REPUBLIC OF LIBERIA

BARRIER ANALYSIS & ENABLING FRAMEWORK REPORT FOR THE ADAPTATION SECTOR – AGRICULTURE SECTOR

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Foreword

In September 2015, Liberia, as a signatory of the UN Climate Change Convention, submitted the Nationally Determined Contribution (INDC) in advance of the new climate change agreement reached at the UN Climate Conference in Paris in December. Liberia's INDC was designed as a platform to integrate its Low Carbon Development Strategy into the country's long-term sustainable development vision by 2030 (Agenda for Transformation). Liberia ratified the Paris Agreement in August 2018 and is working hard to revise its NDC for submission. Regardless of the many contributions to climate change, Liberia, like many other developing countries, is especially vulnerable to its impacts. The country is at this moment susceptible to the adverse effects of climate change such as shifting cultivation in the agriculture sector, unsustainable logging practices, unregulated coastal mining, high level of biomass consumption in the form of charcoal and fire wood for local energy use, and decreasing river flow due to high level of evaporation. The agricultural sector, which ensures the livelihoods of around 70% of the population, remains vulnerable to flooding and erosion with changing rainfall patterns putting lives at risk in a country where nearly 8 out of 10 people do not have secure access to food. Current climate change vulnerability in Liberia include; increase in extreme events (e.g., exacerbated floods, extreme drought), sea level rise, flooding and coastal erosion being experienced on an annual basis that eats up the coast as observed in Monrovia, Buchanan and Greenville.

I would like to add that Liberia has an overall lack of energy. In most rural areas in Liberia, less than 5% of the population has access to electricity while most homes run mini generators. The current energy situation in Liberia is characterized by a dominance of traditional biomass consumption, low access to poor quality and relatively expensive modern energy services. It is estimated that over 95% of the population rely on firewood, charcoal, and palm oil for their energy needs.

The EPA of Liberia is overly happy with the level of the assessment done by the Technology Needs Assessment Team (TNA) through a national stakeholder's participatory process emulating from the identification and prioritization of environmentally sound technologies to the diffusion of these technologies to mitigate and adapt to climate change. We would like to recognize the United Nations Environment Programme (UNEP), DTU Partnership and Global Environment Facility (GEF). Your contributions have resulted in this rich source of information and we hope that this report will spur parties into seeking out partnerships for the purpose of accelerating climate action and increasing ambition in Liberia.

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EXECUTIVE DIRECTOR/CEO

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LIST OF ACRONYMS

AfT	Agenda for Transformation
BA&EF	Barrier Analysis and Enabling Framework
CARI	Central for Agriculture Research Institute
CBO	Community-Based Organization
CU	Cuttington University
DNA	Designated National Authority
DTU	Danish Technical University
EPA	Environmental Protection Agency
EST	Environmentally Sound Technology
FAO	United Nations Food and Agriculture Organization
FDA	Forestry Development Authority
GEF	Global Environment Facility
GDP	Gross Domestic Product
GHG	GreenHouse Gases
GoL	Government of Liberia
IFDC	International Centre for Soil Fertility and Agricultural Development
IDPs	Internal Displaced People
IPCC	Inter-Governmental Panel on Climate Change
ISFM	Integrated Soil Fertility Management
LACRA	Liberia Agriculture Commodity Regulatory Authority
LATA	Liberia Agriculture Transformation Agenda
LESA	Liberia Endangered Species Association
LIBA	Liberia Business Association
MFPD	Ministry of Finance Planning Development
MICAT	Ministry of Information Culture and Tourism
MOA	Ministry of Agriculture
MOFA	Ministry of Foreign Affairs
MOH	Ministry of Health
NCCSC	National Climate Change Steering Committee
NCCS	National Climate Change Secretariat
NGO	Non-Governmental Organization

NHRM	National Human Right Monitor
NPHIL	National Public Health Institute of Liberia
SCNL	Society for the Conservation of Nature Liberia
SWGs	Sectorial Working Groups
TAP	Technology Action Plan
TFS	Technology factsheet
TNA	Technology Needs Assessment
UDP	UNEP DTU Partnership
UL	University of Liberia
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development

DEFINITION OF KEY TERMS[1]

Adaptation- is short for 'climate change adaptation', meaning adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities (IPCC, 2007). Adaptation is a process, not an outcome.

Adoption- The process by which a technology is selected for use by an individual, an organization or a society

Barrier - A reason why a target is adversely affected, including any failed or missing countermeasures that could or should have prevented the undesired effect(s).

Capital goods- Machinery and equipment used in the production of other goods, e.g. consumer goods, boilers, motors, steel or pumps. May also be termed 'producer goods'

Consumer goods - Goods and products specifically intended for the mass market and purchased by (private) consumers.

Diffusion - The process by which a technology is spread or disseminated through various channels over time in a society, where the technology is gradually adopted by more and more members of the society (people, institutions, companies, etc.).

Enabling environment-The set of resources and conditions within which the technology and the target beneficiaries operate. The resources and conditions that are generated by structures and institutions that are beyond the immediate control of the beneficiaries should support and improve the quality and efficacy of the transfer and diffusion of technologies.

Market mapping- An analytical framework for understanding market systems and an approach to market development that is both systemic and participatory.

Measure - Any factor (financial or non-financial) that enables or motivates a particular course of action or behavioral change, or is a reason for preferring one choice over the alternatives. Often the word 'incentive' is used synonymously, sometimes with a slightly different interpretation

Non-market goods - Goods not traded in a market

Publicly provided goods - A category of technologies characterized by large investments, general public ownership, and production of goods and services available (free or paid) to the public or a large group of persons

Stakeholder - A person, group, organization or system that affects or can be affected by an organization's actions.

Technology - is a piece of equipment, technique, practical knowledge or skills for performing a particular activity. It is common to distinguish between three different elements of technology: the tangible aspects, such as equipment and products (hardware); the know-how, experience and practices (software) associated with the production and use of the hardware; and the institutional framework, or organization, involved in the transfer and diffusion of a new piece of equipment or product (orgware).

Technology transfer - involves vertical technology transfer, which is understood as the movement of technologies from the R&D stage through to commercialization, and horizontal transfer, which involves the spatial relocation or diffusion of technologies across space

[1] Nygaard & Hansen, 2015

EXECUTIVE SUMMARY

This report is in continuation of Liberia's participation in phase III of the TNA process. This report focuses on three adaptation technologies for the agriculture sector that were identifed, prioritized, accepted and taken for the barrier analysis and enabling framework through a stakeholder participatory process. The agriculture sector is one of Liberia's adapatation strategy sectors to combat climate change. It was prioritized along with the coastal zone sector excussively for adaptation. For Liberia to deal with the impacts of climate change, the agriculture sector must be capacitated, equipped and be ready to support food security for the growing population now and tomorrow.

For many years now, the agriculture sector continue to serve as a source of employement for about 70% of rural population and has contriducted greatly to the Liberian economy through Gross Domestic Product (GDP) and export earnings. However, climate change impact such as warmer temperature, and an increase in pests and diseases are potentially reducing yields for some crops like maize, rice, rubber, and cassava. In addressing these challenges and many more, the country has selected three adapatation technologies that will be used to leverage support for the agriculture sector.

The identification and prioritization of the technologies was based on the technology's potential to reduce vulnerability and increase resiliency to climate change. Specifically based on the social, economic, and environmental benefits of the technologies, the process was participatory, gender sensitive and it ensured the involvement of cross-sectorial experts, technicians and stakeholders. Below are the three technologies that were identified and prioritized to be used:

1. Value addition to agriculture products (rice, cassava, vegetables and fruits);
2. Improved Storage (drying and freezing of agriculture products); and
3. Integrated Soil Fertility Management.

For Liberia to successfully adopt these environmentally sound technologies in the agriculture sector, it must first of all deal with some critical barrirers. Therefore, this report is soley addressing barriers to these technologies using the Barrier Analysis and Enabling Framework (BA&EF) to assess potential barriers that could impede the transfer and diffusion of the three technologies and in addition, provide the enabling framework or possible measures to overcome the identified barriers to the transfer and diffusion of the above technologies for the agriculture sector of Liberia.

