Fiji

BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT - ADAPTATION

[August 2021]

List of Acronyms

ALTA	Agricultural Landlord and Tenant Act
CePaCT	The Centre for Pacific Crops and Trees
CSA	Climate Smart Agriculture
CVA	Climate Vulnerability Assessment
EIA	Environmental Impact Assessment
FDB	Fiji Development Bank
FNU	Fiji National University
GDP	Gross Domestic Product
INM	Integrated Nutrient Management
LPA	Logical Problem Approach
MMP	Mangrove Management Plan
MoA	Ministry of Agriculture
NAP	National Adaptation Plan
NDP	National Development Plan
OT	Objective Tree
PaCE-SD	Pacific Centre for Environment and Sustainable Development
PES	Payments of Environmental Services
PPP	Public Private Partnership
PT	Problem Tree
SDP	Strategic Development Plan
SLR	Sea level Rise
SPC	The Pacific Community
TNA	Technology Needs Assessment
USP	the University of the South Pacific

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Executive Summary

Agriculture and coastal zones were two sectors prioritized for adaptation in the TNA process. Both these sectors support national economy and livelihoods of local people, where people in the rural areas generate income through resources derived from agricultural and coastal zone sectors. Climate change is one of the biggest threat to the national development and economy, particularly loss and damage incurred by intense cyclones. Hence technologies that were prioritized in these sectors were climate resilient, aligned to the national development plans and national adaptation plan so that it would boost the economic growth of the country. This report is the second phase of the Fiji TNA project and highlights the barrier analysis and enabling framework for transfer and diffusion of prioritized technologies for climate change adaptation in the agriculture and coastal zone sector.

The following technologies were prioritized in each sector and are listed below with the market characteristics:

Agriculture Sector

- Agroforestry - non-market goods
- Integrated Nutrient Management (INM) – non-market goods
- Improved Crop Varieties - non-market goods

Coastal Zones

- Mangrove rehabilitation – non-market goods
- Construction of Seawalls with gryones - publicly provided goods
- Flood hazard and risk assessment mapping – non-market goods

The Barrier Analysis and Enabling Framework (BAEF) involved a stakeholder consultative process whereby identification, screening, decomposition and analysis of root causes of barriers were undertaken through the national workshop conducted. The preliminary barrier identification was carried out through thorough literature search and through bilateral meetings with relevant stakeholders. This long list of barriers were screened and revised by grouping similar barriers, while unimportant and irrelevant barriers were eliminated in the technical working group meeting. To facilitate the identification of barriers, logical problem analysis (LPA) was used to identify the root causes of the main barriers that are impediments to the implementation of each adaptation technology. Using a Problem Tree (PT), the main barriers were decomposed to identify the root causes of barriers, and an Objective Tree (OT) that mirrors the PT was developed to provide an insight into measures needed to overcome the root causes of identified barriers and successfully diffuse the technology. Table 1 summarises the barriers and measures identified for the agriculture sector and Table 2 summarises the barriers and measures identified for the coastal zone sector.

In addition, linkages of barriers in each sector showed similar barriers and the barriers common to all prioritized technologies were:

Economic barriers: All technologies needed huge financing beyond the increase in national budgetary allocation and it was noted that funding was needed for technical capacity development, infrastructure, equipment and providing incentives and subsidies.

Policy and regulatory barriers: Lack of policy and clear mandate for designated national authority to spearhead development and diffusion of new technologies. The lack of mandate clearly leads to organisational and institutional barrier which leads to lack of coordination between different stakeholders and lack of enforcement and monitoring. This barrier was only common in the agriculture sector and not the coastal sector.

Technical barrier: Lack of technical expertise was noted as one of the barriers in all technologies prioritised. The root cause for this barrier seems to be lack of financing opportunities, capacity development and training. The skillsets need to be developed so that local expertise are available.

Information and Awareness barrier: A common impediment in diffusing technologies in all the sectors was generally lack of information and awareness**.** People are not aware of the new technology and do not know where to get first-hand information. There is lack of local community involvement in the projects and traditional knowledge is generally not incorporated in technology development.

Furthermore, the report discusses the enabling environment that needs to be created and facilitated in order for the technologies to be diffused successfully with higher adoption rate. Some key enabling factors are listed as such:

- Access to climate change finance and an increase in national budgetary allocations.
- A coherent policy and regulations setting the legal framework for climate smart agriculture and coastal management.
- Engaging in R&D opportunities and partnership with tertiary institutions, regional and international organizations.
- Training opportunities for local people to develop capacity.
- Sharing Information and creating awareness of technologies to promote uptake of these technologies.
- Create Public Private Partnership.
- A dedicated hub or unit within the Government Ministry to coordinate all the activities related to diffusion of these technologies.

Table 1: Identified measures and barriers in the agriculture sector.

Technology		Barriers	Measures
Agroforestry	Economic	• High Investment Cost. • Farmers' inaccessibility to credit market. • Long term pay-off period.	• Subsidies on machinery and equipment and fertilizer • Access to loans at lower interest rate and subsidized equity from the Government. • Incentives or Payments of environmental services (PES) needs to be explored. • Value adding chains for non-timber agroforestry products.
	Non- economic	• Limited synergies between sectoral policies leading to ineffective coordination. • Policy and regulations barrier relating to agroforestry and property and land tenure. • Lack of technical expertise in executing agroforestry plan and landscape diversification. • Lack of knowledge on the significance and the implementation. • Lack of support for extension services to promote agroforestry.	• Agroforestry policy needs to be developed and mainstreamed into the National Development Plan and climate change National Adaptation Plan (NAP) with a clear designated national authority. • Agricultural Landlord and Tenant Act (ALTA) needs to be strengthened to give long tenure and tree rights to be given to farmers and needs to be gender inclusive. • Farmers Field School and more demonstration plots to be set-up. Tertiary institution to strengthen the agroforestry curriculum. • Formation of agroforestry farmer organization to share best practices and implementing award system for best practices. • Budgetary allocation should be increased to strengthen extension services in terms of human capacity to provide training to local farmers.
Impro ved Crop Variet ies	Econo	• High investment cost in terms of research facilities and human capacity to evaluate new varieties	• Increase Government allocations and source funding from donor agencies.

	Non-economic	• Lack of synergies between the relevant institutions. • Lack of human capacity and lack of local plant breeders. • Fiji Seed Policy needs finalization and implementation. • Lack of awareness of new improved varieties. • Market failure for new improved varieties.	• Strengthen the coordination between the institutions and form working groups with a structured work plan and pooling resources for targeted breeding programmes. • Staff should be sent on training programmes. Local tertiary institutions should deliver shorts courses on plant breeding techniques. • Fiji Seed Policy needs finalization. • Design and conduct awareness campaign for new improved varieties. • Create Public Private Partnership (PPP) to promote new improved variety.
Integrated Nutrient Management	Economic	• Capital cost investment is high • Lack of budgetary allocation at national and sectoral levels • Lack of incentives to attract private sector investment. • No subsidies provided for use of organic fertilizers compared to inorganic fertilizers in sugar cane fields.	• Source financing from donor agencies to set-up national composting facilities and strengthen soil testing facilities. • Provide incentives to attract private business participation. • Provide subsidies to encourage the use of organic manure. • Consider cost effective traditional practices to enhance soil fertility.
	Non -economic	• Lack of policy to mandate INM • Lack of trained personnel to assess soil fertility and advice on INM plan. • Lack of information of know-how and understanding importance of INM. • Farmers lack interest in INM because it is labour intensive and time consuming.	• Develop appropriate policy to mandate INM and to provide better coordination between different stakeholders. • Train local experts through exchange programmes on soil testing and devising appropriate INM plan. • Strengthening extension services and improve liaison between farmers and extension services. • Establishing farmers' groups or cooperatives to engage in knowledge sharing, pool resources together to practice INM.

Table 2: Identified barriers and measures in the coastal sector

Technology		Barriers	Measures
Mangrove Rehabilitation	Economic	• Lack of funding • Economic assessment of mangrove resources not quantified • Lack of incentives or ecological service fee	• Develop proposals to seek donor agency funding. • Commission study on tangible and intangible economic valuation • Introduce incentives under the REDD+ and Blue Carbon
	Non-economic	• No designated National authority to conserve and manage mangroves • Lack of National Mangrove Policy and enforcement • Lack of scientific knowledge and tools for mangrove restoration programmes. • Zonal mangrove map needs to be updated • Lack of awareness • Limited recognition of the resource owners in decision making process	• Clear mandate on national authority. • Develop national mangrove policy. Mangrove Management Plan (MMP) to be endorsed and implemented. • Strengthen enforcement and monitoring such as EIA • Develop National Land-use Plan • Develop mangrove restoration manual. • Develop scientific capacity and research in mangrove rehabilitation programmes. • Update zonal mangrove map. • Create mangrove appreciation awareness • Engage local communities in mangrove rehabilitation programmes.
Construction of Seawalls with Groynes	Economic	• Huge investment cost	• To source funding either through higher national budget allocation or from donor agencies • Provide 20% tax exemption on machinery and equipment

	Non –economic	• Lack of scientific knowledge for effective designs • Lack of awareness amongst different stakeholders • No skilled or specialised contractors • No involvement of local community in the decision making process	• Encourage nature based solution or cheaper options such as geotextile bags filled with sand or gabions could be considered. • R&D opportunities needs to be explored between Fiji Meteorological Services, Pacific Centre for Environment & Sustainable Development (PaCE-SD), and Pacific Community (SPC) to obtain environmental monitoring data. • Enhance the technical expertise through capacity building • Involvement of local community in decision making process.
Flood Hazard and Risk Assessment Mapping	Economic	• High Investment Cost	• Government to allocate budgetary funds and also access funds from Green Climate Fund (GCF).

	Non - economic	• Lack of institutional coordination • No coherent regulations/policy for coastal risk assessment • Lack of local expertise or human capacity within Government Ministries • Lack of high resolution bathymetry and topographic data and national vulnerability function • Lack of clear pathway for dissemination of information decision makers.	• Strengthen institutional capacity for good governance in coastal risk management through a designated national hub. • Develop coherent policy and regulations for coastal risk assessment need. • Tertiary institution should develop high level physical oceanography for coastal monitoring and mapping. • Provide more training opportunities for local meteorologists, hydrologists and coastal scientists. • To obtain data using modern technologies such as Light Detection and Ranging (LIDAR), Multi-Beam Echo-Sounder (MBES), Global Navigation Satellite System (GNSS) and drones.

Chapter 1 Agriculture Sector

The Fiji Government prioritised agriculture sector for TNA process as it is one of the most vulnerable sector to climate change. The prioritisation of the agriculture sector is aligned with the 5-Year and 20-Year Fiji National Development Plan (NDP) and National Adaptation Plan (NAP). The Climate Vulnerability Assessment (CVA) report highlighted an estimated damage of FJD 791 million in the agriculture sector from climatic hazards between 2000 and 2016. Although the future costs, losses or damages are highly uncertain, climate change impacts are projected to increase, such as rise of sea level and increase intensity of cyclones that could only increase our economic losses and elevate poverty. Hence, there is a need for technology transfer and climate financing to reduce the vulnerability of the agriculture sector and promote economic growth of the country. Three technologies prioritised during the first stage of the TNA project are given below:

1. Agroforestory
2. Integrated Nutrient Management
3. Improved Crop Varieties

In this chapter, barriers delaying the diffusion of prioritised technologies for the agriculture sector are identified and measures to overcome the barriers and enabling environment for successful diffusion of these technologies are discussed further. During the stakeholder engagement the long list of barriers were screened. To facilitate the identification of barriers, the logical problem analysis (LPA) method was used to identify the root causes of the main barriers that hinder the diffusion of each adaptation technology. The main barriers were decomposed to identify the root causes of barriers using the Problem Tree (PT). An Objective Tree (OT) that mirrors the PT was developed to identify possible measures to overcome the identified barriers.

Preliminary targets for technology transfer and diffusion

The agriculture sector contributes significantly to the Fijian economy through supporting livelihoods. There are three prominent agricultural systems in the country which include subsistence, semi-commercial and commercial farming of which a 70 to 80 % are subsistence level farms. A substantial 44 % of farm sizes are less than a hectare and a small portion are commercial. The Ministry is thus trying encourage the shift towards semi-commercial farming in its wider vision to commercialise agriculture in Fiji.

According to the Fiji Agriculture Census 2020, 70,991 households that derive income from agriculture and 88.1% of these households were man-headed and 11.9% are female headed (MoA, 2020). It was noted that the crop and livestock contribution to GDP increased at an average growth rate of 2% per annum from 2007 – 2017 (MoA, 2019). From 2013 – 2017, non-sugar agriculture GDP increased by 13.2% in the range of $452.9 m – 512.6 m, however Fiji's total agricultural import increased by FJD 678m in 2017 to FJD 782m in 2018. Crop imports such as wheat, vegetables, rice, potatoes and fruits makes up 90% of the total imports (MoA, 2019). The non-sugar agriculture export was dominated by ginger, taro, kava, cassava and wild turmeric and saw an increase of 5% for the period 2014 – 2018 despite the set-backs in terms of natural disasters such as intense cyclones, flooding and social reasons for example land tenure issues. In 2021, the country's Gross Domestic Product (GDP) declined by 5.1 percent. The Gross Value Added (GVA) in Agriculture (inclusive of growing of sugarcane) which accounted for 9.1 percent (763.9 million FJD) of the GDP, recorded a 1.0 percent growth during the year. The non-sugarcane agriculture contributed 8.2 percent (689.3 million FJD) to total GDP and showed a 3.7 percent growth as compared to 2020 (Fiji Agriculture & Rural Statistics Unit, 2021).

The Ministry of Agriculture launched its 5-year Strategic Development Plan (SDP) 2019 – 2023 which has the primary objective to build a "sustainable, competitive and resilient agriculture sector" and contribute to the Fiji NDP thus building a vibrant and robust economic growth. The priorities of SDP are well aligned to the NDP and Sustainable Development Goal (SDG) as shown in Table 3.

Table 3: Ministry of Agriculture priorities in SDP aligned to NDP and SDG.

Strategic Priorities	Source of Priority NDP	SDG linkage
1. Improve food and nutrition security for all Fijians.	NDP: 3.1.4 Food and Nutrition Security NDP: 3.1.6 Health and Medical Services NDP: 3.2.10 Expanding the Rural Economy NDP: 3.2.12 Non-sugar Agriculture	Goal 1: No Poverty Goal 2: Zero Hunger Goal 3: Good Health and Well-being Goal 4: Quality Education Goal 12: Responsible Consumption and Production
2. Increase farmer household income for sustainable livelihoods.	NDP: 3.1.4 Food and Nutrition Security NDP: 3.1.7 Social Inclusion and Empowerment NDP: 3.1.9 Women in Development NDP: 3.2.12 Non-sugar Agriculture	Goal 1: No Poverty Goal 2: Zero Hunger Goal 5: Gender Equality Goal 8: Decent Work and Economic Growth
3. Increase adoption of sustainable resource management and climate smart agriculture.	NDP: 3.1.4 Food and Nutrition Security NDP: 3.2.12 Non-sugar Agriculture	Goal 1: No Poverty Goal 2: Zero Hunger Goal 9: Industry, Innovation and infrastructure Goal 13: Climate Action Goal 15: Life on Land
4. Establish and improve commercial agriculture	NDP: 3.2.10 Expanding the Rural Economy NDP: 3.2.12 Non-sugar Agriculture NDP: 3.1.4 Food and Nutrition Security	Goal 1: No Poverty Goal 8: Decent Work and Economic Growth Goal 12: Responsible Consumption and Production
5. Improve quality public sector performance and service delivery.	NDP: 3.1.4 Food and Nutrition Security NDP: 3.2.10 Expanding the Rural Economy NDP: 3.2.12 Non-sugar Agriculture	Goal 9: Industry, Innovation and Infrastructure Goal 16: Peace and Justice Strong Institutions

(Source: MoA, 2019. 5 year Strategic Development Plan 2019 – 2023. Prepared by Ministry of Agriculture.)

The strategic plan realises the potential in agriculture sector to reduce the import of crops and fruits through a holistic approach supported through technological interventions, financing, integrated framework of policies, farmers and youth farming programs, incentives and infrastructure investment. The SDP does take into consideration that the major threat to the agriculture sector is due to the impacts of climate change such as increase in incidence of high intensity cyclones, rainfall and increasing temperature giving rise to increase of incidence in pest and diseases. The future climate will also impact soil degradation, salinization of groundwater, desertification and further shift of agriculture cultivation to marginal slope. In addition, the following risks in the agriculture sector were also identified:

- Land tenure or land rights could be an impediment in accessing credit or loan from the financial institutions.
- Poor road infrastructure in remote rural areas leading to inaccessibility to markets.

