60 - 75mm)
A1	1.5 inches to 2.0 inches (40 - 50 mm)
Swel thee	1 inches to 1.5 inches (24 - 40 mm)

A ten-year price comparison of potato grades in Shan State and Yangon (Figure 16) shows that for both areas and almost all grades, potato prices reached a maximum in 2010. It then dropped in 2011 to 2013 and has gradually increased since then, reaching a new maximum price in 2015. Meanwhile, monthly potato prices from Yangon and Shan State show different patterns (Figure 17) among potato grades. For example, Swel Thee prices in Yangon were less than in Shan, where this grade is used as seed for the next planting season.

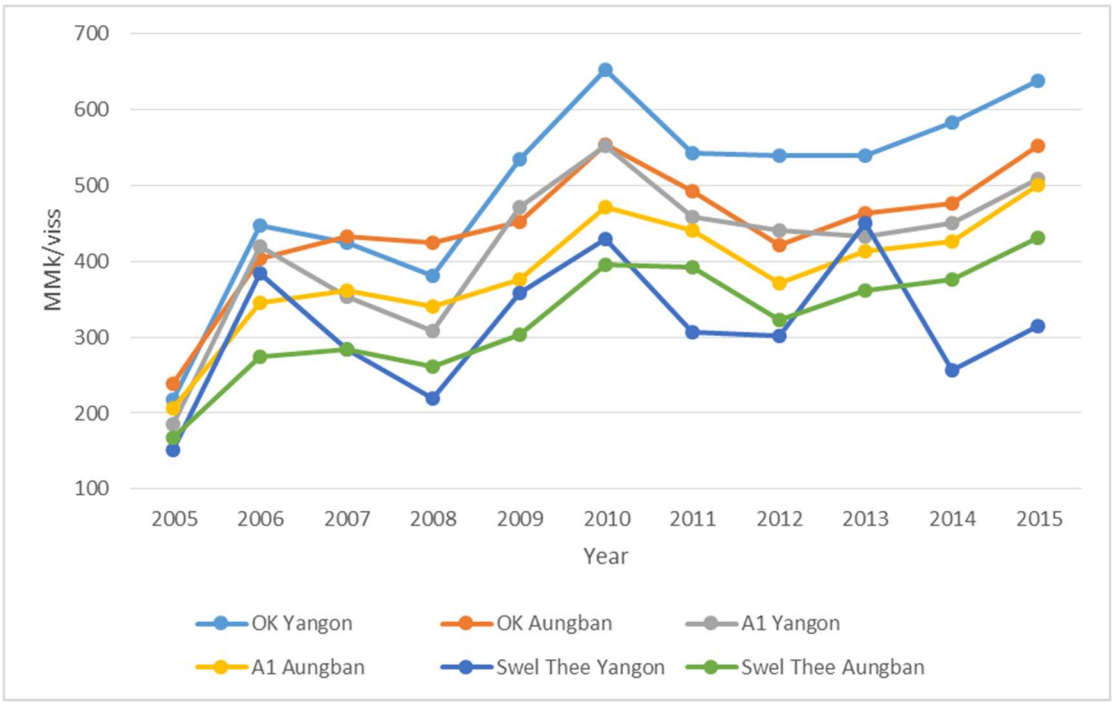

Figure 16.Average potato prices by grade from Aungban, Shan State and Yangon from 2005-2015.

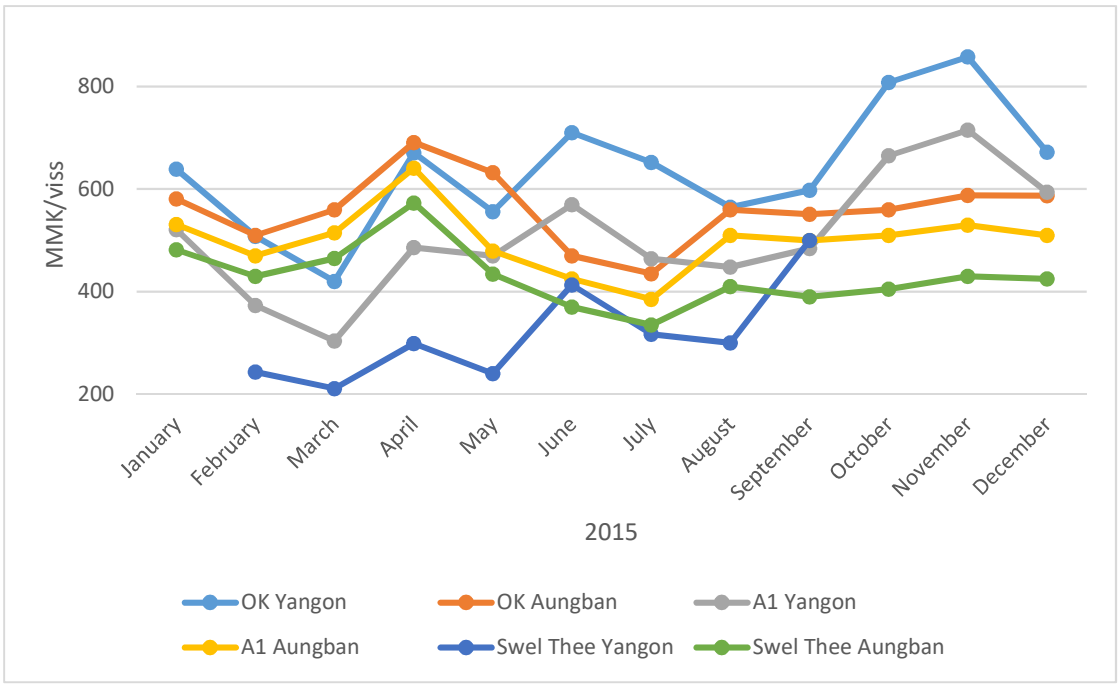

Figure 17. Average monthly potato prices by grade in Aungban, Shan State and Yangon in 2015.