The logical problem and solution trees analysis and market mapping were employed to analysis for barriers that were identified and categorized according to the type of goods and services they belong or contribute to, or their respective market characteristics. *See table below.*

Table 1: Prioritized Technologies and their Categories – Agriculture Sector

No.	List of prioritized Technologies	Market Characterization
1	Value Addition (Rice, Cassava, Vegetables & Fruits)	*Consumer goods*
2	Improved Storage (Drying and Freezing)	*Publicly provided goods*
3	Integrated Soil Fertility Management (ISFM)	*Combination of consumer goods and non-market goods*

During the barrier analysis process, barriers were categorized into two major categories: economic/ financial barriers, and non-financial barriers. The non-financial barriers for two of the technologies that fall under publicly provided goods as seen above in the table, were analyzed from a socio-environmental cost-benefit context and market mapping for the technology under consumer goods. The identified enabling framework or measures to overcome the identified barriers were as also classified as economic/ financial measures, and non-financial measures.

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CHAPTER 1: AGRICULTURE SECTOR

Prior to 1989, agriculture accounted for approximately 40% of GDP; at which time Liberia was the producer and exporter of basic raw materials such as timber and rubber (FAO, 2015; USAID, 2015). The agriculture sector accounted for employment of nearly 70% of the economically active population, and over 90% of total export. By the end of 1996, real GDP was as low as 10% of its pre-war level (FAO, 2015)

However, from 1997 it increased, reflecting a post-war surge in rice, timber and rubber production; and in 2002, reached US$442 million (FAO, 2015). In 2007 GDP further increased to US$725 million, of which agriculture accounted for 66 % (FAO, 2015). The agriculture sector is forest based, dominated by traditional subsistence farming systems mainly in the upland (MOA, 2009). It is labour and land intensive and also characterized by shifting cultivation, low technologies and low productivity (FAO, 2016).

The sector is confronted with numerous challenges, such as low capacities of farmers and institutions and ruined infrastructures (FAO, 2016). While about 235 000 ha of swamp rice were cultivated in the mid-1980s, this figure dropped to 120 000 ha in 2003, leading to a decrease in total rice production from about 290 000 tons in the mid-1980s to 110 000 tons in 2003 (Ministry of Agriculture, July 2008).

About 4.6 million ha of the total land area (little more than 12 million acres) of Liberia is arable (FAO, 2015). Of this arable land, 4 million ha is upland while the remaining 600,000 ha is swampland with irrigation potential. Prior to the war, about 634,000 ha (13.8% of total arable land) was cultivated, mainly with rice and cassava (MOA, 2009). At present, it is estimated that annual cultivation is less than 5% of the arable land (FAO, 2016). Liberia's agriculture sector is dominated by traditional subsistence farming systems (MOA, 2009). These systems are mainly practiced on uplands that are characterized by shifting cultivation, labour intensity, low technologies and use of rudimentary inputs, all of which contribute to low productivity (FAO, 2016). The farming systems are primarily forest based and covers the largest portion of cultivated land area (MOA, 2009; FAO, 2016). They are mainly concentrated in the central belt of the country and account for almost 50% of the total land area and almost 90% of arable land (MOA, 2009).

Small acreages of tree crops are maintained for generating cash income; while rice, intercropped with vegetables, maize and other food crops (e.g. often cassava), occupy the major portion of cultivated land (about 87%) on upland (MOA, 2009). Currently, over 95% of Liberia's farms are located on uplands, which are far less productive (than lowland) and contribute to environmental degradation (FAO, 2016).

A secondary root and tuber-based farming system is concentrated in the northern region, and a third farming system occurs in the coastal belt, with fishing as a major activity complemented with mixed cropping involving mainly rice with cassava and vegetables (FAO, 2016, EPA, 2019).

Commercial agricultural activities are almost exclusively plantation estates of rubber and, to a lesser extent, oil palm (FAO, 2016). Coffee and cocoa are produced mainly by smallholders and exclusively for export (MOA, 2009; FAO, 2015).Value addition is limited and done for both rubber and oil palm (FAO, 2016). Besides the plantation estates, very little commercial investment has been made in the agriculture sector, except for limited 'commodities' trading, which has persisted over the years, and a few recently established poultry and other livestock farms (FAO, 2016).

The livestock sub-sector was decimated as a result of years of civil conflicts. Current livestock population is below 10% of national requirements (EPA, 2019). The fisheries sub-sector is underdeveloped but has good potential for growth; only about 6.8% of sustainable yield is harvested annually (EPA, 2019).

Besides, climate change hazards have been identfied in Liberia; and this is impacting the agriculture sector (EPA, 2019). The EPA (2019) report reveals that warmer temperatures which have led to a reduction in chill hours potentially reducing yields for some crops like maize, rice, rubber, and cassava. It was also reported that for every 1^{o}C increase above 30^{o}C temperature per day during maize growing season, there is a corresponding 1% reduction in yield each day under optimal rain fed condition (ACPC, 2014). In 2000, agriculture and forestry contributed over 90 percent of export earnings, mainly from rubber, timber, cocoa and coffee (FDA, 2006; MOA, 2009). Agricultural activities locally are still considerably reduced and the country relies on importation of its staple food (rice) mainly from China and India.

Given all of the above, during the first phase of the Liberia Technology Needs Assessment (TNA), it was reported that Liberia has not fully adopted technologies in its agriculture sector. Therefore, making anaylsis of the main focus area in TNA will be based on the technologies prioritized by the stakeholders for the agriculture sector of Liberia. The followings are technologies identifed and prioritized for the barrier analysis and TAP;

4. Value addition to agriculture products (rice, cassava, vegetables and fruits);
5. Improved Storage (drying and freezing of agriculture products); and
6. Integrated Soil Fertility Management.

This report is the output of the second phase of the TNA process that covers barrier analysis on transfer, and diffusion of the prioritized adaptation technologies in the Agriculture Sector. In addition, the enabling framework and measures for overcoming barriers are discussed and addressed. For each of the three technologies identified for the agriculture sector, a systematic approach of describing and analyzing technology barriers, and the identification of measures and enabling framework was adopted. The process included:

1. Identify preliminary targets for the technology development and diffusion in the Agriculture Sector.
2. Describe the technology's properties and its potential adaptation benefits, categorize the technology either as a market or a public good and briefly elaborate on its current status in the country.
3. Identify measures for overcoming the barriers, possible linkage between different technology barriers within a sector and outline a technology enabling framework that would help to overcome barriers and create a supporting environment for the development and successful diffusion of the selected technologies. *See table below*.

Table 2: Methodology used in conducting the Barrier Analysis and enabling framework

Stages of Analysis	**Methods and Tools used**
Identification of stakeholder (s)	In collaboration with Environmental Protection Agency, stakeholders were identified and invited.
Identification of potential barriers	Extensive literature review, brainstorming and meeting with relevant experts
Analysis of barriers	Detailed analysis using logical problem tree and market mapping with a group of 10 people in a gender sensitive stakeholder/expert workshop and consultations
Measures development to overcome barriers	Translating barriers into measures using logical solution tree in consultation workshop
Screening and validation of important barriers and measures	Validation through extensive consultation during Stakeholders/experts workshop
Submission of Draft Report & Final Report	Via email to the UDA & DTU Partnership project Coordinator

1.1 Preliminary targets for technology transfer and diffusion in the Agricultural Sector

The Agriculture sector in Liberia accounts for 70% employment for rural households contributing 23.9 % to the real GDP (EPA, 2018, USAID, 2015). The recent climate change projections for the agriculture sector indicate increase in temperature, changes in rainfall patterns and changes in wind and solar radiation patterns that will adversely affect crop productivity with a looming threat to the national food security gains ((EPA, 2019).

The national development framework, the Agenda for Transformation (AfT) document, is a guiding policy that focuses on increasing agriculture production and productivity and ensure food security and poverty reduction especially for rural population (GoL, 2012). However, it has been identified that one of the most important challenges to the growth of the sector is the absence of technological innovation due to limited capacity to deliver crucial services and respond to reforms adequately (FAO, 2016). Hence, to cope with the severe impacts of climate change, the agriculture sector needs to adopt environmentally sound technologies to move towards climate resilient development pathway.