- Low uptake of new technologies, breeds and varieties by farmers.

- Aging farmers' population and low youth involvement. The Fiji agriculture census report highlights that 15.4% of farmers are above the age of 60 and 57.3% of farmers are aged 40 or above (MoA, 2020).

- Lack of public private partnership (PPP).

- Lack of expertise in research, science, genetics and other areas.

- Lack of financial resources to ensure there is sufficient staffing, infrastructure and technical resources.

Acknowledging the risks, the Ministry of Agriculture, continues in its efforts to reduce the mentioned risks by continuing to find markets working with its partners, leveraging financial institutions, upgrading farm infrastructure through various support package and programs, promoting PPP concepts, and addressing the issues of staffing, infrastructure and technical resources. The Ministry of Agriculture, is currently in the process of updating its Strategic Development Plan for the financial period 2024- 2028.

The barrier analysis and enabling framework for the identified technologies for the agriculture sector is very timely as this overlaps with the prioritised areas of SDP of MoA. The three identified technologies, that is, agroforestry practices, improved crop varieties, and integrated nutrient management, broadly falls under the climate smart agriculture priority number 3 of SDP which states "*Improve the adoption of sustainable resource management and climate-smart agriculture (CSA)*" and have developed the following strategic KPIs:

i. Improved MoA institutional, technical and scientific capacity for evidence-based planning and targeted research agendas;
ii. Increased access to resilient crop varieties, livestock breeds and social safety nets and market products that mitigate risks for farmers and
iii. Increased awareness and adoption by farmers of sustainable resource management and climate smart agriculture practices.

The SDP notes that CSA will be supported through a strong climate resilience R&D that will enhance tissue-culture laboratory that promotes plant breeding of heat, drought, flood and salt resistant varieties. It also recognises the strengthened partnership with regional and international researchers' networks and also reiterates the support for sustainable land management, better soil management, integration of traditional and modern farming practices, agroforestry, integrated fertilizer application. The SDP also mentions about the extension of seed nurseries that will be achieved through public and private partnership through pulse seed production.

Since MoA have identified CSA as one of the pathways for agricultural boost and making the agriculture sector more climate resilient, it only makes sense that the preliminary targets for technology transfer are aligned to the 5 year target of SDP for the strategic theme: adoption of sustainable resource management and CSA practices so that it will gain political support and will for faster diffusion.

For each of the prioritised agriculture technology, below are the implementation approaches aligned to the targets of SDP:

1. Establish 40 farms practising agroforestry with fruit orchards (mangoes, avocados, guavas, dragon fruit, breadfruit, citrus, passionfruit and Tahitian chestnuts) with leguminous cash crops such as beans, peas, chickpeas and trees such as tamarind and sandalwood.
2. 3 new crop varieties released through a strengthened germ-plasm facilities and expanded seed nurseries.
3. Establish two soil diagnostic labs in Western and Northern division and three national composting facilities so that there is an increase of 25% in number of farmers adopting organic production with secure market access.

Barrier Analysis and possible measures for Agroforestry

1.2.1 General Description of Agroforestry practices

Agroforestry is a land-use system that aims towards an optimal utilization of available land resources by agriculture and forestry and leads to many associated benefits of such practices. The main purpose of Agroforestry activities is to sustain the fertility of the soil by substituting the nutrition required by intensive agriculture. The World Agroforestry Centre defines the technology as an integrated approach to the production of tress and non-tree crops or animals on the same piece of land. The crops can be grown together at the same time, in rotation, or in separate plots. Agroforestry systems are divided into five categories (Wakesa & Jonsson, 2014):

i. Agro-silviculture (crops + trees)
ii. Silvo-pastrol (livestock + trees)
iii. Agrosilvopastrol (crops + trees + livestock)
iv. Entomo-silvicultural (insects + trees)
v. Aquasilviculture (fish + trees)

The annual cash crops could be integrated with trees in different landscape such as alley cropping, intercropping, hedgerows systems and improved fallows (Sharma et al., 2017).

Agroforestry systems take advantage of trees for many uses:

- Stops soil degradation by adding organic matter to soil through litter, holds the soil and reduces erosion and addresses the nutrient deficiency.

- Trees relieve water stress in farm systems through more efficient use of rainwater through the root system that helps in water distribution. It reduces surface run-offs by improving infiltration leading to groundwater storage and hence conserving water in the farm landscape.

- The nitrogen fixing trees reduce the dependency on the application of inorganic nitrogen fertilizers and assists in curbing its associated environmental pollution such as GHG emissions and contamination of aquatic systems.

- Agriculture in Fiji is known to emit 550k tonnes of greenhouse gases (GoF, 2018). Agroforestry practices can enhance mitigating greenhouse gases from agriculture as it increases carbon sequestration aboveground in biomass particularly in the tropics and through incorporation of leaf litter and roots underground that assist in mobilisation of organic material into soil. Also the nitrogen fixing plants may increase nitrous oxide (N_2O) emission but it will decrease the application of N-based fertilizer decreasing the net emissions of N_2O thereby further mitigating greenhouse gas emissions. Research have shown that agro silvicultural system has the carbon sequestration potential of 7.2 ± 2.8 tons C per ha (Kim et al., 2016).

- Conserves biodiversity for a number of ecosystem services such as pollination.

- Bioenergy in the form of fuel wood from trees for cooking and this is also promoted in the Fiji 2020 Agriculture Sector Policy Agenda.

- Trees help in modifying microclimate by providing shade and providing cooler environment and also act as wind breakers in the event of strong winds.

- Agroforestry yields the desired timber for construction, fuel wood and non-wood forest produce.

The Agroforestry models concentrate both on the short term returns from agriculture as well as long term returns from forestry activities. Agroforestry activities also ensure diversity in crops raised as well as enhances species diversity by encouraging plantation of multiple-tree species for various uses or plantation of multiple- purpose tree species. Agroforestry if practiced properly not only increases agricultural yields but alleviates food insecurity and poverty levels of farmers while increasing resilience of farm systems to more variable and extreme climate. It has been proven that agroforestry is a gender inclusive and sensitive technique as it allows women, which play major role in food production and collecting firewood, greater access to natural resources and contributing to the benefits of agroforestry (Agroforestry Network, 2020). Although agroforestry is not new in Fiji but is practiced at a rudimentary level due to numerous barriers faced by local farmers to upscale this technology in the country.

1.2.2 Identification of Barriers for Agroforestry practices

Agroforestry is classified as other non-market goods as it will require donor or Government funding to transfer and diffuse this technology under non-market conditions and it also serves the overall political objectives in terms of climate change mitigation and adaptation. The consultant conducted biennial meetings with the relevant stakeholders (see Annex VII) and carried out desktop literature review which resulted in a long list of barriers identified. The long list of barriers are given below and is not listed in any order of significance

1. Lack of knowledge on significance and implementation of technology
2. High investment cost
3. Long term pay-off period
4. Lack of sustainable land use policy
5. Inefficient Extension services

6. Lack of state financial supporting mechanism
7. Lack of quality seedlings
8. Slow uptake of climate indexed insurance
9. Low priority in climate change adaptation measures
10. Lack of Flexibility in Land tenure gives limited ownership rights for trees.
11. Lack of coordination between Ministries
12. Lack of value added chain for non-timber Agroforestry
13. Inaccessibility to credit or loan schemes for Agroforestry
14. Lack of technical expertise on Agroforestry
15. Lack of enforcement and monitoring for clearing forests and implementation of Government actions.
16. Lack of knowledge on landscape diversification
17. Poor access road to farms leading to market inaccessibility
18. Lack of incentives to plant trees
19. Increasing demand of wood for fuel

In the next step, barriers were screened according to their significance following the stakeholder (See Annex VII) held on 4 September, 2020. As a result, a shortlist of the essential barriers for the technology transfer and diffusion were developed (see Table 4). Moreover, the selected barriers were classified into a hierarchy of categories and a logical problem tree based approach was used to identify the underlying 'root' barriers. The enabling framework process encompassed determination of measure for the identified barriers taking into account the existing market and technological conditions, institutions, policies and practices, which resulted in problem and solutions trees provided in Annex I.

Table 4: List of screened and categorised barriers in the agroforestry sector.

#	Barrier	Barrier Category	Significance
1	High Investment Cost	Economic and financial	Crucial
2	Long term pay-off period	Economic and Financial	
3	Lack of knowledge on significance and implementation of technology	Information and awareness	
4	Inadequate synergies between sectoral policies.	Legal and regulatory	
5	Lack of state financial supporting mechanism	Economic and Financial	Important
6	Lack of coordination between Ministries	Institutional	
7	Land Tenure Issues	Legal and regulatory	
8	Inaccessibility to credit or loan schemes for agroforestry	Economic and Financial	
9	Lack of expertise on landscape diversification	Human skills	

10	Lack of value added chain for non-timber products	Technical	Low important
11	Lack of incentives to plant trees	Economic and financial	
12	Poor road conditions leads to market inaccessibility	Institutional	
13	Lack of Enforcement and monitoring	Legal and Regulatory	
14	Slow uptake of climate indexed insurance	Financial and Economic	

Then barriers were decomposed, and the simplified problem tree (PT) was developed (Annex IA) which was transposed into objective tree (OT) identifying measures to overcome these barriers (See Annex IB).

1.2.2.1 Economic and financial barriers

One of the key barriers in upscaling the Agroforestry technology is economic and financial barrier in terms of high investment cost, lack of funds to implement the technology, farmers' inaccessibility to credit or loan schemes for agroforestry and the most detrimental is the long term pay off period. During the development of the factsheet for this technology an estimate of FJD 3 - 5 million was endorsed by the stakeholders based on expert judgement and upscaling of current Agroforestry projects in Fiji.

The high investment cost emanates from establishing an agroforestry farm system which involves site preparation, buying high quality seedlings, labour, equipment and machineries needed for planting, fencing the farm, building access roads to farms, fertilization and pest and disease control. It requires a large upfront investment but the economic returns are very long term in comparison to annual mono-cropping. There is no state financial supporting mechanism or financial models to boost agroforestry. Consequently, farmers usually lack buffers and capital to do long term investment and this is further exacerbated by their inaccessibility to credit or loan schemes. The financial institution in Fiji such as Fiji Development Bank (FDB) have specialised agricultural loans for forestry and agriculture but nothing tailor made specific to Agroforestry sector. In order to access agriculture loans from FDB, farmers need to provide an equity of 10 – 20% and pay a capital interest of 15% per annum. This is an additional burden on farmers as the economic returns are slower or is a long-term pay-off period and also discourages farmers cooperatives to be involved in agroforestry. This coupled with losses incurred from extreme weather events such as high intensity hurricanes and in the slow uptake of climate indexed insurance it increases the risk of investment.

The long term economic returns are mostly due to timber trees dominated agroforestry and limited value adding chains for non-timber agroforestry products such as vanilla, cocoa and mullbery. There is limited advocacy for development of value added chain for agroforestry products in Fiji due to inefficient input from market and market support systems for agroforestry products that increases prices paid to farmers and reduce the investment cost.

Access to market due to poor condition of roads and mode of transport for selling their products is also a major setback in generating fast income for households.

1.2.2.2 Non-financial barriers

Institutional and organizational barrier

There is limited synergies between sectoral policies in agroforestry resulting in agroforestry not being mainstreamed into national development plan and has low priority in climate change national adaptation plan in Fiji. Since agroforestry is multi-level facet technology dealing with agriculture, forestry, land and environment and due to lack of coordination between different line Ministries, it falls through the cracks between sectoral policies. This leads to poor monitoring and enforcement of policies that further incapacitate the agroforestry system as it is not well integrated into planning and financing under any key Ministries.

Fragmentation and ineffective coordination among Government institutions and stakeholders dealing with the different elements of agroforestry practices (private sectors, non-Governmental organizations (NGOs), research and academic institutions) leads to inefficiencies in financial resources use as well as duplication or poor attention to needed efforts. There is lack of specialised agroforestry curricula in tertiary institution and lack of research and development in agroforestry practices due to unclear mandate from the Government policies on “production and protection” since the focus is usually more on production to alleviate food insecurity.

Legal and Regulatory Barrier

Fiji does not have a law, policy or strategy in place for agroforestry but have number of policies which addresses some issues on agroforestry either directly or indirectly. There are laws and policies on land use systems and tenure, agriculture, land degradation and forestry biodiversity and biosecurity which may be relevant to agroforestry. It is evident that there are gaps in these policies and as a result agroforestry has not been sufficiently mainstreamed or supported yet through existing strategies or policy frameworks.

Property and tree tenure is regarded as an impediment to adoption of agroforestry. In Fiji most of the agricultural lands are native or customary land owned by land-owning units called mataqali. The leasing of agricultural land is mostly governed by Agriculture and Landlord Tenant Act (ALTA) which usually give leases for 30 years. A total of 13,140 leases will expire between 1997 and 2028. It has been noted that the land leases under ALTA is not encouraging adoption of more long term sustainable land resources management but lease agreements are more geared towards land-use for more economic gains such as using it for mono-cropping such as taro and kava for maximum economic returns from the land. The land tenure system creates uncertainty amongst farmers to adopt agroforestry as it requires long term investment. Longer lease for forestry or agroforestry is technically possible under ALTA and Land Use Decree 2010 but this is mostly challenged by landowners which causes further uncertainty within farmers to engage in long term investment.

Human skills /technical barrier

To adopt agroforestry successfully there is a need in the country for expertise to provide landscape designs and planning in agroforestry projects to enhance the ecological, environmental and economic benefits acquired from this technology. There is lack of human skills to provide guidelines to create an agroforestry plan, which allows for more systematic approach for landscape diversification rather than ad-hoc practices. There needs to be an understanding of natural processes which will support different species that will adapt better in a particular environment. More appropriate agroforestry techniques could be applied by classifying landscape units and existing land-use systems which then leads to careful landscape planning for a sustainable implementation.

Information sharing and Awareness barrier

The low rate of adoption of agroforestry in some areas is simply due to lack of knowledge on the significance and implementation of the technology. There are few demonstration plots and farmers' field training on agroforestry practices and therefore and knowledge and skills is not sufficient to upscale the technology. Since agroforestry is not mainstreamed into national policies and therefore does not give a clear direction or mandate to the agricultural extension services to promote agroforestry at large scale. Additionally, agriculture extension services are under-staffed, underfunded and under capacitated and unable to support farmers in developing their agroforestry systems. The support systems for local knowledge sharing amongst farmers is almost non-existent at a larger scale due to lack of small holder agroforestry farmers' cooperatives.

1.2.3 Identified Measures in Agroforestry

The measures were identified during the stakeholder engagement meetings through the tools developed for identification of barriers and measures. The stakeholders developed simplified problem tree (PT) (Annex IA) which was transposed into objective tree (OT) identifying measures to overcome these barriers (See Annex IB).

1.2.3.1 Economic measures

To overcome the high investment cost the following measures could be adopted to promote higher adoption of agroforestry:

- Improving access to loan with suitable financial model tailor made for agroforestry with subsidies from the Government. This entails developing a specialized loan package with Fiji Development Bank with lower interest rate, longer holiday repayments and subsidised equity by Government. The incorporation of low cost agricultural climate indexed insurance into the loan package would be beneficial as it will protect farmers from losses incurred from extreme climate events.

- Government subsidies to encourage farmers to convert from mono-cropping to agroforestry practices. Subsidies on tax exemptions on equipment and machineries used in the agroforestry sector and subsidising building materials, fertilizer and pesticide costs would lower the investment cost.

- Donor or state funding needs to be channelled to set-up agroforestry tree germplasm systems to produce high quality seedlings for indigenous tree species. Establishment of large nurseries in countries to ensure mass supply of tree seedlings at a subsidised cost by Government would further reduce the investment cost.

- Government should provide incentives to farmers practicing agroforestry. Planting trees leads to carbon sequestration and therefore generating additional income for farmers through carbon credits. Payments of environmental services (PES) for save-guarding biodiversity and watershed management needs to be explored (Jacobi et al., 2017). It was noted in Costa Rica that implementation of PES for agroforestry had a positive impact on the economic and adoption rate.