3.2 *Cassava value chain*

The cassava value chain in the Ayeyarwaddy Region is quite straightforward with not many steps of actors involved, despite involving processing and milling activities (Figure 18). Almost all farmers sell fresh roots to local starch processors or to traders who purchase on a whole farm basis even before harvest time. Under this system, the harvest costs is paid by the traders who then send the harvested fresh cassava roots to starch processors for processing for lump sum fee of about 5,500 MMK for 100 viss of fresh cassava roots for processing. From this quantity of fresh cassava, the processor returns only 30 viss of dry starch, with approximately 12-13% moisture content.

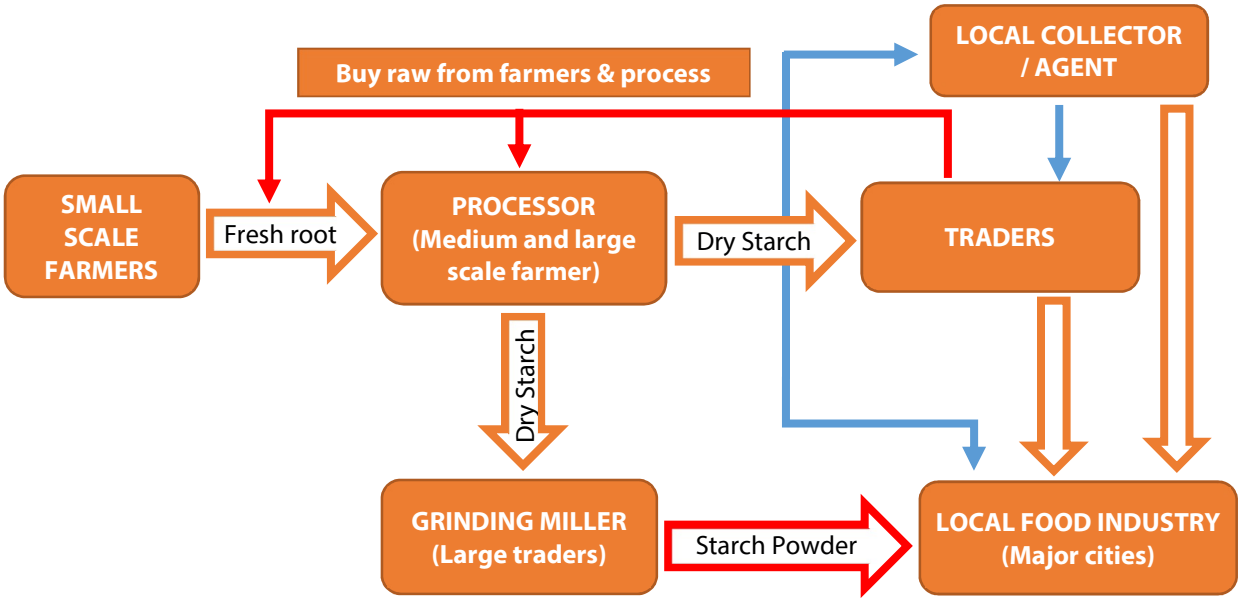

Figure 18. Typical cassava value chain in the Ayeyarwaddy Region.

Dry cassava starch from the processors are then sold to local collectors, agents of food industries, and other traders. Large scale traders also operate mills to grind the sun-dried starch to a finer grade of powder, suited for food industry use. Both dry starch and starch powder are used and further processed by the food industry into other food items. According to the FGD with cassava farmers, the cassava fresh root tuber price has gradually increased in recent years. The price trend is shown in Figure 19.

Figure 19. Fresh cassava root tuber price from 2011-2012.

4.0 Other Relevant Information

4.1 Previous projects in the study area

This research found only a few RTC related projects in the study sites. Focusing only on potato and cassava.

Potato

- Potato value chain development project – CDN
- Seed potato project at Heho, Shan state – CDN
- Potato cultivation Training-of-Trainers (ToT) – WUR

In 2012, the CDN supported an initiative to reinforce rapid multiplication techniques, with the construction of a screen-house and on farm introduction. Insufficient knowledge by the project implementors led to all the seed produced being diseased. Therefore in 2014, the WUR, with limited funding from the European Community Development Network (EuCDN), intervened to set up hygiene protocols and equipment (soil steamed and detached) and Hazard Analysis and Critical Control Points (HACCP) protocols (Holdinga et al., 2014). The mission found that the project at Heho has ceased activities. Therefore, with some remaining funds the project purchased a container of seed potatoes from the Netherlands (Markies and Carolus varieties) to be distributed to over 100 growers (Pronk et al., 2015).

In August 2015 to April 2016, a baseline survey on potato production in Myanmar was carried out by two experts from the WUR and two students of the Aeres Group Dronten, together with various stakeholders in the potato sector in Myanmar. This baseline survey is one of the fast-tracked activities proposed during the Netherlands potato mission to Myanmar in early 2015. The mission's main objective was to scope the possibility of a Myanmar – Netherlands PPP Programme that aims to support the development of a strong, sustainable, and competitive potato sector in Myanmar.

Cassava

Previous projects for cassava focused on farms trials of new varieties, implemented through collaboration between local and international organizations, including:

- CGMTA and CIAT cassava variety trials.
- Australian Center for Agriculture Research (ACIAR) funded farm trials implemented by the Yazmin Agriculture University and DAR.