Keeping in view the above stated projected climate change impacts on the agriculture sector, the TNA project in its phase-I identified and prioritized the following three climate change adaptation technologies in the agriculture sector of Liberia:

1. Value addition to agriculture products (rice, cassava, vegetables and fruits);
2. Improved Storage (drying and freezing of agriculture products); and
3. Integrated Soil Fertility Management

The above mentioned technologies in the agriculture sector are mainly prioritized as adaptation measures to reduce the vulnerability of the population linked with or dependent on agriculture sector to the impact of climate change. However, it is emphasized from the outset that all the above three technologies are not available and not in use in the country.

The preliminary targets identified under the TNA project, the government will seek and leverage support for the transfer and diffusion of these technologies in the agriculture sector. Furthermore, the strategy for funding will include a public-private and community partnership to secure required and predictable finances.

For each of the prioritized agriculture technology, below are the implementation approaches:

1. Establish 3 major facilities for value addition of agricultural products (rice, cassava, vegetables and fruits).

2. Introduction of Improved Storage (drying & freezing) – is to build 3 storage facilities for seed, grain and vegetables in 3 agro-ecological zones of Liberia; and

3. Introduce and run at least 4 Integrated Soil Fertility Management facilities in four agro-ecological zones of Liberia.

1.2 Barrier analysis and possible enabling measures for Value Addition to Agriculture Products (rice, cassava, vegetables and fruits); Technology

During the stakeholder workshop on January 9, 2020 in Monrovia, the stakeholder working group identified barriers and developed an enabling framework or measures according to the barriers analysis and enabling framework process (Nygaard and Hansen, 2015), to overcome the potential barriers that could impede the possible transfer and diffusion of the three prioritized adaptation technologies in the agriculture sector of Liberia. Besides, several consultative meetings with experts and technical working sessions were held beyond the general workshop in order to achieve our objectives. Some key barriers were identified through the stakeholder's consultation process. All barriers and measures identified during the workshop for the prioritized technologies were grouped under two major categories, namely: *Financial and Non-Financial;* they were further analysed and decomposed. The barriers and measures identification process were conducted using a logical problem analysis (Painuly, 2001), by means of problem and objective trees *(Annex: III and IV).* For the three technologies prioritized in the agriculture sector, Value Addition technology is categorized as *consumer goods*, while Improved Storage falls under *publicly provided goods* and Integrated Soil Fertility Management a combination of *consumer goods and non-market goods* (Nygaard &Hansen, 2015). Therefore, the non-financial barriers analysis for ISFM and Improved storage was done from a socio-environmental impact analysis as recommended by the TNA's BA&EF guidebook (Nygaard and Hansen, 2015) and market mapping applied to Value Addition only.

1.2.1 General Description of Value Addition to Agriculture Products (rice, cassava, vegetables and fruits); Technology

Generally, value-added agriculture refers to manufacturing and production processes by which the values of primary agricultural commodities are increased, thereby increasing the economic value and consumer appeal of an agricultural commodity. It also involves the process of transforming the raw agricultural product into something new that changes a product from its original crude form, and as a consequence, improving the revenue potentials of producers (Lindgreen et al, 2012). This technology includes intensive farming and extending an agricultural product's potential which doesn't require large expanses of land to achieve profitability. Adding value to a product is important for maximizing profit (Lindgreen et al., 2012).

Most often in Liberia, a wide variety of agricultural products are produced, but we have not yet optimized the economic benefits that can be derived from them. There are several impediments, including inadequate knowledge of appropriate value-adding technologies, and lack of infrastructure facilities.

Value addition is an important concept and approach in today's business environment where innovation in farming and agricultural food processing are important to remain competitive and to optimize returns from an enterprise. It has the potential to create jobs, especially at a time when unemployment is widening. Adding value to products gives recipients many choices in selecting products as per their need (Flint et al., 2011).

1.2.2 Identification of barriers for Value Addition to Agriculture Products Technology

The barriers identification, analysis and enabling measures process began with an initial desk study of policy papers, reports, project documents and web pages to ascertain why the technology is not widely adopted, and why neither the private nor public sectors have invested significantly in it.

Information gathered was noted before the workshop. Also, information was gathered during the cross-sectorial workshop with stakeholders, technicians, and representatives from NGOs, CBOs and other private groups to conduct a barrier analysis and develop an enabling framework or measures to overcome the potential barriers that could impede the possible transfer and diffusion

of each prioritized adaptation technology in the agriculture sector. The general workshop was followed by a series of technical working sessions for a successful process. *See pictures at Annex XI.*

As such, the Value Addition Technology is classified as *consumer goods* (Nygaard and Hansen, 2015). The identified barriers and their measures were screened and the most essential were then grouped under two major categories, namely: *economic and financial and non-financial.* The non-financial barriers were further classified/ broken into information and awareness legal and regulatory, institutional arrangement. These analyses were conducted through stakeholder's consultations and expert inputs using logical problem analysis and market mapping.

1.2.2.1 Economic and financial barriers

The startup of manufacturing and production processes requires substantial capital outlay. Potential economic and financial barriers include:

I. The attendant cost of securing machineries, equipment, improved planting materials;

II. Cost of maintaining high level trained human resources;

III. Lack of economic incentives in terms of subsidies to drive the technology.

1.2.2.2 Non-financial barriers

Policy, legal and Institutional:

The non-financial barriers identified are mainly policy, legal and regulatory, gender and other social cultural issues, and include:

i. Inadequate policy, legal and regulatory framework;
ii. Incoherent strategies in the implementation of agriculture value-addition;
iii. Lack of technical and human resource capacities;
iv. Weak national institutions to manage the technology.

Gender and other social –cultural issues

i. Limited recognition of women participation in value addition

ii. Lack of training and marketing and tariff information for women

iii. Other vulnerable groups that have emerged, such as IDPs, disadvantage youths and the elderly are not regularly reached out to;
iv. Lack of incentives to attract potential labour force.

1.2.3 Identified measures

The identified measures to the barriers that could potentially affect the transfer and diffusion of Value Addition technology were analysed through stakeholder consultations and expert inputs. The measures identified include the followings:

1.2.3.1 Economic and financial measures

i. Provision of subsidy to local small and medium scale entrepreneurs to ease their burden of liquidity deficits and make them more financially viable in pursuing their investment objectives thereby contributing to the advancement of the industry;

ii. Consider reducing import duties on inputs, materials, equipment and accessories being brought in country in order to encourage wider stakeholders participation and incentivize them to keep technology viable and sustainable;

iii. Take appropriate policy actions to ensure financial and lending institutions provide reduced interest rates or even free-interest loans to firms, entities and entrepreneurs with proven and predictable need and desire for purchasing implements;

iv. Supply and install associated facilities and equipment on farm to shift the burden off local investors or entrepreneurs that may endeavor into the industry.

1.2.3.2 Non-financial measures

i. Revisit existing policies, laws and strategies to conform them to current realities;
ii. Promulgate where appropriate new strategies;
iii. The government should ensure existing policies and strategies appertaining to said technologies are implemented;
iv. Improve outreach initiatives to women, the elderly and disadvantaged population;
v. Provide requisite training for women in marketing;

vi. Disseminate tariff information and involve women in the negotiation of same.

1.3 Barrier analysis and possible enabling measures for Improved Storage of Agriculture Products Technology

As stated in previous sections, all other protocols leading to the identification of barriers and enabling measures were carried out for this technology. This technology is categorized as *publicly provided goods* (Nygaard and Hansen, 2015). The logical problem and objective trees analysis were carried out on Improved Storage technology to identify barriers and their possible measures during the workshop (Painuly, 2000; Nygaard and Hansen, 2015). The barriers identified, and their enabling frameworks were grouped under two major categories: *economic and financial, and non-financial* in regards to their socio-environmental impact analysis. *See Annex V & VI* .

1.3.1 General Description of Improved Storage of Agriculture Products Technology

Preventing post-harvest losses of crops is a challenge for farmers in the tropics, thereby necessitating improved storage technology. Improved storage structures have a higher storage capacity for long term storage of food crops than traditional storage structures.