- To ensure higher economic returns from the agroforestry, careful planning is required regarding diversification of crops and trees that would generate income on short-term, medium term and long term. Value adding chains for non-timber agroforestry needs (such as biomass energy generation, handicrafts) to be developed with support from market access and product commercialisation. Incorporation of right kind of fruit trees and cash crops with some native trees and non-timber product development such as fruit pickles as practised by The Foundation for Rural Integrated Enterprises & Development (FRIEND) Fiji could be a classic example. The sandalwood seedlings could be also sold to the Government nurseries and producing dried fruits with installation of solar dryer could provide an additional pathway for faster economic returns. Market access for cash crops could be improved with better access roads and transport system. Forming and strengthening farmers' organizations such as cooperatives amongst smallholder farmers will enhance development of value chains, and pooling their resources for better market access and land access and price (Agroforestry Network, 2020)

1.2.3.2 Non- financial measures

- Agroforestry needs to be mainstreamed into NDP and climate change NAP. Fiji should develop and implement a national agroforestry policy, strategy, and implementable action plan that provides clear guidance and alignment and that can be integrated into subnational level plans, programs, and policies that would focus on upscaling agroforestry. The development of policies and strategies will provide designated responsibilities within different Ministries for more coherent coordination efforts and lay out incentive structures and information as an actor or driver of practice change. The development of appropriate policy mechanisms and instruments for agroforestry will ensure that state financial funds are directed to catalysing the adoption of the technology at the district and national levels.

- Land reforms are needed in line with the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security. ALTA needs to be strengthened to give long tenure and tree rights to be given to farmers and needs to be gender inclusive. With clear rights over trees, women and men farmers are strongly incentivized to invest in agroforestry.

- There is a dire need to increase investments in Government-led extension services with clear mandate to provide training in landscape planning and diversification to support farmers in the agroforestry sector. Strong collaboration links with the Government Ministries and tertiary institution like the College of Agriculture, Fisheries and Forestry at Fiji National University (FNU) is mandatory to enhance the curriculum on agroforestry particularly on landscape planning and diversification which will develop human skills capacity within the region. A platform for more engagement and better coordination between relevant extension and research organizations, as well as NGOs and other stakeholders such as private partnership would lead to identification of gaps that needs to be addressed. Such engagement would facilitate further research to get value adding chain for agroforestry products from a sustainable farming system.

- There should be greater need for information sharing and creating awareness about the benefits and incentives given for agroforestry practices. The Government led extension services should play an active role here to create awareness about the technology through farmers' field training including demonstration plot and producing an agroforestry manual. Agroforestry farmers are often in remote areas and not well connected to each other or supportive organizations hence forming an agroforestry farmer organisations or cooperatives will allow knowledge sharing amongst farmers and awards to be given for best practices which needs to be publicised widely so that it would encourage farmers to adopt these practices and increase the adoption rate of the technology.

1.3 Barrier Analysis and possible enabling measures for Improved Crop Varieties

1.3.1 General description of Improved Crop Varieties technology

The introduction of improved crop varieties is aimed at enhancing crop yield, nutritional value and increasing crop's adaptive capacity to diseases, pests and changing climate and soil conditions. Plant breeding results in improved crop varieties with desired traits that are well adapted to changing climate. The process requires farmer experimentation with new varieties whereby agricultural researchers and extension agents can help farmers identify new varieties. Plant breeding is conducted in research institutes and big nurseries, and requires lab and field experimentations as well as genetic resources conservation facilities (seed bank, mother plants orchard, etc.). The varieties are tested for their characteristics for several years in trial plots and following are the criteria used for evaluation of the new variety:

- Fruit characteristics (flavour, colour, calibre, maturity date, etc.)

- Plant characteristics (shape, vigour, type and date of blossom, etc.)

- Agriculture characteristics (yield, bearing year for trees, resistance/tolerance to pests and diseases, training and pruning type for trees, winter/summer crop for field crops, etc.)

- Environmental characteristics (tolerance/resistance to: different soil conditions, high/ low temperatures, chilling requirement, drought, etc.)

Plant breeding requires scientific research and field studies before releasing the new obtained breed to farmers for plantation on a commercial scale. To introduce a new variety there must be sufficient evidence that new varieties offer benefits rather than new threats. An introduction of new variety can increase farmers' livelihoods by increasing yields through improving resilience to changing climate (drought, flooding and heat stress) and pests and diseases and also capturing new market. This technology allows innovative partnerships between producers, research institutes and the private sector. However, market demand could be low for new varieties and the failure of farmer experimentation is the misconception that local species have low productivity. The countries that adopted this technology also noted that more trained breeders are needed. It was also noted that in the Pacific Island, crops and cropping systems were more vulnerable to the impacts of climate change due to narrow genetic base of these crops (McGregor et al., 2011)

Plant breeding requires substantial investments in skills such as tissue culture, labour, equipment, money and time. Plant breeding is a specialised skill and there are very few breeders in the Pacific Island countries. Maintaining the varieties require the conservation of parents and varieties in seed banks or orchards. Only research institutions have the capacity to ensure such operation and maintenance in Fiji such as SPC CePACT, USP, and Sugar Research Institute of Fiji (SRIF). This ensures that farmers have access to genetic diversity that could be used and evaluated for its desired traits. Mcgregor et al., (2011) noted that long term investment in introducing and conserving diversity in crop genetic material in regional and national collections are needed and these could be further supplemented by genetic reservoirs in farmers' fields.

This technology is not new to the region and there have been a number improved varieties of bean that can contribute to food and nutrition security. Improved crop varieties such as new taro leaf blight tolerant varieties ("Tarova Loa" and "Tarova Vula" and new sweet potato variety ("Golden Brown") which is drought tolerant and resistant to kumala scab disease. The Pacific Adaptation to Climate Change (PACC) Programme is the one of the initial climate change initiative implemented in Fiji through SPREP to improve crop resilience to extreme events such as flooding by improving drainage systems in lowland farming areas in the Tailevu-Rewa and Serua-Namosi Province. The project also tested staple root crops (taro, cassava and sweet potatoes) for saltwater and waterlogging tolerant varieties at two pilot sites.

Figure 1: An illustration of improved taro variety and kumala variety developed in Fiji. (Source: https://fijisun.com.fj/2018/07/07/Ministry-releases-new-dalo-and-kumala-varieties/)

1.3.2 Identification of barriers for Improved Crop Varieties technology

The improved crop varieties is a hybrid between market and non-market technology. It does have a high number of potential consumers and demand depends on the awareness of farmers however initially the technology is more research and development focussed in terms of establishing a seed bank. The research and development requires donor or Government funding is terms of enhancing the facilities, technical expertise and creating awareness about the new improved varieties by the Ministry of Agriculture and therefore is classified as a non-market good.

The barriers were identified through screening, decomposition by relevant stakeholders during the national stakeholder engagement (See Annex VII). The selected barriers were classified into a hierarchy of categories by the stakeholders and a logical problem tree based approach was used to identify the underlying 'root' barriers. The enabling framework process encompassed determination of measure for the identified barriers taking into account the existing market and technological conditions, institutions, policies and practices. A problem tree (See Annex IIA) was developed and then it was reversed to obtain an Objective Tree (OT) highlighting measures for the main barriers (See Annex IIB).

1.3.2.1 Economic and financial barriers

The key financial barrier is huge investment cost in research laboratory facilities and human capacity to develop and evaluate improved varieties. Based on previous projects carried out in Fiji and the need for upscaling the diffusion of this technique it is estimated that the cost of the technology will be in the range of FJD 250,000 – FJD 500, 000. The financial capacity of the current institutions such as SPC CePaCT and SRIF is very limited. Funding is also required to train people in plant breeding programmes and also to strengthen the extension services within MoA to provide farmer's field school to train farmers on plant breeding. There could be cost associated with the import of parent materials or seeds of new variety from elsewhere and also for field trials. It was noted that for this technology to be viable it demands continuous funding for a number of years and therefore is a significant barrier hindering the upscaling of this technology in the country.

Also the farmers have limited access to good quality seeds and the improved variety could be expensive which could make the technology adoption rate lower particularly amongst the poor small-scale farmers.

1.3.2.2 Non-financial barriers

Institutional and organisational barrier

There is lack of synergies of coordination between the relevant institutions such as SPC CePaCT, SRIF, MoA, FNU and USP to chart out the national needs or structured plan of action for the introduction of improved crop varieties. The need for desired collaborations would lead to pooling resources together for better outcome.

Human capacity

There is lack of human capacity in research facilities and also lack of local plant breeders and farmers or MoA to evaluate improved varieties. This emanates from lack of national commitment to train people in the area of plant breeding and evaluation and lack of an enhanced training programmes such as short courses on plant breeding within tertiary institutions.

Policy, legal and regulatory barrier

The NAP and the Fiji Agriculture Sector Policy 2020 does highlight that new improved varieties need to be explored so that the agriculture sector is more resilient to climate change impacts and to enhance the national food security. However, there is no clear mandate or designated authority to spearhead the activities of new improved varieties.

The Fiji Seed Policy needs finalisation and implementation as there is no control of seeds entering Fiji. The main objective is to develop, evaluate and distribute pest resistant/tolerant high yielding varieties that are well adapted to local climate regime. The policy will also ensure that that farmers have access to clean good quality seeds to meet production requirement. The Fiji Seed Policy is not being advanced at an acceptable rate due to limited awareness and coordination amongst relevant stakeholders.

Information and Awareness

In general, farmers are not aware of the new improved varieties and the benefits of the technology and therefore it hinders uptake. Farmers are also not aware of methodologies to multiply new varieties of crops and have to buy the new improved varieties from the market which incurs recurring cost and thereby preventing it widespread diffusion.

Market Barrier

There is a lack of targeted breeding as the need for the improved varieties should be market driven. It is challenging to expand market for a new variety when the export market is dominated by some old varieties and changing the consumption habits is not easy. Hence, farmers are reluctant to adopt improved crop varieties as they have difficulties in marketing new products. There is lack of Private-Public Partnership (PPP) to drive the market for improved crop varieties to create the demand of particular product.

1.3.3 Identified measures

1.3.3.1 Financial Measures

There is a large investment cost initially and funds needs to be sourced from donor agencies that would develop the following capacities:

- Strengthening of research laboratories such as developing molecular DNA fingerprinting facilities at universities and other institutions for R&D.

- Development of human resources and technical knowledge.

- Knowledge transfer and exchange programmes

- Strengthening extension services for wider dissemination of information through farmers' field school.

To encourage farmers to adopt this technology and undertake new varieties for trials, the Government needs to provide incentives such as if farmers uptake this technology then they will get subsidised inorganic fertilizers or subsidies on improved variety seeds.

1.3.3.2 Non –Financial measures

- Strengthen the current institutions (such as SPC CePaCT, SRIF, FNU, USP and MoA) with human resources and required facilities for accelerating research in developing new varieties, preserving traditional varieties and undertaking field trials for evaluation before distribution to farmers. To create synergies between the institutions so that they can have a structured workplan and pool resources together for targeted breeding programmes. Staff should be sent on exchange programmes or capacity building programmes so that they are trained on the latest techniques and therefore increasing the institutional capacity in terms of developing new varieties.

- Design and conduct awareness campaigns to spread information about challenges with existing crops and the need to develop and disseminate new varieties of crops that are pest and drought resistant. This will potentially consist of:

    I. Sharing of success stories in local media to attract attention
    II. Farmers' field schools organised nationwide by extension services
    III. Organising awareness campaigns and preparing campaign materials suited for farmers.

IV. Collaborating with village level bodies such as farmers' cooperatives to disseminate information to local people.

- The Fiji Seed Policy needs to be finalised. However before drafting the policy, relevant Ministries should be enlightened with the need of such policy. A working group consisting of relevant stakeholders should be formed and a consultant should be hired to formulate the policy which is in line with the guidance provided by Food and Agriculture Organisation (FAO).

- The tertiary institutions such as FNU and USP should provide short courses on plant breeding techniques or how to multiply seeds. The curriculum in the agricultural programmes should be re-visited and plant breeding components needs to be enhanced to address the lack of human capacity barrier in this field.

- Create PPP to promote new improved variety through marketing campaigns, product traceability establishment and promotion of multiplication of local certified plant material.

1.4 Barrier analysis and possible enabling measures for integrated nutrient management technology (INM)

Integrated nutrient management (INM) deals with increasing the fertility of the soil to make the agriculture sector sustainable and more resilient to climate change. This technology is regarded as a non-market good as it is not driven by market condition but requires huge donor or Government funding to build research and testing facilities, construction of composting facilities and is aligned to the Government's initiative for developing a sustainable agriculture system that would address the food security issues in the country.

The barriers were identified through screening, decomposition by relevant stakeholders during the national stakeholder engagement (See Annex VII). The selected barriers were classified into a hierarchy of categories by the stakeholders and a logical problem tree based approach was used to identify the underlying 'root' barriers. The enabling framework process encompassed determination of measure for the identified barriers taking into account the existing market and technological conditions, institutions, policies and practices. A problem tree (See Annex IIIA) was developed by the stakeholders and the measures were identified through an objective tree (See Annex IIIB).

1.4.1 General description of integrated nutrient management technology

The aim of INM is to integrate the use of inorganic, organic and biological components to maintain soil fertility at an optimum level to increase crop productivity and preserve soil productivity for future generations. Organic fertilizers have gained worldwide attention in INM approaches because it increases productivity and decreases environmental pollution in terms of greenhouse gas emissions and water pollution. If organic fertilizers such as manure are applied incorrectly and excessively then nutrient could leach to waterways causing algal blooming.

Organic fertilizers are derived from substances of plant or animal origin, such as manure, compost, seaweed and vegetable peelings. Organic matter amendment of the soil, helps to condition soil by improving water and nutrient retention capacity, buffer pH changes and thereby increasing the soil health for better yield. This use of organic matter decreases the dependency on the application of N-based synthetic fertilizer. The decrease usage of nitrogen based fertilizers because of adoption of INM leads to less nitrogen leaching and losses to water and atmosphere. It decreases the N_2O emissions to the atmosphere and help in reducing the national carbon footprint. However, it should be noted that sometimes the organic sources may not have all the necessary micro and macro nutrients required by plants and therefore needs to be supplemented by inorganic fertilizers. Efficient use of all nutrient sources, including organic sources, recyclable wastes, mineral fertilizers and bio-fertilizers should therefore be promoted through INM.

INM relies on a number of factors, including appropriate nutrient application and conservation and the transfer of knowledge about INM practices to farmers and researchers. In addition to the standard selection and application of fertilizers, INM practices include new techniques such as deep placement of fertilizers and the use of inhibitors or urea coatings (use of area coating agent helps to retard the activity and growth of the bacteria responsible for denitrification) that have been developed to improve nutrient uptake.

For successful implementation of INM strategy, it involves several key steps highlighted by Wu and Ma (2015) such as:

i. Determine the soil nutrient availability and nutrient deficiency in crop plants. These can be achieved through soil/plant sampling and subsequent lab analysis or it can be also evaluated through visual inspection that could provide indications of nutrient deficiencies.
ii. Based on the feedback of the test results a systematic appraisal of constraints and opportunities in the current soil fertility management practices and how these relate to the nutrient diagnosis is undertaken.
iii. Determine the farming practices and technologies that would balance nutrients. Different climates, soil types, crops, farming practices such trash conservation, contour planting and vetiver along edges, and technologies dictate the correct balance of nutrients necessary. Once these factors are understood, appropriate INM technologies can be selected.
iv. Assess the productivity and sustainability of INM practices through the inputs/feedbacks from farmers’ participatory involvement in testing and analysis. Participatory farmer-led INM technology experimentation is necessary in technologically development such as biochar incorporation and composting.

1.4.2 Identification of barriers for INM technology

1.4.2.1 Economic and financial barriers

- Capital cost investment is high to set-up national composting, biochar/biofertilizer facility and to increase the capacity of the soil testing facilities in terms of resources (equipment and human resources). During the stakeholder engagement for the development of the technical factsheet the cost of the technology was estimated to be in the range of FJD 2 – 2.4 million.

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

- Lack of incentives such as tax subsidies on machineries to attract private sector participation.

- The organic fertilizers could be costly and no subsidy given for organic fertilizers as compared to inorganic fertilizers decreases the adoption rate amongst the farmers.

1.4.2.2 Non-financial Barriers

<u>Policy, legal and Institutional</u>

- Lack of policy to mandate INM which results from limited coordination between different stakeholders. There is also inadequate policy, legal and regulatory framework to advance research and development of the technology.

<u>Technical Expertise</u>

- Lack of training for people to assess soil fertility and devise a plan for INM. There needs to be more research and development in enhancing soil fertility within MoA and results of the research to be transferred into practice at local levels.

<u>Awareness and Information</u>

- Framers lack interest in INM because it is labour intensive and time consuming and the application method of organic materials is difficulty as opposed to granular fertilizer. Farmers lack information of know-how and understanding importance of INM due to limited resources and mandate of extension services.