4.2 *Policy environment relevant to RTCs*

There are no specific policy relevant to RTCs in Myanmar, however, RTC seed and planting material are governed by two laws referred to as The Seed Law and The New Plant Variety Protection Law. These policies grant the protection of new plant varieties and encourage research and breeding of new varieties, particularly in the private sector in line with Myanmar's obligations under the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement). Article 8 of the Seed Law mentions that "Any person desirous of producing or introducing new plant variety for commercial purposes shall apply to the National Seed Committee in accordance with the stipulations by submitting complete facts of the new plant variety together with seed sample to obtain the recognition certificate for the new plant variety which he desires to produce or introduce." The current system of releasing new seed varieties in Myanmar follows the steps illustrated in the figure below (Figure 20).

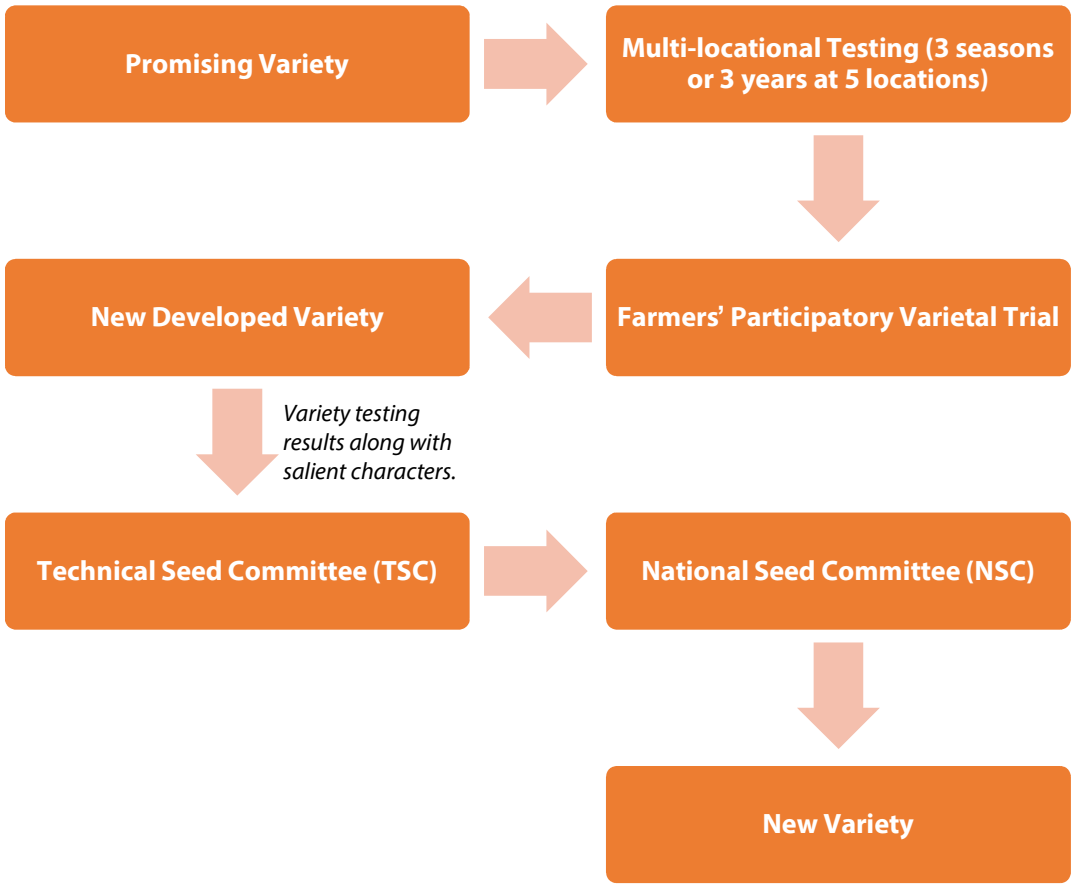

Figure 20.Current system of releasing new seed varieties in Myanmar.

It was noted during the stakeholder workshop new potato seed variety approval efforts by Pepsi Co are now underway to be able to formally release the Atlantic variety following the system mentioned above. Also, potato clusters have imported new varieties of Markies and Carolus in accordance with the Seed Law.

Other RTC related local policies include the government irrigation scheme for the benefit of potato production as a winter crop after paddy harvest at Heho in Shan State. Moreover, interviews with members of the CGMTA and discussions with participants of the stakeholder workshop revealed that the Ayeyarwaddy Regional government supported the activities and encouraged the formation of associations, and even granted them land for new cultivation, to support the development of the cassava sector. In addition, the union government has encouraged the development of PPP and foreign direct investments for agriculture sector in general, including RTCS.

5.0 Stakeholder Analysis

5.1 Government agencies (policy & implementation institutions)

In Myanmar, there are several government agencies related to the agriculture sector. The MOALI is focal ministry for agriculture sector management and development. Under it, the DOA is responsible for technical support through the extension service and for seed multiplication through seed firms. Under the DOA, the Land Use Division and Plant Protection Division are responsible for testing and issuing certificates related to chemical content percentage, while the DAR is responsible for seed sector development through their laboratory and research farms. Other relevant departments under the DOA include: the Land Survey and Record Department responsible for recording land use, the Agriculture Mechanization Department which provides technical and physical support for agriculture mechanization, the Irrigation and Water Utilization Department responsible for irrigation related management, and the Department of Planning responsible for coordination among ministries and is the focal department for foreign aid related issues.

Meanwhile, the Ministry of Commerce (MOC) is the focal ministry for export and import processing, including agriculture related products such a seed imports and end-product exports. The Ministry of Natural Resources and Environmental Conservation (MONREC), on the other hand, is the focal ministry for environment related issues. Under this ministry, Environmental Conservation Department (ECD) is responsible for supervising and monitoring of environmental conservation related issues.