Storage competes with other activities valued by farm families, and it is necessary to understand where storage fits in to the entire farming system and household economy in order to assess the need for interventions and the probability of their uptake. Over the past two decades the need for economic and social analysis in the planning and design of storage interventions has become more widely recognized (Scheepens, et al., 2011). This stems from the realization that any improvements in storage will only be attractive to farmers, traders or governments if the perceived benefits substantially outweigh the costs. Technical superiority is generally insufficient and farmers and traders are likely to tolerate quite high storage losses before undertaking complex or expensive changes to their storage systems.

According to Scheepens, et al (2011), agricultural products cannot be stored indefinitely. The maximum storage duration (the shelf life) of agricultural products varies and can be only a few

days for some fruits and vegetables, a couple of months for most tubers and bulbs, and over a year for dried food grains or other seeds.

You can extend the shelf life of some fresh agricultural products by cooling, but this is expensive and it is not described in detail in this report. For all crops, the most important thing is that they remain edible during storage. Most fruits and vegetables should also keep their attractive appearance. A wrong colour, wrinkles, etc., make them less attractive to consumers. For each product there are numerous factors that pose a threat to their shelf life. These threats are present not only during storage, but during the whole pipeline from food production to consumption or marketing. Each step can have an impact on the quality and quantity of the products. Cereals, pepper, potatoes grains, cassava leaves, etc. are very important grains products for storage. Good storage helps ensure household and community food security until the next harvest and commodities for sale can be held back so that farmers can avoid being forced to sell at low prices during the drop in demand that often follows a harvest. While considerable losses can occur in the field, both before and during harvest, the greatest losses usually occur during storage. Therefore, the basic objective of good storage is to create environmental conditions that protect the product and maintain its quality and its quantity, thus reducing product loss and financial loss. Only well-dried seeds should be stored. Seeds with moisture in them become damp, mouldy and vulnerable to insect attacks.

1.3.2 Identification of barriers for Improved Storage of Agriculture Products Technology

The barrier analysis and development of an enabling framework or measures to overcome the potential barriers that could impede the possible transfer and diffusion of Improved Storage technology in the agriculture sector are as follow;

1.3.2.1 Economic and financial barriers

Potential economic and financial barriers to this technology include:

i. Low or no budgetary allocation for research into the technology;

ii. High cost of constructing physical infrastructure and storage facilities;

iii. Lack of economic and financial incentives for community ownership and participation.

1.3.2.2 Non-financial barriers

Policy, legal and institutional

i. Lack of appropriate policy, legal and regulatory framework;

ii. Inadequate technical expertise;

iii. Poor communication/extension approaches;

iv. Insufficient data sharing and collaboration among relevant institutions

Gender and other cultural-issues

i. Lack of women specific considerations in occupational health and safety;

ii. Check gender based disadvantages and abuse in the work setting;

iii. Disfavour of persons with disability and other disadvantage youths and the elderly.

1.3.3 Identified measures

The identified measures to the barriers that could potentially affect the transfer and diffusion of Improved Storage technology were analysed through stakeholder consultations and expert inputs. The measures identified include the followings;

1.3.2.1 Economic and financial measures

i. Governments needs to allocate or dedicate funding for the development of the technology;

ii. Ensure reduce taxes on research instruments, and other necessary materials used for development of the technology;

iii. Foster public-private partnership in research and development of the technology

1.3.2.2 Non-financial measures

i. Strengthen institutional capacity of agriculture research;

ii. Agricultural extension services may be geared to disseminate appropriate knowledge and awareness about the availability and potential benefits of the technology;

iii. Review existing policies and strategies

iv. Develop occupational health and safety measures that are women sensitive;

v. Incorporate safeguard that disallowed gender based offenses and abuse in the work setting;

vi. Provision of incentives to encourage persons with disability and other disadvantaged youths and the elderly to fully participate.

1.4 Barrier analysis and possible enabling measures for Integrated Soil Fertility Technology

As described in preceding sections, steps and guidelines were followed to gather important information about ISFM technology from relevant documents and web pages, stakeholder consultations, expert meetings, inputs from technicians in the sector etc. This technology is a combination of *consumer goods and non-market goods* category (Lundvall et al., 2009; Nygaard and Hansen, 2015). In this technology, consumer goods include agrochemicals, fertilizers, composts and manures; while non-market goods are facilities, capital machineries and infrastructure and provided by government agencies requiring large investment most likely funded by international donors or governments.

Therefore, the logical problem and objective trees analysis was only carried out on ISFM technology to identify barriers and their possible measures during the workshop (Painuly, 2001). The barriers identified, and their enabling frameworks were grouped under two major categories: *economic and financial, and non-financial* in regards to their socio-environmental impact analysis. *See Annex VI & VIII.*

1.4.1 General Description of Integrated Soil Fertility Technology

Integrated Soil Fertility Management is the application of soil fertility management practices and the knowledge to adapt these to local conditions, which maximize fertilizer and organic resource use efficiency and crop productivity. Integrated Soil Fertility Management (ISFM) also involves

making the best use of inherent soil nutrient stocks, locally available soil amendments (for instance, crop residues, compost, animal manure, green manure), and inorganic fertilizers to increase productivity while maintaining or enhancing the agricultural resource base (IFDC, 2003).

These practices necessarily include appropriate fertilizers and organic input management in combination with the utilization of improved germplasm (Sanginga and Woomer, 2009).

Poor soil fertility and nutrient depletion continue to represent huge obstacles to securing needed harvest. Improving access to fertilizers is a necessary countermeasure, particularly when farmers develop skills in selecting which fertilizers are required and how to best derive benefits from their application.

Shifting cultivation (slash and burn) is the traditional farming practice known in Liberia (MOA, 2009). Farmers move from one area of cultivated land to another in search of fertile soil for agricultural production. Liberia has lost 600,000 ha of forested area to shifting cultivation as was reported in 2002 (FAO, 2015).

1.4.2 Identification of barriers for Integrated Soil Fertility Technology

The barrier analysis and development of an enabling framework or measures to overcome the potential barriers that could impede the possible transfer and diffusion of ISFM technology in the agriculture sector are as follow;

1.4.2.1 Economic and financial barriers

I. Cost associated with research and development of the technology, as Liberia has not yet ventured into the technology;

II. Lack of budgetary allocation at national and sectoral levels for the development of the technology;

III. Lack of economic incentives to attract private sector involvement or participation.

1.4.2.2 Non-financial barriers

Policy, legal, and Institutional

I. Inadequate policy, legal and regulatory framework expedient for research and development of the technology;

II. Limited institutional capacity and human resource capacity of relevant government institutions;

III. Weak capacity of training and research institutions to carry out research into the technology;

IV. Complexity of land use and land tenure across the country;

V. Inadequate awareness and information on the benefits of technology;

VI. Limited research findings on the characteristics of soil and its fertility across the country,

1.4.2.3 Gender and other social –cultural issues

I. Competitive ownership of land amongst community members;

II. Problems associated with false promises and unduly raising of community expectation;

III. Problems with ignoring existing land tenure regime;

IV. Lack of traditional knowledge in enhancing soil fertility.

1.4.3 Identified measures

The identified measures to the barriers that could potentially affect the transfer and diffusion of ISFM technology were analysed through stakeholder consultations and expert inputs. The measures identified include the followings:

1.4.3.1 Economic and financial measures

I. Prioritize adequate budgetary allocation at sector specific and national levels for the development and management of the technology;

II. Provide economic incentives to attractive private sector and community participation

1.4.3.2 Non-financial measures

I. Develop appropriate policy, legal and regulatory prescriptions for the development of the technology;

II. Carry out effective education and awareness on the benefits of the technology;

III. Provide and or increase financial support to relevant institutions for enhancing their capacity to management the development of the technology;

IV. Intervention of land tenure should consider existing tribal or other related community issues to land acquisition

V. Land acquisition should consider the complexity of land tenure to avoid disadvantage in women, persons with disability, IDPs and elderly;

VI. All interventions should consider existing land tenure regime in the locality;

VII. Consider traditional knowledge to enhance soil fertility.

1.5 Linkages of the barriers identified

This section captures the common barriers identified amongst the three prioritized technologies in the agriculture sector such as value addition (rice, cassava, vegetables & fruits), improved storage (drying and freezing of agriculture products), and integrated soil fertility management ISFM). The barriers identified in the table below are for the three technologies which are common and inter-linked to each other. Therefore, overcoming one barrier for one of the three technologies will result in resolving some challenges for the other two which could lead to clearing the way for the smooth adoption and diffusion of all of the technologies in the agriculture sector of Liberia. *See table below*.