- Increased involvement farmers' cooperatives to engage in knowledge sharing, pool resources together to practice INM.

1.4.3 Identified measures

1.4.3.1 Economic and financial measures

- To source external funding from donor agencies to set-up national composting facility and strengthening the soil lab testing facilities.

- Increase budgetary allocations at specific sector and at national levels to develop the technology.

- Provide incentives to attract private business and community participation.

1.4.3.2 Non-financial measures

- Develop appropriate policy to mandate INM and to provide better coordination between different stakeholders.

- Educating farmers on the benefits of INM practices and through extension services knowledge on manure preparation/composting should be demonstrated. There is a need to collate success stories of INM projects in Fiji and communicated to farmers. Farmers should be able to access relevant contacts in the extension services.

- Establish new groups/cooperatives specifically for INM or finding pathways to integrate INMs into existing farmers group, farmers field schools and MoA extension services.

- Consider cost effective traditional practices to enhance soil fertility.

- Train local experts through exchange programmes on soil testing and devising appropriate INM plan.

1.5 Linkages of the barriers identified

The three adaptation technologies prioritised in the agriculture sector, that is, Agroforestry, improved crop varieties and INM have the following interrelated implementation barriers:

I. Financial Barrier
II. Policy and regulatory Barrier
III. Technical Barrier
IV. Information and Awareness Barrier

Figure 2 shows that graphical representation of linkages between barriers for the three technologies. It is apparent that the organisational and institutional barriers are common to agroforestry and improved crop varieties. This mostly results from inefficient coordination between different stakeholders, where the responsibilities of different players are fragmented and does not lead to effective implementation of the technology. This barrier is mostly linked to policy and regulatory barrier, which provides the legal framework for designated national authority with a defined task. The interlinkages of barriers for the three technologies in the agriculture sector are explained further in Table 5.

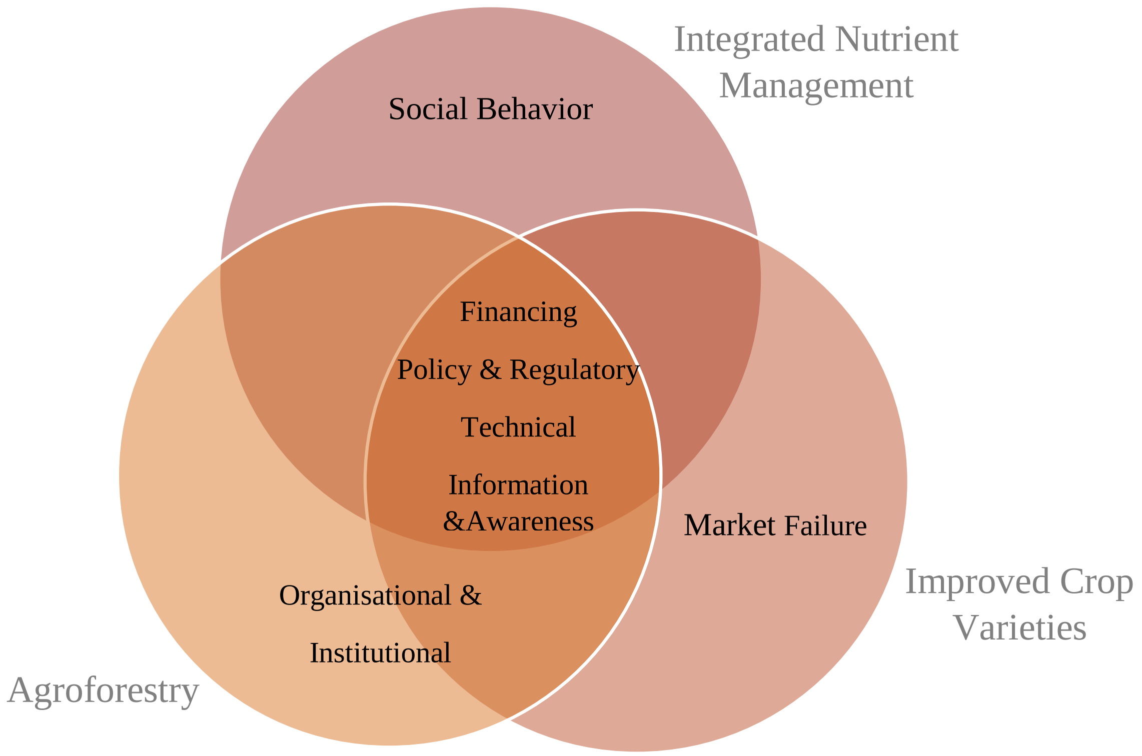

Figure 2: An illustration of an overlap of barriers identified in the three technologies prioritised in the agriculture sector.

Table 5: An explanation of linkages of barriers in the agriculture sector.

Barriers	Linkages
Financing	This is a major implementation barrier. Farmers have limited access to credit from financial institutions due to strict lending conditions and also these technologies incur upfront high investment cost. Funding is also required to develop research facilities and human capacity and to create awareness amongst the farmers. Financial constraints in terms of unavailability of incentives and subsidies are regarded as an impediment in the adoption of these technologies.
Policy and regulatory	Adequate policies and regulations are needed to allow diffusion of these technologies successfully. These technologies are not mandated by policies and not mainstreamed into the climate change adaptation policies such as agroforestry is not regarded as a climate change adaptation technology. There is generally lack of legal framework to mandate these technologies.
Technical	Technical expertise and human capacity is lacking in all the three technologies. There is insufficient research and development opportunities in these technologies locally to develop skillset. This barrier is exacerbated by lack of budget to train local people and invest in research facilities for new improved crop varieties and INM.
Information and Awareness	The farmers are not aware of the significance of the technology and "know-how" for successful implementation of these technologies. There is no common platform for sharing knowledge and promoting new technology and this is further incapacitated by ineffective extension services.

1.6 Enabling framework for overcoming the barriers in Agriculture Sector

In order to implement the prioritised technologies in the agriculture sector, a robust enabling environment should be created to diffuse these technologies successfully. The following enabling measures have been identified in the strategic development plan 2019 – 2023 of MoA (GoF, 2019) and have been broadly categorised as such:

- **Access to climate change finance and an increase in national budgetary allocations** to facilitate huge capital investments such as research labs, strengthening the germplasm facilities, expanded seed nurseries, soil testing facilities, composting facilities to provide organic manure and providing training opportunities to extension officers in R&D competencies. Finance is also required to incentivise climate smart agriculture such as agroforestry practices and use of organic manure in initial stages to promote increased uptake rate of adoption.

- A consolidated **policy** which sets the framework for climate smart agriculture practices needs to be developed in consultation with all the relevant stakeholders and are prioritised within the national adaptation plans to attract climate financing which is the major impediment. The policy will clearly provide the designated institution with a mandate to coordinate all climate smart agriculture activities and its subsequent regulations will strengthen the agricultural lease for longer period and incentives will be paid out to farmers to sustain successful rate of adoption.

- **Engaging in R&D and partnerships** with research institutions and tertiary institutions both locally and internationally to enhance tissue-culture facilities and promote plant breeding programmes and development of evaluation methodologies and applications of climate resilient varieties of staple crops. Partnerships with regional and international researchers' network and farmers' organisations is strongly encouraged for plant breeding, pulse seed production and conservation, access and dissemination of information. Exploring R&D opportunities with the research institutions will also develop technical expertise within the country. Established and renewed collaboration with tertiary institutions could facilitate the training needs of the workforce through enhanced curriculum offered through School of Agriculture at USP and College of Agriculture, Fisheries and Forestry (CAFF) at FNU.

- **Local technical experts** are needed to provide advice and guidance to farmers on climate smart agriculture practises so that good community of practitioners could be sustained. The MoA should prioritise enhancing the technical capacity of research officers and extension officers through actively seeking training opportunities so that they are up-to-date with the technology. This could be facilitated through increase budgetary allocation for local capacity building programmes.

- **Sharing of information and creating awareness** of CSA technologies to promote uptake of these technologies. This could be achieved through strengthened extension services that conduct farmers' field school and set-up demonstration plots to impart knowledge on "know-how" and significance of CSA technologies. Farmers should be able to access information easily and contact the extension services directly and seek advice and information on the technology. Small farmers' cooperative or farmers' organisation should be encouraged so that a good community of practitioners could be established that would provide a platform for sharing best practices or traditional knowledge. The formation of such farmers' organisation could also help in providing better access to markets, loans through cooperative body and ways to generate additional income through pooling resources together and sharing the expenses. The best practices nominated by MoA should be awarded by some rewarding schemes. Also there needs to be more concerted effort in design of awareness campaigns on new improved varieties and

Create Public Private Partnership to facilitate demand due to market conditions for improved crop varieties, value adding for non-timber products and clean seed production. This could be achieved through marketing campaigns, product traceability establishment and promotion of local certified plant materials or organic product certification.

Chapter 2 Coastal Zones Sector

The Fiji Climate Vulnerability Assessment (2017) identified coastal zones (coastal communities and fisheries) to be more vulnerable to natural hazards such as coastal flooding and tropical storm surges. The impacts of climate change and sea level rise is now evident in many coastal communities. It was reported that shoreline retreats of 15 – 20 m over recent decades have been observed in Fiji and this was partly attributed to loss of mangroves (World Bank, 2000). In 2013, the village of Vunidogoloa was the first village to be relocated (McNamara and Des Combes, 2015) with an additional 42 communities identified to be at risk from rising sea level. Hence some interventions in adaptation measures in safeguarding the coastal communities from extreme climatic hazards and long-term climate change impacts is of national paramount importance.

The following three technologies were prioritised in the first phase of the TNA process:

1. **Mangrove Rehabilitation:** The technology already exists in Fiji and the barriers for implementation of such technology is well known, such as survival rates of mangrove seedlings, species selection and lack of commitment from the local communities to sustain the mangrove. Nonetheless, it is a soft mechanism that will protect coastal erosion from storm surges and provides a buffer between the coast and the reef system in terms of trapping nutrients, chemicals and sediments which could potentially damage the reef system. Mangroves will increase biodiversity and could improve the livelihoods of local women in terms of harvesting clams ("kaikoso"), mud crabs, fish and contributes to carbon sequestration.

2. **Construction of Sea wall with Groynes**: Sea walls of various forms have been around Fiji since 1960s, however the durability of the technology remains a concern and therefore appropriate and sustainable designs needs to be implemented. Nonetheless, there was great consensus that despite high cost the technology is proven to provide more environmental, social and economic benefits from sea level rise (SLR) and storm surges. The construction of seawalls with groynes will be relatively new technology and this will help in withstanding the strong backwash in waves that undercuts the seawall causing it to collapse. The groynes could be wooden structures or gabions perpendicular to the coastline extending out into the sea. The groynes prevent the movement of sand and helps in building a larger section of beach in front of seawalls. The new beach will increase the distance that waves have to travel to reach the coast and, in the process lose most of their energy, reducing their impact on the seawall.

3. **Flood Hazard Mapping:** An important tool to map out coastal regions which are more prone to flooding in future due to climate change. In Fiji flooding causes huge economic losses in terms of structural damage to infrastructure and damages to agriculture sector. The use of LIDAR measurements in conjunction with changes in bathymetry and topographic data could provide useful flood hazard mapping and robust risk assessment that could steer away infrastructure developments from future climate hazard and could also be useful in planning national disaster risk reductions programs.

In this chapter, barriers delaying the diffusion of prioritised technologies for the coastal zone sector are identified and measures to overcome the barriers and enabling environment for successful diffusion of these technologies are discussed further. During the stakeholder engagement the long list of barriers were screened. To facilitate the identification of barriers, logical problem analysis (LPA) was used to identify the root causes of the main barriers that hinder the diffusion of each adaptation technology. The main barriers were decomposed to identify the root causes of barriers using the Problem Tree (PT). An Objective Tree (OT) that mirrors the PT was developed to identify possible measures to overcome the identified barriers.

2.1 Preliminary targets for technology transfer and diffusion

The technologies prioritised in the coastal zone sector were aligned to the Fiji NAP and CVA. The adaptation measures for natural hazards and natural environment identified in NAP (GoF, 2017) which are aligned to the prioritised technologies are as follows:

- Integrate ecosystem-based adaptation measures into considerations regarding the construction of seawalls and river banks, including mangrove planting.
- Implement coastal protection measures in highly vulnerable communities (e.g. foreshore protection, artificial wave break etc).
- Create flood risk and management action plans for all human settlements which operate at the catchment scale and involve either hybrid or nature-based solutions and payments for ecosystems services.
- Flood management activities for priority river systems, such as Nadi River, Sigatoka River, Rewa River, Labasa River.
- Conduct regular river flow monitoring and flood forecasting.
- Strengthen enforcement of planning and environmental legislative and institutional frameworks, most notably the Environment Management Act and Environment Impact Assessment (EIA) process.
- Prioritise and delineate critical areas for protection and sustainable management based on ecosystem services, cultural importance, biodiversity, food security, water security, access and benefit sharing, and importance for adaptation and disaster risk reduction.
- Assess and monitor the state of coastal ecosystems and protect and enhance the natural coastal defences.
- Gain endorsement of Mangrove Management Plan (MMP), implement mangrove rehabilitation projects and strengthen the regulations regarding mangrove removal and conversion.

More recently Fiji developed the Low Emission Development Strategy (LEDS) and it highlighted the potential of mangrove ecosystem in GHG emission reduction. It was envisioned that in the high ambition scenario of blue carbon economy sector that the total area of mangroves is expected to increase by 13% of the 2008 levels. The total mangrove area in 2008 was 48,317 ha so by 2050 a total area of 54,762 ha would see a net sequestration rate of -531, 204 tCO2e in 2050. The 13% increase is only possible with concerted mangrove rehabilitation programme and strict regulations in place that would enforce a moratorium on mangrove removal. This is an important strategy in maintaining national commitment to Paris Agreement and attaining a carbon neutral economy by 2050. The preliminary target for mangrove rehabilitation should support this national commitment. The coastal areas are also impacted by intense cyclones resulting in tidal surges and coastal flooding and increasing sea level rise that results in the damage of infrastructure and loss of livelihoods. In this context, the following technology targets are proposed:

1. **Mangrove rehabilitation**: The project target to replant 1,000 ha of mangrove by 2030 particularly those areas that are faced with storm surges associated with the impact from high intensity cyclones.
2. **Construction of seawall with groynes**: The project target to build sustainable seawall in northern and western divisions and hard engineered structures in 3 maritime sites.
3. **Flood hazard and risk assessment mapping**: To develop flood hazard and risk assessment mapping for Sigatoka River, Rewa River and Labasa River basins or watersheds.

2.2 Barrier analysis and possible enabling measures for mangrove rehabilitation

2.2.1 General Description of Mangrove Rehabilitation

Fiji has the third largest mangrove area in the Pacific spanning over 517 km^2 in 1985 (Ellison and Fiu, 2010). Mangroves are part of the wetland ecosystems and provide many direct and indirect benefits for our communities. One of the most important function of mangroves is to provide coastal protection against coastal flooding. They induce wave and tidal energy dissipation and act as a sediment trap for materials, thus helping to build land seawards. The dense root mats of wetland plants also help to stabilise shore sediments, thus reducing erosion. The greatest threat to mangroves in Fiji is from coastal development. A classic example is the Freesoul Real Estate development at Malolo Island in 2018 that removed large areas of mangroves without any Environmental Impact Assessment (EIA) being carried out. The tourism development in Nadi Bay from 1986 – 2005 resulted in removal of 200 ha of mangrove cover and further 200 ha was removed from the Denarau Island to enable tourism development with permit issued in 2009. The most current estimate of mangroves was done in 2008 and was believed to cover approximately 48,000 ha (GoF, 2018). Other threats include firewood harvest, pollution, watershed alteration and increased sedimentation, overfishing, sea level rise and invasive species. Restoration of degraded mangrove ecosystem is required not only to provide coastal defence from extreme climate events but it also provides other benefits for the local community and the environment.

Mangrove ecosystem supports the livelihood of the local communities. The women in the community depends on the surrounding mangroves for food and firewood as it is easily accessed without the need of any cost incurred in transportation. Many households in the coastal communities rely on fishes, bivalves and mangrove lobster caught in the mangrove areas. Mangrove is also a major source of firewood, charcoal and also used in the construction as well. The leaves of mangroves have a number of medicinal uses and used in the local community to treat blood pressure, leprosy, epilepsy, diarrhoea (Greenhalgh et al., 2018). In addition, it has been used for making traditional artefacts particularly using the bark to prepare traditional clothing used for weddings.