The following sub-sections on government extension service and research institutions gathered information from the publication Data Collection Survey on Agriculture Sector in the Republic of the Union of Myanmar by the Japan International Cooperation Agency (JICA, 2013).

5.1.1 Extension service

The DOA is the sole government institution responsible for providing the public extension services to farmers such as crop cultivation, cropping systems, appropriate utilization of agricultural inputs, and pest control, in order to improve their living standards. Agricultural extension organizations under the DOA are composed of state/region agricultural offices, and district/township agricultural offices. At each district or township office, a manager or township manager is assigned as the leader with two or more assistant managers and accountants are working under the leader. Assistant managers are responsible for extension and input supply, while the assistant manager who is in charge of extension also manages the extension base or camp as the camp leader.

At present, most of these extension camps are not functioning and has deteriorated over time. The extension camp should consist of one to four village tract managers and four to eight village managers, and cooperates with the district or township office for extension services. With relatively few resources available, present extension services have focused on rice and other priority crops, and pays little attention to RTCs.

5.1.2 Research institutions

The DAR is the principal government agency involved in agricultural R&D under the MOALI, while the DOA has also established research centers, as discussed below. Other agencies that also conduct research on production technology and agricultural economic development include the Department of Industrial Crops. Development (DICD), Irrigation Department, and Yezin Agriculture University (YAU). Notable, an Agricultural Science Indicators (ASTI) survey conducted on research and development for Myanmar in 2007 indicated that Myanmar is one of the Asian countries with the lowest number of trained researchers at the post graduate level.

DAR

DAR'S mission is to systematically conduct research activities that would cater to the needs of all stakeholders, including producers, distributors, and consumers, through dissemination of regionally adopted crop varieties and crop production technologies. DAR's research focuses on increasing crop production through improved seed, crop management, crop protection techniques, and cropping systems tailored to suit the country's various agro-ecological zones. These research activities contribute to enhancing the agricultural productivity in the country.

There are six major divisions under DAR. These are the Rice and Other Cereal Crops Division; Oil Seed Crops and Food Legumes Division; Soil, Water Utilization and Agricultural Engineering Division; Agronomy, Agricultural Economics and Statistics Division; Biotechnology, Plant Genetic Resources and Plant Protection Division; and the Industrial Crops and Horticulture Division (ICHD), of which RTCs fall under.

DAR also manages seven research centers and 17 satellite farms located in various state/regions. There are also a laboratory in YAU and a satellite farm in the Shan State for conducting tissue culturing for seed production, but their capacity was limited for experiments only.

Central Agriculture Research and Training Centre (CARTC)

CARTC is an umbrella organization of DOA, and was established in 1984 under technical cooperation by JICA. It was previously named "Central Agriculture Development and Training Center", but was changed in 1999 to highlight the enhanced research function of the center. At present, however, research activity is quite limited to survey response of paddy to fertilizer application, and its main activities focused on providing trainings to DOA officials.

Vegetable and Fruits Research and Development Center (VFRDC)

VFRDC was founded in 1986 as a research institute under the Horticulture and Bio-technology Division of the DOA. As of October 2013, the center has 48 officials including around 30 researchers. However, capacity development of researchers is needed since the center's researchers are limited to one doctorate degree and for master's degree. It has eight sections in Yangon including vegetable, fruits, tissue culture, plant protection, soil fertility, in addition to eight research farms in the Union. Their main activities are production and sale of hybrid and certified seeds of vegetables and fruits, as well as extension of these seeds to farmers.

5.2 Private institutions

There are two RTC related regional level associations existing in Myanmar as 1) Potato Cluster and 2) Cassava Growers, Millers and Traders Association.

5.2.1 Potato Clusters

Formed under the Myanmar Fruit, Flower and Vegetable Producers and Exporters Association (MFVP), one of the sister associations of the Union of Myanmar Federation of Chambers of Commerce and Industry (UMFCCI), potato clusters were organized by large scale potato farmers in specific regions. It was noted that three potato clusters were founded as area production bases in Heho, Naungtayar (South Shan) and Sin Phyu Kyun (Central Dry Zone).

Even though these organizations only have 10% to 20% of potato farmers as members, most of the potato farmers in their respective areas are aware about the activities of each potato cluster. It was noted that potato clusters in each areas are at their early stage, and presently have more than 100 members in total. The potato clusters are coordinating not only with government institutions such as DOA and DAR, but also with private institutions, both profit and non-profit oriented, for potato sector development. The potato clusters are conducting on-farm trials of new varieties at their key members' own expense, and are also importing new varieties from both The Netherlands and China.

In Heho and Naungtaya, key farmers from the potato clusters are conducting trial plots with 12 new varieties imported from Netherlands, supported by a project with the Netherlands Embassy that engages the Dutch private sector, including training of extension agents and cluster members in potato production technology and practices. In addition, key farmers from the Sin Phyu Kyun potato cluster are conducting trial plots for 4 new Chinese varieties.

5.2.2 Cassava Growers, Millers and Traders Association

This association was organized by large scale cassava growers and millers with the support of the Regional Chief Minister of the previous government. The CGMTA was formed at the regional level, although there are plans to scale up to union level soon. Most of the members are large scale growers and processors and majority of small scale cassava growers and processor are generally not aware of it.

Current membership in the CGMTA is less than 100 members, but even though the number of members are limited, it is still able to work closely with the ICHD under DAR and with CIAT for variety development. They have organized on-farm trials in their own farms as well as in new potential areas for cassava production, with the support of the regional government.