Table 3: Common barriers identified for different prioritized technologies in agriculture sector

Barrier Category	Barriers
Economic & Financial	High capital cost, for installation, operation and maintenance cost
	Lack of incentives in the form of soft loans and subsidy
Institutional arrangement and capacity	Limited institutional capacity
	Weak capacity of training & research
Policy, legal and regulatory	Inadequate policy for agricultural technology
	Lack of legal framework

	Lack of enforcement
Gender and other socio-cultural issues	Lack of recognition of women, disadvantage youths and elderly
Information & awareness	Insufficient data sharing and collaboration among relevant institutions

The listed barriers in the table are common and inter-linked across the technologies in the agriculture sector. Therefore, overcoming these barriers will lead to a possible adoption and diffusion of all three prioritized technologies in the agriculture sector of Liberia.

1.6 Enabling framework for overcoming the barriers in the Agriculture Sector

For Liberia to overcome barriers and to successfully diffuse all three agriculture technologies, it has to rely upon the National Policy and Response Strategy on Climate Change which encourages technology innovation for the agriculture sector as an essential mechanism to increase the resilience of rural agricultural communities to the impacts of increased pests, changes in rainfall pattern, and high temperature (EPA, 2018). As of now, the government is currently using the Liberia Agriculture Transformation Agenda (LATA) as the national framework to form synergies across agriculture sub-sectors (FAO, 2016). It will also require annual budgetary allotments, strong institutional capacity and collaboration, involvement of key sector players, community leaders, regulation and enforcement of laws. *See table below*.

Table 4: Enabling framework for the major cross-cutting barriers to the technologies

Barrier category	**Broad/ common barrier**	**Enabling framework**	**Technology**
Economic and Financial Barriers	High initial cost.	Through national budget allocation and grants these technologies can be setup from the beginning. Also, the needed capacity can build.	- Improved Storage (dry & Freezing Technology - Value addition (Rice, Cassava, Vegetables & Fruits) Technology - ISFM Technology
Information and Awareness Barriers	Inadequate information/limited information about the technologies.	Improved education and awareness rising. Involve local community radio stations, farmers Field Schools, Farmers corporative, social clubs. Use local vernaculars disseminate information.	- Improved Storage (dry & Freezing Technology - Value addition (Rice, Cassava, Vegetables & Fruits) Technology - ISFM Technology

Gender and other social-cultural issues	Problem with acceptance of new technology by locals.	Through the local government, involve communities from the very beginning to participate in the decision making process; To ensure interventions conform in a harmonious manner with existing cultural practices and norms.	- Improved Storage (dry & Freezing Technology - Value addition (Rice, Cassava, Vegetables & Fruits) Technology - ISFM Technology
Legal, Policy, and Regulation Barriers	Policy for agricultural technologies not in place/ huge tax on agricultural equipment, lack of enforcement and monitoring.	Enact laws specifically for agricultural technologies that meet international best practices and standards. Reduce tax on agricultural equipment, and encourage law enforcement.	- Improved Storage (dry & Freezing Technology - Value addition (Rice, Cassava, Vegetables & Fruits) Technology - ISFM Technology
Institutional Arrangement and capacity	Poor coordination between and amongst institutions.	Establish technology focal point in each line ministry and agency of government that will report directly to the minster or director. The head of the technology focal points should be seated in the president's office.	- Improved Storage (dry & Freezing Technology - Value addition (Rice, Cassava, Vegetables & Fruits) Technology - ISFM Technology

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Annex I: Market Mapping and Problem-Solution Trees

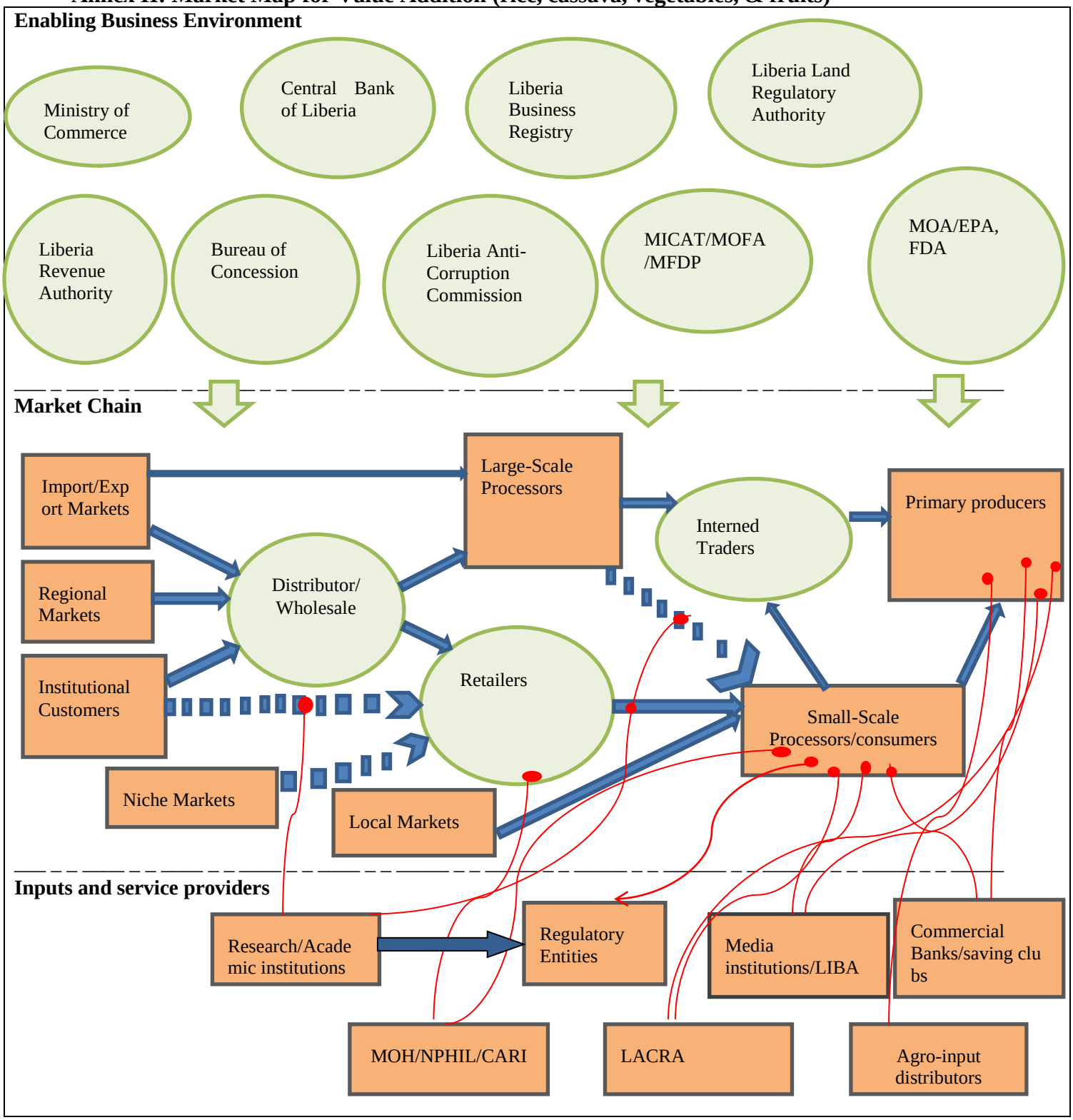
Market Mapping: Market mapping is only applied to technologies which are identified as the market consumer goods such as value addition for the agriculture of Liberia especially looking at rice, cassava, vegetables and fruits.

During the market mapping exercise, the stakeholders helped to identify market chains and discussed its different components and their inter-linkages. The construction of such maps has helped to communicate the institutional and commercial environment in which a specific technology developer, user and a manager operates and impact the technology demand and supply chains through holding or releasing the required information.