The mangrove ecosystem acts as the nursing ground for a number of reef fish such as snapper, jack, trevally and surgeonfish. Mangroves also provide habitats for crabs and shrimps and the ecological benefits also extend to offshore. Mangroves trap sediments and nutrients from the river and maintains good water quality offshore for heathy growth seagrass bed and coral that further increases the fish stock. The sediment trapping depends on the type and health of mangrove species and the density of mangroves. Complex mangrove root systems, the amount of sediment and the strength of wave action also contributes to this process. Inland deforestation or piling dredged sediment near mangrove system can cause the silting of mangroves and reduces their health and their ability to regenerate. Such actions kill the ecosystem and therefore the sediments are no longer trapped by the mangroves. Mangroves can capture human or animal waste and recycle nitrogen, carbon and sulphur and absorb other large amounts of pollutants such as heavy metals and keep the coastal pollution free to sustain healthy coastal aquatic life.

Mangroves provide coastline protection against waves, storms, flooding, and coastal erosion and therefore protect coastal developments such as buildings, agricultures and road systems. It was estimated that 100m of mangrove forest can dissipate wave energy by 20% (Mazda et al., 1997). The importance of mangrove system was realised during Cyclone Winston, a category 5 cyclone, whereby houses in Ra province were badly damaged particularly in the areas where there were no mangroves to provide protection from the wave force and winds (SPC, 2015). Mangroves have provided benefits in protecting the sea walls, protecting the life of sea wall by reducing sediment erosion from foundation of these structures. Hence mangroves reduce the maintenance cost of seawalls and makes it more durable (Greenhalgh et al., 2018).

Mangroves are highly efficient in removing or sequestrating carbon dioxide (CO_2) from the atmosphere and storing in the plant material and also storing in soil as well. It is estimated that mangroves can remove approximately 1,000 tonnes of CO_2 /ha and therefore mangrove conversion results in the emission although this emission is not accounted for in the National Greenhouse Gas Inventory. Removal of mangrove in the Rewa Delta resulted in in emissions of 1.513 Mg CO_2e /ha. The carbon sequestered by mangroves can be used to offset greenhouse gas emissions. There is great potential that mangroves could provide opportunities for the REDD+ implementation and ecotourism.

For mangrove restoration, it is necessary to collect plant propagules from a sustainable source, prepare the restoration site for planting and directly plant propagules at regular intervals at an appropriate time of year (de Lacerda, 2002). In re-establishing mangroves, it may also be desirable to establish nurseries to stockpile seedlings for future planting (de Lacerda, 2002). Mangrove re-establishment can also be achieved by planting dune grasses. These grasses provide a stable, protective substrate for mangroves to establish their root systems. However, as the mangroves grow, they will eventually overshadow the dune grasses, causing them to die. Thereafter, the mangrove becomes the dominant species.

2.2 Identification of barriers for Mangrove Rehabilitation

Mangrove Rehabilitation is classified as other non-market goods because this technology is not transferred as part of a market but within a public non-commercial domain and requires huge financing from donor or Government agencies.

The barriers were identified through screening, decomposition by relevant stakeholders (See Annex VII) during the national stakeholder engagement on 4th September, 2020. The selected barriers were classified into a hierarchy of categories by the stakeholders and a logical problem tree based approach was used to identify the underlying 'root' barriers. The enabling framework process encompassed determination of measure for the identified barriers taking into account the existing market and technological conditions, institutions, policies and practices. A problem tree was developed to identify the root causes of the barriers (See Annex IVA). The problem tree was inverted to obtain the objective tree for the identification of measures (See Annex IVB).

2.2.2.1 Economic and financial Barriers

Lack of funding to carry out the restoration work is the greatest challenge. Usually the restoration work is funded by donor agencies and the restoration programme requires sustainable funding throughout the different stages such as planning, implementation and post management of the projects. The RESCCUE mangrove restoration work undertaken in Ra Province in 2017 estimated a mangrove restoration cost of FJD 23,755/1000m^2 (Greenhalgh et al., 2018) The funding should cater the need of the mangrove ecosystem to be restored and not the interest of the donor agencies.

The economic assessment of the mangrove resources is not quantified. The lack of economic valuation of tangible and intangible benefits of mangrove system does not highlight the economic significance of the ecosystem and the need to preserve the mangroves for sustainable economic growth of the local communities. There is lack of monetization of the following direct benefits supported by mangroves such as food, firewood, charcoal, timber, fish smoking, fish bait, traditional medicines, traditional artefacts such as cloth would place emphasis for more restoration work.

There is lack of incentives of ecological service fee for managing and maintaining the mangroves. This probably emanates from the fact that economic valuation of indirect benefits of mangroves is not being conducted. The economic returns associated with nursery, feeding and breeding ground for freshwater animals, inshore reef and oceanic fish, coastal protection from tidal surges, flooding and erosion, carbon dioxide removal from the atmosphere and removal of waste would probably determine the level of incentives to be paid to the local communities. There is simply the lack of incentive programme like in the REDD+ particularly when mangroves are the highest remover of carbon from the atmosphere.

2.2.2.2 Non-financial barriers

Institutional and organizational Barriers

Initially Fiji's mangroves were constituted as Forest Reserve and the primary responsibility was given to the Fiji Forestry Department. Once mangroves were undeclared as Forest Reserve it came under the jurisdiction of the Ministry of Lands and more recently it sits with Department of Environment. The coordination between the different Government Ministries remains largely fragmented. This emanates from the lack of policy or legislation mandate for designated national authority in Fiji to conserve and manage the mangroves. Consequently, this leads to other barriers such as the endorsement of Mangrove Management Plan (MMP) and the development of implementation framework for MMP. The Draft MMP 2013 clearly states that Department of Land is not equipped to monitor "on the ground" management requirements, declining role of Department of Forestry in monitoring harvesting of mangroves and the lack of Department of Environment's role in enforcing Environmental Management Act.

Policy and regulatory barriers

National Mangrove Policy for Fiji or legal legislation regarding mangroves is non-existent. There have been a number of policies in the country providing broad legal framework covering mangroves:

- Crown lands Act Cap 134, which stipulates that all mangroves are state owned and all applications for use, development or conversion are processed by Department of Lands (DoL).
- Environmental Management Act (2005) sets the policy principle that any developments of mangroves require Environmental Impact Assessment (EIA) which falls under the jurisdiction of Department of Environment.
- Forest Decree (1992) gives the Ministry of Forestry the power to regulate the utilisation and management of mangroves, but they only do so after DoL have approved an application for mangrove harvesting and they only regulate harvesting. They do not have a continual monitoring role or presence.
- The Fisheries Act (Cap 158) and the Cabinet paper (CP 74(204) on "qoliqoli" bill is relevant to mangroves as it regulates a wide range of activities pertaining to fishing and marine life;

The lack of one consolidated mangrove national policy leads to limited coordination between Governmental and non-Governmental agencies in decision making process regarding the management, issuing development permits or foreshore leases, monitoring and enforcement of regulations, endorsement of mangrove protected areas and development of principles giving recognition to integrated and community management.

Technical Barrier

There is lack of scientific knowledge and tools for mangrove restoration programmes to succeed. The lack scientific knowledge resulting from the paucity in the understanding of hydrological (depth, duration and frequency of tidal inundation) coastal processes for an effective rehabilitation programmes. There is lack of collation of such data on a national scale. The lack of tools for mangrove restoration such as national mangrove restoration manual and mangrove zonation maps. Absence of any national mangrove restoration manual does not provide any guidance on ecological assessment of the site and appropriate species for the chosen site for restoration. These are the two common factors contributing to low success rates of the mangrove restoration. Planting mangroves on sites where mangroves never grew historically is a disaster and lack of mangrove zonation map does not provide any assistance in this perspective.

The mangrove zonation maps need to be updated as it acts as a decision tool for better land use planning. It is acknowledged that there is insufficient capacity and resources currently to produce spatial maps with zones demarcated for different purposes such as housing, industrialization, tourism, agriculture and reserves.

The survival rate of propagules is only 6 – 7% (GoF, 2018). There is a lack of nurseries to germinate propagules and provide a selection of healthy seedlings. There is growing evidence that the use of transplanted seedlings increases the survival rate as transplanting seedlings improve root stabilization and are able to adapt to harsh conditions of sea.

Awareness and Information

There is limited understanding of the importance of wetlands and the ecological benefits associated with mangroves amongst the village leaders to ensure sustainable use of mangroves such as firewoods. There is lack of public awareness about its importance and the need for the public to protect and conserve its natural resources. There is lack of awareness about successful mangrove restoration projects and therefore there is limited wider dissemination of information such as do’s and don’ts or best practices of mangrove restoration project.

Social, cultural and behavioural barriers

There is lack of recognition of the resource owners in decision making regarding the management of mangrove areas. Communities have limited ownership and participation in the restoration programmes in protecting and maintaining mangroves. The lack of technical guidance given to empower local communities in monitoring and maintaining mangroves and lack of understanding of functional, traditional ecological links between mangrove ecosystems and resources such as fish are one of the contributory factors for less participation from local communities in mangrove restoration programmes.

2.2.3 Identified Measures

2.2.3.1 Economic and Financial measures

- To attract sufficient donor agency funds in the range of few thousand dollars (FJD 100,000 – 300,000), the implementing agencies to develop proposals that demonstrate that the restoration work will be successful through a thorough cost benefit analysis of the ecosystems and highlighting the successful restoration work carried out previously. The costing of the project in the proposal needs to include the following: consulting with the community and planning, establishing nursery, planting of mangrove seedlings and monitoring.

- Commission a national or local level study on tangible and non-tangible economic valuation of mangrove resources and develop pathways for creating alternative source of income for the local communities.

- Conserving mangrove forest for protection and rehabilitation should be incentivized under the Blue carbon and REDD+ schemes.

2.2.3.2 Non-Financial measures

- Develop a national mangrove policy that will designate a clear national mandated authority on mangroves and will assist multiple stakeholders to make sound decisions regarding the use of the resources.

- The cabinet to endorse the MMP so that the implementation framework for MMP could be commissioned. This will result in the revival of an effective and efficient MMC, which should constitute of policy regulators, scientific/academia and NGOs.

- Develop national land use plan that will guide development and will identify mangrove protected areas.

- Strengthen enforcement and monitoring such as EIA.

- Develop tools to succeed such as updated zonal mangrove maps needed as a decision tool for better land use planning. This also includes developing a mangrove restoration manual clearly outlining the methodology for mangrove regeneration by planting seedlings taking into account the site selection criteria, how to plant seedlings and the role and impact of hydrology and pests for successful mangrove rehabilitations.

- Create mangrove appreciation awareness for communities and the role communities should play in protecting their mangrove.

- Involve local communities in mangrove rehabilitation programmes from the planning phase, implementation and monitoring post implementation. Appreciate the role of local communities in the management of rehabilitation work and providing necessary skills and knowledge to succeed, empowering local communities to take ownership on the management and protection of mangroves.

- Identify incentives for mangrove protection and rehabilitation under the Blue Carbon and REDD+ schemes.

- Commission a national or local level study on economic valuation of mangroves.

- Develop scientific capacity and research on mangrove rehabilitation through identifying educational opportunities for local mangrove research.

2.3 Barrier analysis and possible measures for construction of seawalls with groynes

Construction of seawall with groynes is classified as publicly provided good as it involves large scale investments usually decided at the Government level and contracts for construction of seawalls are procured through the national tender process. The construction of seawalls is only available at few sites based on the assessment carried out by the respective Government unit.

The barriers were identified through screening, decomposition by relevant stakeholders during the national stakeholder engagement (See Annex VII). The selected barriers were classified into a hierarchy of categories by the stakeholders and a logical problem tree based approach was used to identify the underlying 'root' barriers. The enabling framework process encompassed determination of measure for the identified barriers taking into account the existing market and technological conditions, institutions, policies and practices. The barrier analysis for this technology is carried out through the screening and decomposition process and then finally through a development of a problem tree (See Annex VA) by the stakeholders (See Annex VII) and the measures were identified through the objective tree (See Annex VB).

2.3.1 General Description of construction of seawall with groynes

Seawalls are hard engineered structures that are built parallel to the shoreline in coastal areas and provides protection from coastal erosion and flooding due to SLR and extreme wave force associated with intense cyclonic activities. The scientific assessments of global climate change indicate that sea level rise will have significant impacts on coastal environments and their biotic communities, including human settlements. The physical form of these structures is highly variable and is dependent on the level of funding available and sustainability and protection viability. Seawalls can be vertical or sloping and constructed from a wide variety of materials. They may also be referred to as revetments. Seawalls range in type and may include steel sheet pile walls, monolithic concrete barriers, rubble mound structures, brick or block walls or gabions (wire baskets filled with rocks) and geotextile bags filled with sands. Rubble mounds constructed using granite boulders and masonry vertical seawalls is common in Fiji. However, during the extreme events the rubble mounds neither protected the coastal infrastructure nor stopped soil erosion within the coastal belt of Fiji. Therefore, revetments, masonry vertical walls (See Figure 3) and the sea walls with irregular face with a wave return wall would be the hard defence structures that could be considered as most suitable for coastal belts that needs protection from high wave action and storm surge.

Figure 3: An illustration of different types of sewalls constructed in Fiji (source:https://www.caritas.org.au/act/our-common-home/rusis-story-turning-the-tide)

The construction of seawalls with groynes offers many benefits to the local community. Some of the benefits of this technology are listed below:

- Sea walls provide a high degree of protection against flooding in low-lying coastal area particularly during the storm tidal surges.

- Seawalls also halts soil erosion and soil salinity and therefore protects agriculture and livelihoods of the village.

- Seawalls not only protects the infrastructure along the coast but also protects the cultural identity of villagers and their ancestral burial ground which is of immense sentimental value to the villagers.

- The sloped seaward edge or groynes (see Figure 4) leads to greater wave energy dissipation and reduced wave loadings on the structure compared to vertical structures. This is achieved because these seaward slope forces wave to break as the water becomes shallower.

- Wave breaking causes energy dissipation and is beneficial because the process causes waves to lose a significant portion of their energy. Because the waves have lost energy, they are less capable of causing negative effects such as erosion of the shoreline.
- By reducing wave loadings, the probability of catastrophic failure or damage during extreme events is also reduced and prolongs the life of the seawall and becomes a sustainable measure.

- Expansion of tourist hotels will also provide more employment opportunities.

- The groynes prevents the movement of sand and helps in building a larger section of beach in front of seawalls. The new beach will increase the distance that waves have to travel to reach the coast and, in the process lose most of their energy, reducing their impact on the seawall.

- The seawall stops coastal erosion and consequently allow expansion of tourist hotels that will also provide more employment opportunities

Figure 4: Construction of gabio Groynes at Narewa Village in Nadi (source: https://mwlfiji.com/projects/)

Local community should be empowered for a greater role play in decision-making and implementation phase of seawall construction. There are many examples of ad-hoc construction to protect individual properties and communities but such ad-hoc approach does not take into consideration the water levels, wave heights and wave loadings during an extreme event. This type of basic coastline defence constructions are not very effective against significant events, however, and in many cases, these defences are washed away during extreme events (Mimura & Nunn, 1998). It is imperative that the local communities seek guidance from technical experts on the design of the seawall to improve their effectiveness during extreme events. Seawall maintenance could be carried out at a community level when given appropriate training. This may include educating maintenance engineers on the likely failure mechanisms, how often to survey the structure, what to look for and how to identify weaknesses in the design. If major weaknesses are found, it may be necessary to employ a professional organization to repair the structure in the most effective manner.

More recently some villages have banned seawalls stating that seawalls can accelerate rate of erosion in front of the seawall due to wave reflection and at the end of the structure caused by wave focusing. When all the available sediments are removed from the foundation of the seawall then it collapses (SPREP, 2015). Hence the hybrid mode of seawalls with groynes are being considered and in many instances seawalls have been combined with nature based solutions such as mangroves and vetiver grasses to reduce wave loadings on the structure and prevent coastal erosion. There are so many requests from the local communities for the construction of vertical masonry seawalls but it is very costly and now Government is looking into nature based solutions to protect the coastline.