5.3 National and international NGOs

There are many international agencies including donor organizations carrying out activities toward livelihood improvement in Myanmar, including support for agriculture sector development. Among them are the World Bank (WB), Asian Development Bank (ADB), International Fund for Agricultural Development (IFAD), U.S. Agency for International Development (USAID), Department for International Development (DFID), and the Australian Centre for International Agricultural Research (ACIAR). In addition to these institutions, the Livelihood and Food Security Trust Fund (LIFT), a multi-donor fund, also plays a key role; as well as the Netherlands Embassy in Myanmar, which is actively involved potato sector development in Shan State.

Moreover; the Food and Agriculture Organization (FAO), World Food Program (WFP), Japan International Cooperation Agency (JICA), and the German Society for International Cooperation (GIZ) also provide support to the agriculture sector development but not specific to RTCs.

5.4 Private companies

The following are the known examples of private sector participation in the development of the RTC sector:

1. The EUROPLANT Pflanzenzucht GmbH and Ter Beke Agriconsult are well connected with potato cluster from Heho and Naungtayar.

2. Pepsi Co is conducting limited contract farming for potato production in Heho and Sin Phyu Kyune, for export to Thailand and Indonesia to be processed into snack foods.
3. Tint Tint Myanmar Company are conducting limited cassava contract farming in the surrounding area of Nyaung Hnit Pin agriculture zone in Hmawbi Township.

5.5 Value chain actors

Majority of the RTC producers in the study sites are smallholder farmers, and their main concerns include the lack of investment capital, limited access to markets, and vulnerability to climate change impacts. Farmers also expressed various constraints for expanding RTC production including: 1) lack of improved varieties with disease resistance and higher yield; 2) lack of technical knowledge on land preparation and plant treatment to prevent pest and disease, as well as improve yield; 3) limited access to market which monopolize price; 4) lack of initial investment with limited access to financing; 5) lack of labor force; and 6) low quality of fertilizer and pesticide/insecticide.

In addition, large scale potato farmers also highlight the lack of post-harvest storage facilities for potato which are a major constraint for seed storage practices. Not only farmers, but processors also face losses due to lack of post-harvest storage facilities.

Meanwhile, cassava starch processors mentioned the need to improve old and locally made processing equipment, as well as traditional processing methods. Large processors also want to install modern equipment for cassava processing, but are concerned about fresh root supply if capacity expands, and about price monopolies in the food industry. Since current cassava processing period is only two to three months per year and sun-drying is only feasible between January and March, before the rains start, large scale farmers who are also processors want technical support for expanding the cassava planting and harvesting seasons, and for artificial drying technology in their region. They also expressed issues with complaints by neighboring houses due to waste water effluent from processing.

Finally, traders expressed their desire to expand volumes, highlighting the need to help farmers gain access to better - specifically good yield and disease free - varieties, modern cultivation techniques, and better postharvest practices.

6.0 Key Findings

6.1 Vulnerability and role of RTCs

Climate is considered a major vulnerability factor for RTC farmers. For instance, shifting monsoon seasons can cause problems for cassava growers. In recent years, flooding has also caused considerable damage to cassava farms. Likewise, high intensity rainfall in the middle of the rainy season and unexpected rain during winter season cause crop damage for both potato and cassava.

In addition to climate, access to market and market monopolies by large scale traders in the cassava starch market are also one of the vulnerability factors for small scale cassava growers.

6.2 Perceptions of food security and food insecurity

Food security in a region or household can be assessed through the availability, accessibility, and utilization of food. Since rice is the country's main crop and staple food, over the past six decades and up to as recently as two years ago, government measures have sought to make rice available at affordable prices. However, there are still a few food-insecure households for whom sufficient rice is neither available nor accessible due to limited income and/or the impacts of disasters on their rice production. During these times, families borrow money or rice from neighbors or relatives or eat far less volume of rice than usual, for example having one meal instead of two or eating rice gruel instead of cooked rice.

Because of the tradition of consuming rice as the main staple food, RTCs have less impact on food security in Myanmar.

6.3 Changes in the roles of men and women

For families in Myanmar, particularly those in rural areas, work is shared between men and women family members. In general, men are in charge of the heavy work including land preparation, fertilizer and pesticide application, and machine operation in processing while women are more involved in planting, weeding, and harvesting. However, with the trend of migration among young men in rural areas, more women are found to be involved in the agriculture sector and are doing intensive work than before.

6.4 Labor issues and migration

With globalization and faster information flow than ever before, young people are less and less interested in agriculture thus creating a labor shortage in the sector in many countries, including Myanmar. The younger generation are migrating to towns, cities, and foreign countries to find new opportunities and better employment to better support their family and themselves. The situation is further aggravated by declining income from agriculture. Low and monopolized produce prices, increased production costs, low yield due to traditional farming practices and insufficient capital for fertilizer and plant treatment, all lead to reduced profit margins from agriculture production, including RTCs. To cope, some farmers have no choice but to reduce their production capacity, further limiting their income. This cycle of poverty increase family members' desire to abandon agriculture and migrate to urban areas for better livelihood prospects, especially young people.

The availability of farm labor is also affected by farm labor wages. Although agricultural wages in 2016 have increased by 30-50% compared with 2014 levels at 4,000 - 5,500 MMK/day for men and 3,000 - 4,500 MMK/day for women, most farmers and laborers complain its value is actually lower than what they were receiving in the past.

6.5 Major constraints for RTC sector development

During the stakeholder workshops conducted in both potato and cassava production areas and participated by their respective producer associations, DOA, DAR, and YAU; the participants reached a consensus towards prioritizing the following issues relevant to RTC development.