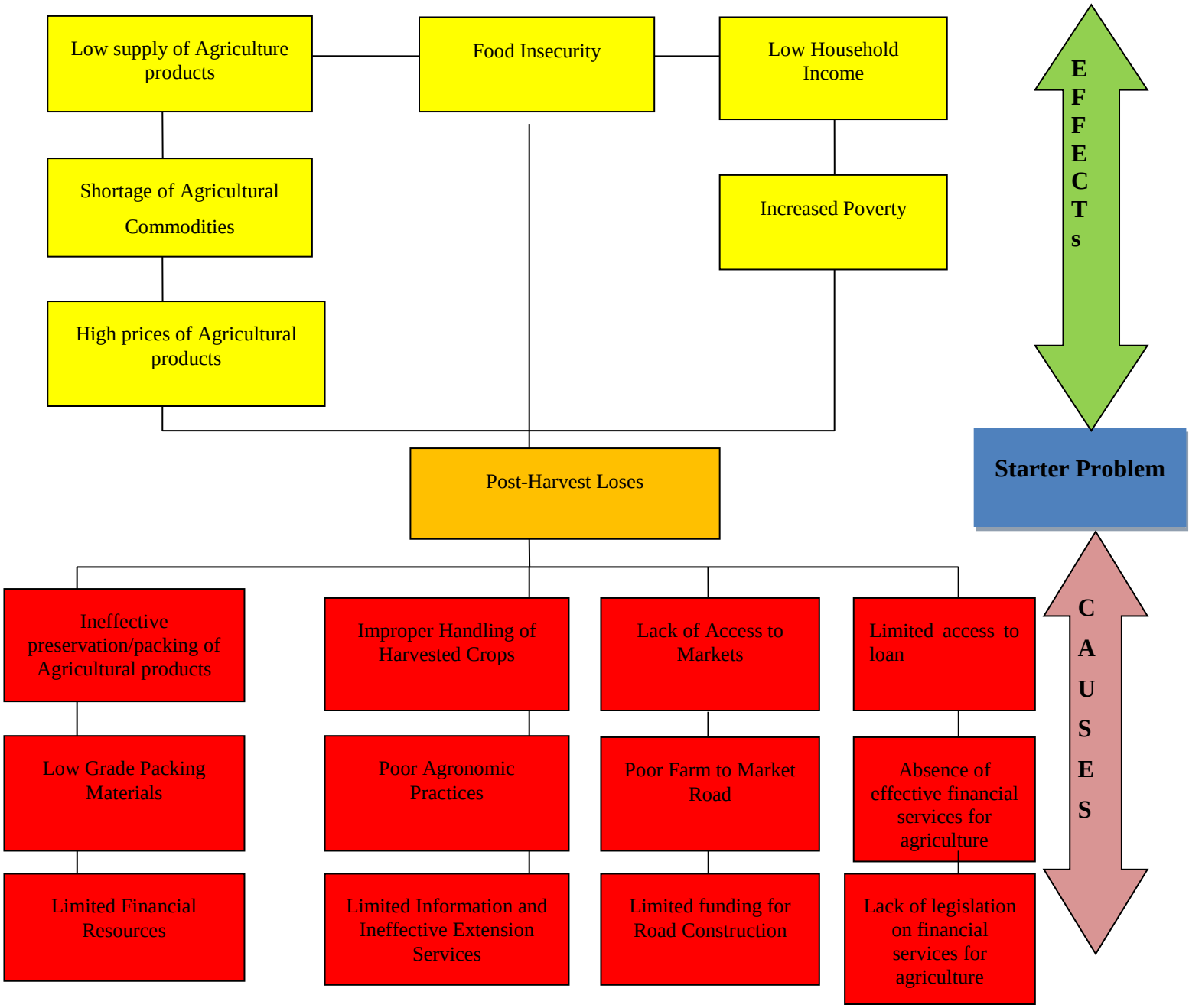
The main market mapping elements considered are: enabling environment- legal, organizational, market chain developers, wholesaler, retailer and consumer, producer etc.

Problem and Solution Trees: The problem and solutions trees for each technology were prepared and used by experts to identify and analyze the barriers and to find measures to overcome the identified obstacles to the diffusion of each technology. Problem/Solution trees for all the three prioritized adaptation technologies are presented in Annex III (C) to Annex VIII (H).

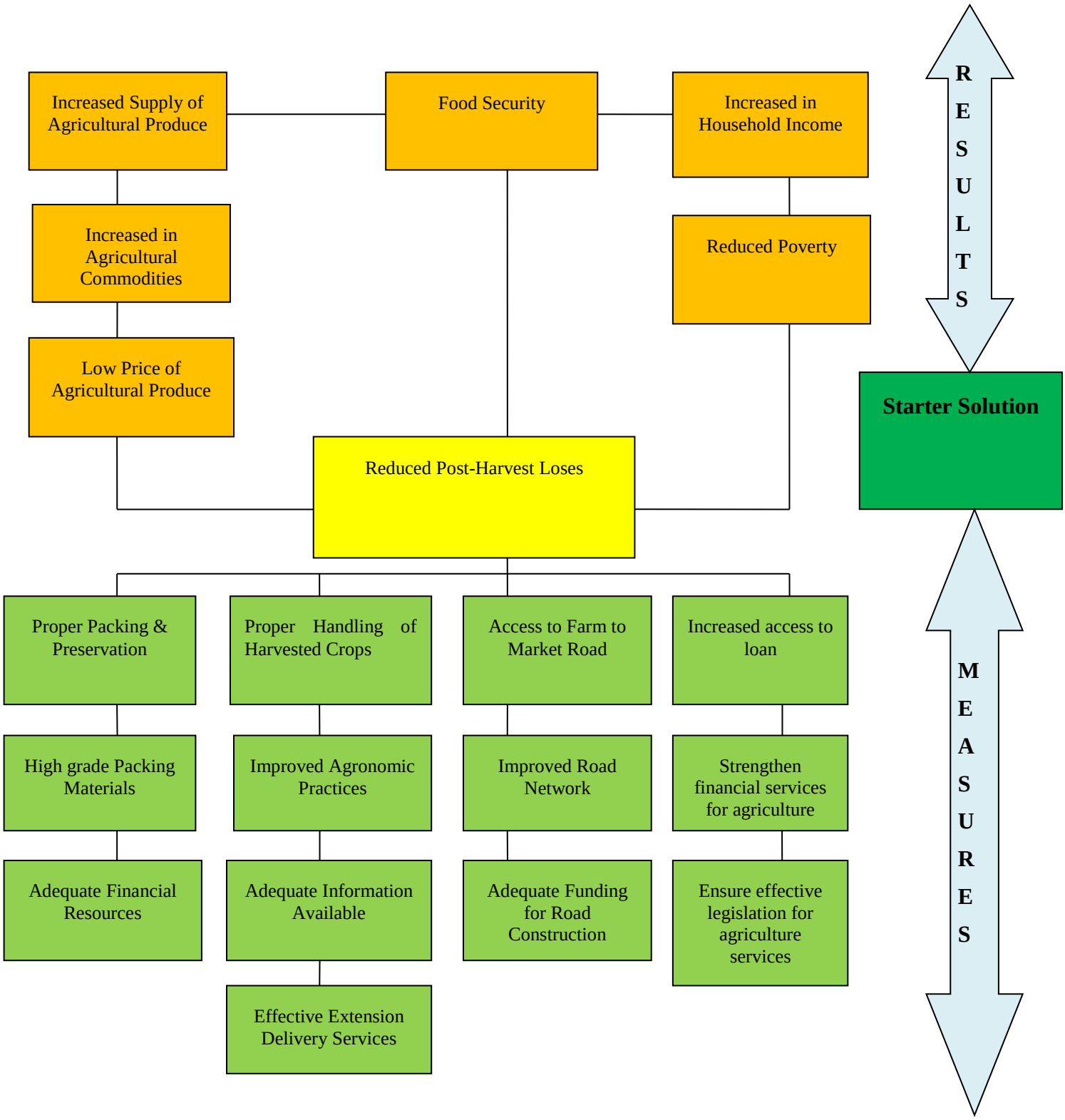
Annex II: Market Map for Value Addition (rice, cassava, vegetables, & fruits)