2.3.2 Identification of barriers for construction of seawall with groynes

2.3.2.1 Economic and Financial barriers

Construction of seawalls in Fiji is a costly affair, within Viti levu it currently costs around FJD 1,700/m whereas in outer islands it currently costs around FJD 3100 – 3300 /m. With the limited national budget allocation of 1.7 million, it is challenging to meet the requests from the coastal communities for a hard engineered structures as defence mechanism. The cost of building seawalls is very high as this is associated with the labour cost coupled with the rising cost of materials such as cement and rubbles that makes the construction projects very expensive to build and maintain. The proximity to and availability of raw construction materials also adds to the high costs. There are also very few contractors who can be mobilized in the maritime areas to execute the project but it comes with a cost. Design height and robust structures that can sustain anticipated wave loadings during extreme climates also inflate the financial cost. Maintenance cost is another significant ongoing expense that is likely to result in significant levels of investment. The high investment cost also arises from the lack of specialized machineries which are very costly.

2.3.2.2 Non-financial Barriers

Technical Barrier

Seawalls need to be durable and provide protection from tidal surges and therefore the design needs to be robust to withstand significant pressure from high wave loadings during an extreme climate event. Currently, the design of sea walls does not incorporate any decision tool based on long term scientific data on wave energy, wave heights and extreme sea level rise. The absence of such long term environmental data allows ad hoc designs that are not suitable and sustainable in long term. Lack of scientific knowledge for effective designs could be also due to lack of expertise in seawall design in the country and this gap is not addressed due to lack of coordination between the Mineral Resources Department for ground assessment/ ground stability, physical oceanographers, National Disaster Management Office (NDMO) and Ministry of Waterways.

Social barrier

There is no involvement of the local community in the decision-making process. Less technological advanced designs can be implemented at local levels utilizing local knowledge and craftsmanship with some technical guidance. The local community are not empowered with the skills to maintain and monitor the durability of the structures and there is lack of liaison between the diverse community and relevant Government Ministries. There is lack of convincing and educating landowners that building seawall at some distance inland reduces interference with coastal processes to protect against coastal flooding and erosion and makes the seawall more sustainable.

2.3.3 Identified Measures

2.3.3.1 Economic and financial measures

- The Government to write proposals to boost the funding required to build seawalls. The funding should be sourced through higher national budget allocation or from donor agencies. The donor agencies which prioritize seawall construction needs to be identified. Some form of cost-sharing mechanism between the public and private entities should be encouraged where resources and money are pooled together to ensure building and maintaining an effective and sustainable seawall.

- Providing incentives such as 20% tax exemption on the import of specialized machinery for seawall construction.

- Where possible encourage nature based solutions such as using boulders with mangroves planted on the seaward side and vetiver grass to stop erosion on the landward side. Such low cost techniques was implemented in Ravi Ravi Village in Macuata and proved its worthy during the Tropical Cyclone Harold. The cost of such system was FJD 67/m.

- Other cheaper alternatives such as geotextile bags filled with sand or gabions could be considered for certain areas.

- The project needs to be undertaken in a partnership with the local community so that village men could be used for manpower and this may reduce some cost associated with labour.

2.2.3.2 Non-economic and non-financial measures

Research Development capacity

Fiji Meteorological Services together with the Marine Geology Unit at the Mineral Resources Department which undertakes studies on costal processes and assessment of vulnerable coastal communities earmarked for relocation and research institutes like Pacific Center for Environment and Sustainable Development (PACE-SD), and the Oceanography section of SPC should strengthen research in the area of oceanography to obtain environmental monitoring data such as wave height, wave energy and future sea level rise. A decision tool such as Coastal hazard mapping needs to be developed that will provide useful information on the adoption of seawall design, whether a hard engineered system is required or a hybrid nature based solutions will be sufficient to protect the coastal communities or the best economical alternative would be relocating the communities. The research development component also has some financial implications.

Enhancing the technical expertise capacity

There is lack of technical expertise that understand about the coastal processes and seawall designs. Understanding the importance of geology and ground stability of the site of seawall construction and the impacts of the coastal process on these materials is similarly lacking. The tertiary institutions should develop curriculum around oceanography and effective seawall designs so that it generates a good pool of skillset in construction of seawalls.

Involvement of local community in decision-making process

The local villages need to be part of the decision making process as these are the people who have local knowledge about the extreme water levels experienced in the past in that area. The local communities could provide insights into designs in the absence of the environmental data. The local communities need to be educated about different effective designs, how to survey and monitor faults in the structures and advise relevant authorities for immediate rectification works. They should know which Ministry and the contact details of the contact person to lodge their concerns.

2.4 Barrier analysis and possible enabling measures for flood hazard and risk assessment mapping

Flood hazard mapping and risk assessment is a classified as other non-market good as this is solely dependent on large donor and Government funding and the diffusion of the technology is not driven by market conditions.

The barriers were identified through screening, decomposition by relevant stakeholders during the national stakeholder engagement (See Annex VII). The selected barriers were classified into a hierarchy of categories by the stakeholders and a logical problem tree based approach was used to identify the underlying 'root' barriers. The enabling framework process encompassed determination of measure for the identified barriers taking into account the existing market and technological conditions, institutions, policies and practices. The problem tree was developed during the national stakeholder engagement to elucidate the root causes of the barriers (see Annex VIA). The problem tree was then transposed to obtain the objective tree that led to the identification of measures (See Annex VIB).

2.4.1 General description for flood hazard and risk assessment mapping

The coastal communities are vulnerable from coastal flooding and erosion and are exposed to high risk. Flood hazard mapping define coastal areas that are risk from flooding and erosion. As such, its primary objective is to reduce the impact of coastal flooding. It acts as an information system to enhance our understanding and awareness of coastal risk. Flood hazard maps are designed to increase awareness of the likelihood of flooding among the public, local authorities and other organisations. It is already proven that science based flood hazard mapping and risk assessment can help local residents and authorities to minimize economic and environmental losses and should be included in the comprehensive flood-loss prevention and management planning programmes (Tingsanchali & Karim, 2010).

Due to climate change and changes in relative sea level, it is important to note that flood hazard maps will require periodic updates in order to reflect the changing risk of flooding. These updates should account for SLR, erosion, changes in storm frequency and intensity, etc. Flood hazard maps can be used by developers to determine if an area is at risk of flooding, and by insurers to determine flood insurance premiums in areas where flood insurance exists.

Due to sparse empirical records and the statistical rarity of extreme coastal events, coastal flood prediction often relies on complex numerical models that approximate the processes and phenomena that lead to coastal floods. Coastal flood hazards are determined by the interaction of storm surges and waves with seabed bathymetry and coastal land cover. These factors determine the inland extent of flooding. Coastal flood models must therefore account for these features, as well as the processes associated with storm surges and waves. The representativeness and accuracy of the flood maps are highly dependent on the quality of the data such as topographic LIDAR and bathymetric LIDAR data (Raji et al., 2011).

The advantages of this technology are listed below:

- Identification of flood risk areas is likely to help in the planning of a more effective emergency response. The flooding hazard map may protect essential infrastructure such as electricity supplies, sewage treatment and services such as emergency services continue to function during a flooding event.

- Allow quantification of what is at risk of being flooded such as the number of houses or businesses. This will help identify the scale of emergency and clean-up operations.

- Once buildings at flood risk identified then raising awareness of flood procedures could be engaged to promote the implementation of flood proofing measures.

- In itself, flood hazard mapping does not cause a reduction in flood risk, it must be integrated into other procedures, such as emergency response planning and town planning, before the full benefits can be realised and making the community more resilient to flooding in future.

- Reduce the damage costs associated with flooding through flood proofing mechanisms to buildings and infrastructure.

- Improves indemnity estimation for the insurance companies.

- Allows the local communities to be ready for risk associated with flooding in high prone areas, access to essential services and minimize any health issues such as water borne diseases.

- Allows the areas to be prioritised for evacuation by NDMO.

- Allow the town planning office to identify high risk areas in future and steer developments away from these areas.

- In the longer term, the flood hazard maps can support planning and development by identifying high risk locations and steering development away from these areas. This will help to keep future flood risk down and also encourage sustainable development. In order for this to occur, the consideration of flood hazard maps must be integrated into planning procedures.

Flood hazard mapping may be difficult to undertake at the community level due to the need for complex numerical modelling for the forecast of extreme water levels, storm surges and wave heights. The required expertise and modelling capacity is very scarce locally. Hence this technology requires some technical expertise and substantial financing for implementation. Flood hazard modelling and risk assessment in the Nadi River Basin, Fiji has been conducted previously by USP in collaboration with National Institute of Water and Atmospheric Research based in Wellington, New Zealand.

2.4.2 Identification of barriers to flood hazard and risk assessment mapping

2.4.2.1 Economic and financial barriers

Coastal mapping and monitoring is classified as other non-market good and incurs an initial high investment cost. It is estimated that FID 1 – 3 million will be required to enable coastal mapping depending the size of the vulnerable area. The high investment cost is associated with the following:

- Specialised equipment such as LIDAR to compile high resolution bathymetry maps.

- Purchase of data management systems such as hardware and software to facilitate ICT issues and protocols. A recurrent budget is required for maintenance and systems upgrades.
- Expertise required in modelling and analysing high resolution satellite imagery is seriously lacking and therefore some investments in training local people is mandatory to address the lack of technical expertise.

There is a limited or non-existent national budget allocation for coastal mapping. Investment is required for flood hazard mapping and risk assessments tools to provide sound science based information to complement ad hoc manner for EIAs on development projects in coastal areas to reduce vulnerability and enhance disaster risk reduction.

2.4.2.2 Non-financial barriers

<u>Weak Institutional Capacity</u>

The weak institutional arrangements for good governance in coastal risk management is due to lack of coordination or collaboration amongst institutions, Ministries and NGO's. Hence there is no concerted effort due to a lack of knowledge awareness about the different roles played by each actors in the field of coastal mapping and risk assessment. There is no clear mandate within the Government for coastal monitoring and management and therefore the communication strategy and leadership to facilitate national risk assessment framework and collaborations are not developed.

<u>Policy and Regulatory</u>

There are no coherent regulations/policy for coastal risk assessment and development that ensures that science based tools are used to assess the risk and enhance disaster risk reduction. There is an EIA process and due to lack of risk assessment data, ad hoc coastal adaptation solution is implemented. In the absence of such policy the following is not adhered to:

- Robust coastal monitoring programme that would provide information on coastal risk information to decision makers.

- Regulations regarding multi-sectoral data sharing and confidentiality and custodian of data.

- Providing clear mandate to Government Ministry to clearly coordinate coastal mapping and risk assessment activities.

- Dissemination of risk assessment data tailor made to the needs of the decision makers

Technical Expertise

There is lack of local expertise or human capacity within the Government Ministries to undertake flood hazard mapping or risk assessment mapping. Insufficient training programs for meteorologists, hydrologists, coastal surge specialists and disaster managers as to how to interpret the coastal inundation and risk assessment data. There is lack of high level physical oceanography curriculum in Fiji's higher education sector that could address the workforce issue within the Government for oceanography roles.

Information and Awareness

The data available to do any coastal mapping and risk assessment is not available easily. High resolution bathymetry and topographic data is required. It is not available because the resources required to attain these data such as LIDAR, multibeam echosounders, global navigation satellite system (GNSS) are very costly or there is not enough specialist to generate these data sets such as there is lack of zero vertical reference point in geodetic data.

To convert hazard into impact or risk assessment there needs to be a robust National Vulnerability function and this results from the lack of systematic post disaster survey for all disasters in Fiji. There may be some assessments done after the major catastrophic events. There is lack of asset data and the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) database needs to be updated. There is also lack of local communities' perceptions and input regarding the flood hazard mapping and risk assessment. The communities could also provide local information from past experiences in extreme climate events and what are the assets that needs to be protected.

There needs to be mass education or awareness raising program on impacts of climate change and how it will affect the coastline and future flooding due to SLR through media programs. This is necessary so that decision makers can make informed decisions about tourism developments or infrastructure investments in the coastal zone. It is critical that decision makers understand the outcomes of the coastal mapping, how the inputs are measured and modelled to inform effective long term planning.

2.4.3 Identified Measures

2.4.3.1 Economic and Financial Measures

The huge investment cost (FJD 1 – 3 million) in terms of purchasing equipment to provide long term measurements, computer hardware and software, storage of data, training of local hydrologists and meteorologists and physical oceanographers could be made possible through accessing funds from the Green Climate Fund.

The Government of Fiji should allocate their budgetary funds for flood hazard mapping and risk assessment activities to protect the coastal development. These funds could be used to recruit experts or train local people to build a pool of local experts in coastal mapping and risk assessment so that it can inform decision makers for an effective long-term planning.

2.4.3.2. Non- Economic and Financial measures

- Strengthen the institutional capacity for good governance in coastal risk management. The GoF is to identify a national hub for flood hazard mapping and risk assessment and could be based at Fiji Meteorological Services within Ministry of Infrastructure and Meteorology Services or alternatively based with the GIS department within Ministry of Lands and Mineral Resources. This unit will be responsible for coordinating all activities of other stakeholders engaged in studies of coastal dynamics and ecosystem and provide a common platform for data sharing to guide decision making. The hub would be similar to the Commonsensing project which is a regional initiative to address disaster risk reduction and building more climate resilient communities within the pacific region.

- Coherent policy and regulations for coastal risk assessment need to be developed that ensures that EIA processes for coastal development incorporates science based data for coastal risk assessments due to climate change and also to use science based data to guide coastal adaptation solution. This policy should also guide multi-sectoral data sharing, providing clear mandate to a specific Government Ministry to coordinate and disseminate information to decision makers as required.

- To address the lack of human capacity in coastal mapping and monitoring the following measures are recommended:

    i. The tertiary institution to develop high level physical oceanography courses that would develop a skill set for coastal monitoring and coastal mapping. The courses could be developed in partnership with international universities known for such delivery of programs.
    ii. Allocate Government funding for staffing that would see an appointment of a coordinator that will oversee data management and liaison between other relevant stakeholders. Funding will be required to hire few more hydrologist and physical oceanographers within the Government Ministry.
    iii. Providing opportunities for local experts to work alongside international consultants undertaking studies of coastal processes and mapping.
    iv. Always constantly seek training opportunities for local meteorologists, hydrologists and coastal scientists to upgrade their skills and learn new technologies available for coastal mapping and risk assessment.

- To obtain high resolution bathymetry and topographic and geodetic data using modern technologies such as LIDAR, MBES, GNSS and drones to generate precise coastal maps and flood hazard maps either through climate finance or through collaboration with international research institutes such as NIWA.

- To undertake a robust national vulnerability function and asset data so a clear picture of what needs to be protected and communities' perceptions and participations are very vital in this process.

- Create awareness programs on how future climate change will affect our coastal developments and coastal inundations. The scientific data and knowledge should be tailor-made to the needs of the decision makers so that they can make informed decisions for an effective long term planning.

2.5 Linkages of Barriers Identified in Coastal Zone Sector

The three adaptation technologies prioritised in the coastal zone sector, that is, Mangrove rehabilitation, construction of seawall and flood hazard mapping have interrelated implementation barriers in the areas of funding, technical expertise and information and awareness (See Figure 5).

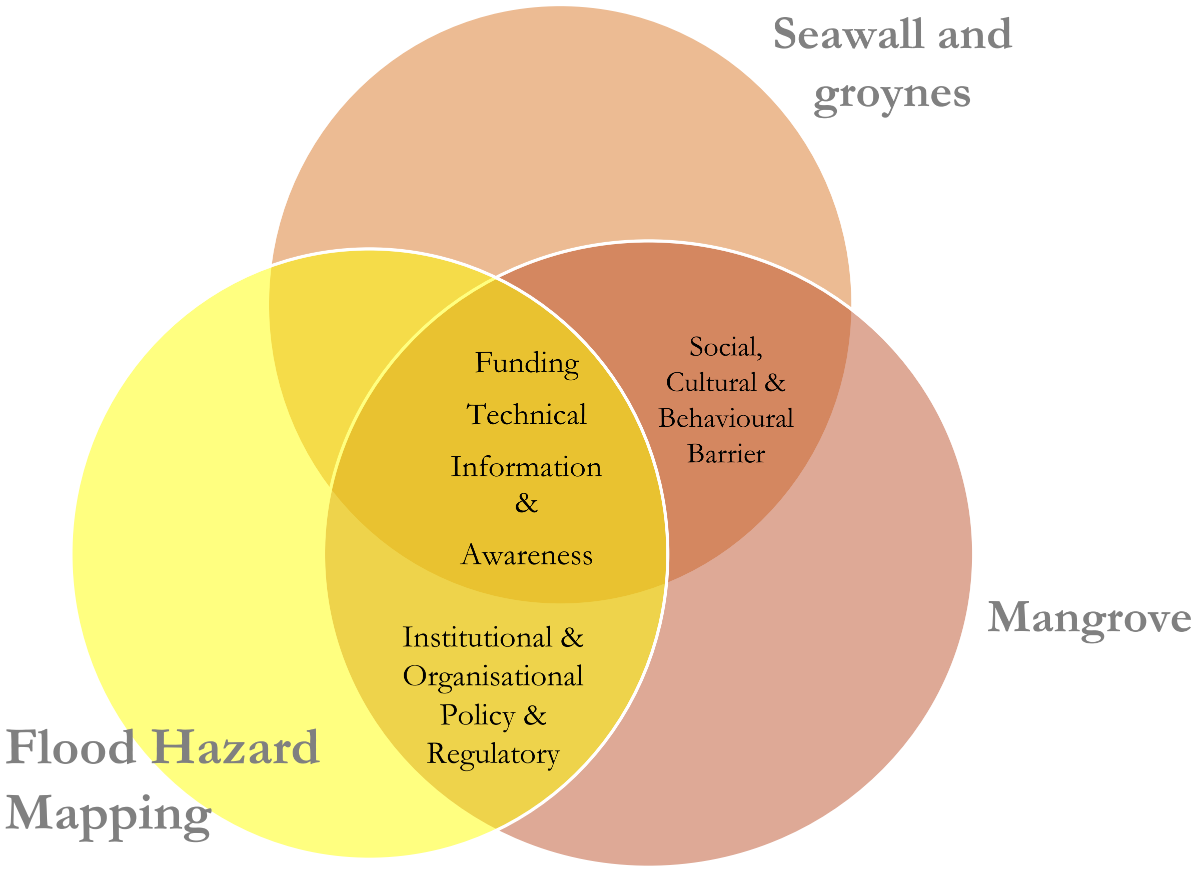

Figure 5: An illustration of an overlap of barriers identified in the three technologies prioritised in the coastal zone sector.