Poor quality seeds

- The lack of proper seed industry and informal seed distribution system contributed to low productivity due to impurity, degeneration, disease bond, and less maturity or less dormancy period of the potato seed.
- Traditional storage practices for cassava stakes which involves open air with direct sunlight and/or under sunshade for next season cultivation will affect yield drop.

Lack of improved variety

- The reach of new varieties for both potato and cassava is so far quite limited.
- New potato varieties imported from Netherland (Carolus and Markies) are attracting potato farmers, but the cost of imported seed price will reduce post-project sustainability, especially for smaller producers.
- Key farmers from potato clusters are conducting trial plots for more new varieties from the Netherlands and China, but the results are still unknown.

- Key farmers from CGMTA are also conducting farm trials for new cassava varieties with support from DAR, CIAT, and ACIAR, but these trials are still in its early stages.

Severe pest and disease outbreaks

- Affected by late bright and bacterial wilt, potato farmers apply high rates of fungicide and pesticides for protection without consideration of environmental hazards.
- Cassava farmers also face diseases and insects (*pya poe*) which affect plant and tuber growth rates, as well as white ants that damage roots in the field, but no proper disease management was mentioned.

Lack of knowledge for plant protection and systematic cultivation practice

- Most potato farmers and smallholder cassava farmers are still using traditional practices for land preparation, plant protection, and plant treatment which lead to low productivity.
- With the collaboration of potato clusters and the DOA and the financial assistance of the Netherlands Embassy, the WUR is providing TOT on proper potato cultivation among farmers, staff of the DOA, and input suppliers.
- CIAT is providing technical training to staff from DAR and some key members of the CGMTA, though the ACIAR project.

High production costs

- Poor crop management with excessive or low input use and lack of quality seed, compounded by climate change effects, results in low yields of potato and cassava. As a result, production cost is higher and farmers receive less profit.

Labor shortage

- Due to low income, the seasonal nature of agricultural jobs, and the lack of economic opportunities; many young rural people in Myanmar are migrating to urban areas for better employment opportunities. As a result, the labor intensive potato and cassava production now face labor shortages during planting and harvesting seasons.
- While some well-off farmers mechanize their production including land preparation on both crops and planting and harvesting for potato, many small and marginal farmers still depend entirely on manual labor and may not maximize their potential profit.

Limitations of the processing sector

- There are a few large scale fried potato chip production companies in Yangon and Mandalay, but the majority of potato processing such as fried potato chips is done at the household level for local markets. As a result, the demand on the overall potato sector is quite limited.
- Almost all cassava processors operate using traditional practices with locally available machines and equipment, as result, their capacity of 1-10 MT fresh roots per day and starch extraction yield from root tubers is limited.
- There is no adequate treatment being done for waste water generated from cassava starch extraction and only a few processors arrange long drain channels for reducing the smell. Waste water simply flows directly into nearby creeks and/or streams and neighbors have complained about the bad smell, however, it seems that processors do not pay attention to the environmental effects of their effluents on soil and water.
- The current practice of sun-drying cassava for starch production limits the processing period to the dry season from January to March. Since raw cassava root tubers need to be processed within 24 hours of harvest to obtain good quality starch, farmers have no choice but to harvest within this period even if yields are not yet optimum.

Lack of market diversification

- The majority of potato produced in Myanmar is consumed fresh in the household kitchen for everyday dishes such as curry, while a small percentage is consumed as a snack food such as fried potato chip. Even though potato is now being exported to other countries, this amount is still limited and not significant.
- Almost all cassava root tubers from Myanmar are processed as starch and are marketed to the domestic food industries. Only by-products like pulp, a processing residue, are sold as animal feed after drying. No other part of the cassava plant, like leaves, are used for any other purpose.

Market monopoly

- Potato market prices are directly determined by supply and demand among many traders, but cassava prices are dictated by the near monopoly held by one large starch trader in the region; who, according to producers and processors, has the financial capacity to corner the market. In addition to this, farmers are also affected by price falls at peak harvest and processing times.

Climate change

- Shifting monsoon periods brought about by climate change are affecting RTC production, especially cassava. Late arrival and early departure of monsoons reduce the growing time for RTCs resulting to low yields. Furthermore, the short duration of monsoons accompanied by more intense rainfall events cause flood damage, especially to cassava farms.

- Drought and heavy rain can both negatively affect potato production, therefore some large scale farmers have installed irrigation systems, based on previous drought experiences.

7.0 Conclusion: Key focus Areas and Priorities for Action Research and Policy Influence

7.1 Seed/planting material

Due to the lack of a formal seed production industry, potato farmers use their own harvested potatoes as seed, while cassava producers use stakes from last year's harvests. Farmers do recognize that poor quality seed and variety affects their potential profit. Therefore, access to good quality seeds and varieties with higher yield and drought and diseases resistance for potato, higher yield and higher starch content for cassava, and higher yield and/or regeneration for sweetpotato are needed for increased economic productivity.

Potato

Using fresh ware potato as seed is a normal practice for potato farmers in Myanmar and potato seeds are stored in the open air with no assurance for staying disease-free or that the full dormancy period has passed. Therefore, access to good varieties with higher yield and disease resistance is key to leverage potato sector development, but for long term sustainability, a domestic potato seed industry development is necessary to avoid continued seed potato imports. Current actions toward this include:

- Potato clusters are now importing new seed varieties from Netherlands and China, but their coverage is limited and prices are high. There are also doubts on the quality of seeds from China.
- The DAR and DOA are working on tissue culturing but progress was slow to lack of technical know-how. A recent masters student on potato tissue culture offers potential to improve this situation.
- PepsiCo is working with the DOA seed farm in conducting potato variety trials while key farmers from local potato clusters are also conducting trial plots in their own farms for suitability in the local context.