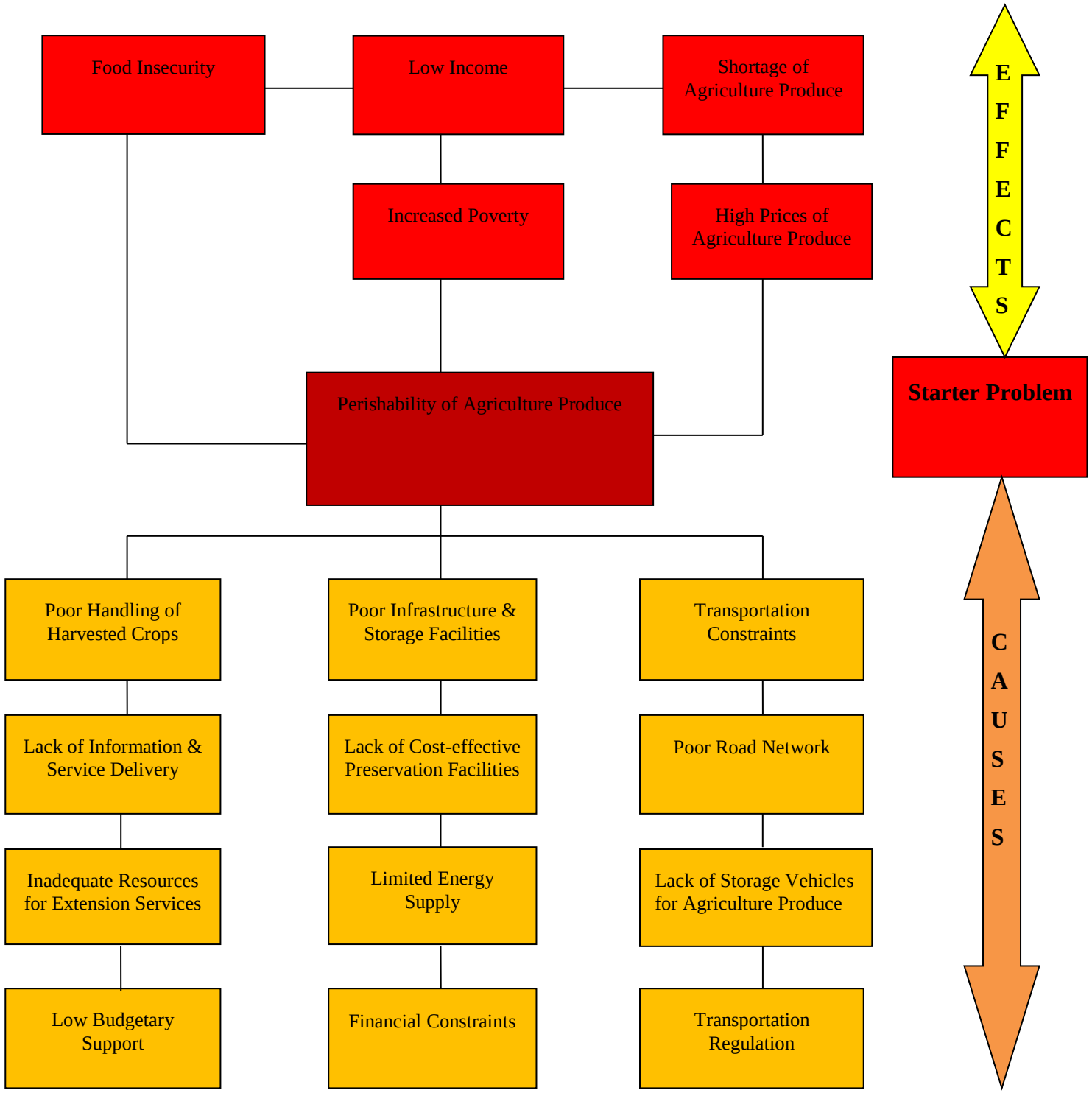
Annex III: Problem Tree for Value Addition Technology (rice, cassava, vegetables and fruits)



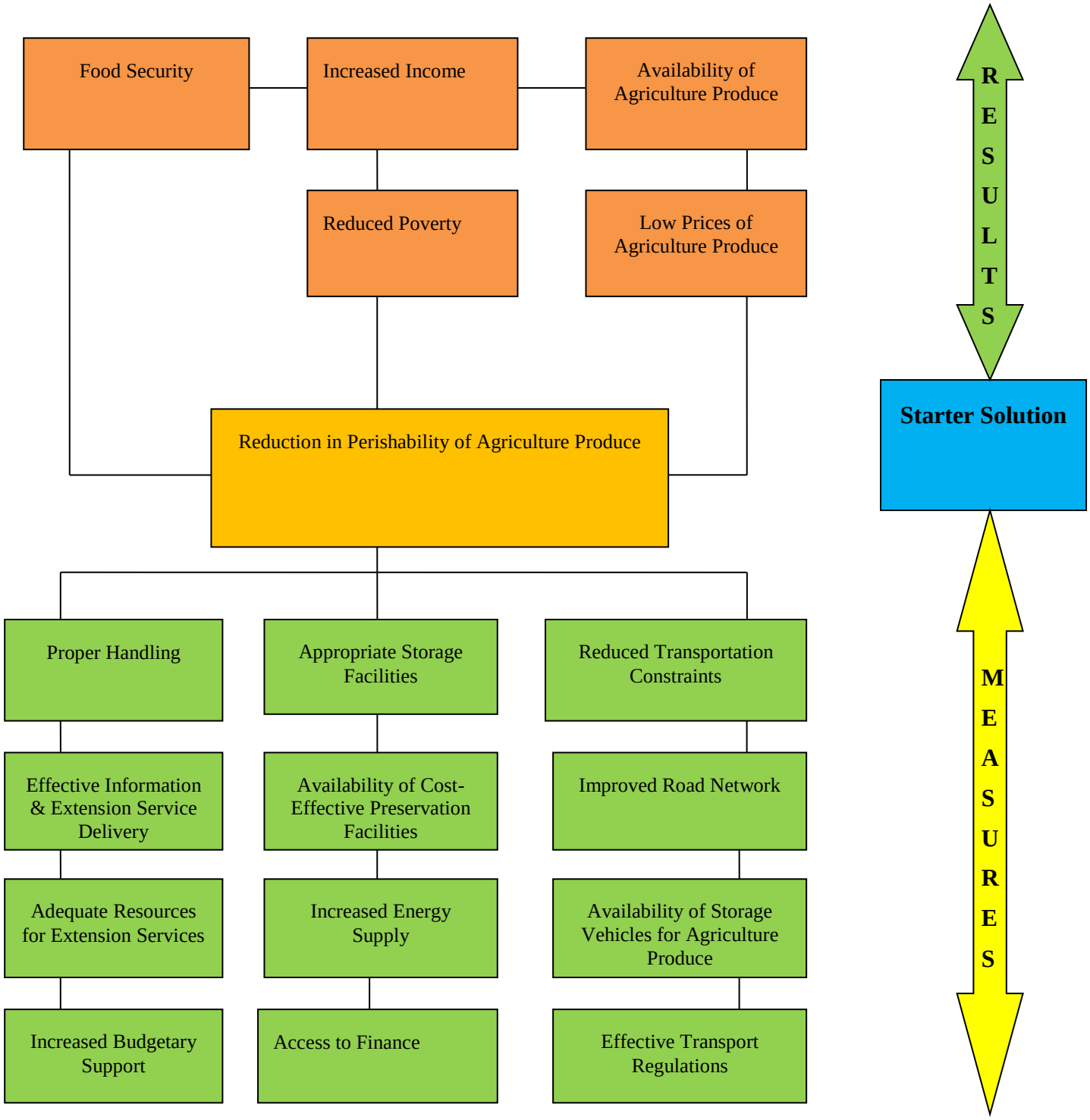
Annex IV: Solution Tree for Value Addition Technology (rice, cassava, vegetables and fruits)