There were some common barriers between Mangrove Rehabilitation and Flood Hazard Mapping dealing with Institutional and Organisational capacity and policy and regulatory barriers. One of the implementation barriers identified for these technologies were lack of coordination between different Ministries and NGOs and therefore a clear mandate is required which could be instituted by some form of policy and regulation. However, this was not seen as an implementation barrier in the case for seawall construction technology. It was noted that the common barrier with mangrove rehabilitation technology and seawall construction technology was social, cultural and behavioural barrier resulting from lack of involvement of local communities in decision making process and not taking their views and perceptions in the implementation of these technologies. The success of these technologies largely depend on local communities taking ownership of these projects and is responsible for maintenance and monitoring of these projects once implemented. The common implementation barriers for the coastal adaptation barriers are further elaborated in the Table 6 below:

Table 6: An explanation of linkages of barriers in the coastal zone sector.

Barriers	Linkages
Economic barrier	All the three technologies face lack of investment or funding to sustain long term coastal adaptation projects. In all cases the funding is from Government or donor agencies. Generally, there is lack of funds to upscale these technologies as huge upfront capital cost is required and in some technologies an ecological service fee payment or training costs of locals are required to attain a higher success rate of implementation.
Technical Barrier	In all the coastal adaptation technologies it was noted that there is limited expertise available to implement technology locally. There seems to be lack of staff with appropriate expertise mandated for the implementation of these technologies. The Government Ministries lack oceanographers to understand about the coastal processes and generate data that is required for all three technologies.
Information and Awareness	Although flood hazard mapping and risk assessment technology requires scientific information to enable decision making and sound planning for coastal developments but similar information such as wave height data could guide mangrove restoration and seawall construction. There is lack of coastal monitoring processes and lack of scientific data to raise awareness about which technology would be an appropriate adaptation strategy rather than ad-hoc solutions. A common barrier is information sharing and awareness among different stakeholders due to inadequate

	institutional arrangement and limited coordination arising from lack of legal and regulatory framework.

2.6 Enabling Framework for Overcoming the Barriers

To enable diffusion of all the three prioritised technologies in the coastal sector, the technologies need to be mainstreamed into national adaptation plan and should be strongly factored into the development and enforcement of climate change policy. A functionally coherent policy framework overarching the diffusion of these technologies will then gain the political support which will provide opportunities to access the climate change funding, which is the major barrier for diffusion of these technologies. Nonetheless some other enabling environment apart from political support are required to ensure successful and sustainable adoption of the technology nationally and these are discussed below:

Financing

The Government should allocate or increase its budget of the mandated Ministry to support the implementation of these technologies. Alternative financing pathways such as accessing donor funds from CTCN or Green Climate Fund could be explored to cover the initial high capital expenses of project implementation and support monitoring and site maintenance to ensure sustainability of these technologies. The Government should allocate budget for training of local people to develop skillset in the field of coastal monitoring.

Technical Expertise

In all cases of the three technologies, there are limited knowledgeable and experienced individuals that understand the coastal processes. There are no physical oceanographer positions within the civil servant structure. To address the technical expertise gap there is a need for strong partnership and coordination with the academia to develop scientific capacity and research on coastal processes that could guide coastal adaptation strategies. The tertiary education sector should develop curriculum or training programmes on physical oceanography and integrated coastal zone management to strengthen the local technical expertise in this sector.

Research and Development

There is lack of science based data to implement sound long-term adaptation technologies in the coastal sector. There needs to be more research undertaken to understand the coastal processes in collaboration with different stakeholders both nationally and internationally. The research will generate database of long term environmental monitoring that would be useful in generating data required for coastal hazard mapping that could guide sound adaptation solutions. Some awareness raising is needed in terms of what individual research data and information different stakeholders can gather or have gathered and use a common platform for sharing data.

Institutional and Organisational Arrangement

There needs to be a clearly designated national authority to coordinate activities and form working groups for each of the prioritised technology. This would enable better awareness of the different roles different stakeholders play and would lead to enhancing networking capabilities resulting in pooling resources and expertise together for successful adoption. A strong governance in coastal sector would lead to better coordination and will strengthen the technical expertise by facilitating stakeholders' participation in projects which is required for successful diffusion of technologies.

Policy and Regulations

Implementation of policies and regulations, particularly for the mangrove rehabilitation and flood hazard maps and risk assessment are very critical for their adoption success rate. The policy and regulations will clearly state the designated authority for implementation and will allow for better coordination between different stakeholders. There are many policies in Fiji but has very weak processes for enforcement and monitoring, for example, the EIA process needs to be strengthened. The policy and regulations would also cover issues relating to data sharing.

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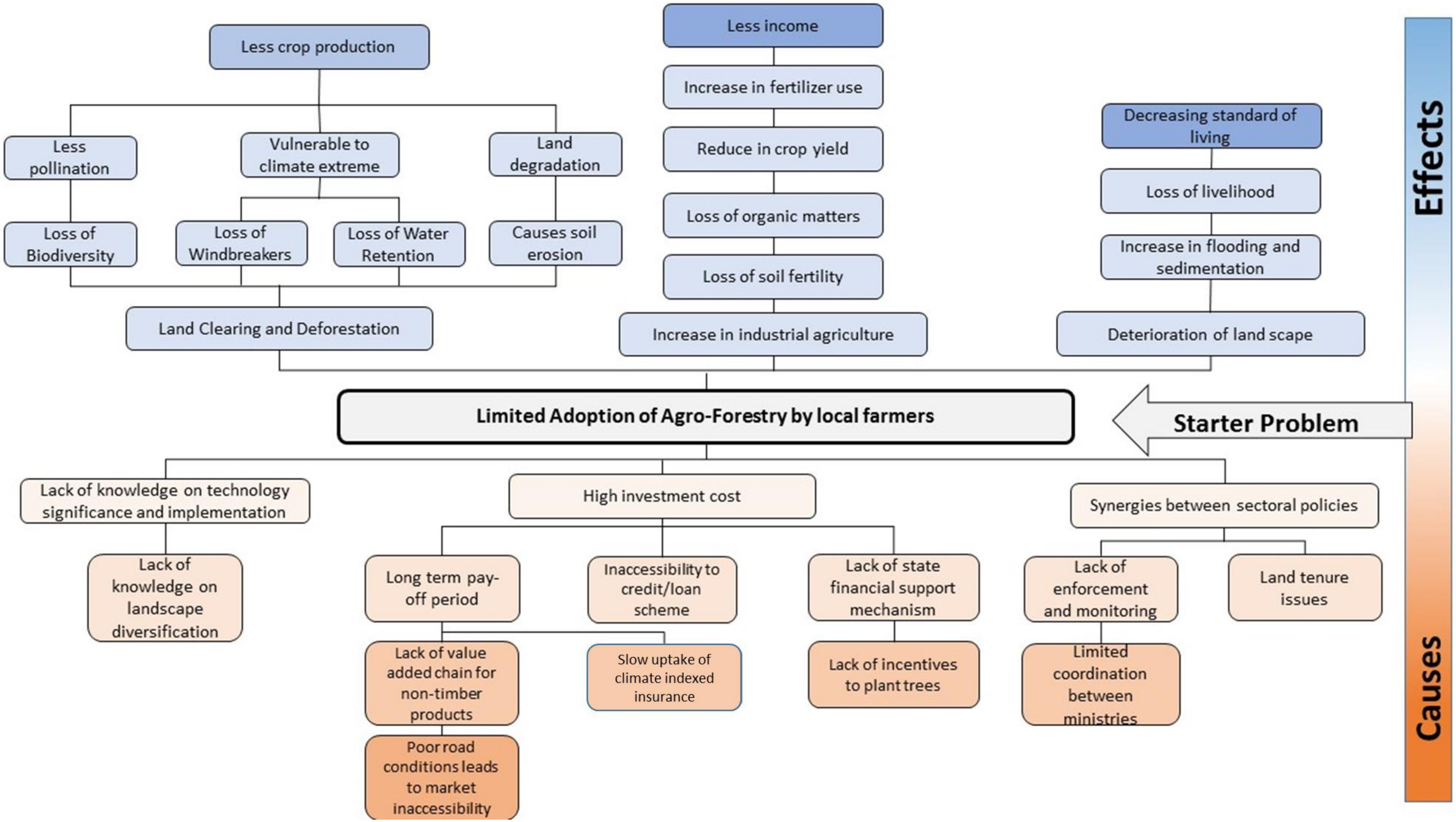
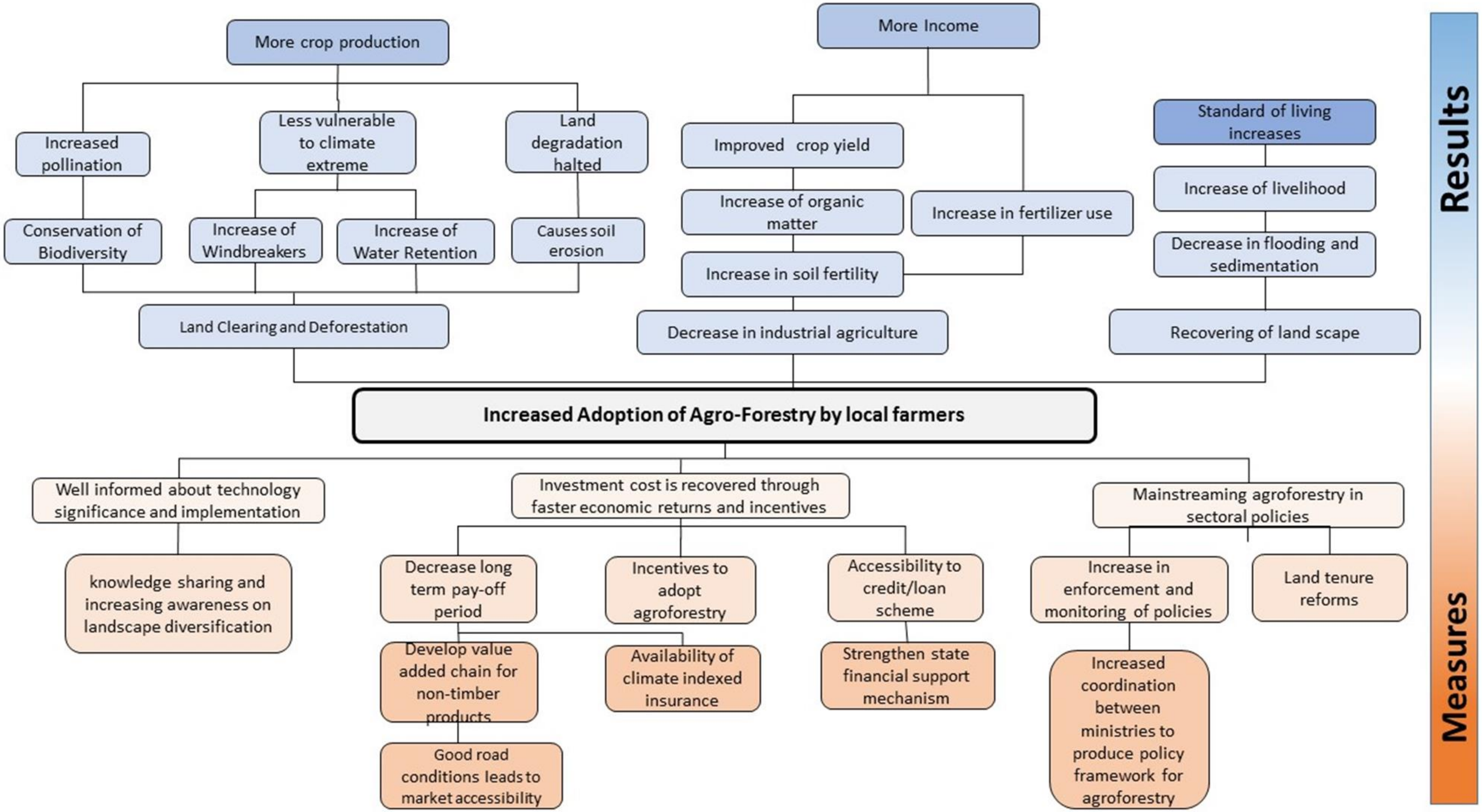
Appendices