Cassava

Keeping stakes after harvest for next season planting material is a traditional practice for cassava farmers. The same with potato, there is no proper storage or treatment for cassava planting material, and almost all are local varieties. Therefore, access to good planting material, including new varieties with higher yield and higher starch content, is key to propel cassava sector development. The following are the current activities on cassava variety sector development:

- DAR is conducting variety trials with support of CIAT, but this haven't reach small and marginal farmers as yet.
- Key members of CGMTA are conducting farm trials of new varieties in both existing and newly develop farmlands.

Sweetpotato

None of the farmers involved in this study were aware about sweetpotato seed variety regeneration. It was noted that even in the DOA farm in Myaung Hnit Pin where sweetpotato is cultivated, no farm trial or research were done on seed improvement. Hence, aside from access to good variety, the dissemination of information related to seedling and proper plant treatment is critical for sweetpotato development.

7.2 Cultivation practice

Traditional cultivation practice and the lack of proper crop management also lead to low economic productivity and environmental degradation. Improved cultivation technology coupled with good agriculture practices should be able to balance improved economic viability and environmental conservation for RTC cultivation.

Potato

- Technical support for modern potato cultivation through TOT for potato clusters in South Shan are being done through financial assistance from the Netherlands Embassy, but farmers still lack support for postharvest technology including handling.

Cassava

- It was understood that CIAT will provide technical support to staff from DAR and key members of the CGMTA, but this is yet to reach marginal farmers.
- Intercropping is currently not being done although this has potential from productivity, livelihoods and conservation perspectives.

Sweetpotato

- Technical support for necessary for modernizing sweetpotato cultivation.

7.3 Agriculture mechanization

Migration among the younger generation of women and men from rural areas has negatively affected potato and cassava production. Labor shortage are found in land preparation, planting and harvesting, and this leads farmers to face uncertainty of economic losses. Access to small-scale agriculture mechanization is necessary.

Potato

Economically better off potato farmers already use more advanced equipment in land preparation, planting, and harvesting, but the majority of marginal farmers still rely on manual labor. Access to agriculture mechanization is vital to potato sector development and the introduction of small-scale planting and harvesting equipment could be the key entry point towards it. This could be done through development of service enterprises, such as equipment for hire, rather than through direct equipment ownership by farmers.

Cassava

Using machines for land preparation is a key entry point for agricultural mechanization for cassava as this can change cultivation practices from the mound to ridge method, which may increase plant density.

7.4 Postharvest

The lack of efficient and environment-friendly postharvest handling facilities and technology for RTCs further contributed to economic loss for farmers and processors alike, as well as environmental degradation. Modern postharvest facilities should be able to add value to RTCs across the value chain.

Potato

Incorrect handling, transportation and storage of potatoes often cause damage to potato tubers, while improper grading cause farmers to face further economic losses. These underline the need to educate farmers on proper handling after harvest and to make cold-storage facilities accessible to farmers.

Cassava

The lack of modern starch processing techniques, particularly the use of inefficient equipment with traditional processing methods, limit the potential to increase the scale of operations in Myanmar. The productivity of starch processing is probably low, estimated at 30% dry starch yield, but this figure is uncertain since farmers and processors use non-standard weighing practices. There is also no measurement being done, or at least estimation using specific gravity, of root starch/dry matter content. It is also likely that the residue by-product still contains

significant starch. These practices cause economic losses for farmers who sell fresh tubers to processors and need to be addressed through proper postharvest education and technologies.

In addition, cassava processors do not use any waste water treatment for their effluents, polluting their environment and drawing complaints from neighbors for the foul odor. This can be addressed through more environment-friendly processing techniques and equipment.

7.5 Value Chain

Like other agricultural products, RTCs tend to be a buyers' market. Potato prices are determined in the Yangon wholesale market, depending on the supply and demand, and only in the case of potato seed are farmers able to bargain over prices. Meanwhile, the price of cassava does not appear to be closely linked to the supply and demand situation since prices are monopolized by one large trader who has the financial power to buy any amount at any time. Also. While the price instability of potato was often due to under or over-supply, this is not the case for cassava. The list below details recommendations for enhancing price stability of potato and cassava.

Potato

- Disseminate market information, including production data from other areas, to farmer level.
- Improve access to financing so that marginal farmers can afford appropriate inputs, including seed, and adopt good agricultural practices.
- Provide access to financing for large scale farmers to invest in improved storage facilities and assist the development of an emerging service provider industry in the potato sector.

Cassava

- Promote market diversification to reduce dependency on one product, particularly starch, and with one major buyer.
- Provide access to financing to reduce farmer and processor financial dependency on large traders.
- Explore and negotiate win-win options for cassava value chain development collaboration with large traders, since, attempts to exclude large traders from the cassava value chain may well be counterproductive.

REFERENCES

ADB [Asian Development Bank]. 2009. Status and Potential for the Development of Biofuels and Rural Renewable Energy: Myanmar. Mandaluyong City, Philippines.

ADB [Asian Development Bank]. 2017. Basic Statistics 2017. Mandaluyong City, Philippines. https://www.adb.org/publications/basic-statistics-2017

Cashin, Jennifer. 2016. Undernutrition in Myanmar; Part 1: A Critical Review of Literature. LIFT. Leveraging Essential Nutrition Actions to Reduce Malnutrition (LEARN) Programme.

CSO [Central Statistical Organization]. 2016. Myanmar Statistical Yearbook 2016. The Government of the Republic of the Union of Myanmar Ministry of National Planning and Economic Development. Nay Pyi Taw, Myanmar.