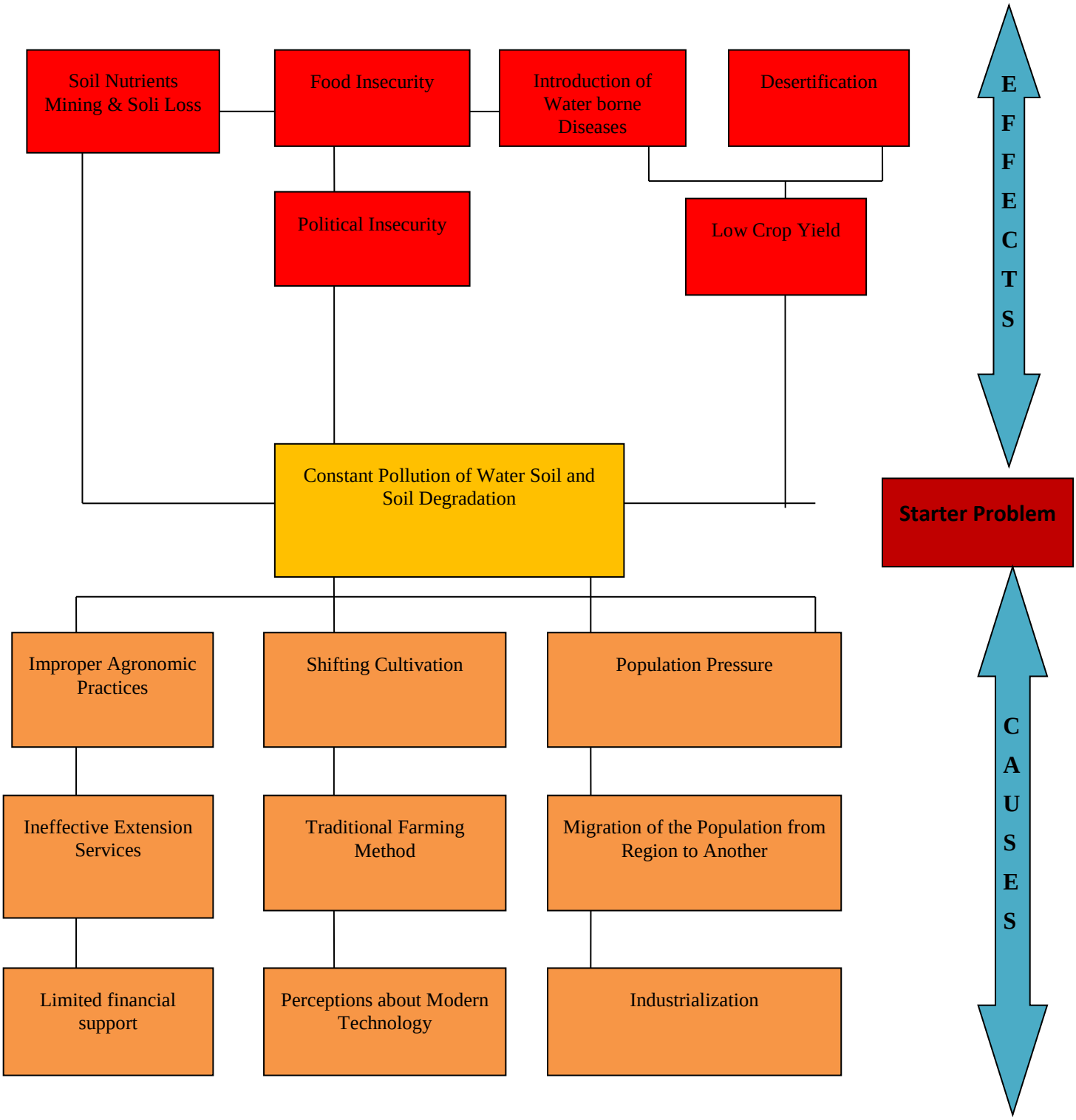
Annex V: Problem Tree for Improved Storage (drying & freezing) Technology



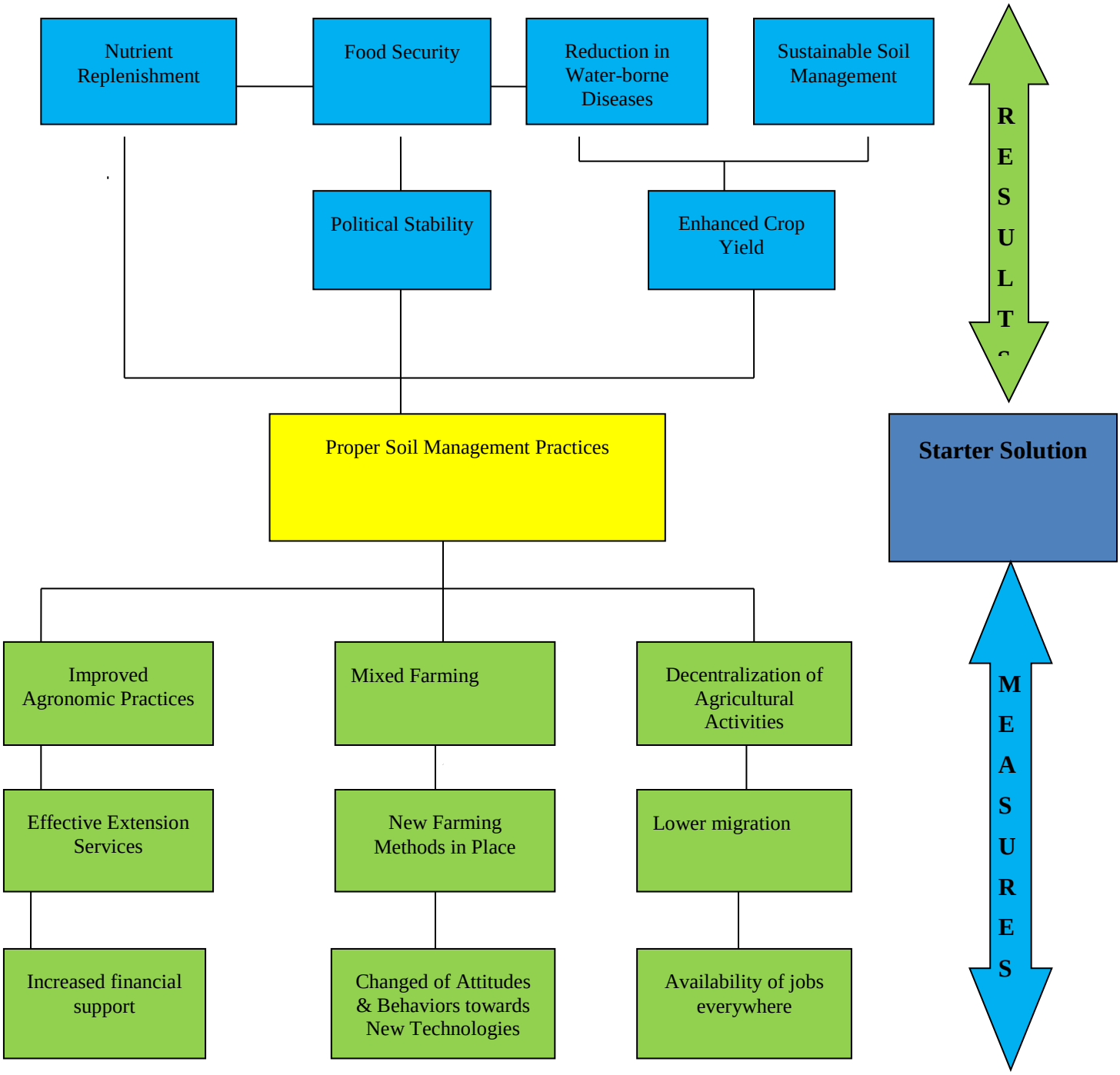
Annex VI: Solution Tree for Improved Storage (drying & dreezing) Technology



Annex VII: Problem Tree for ISFM Technology



Annex VIII: Solution Tree for ISFM Technology



Annex X: List of Stakeholders

No	Name	Institution	Position
1	Sandra Samuels	SCNL	Researcher
2	Henry Tamba Nyuma	UL	Instructor
3	Stephen S. Gbondo	Gbobal Agro	Director
4	Oscar B. Toe	NHRM	-
5	Gertie K. Sulunteh	MoA	-
6	Halala W. Kokulo	MoA	Director
7	Dorothy G. Sonkarlay	MFDP	-
8	Teddy P. Taylor	EPA	Youth Focal Point
9	Charlene J. Freeman	CU	Instructor
10	Jallah Arku	LESA	Project Manager

Annex XI: Pictures from the stakeholder meetings and workshop

Top is the group photo and right is the working section with the sectoral working group in the general workshop, left is meeting with experts.