DOA [Department of Agriculture]. 2015. Cassava harvested area, average yield and production in the various regions and states of Myanmar in 2014/2015. Ministry of Agriculture and Irrigation, Union of Myanmar. (in Myanmar language)

FAO [Food and Agriculture Organization]. 2017. FAOSTAT Statistics Database. Rome, Italy.

FAO and WFP [The Food and Agriculture Organization and the World Food Program]. 2009. Special Report: FAO/WFP Crop and Food Security Assessment Mission to Myanmar. Rome, Italy.

Holdinga, M.R., Wustman, R., Haverkort, A.J., & Pronk, A.A. 2014. Improvement of basic seed potato production in Myanmar: report CDN seed potato project Myanmar. Report / Plant Research International: 597. Wageningen Plant Research International, part of Wageningen UR, Agrosystems Research. http://edepot.wur.nl/344831.

Howeler, Reinhardt H.; Maung Aye, Tin. 2014. Sustainable management of cassava in Asia: from research to practice. CIAT; The Nippon Foundation, Vietnam. 168 p.

IHLCA [Integrated Household Living Conditions Assessment]. 2011. Integrated Household Living Conditions Survey in Myanmar (2009-2010) Poverty Profile. IHLCA Project Technical Unit. Yangon, The Republic of the Union Of Myanmar.

JICA [Japan International Cooperation Agency]. 2013. Data Collection Survey on Agriculture Sector in the Republic of the Union of Myanmar: JICA, Sanyu Consultants INC. Yangon, Myanmar.

Kyaw Yee. n.d. Land Degradation Assessment in Dry Lands of Myanmar. A presentation from the Land Use Division, Myanmar Agriculture Service. MOAI.

LIFT [Livelihoods and Food Security Trust Fund]. 2013. Household Survey 2013. Yangon, Myanmar: UNOPS.

LIFT [Livelihoods and Food Security Trust Fund]. 2012. Baseline Survey Results. Yangon, Myanmar.

MAS and CIP [Myanmar Agricultural Services and the International Potato Center]. 1990. Potato Research and Development in Union of Myanmar (1983-1989). Rangoon and Manilla.

Maung Aye, Tin. 2015. Cassava Production in Lao PDR and Myanmar. Presentation for the Future Prospects for Tapioca Production and Trade in ASEAN. CIAT.

Maung Aye, Tin, Thant Lwin Oo, Nilar Aung, and John Ba Maw. 2015. Potential Role of Cassava in Upland Farming Systems and in Poverty Reduction in Myanmar. *in* CIAT. 2015. Sustainable Cassava Production in Asia – for Multiple Uses and for Multiple Markets. Proceedings of the Ninth Regional Cassava Workshop, held in Nanning, Guangxi, China P.R. 27 Nov – 3 Dec 2011.

Myo Kywe and Kyi Toe. 2015. Overview of Myanmar Agriculture. Presentation.

MNPED and MOH [The Ministry of National Planning and Economic Development and the Ministry of Health]. 2011. Myanmar Multiple Indicator Cluster Survey 2009-2010 Final Report. Nay Pyi Taw, Myanmar: Ministry of National Planning and Economic Development & Ministry of Health, Myanmar.

Ministry of Transport. 2012. Myanmar's National Adaptation Programme of Action 2012. Department of Meteorology and Hydrology, Ministry of Transport. National Environmental Conservation Committee, Ministry of Environmental Conservation and Forestry. United Nations Environment Programme.

MIP [Ministry of Immigration and Population]. 2015. The 2014 Myanmar Population and Housing Census. The Union Report. Census Report Volume 2. Department of Population. Ministry of Immigration and Population. Nay Pyi Taw, Myanmar.

MOAI. 2015. Myanmar Agriculture in Brief 2015. Department of Agricultural Planning, Ministry of Agriculture and Irrigation.

Pronk A.A., A.J. Haverkort, C. van Veldhuijsen, B. Alberts, P. Remijn, J. Peltjes, J. van Waes & P. Kooman. 2015. Report of the potato mission of the Netherlands industry and knowledge institutions to Myanmar: March 7 - 15, 2015. Report / Plant Research International; 611, Plant Research International, part of Wageningen UR, Business Unit Agrosystems Research, Wageningen, 17 pp.

Smith, Martin. 1999. Burma Insurgency and the Politics of Ethnicity. London and New Jersey: Zed Books, 193.

Thae Thae Htwe. 2010. Tapioca factory to open in Kachin. Myanmar Times. 22 November 2010 Issue.

The Economist. 2014. Global food security index 2014: An annual measure of the state of global food security. The Economist Intelligence Unit. New York, USA.

The World Bank. 2017. Agriculture, value added (% of GDP). World Bank national accounts data, and OECD National Accounts data files. https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?end=2016&locations=MM&start=2000&view=chart

Thun M.M., M.M. Myint & A. Hlaing. 2006. Myanmar scenario of potato production, processing and marketing, 5 & 6 July 2006.

Thun Than, U. 1992. Cassava production, processing, utilization and research in Myanmar. In: Howeler, R.H. (ed.). Regional Workshop on Cassava Breeding, Agronomy and Utilization Research in Asia 3, 1990, Malang, Indonesia. Cassava breeding, agronomy and utilization research in Asia: Proceedings. Centro Internacional de Agricultura Tropical (CIAT), Regional Cassava Program for Asia, Field Research Institute. Bangkok, TH.1992.p. 124-143.

The International Potato Center (known by its Spanish acronym CIP) is a research and development organization with a focus on potato, sweetpotato, Andean roots and tubers. CIP is dedicated to delivering sustainable science-based solutions to the pressing world issues of hunger, poverty, gender equity, climate change, and the preservation of our Earth's fragile biodiversity and natural resources.

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