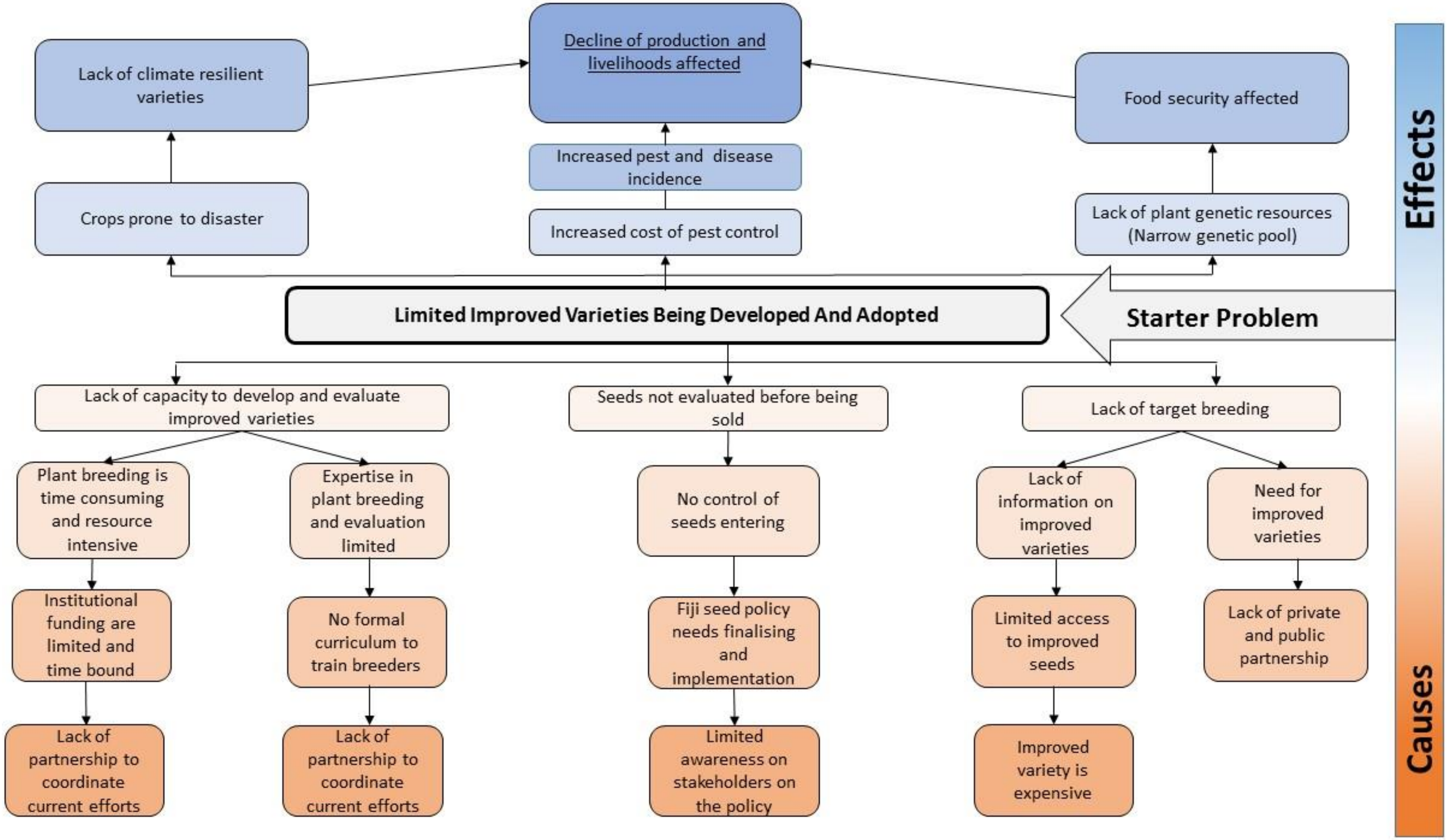
Annex IA: Problem Tree for Agroforestry



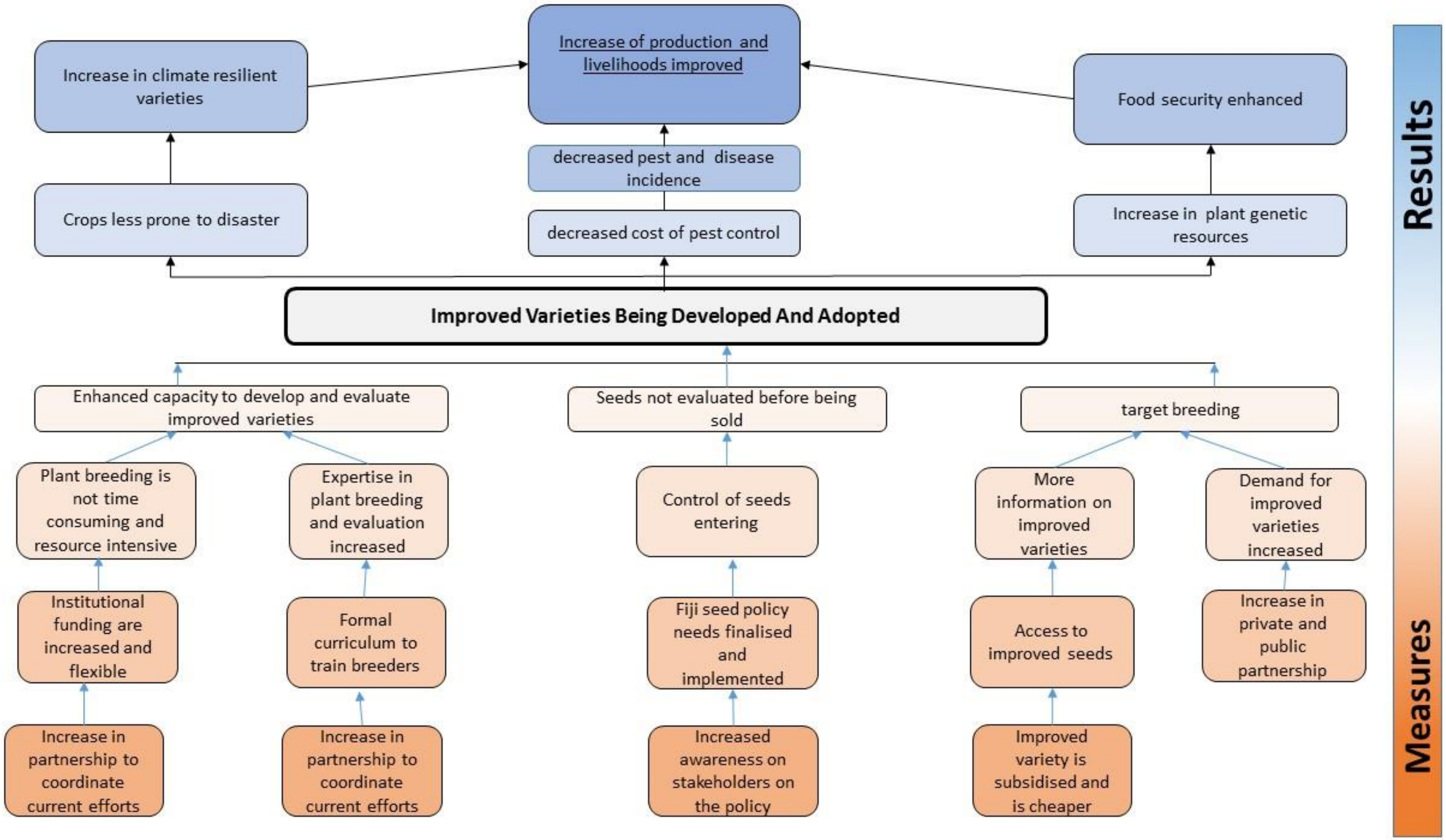
Annex IB: Objective Tree for Agroforestry



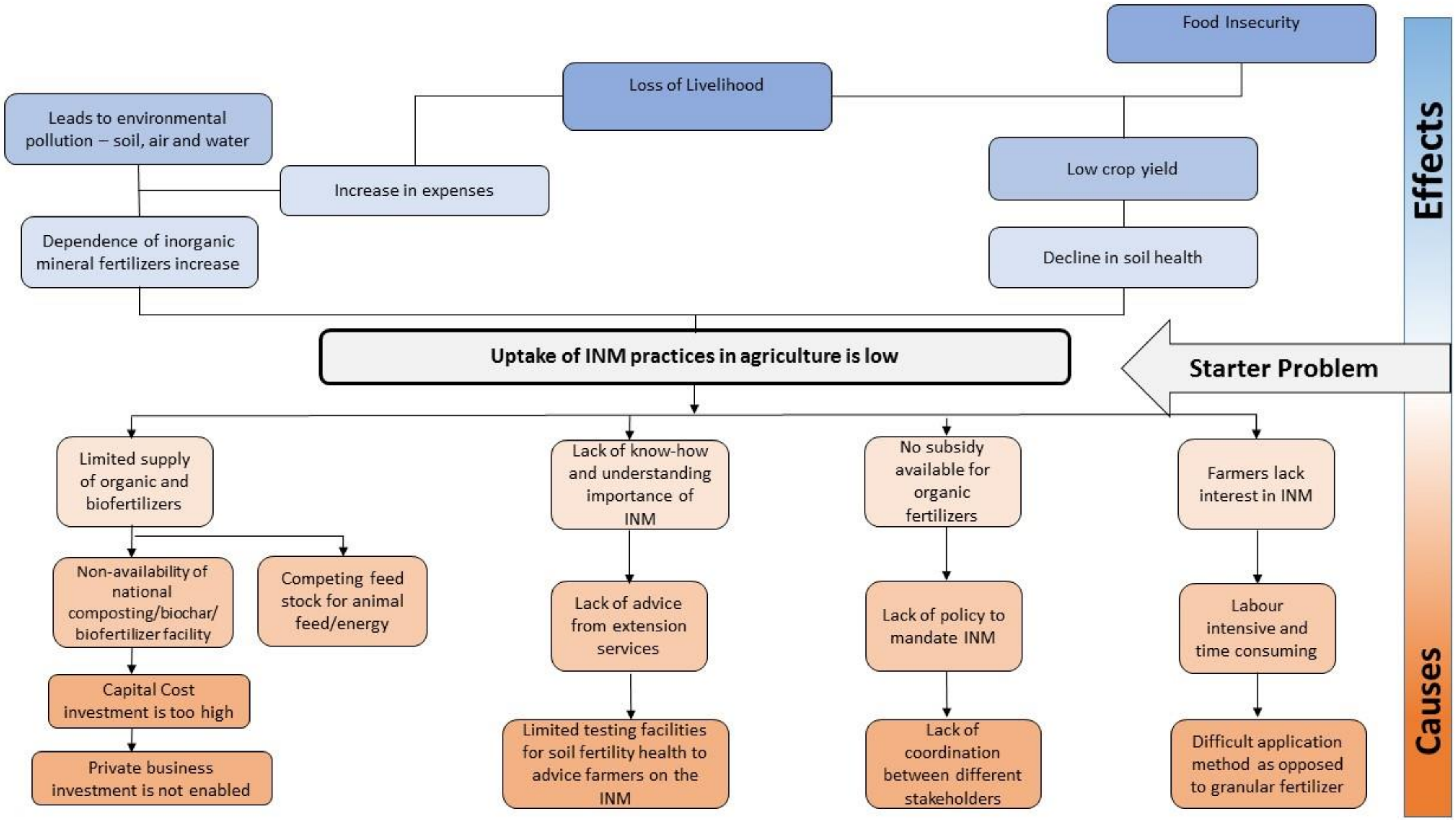
Annex IIA: Problem Tree for Improved Crop Varieties



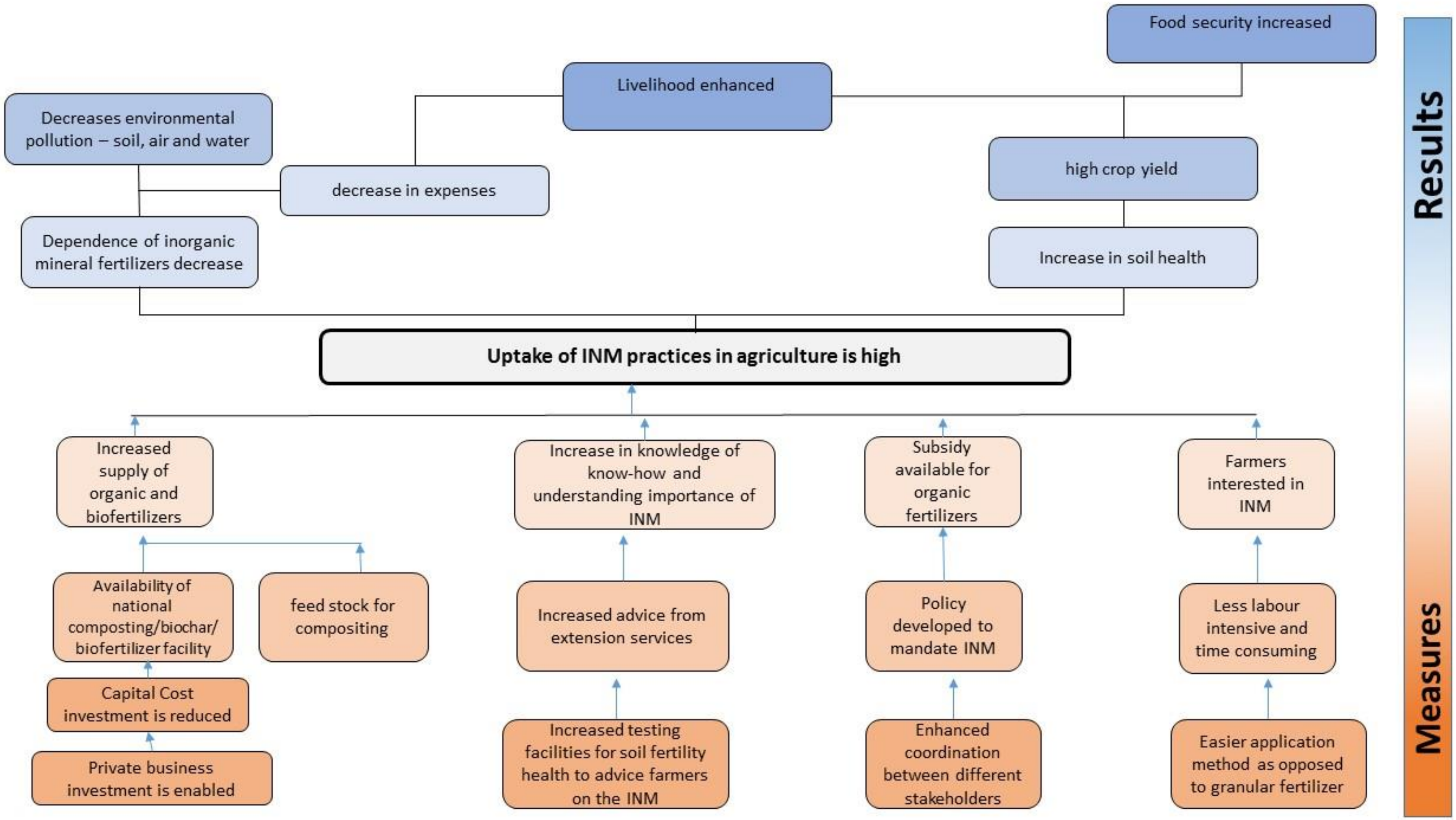
Annex IIB: Objective Tree for Improved Crop Varieties



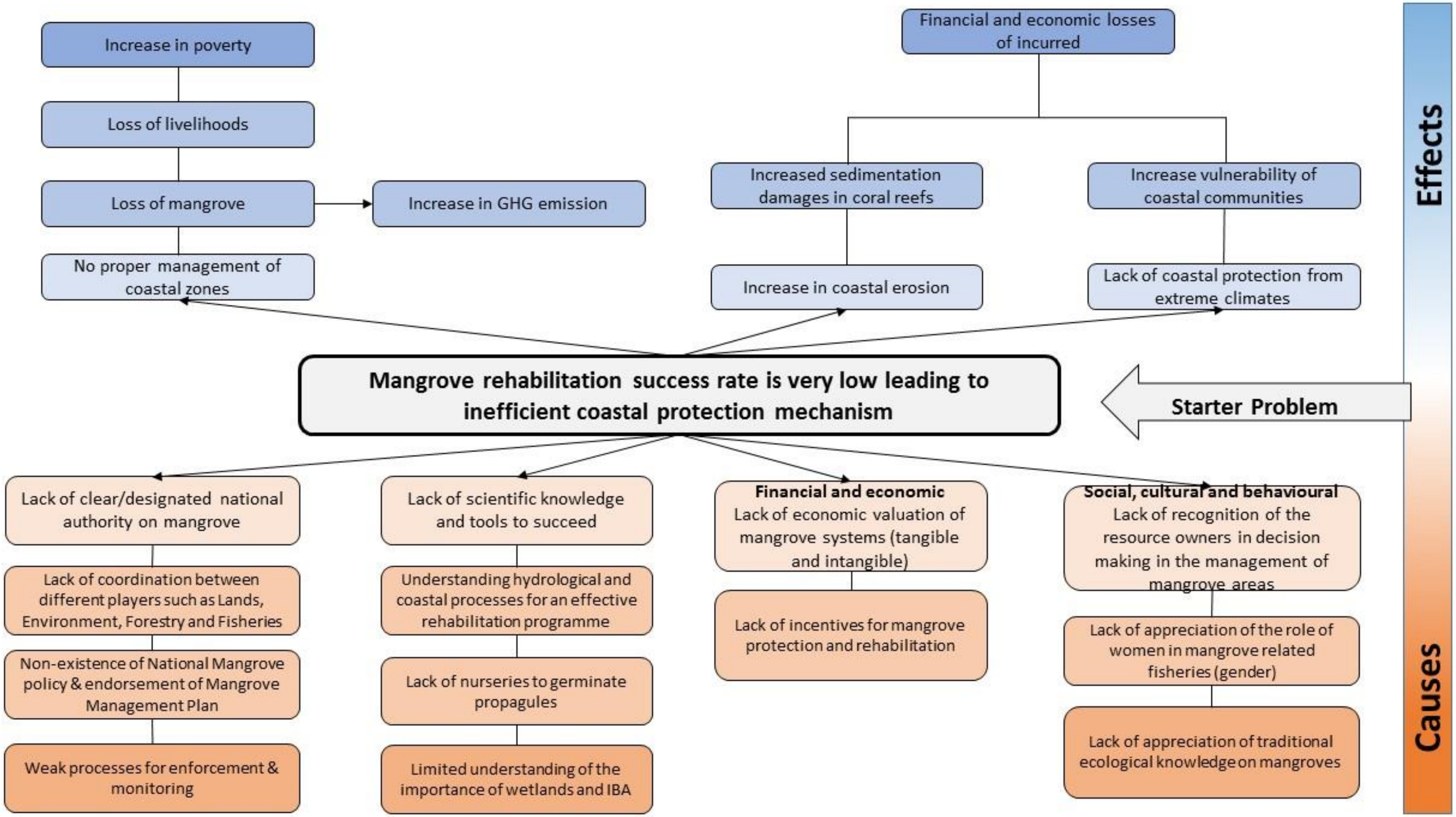
Annex III A: Problem Tree for INM



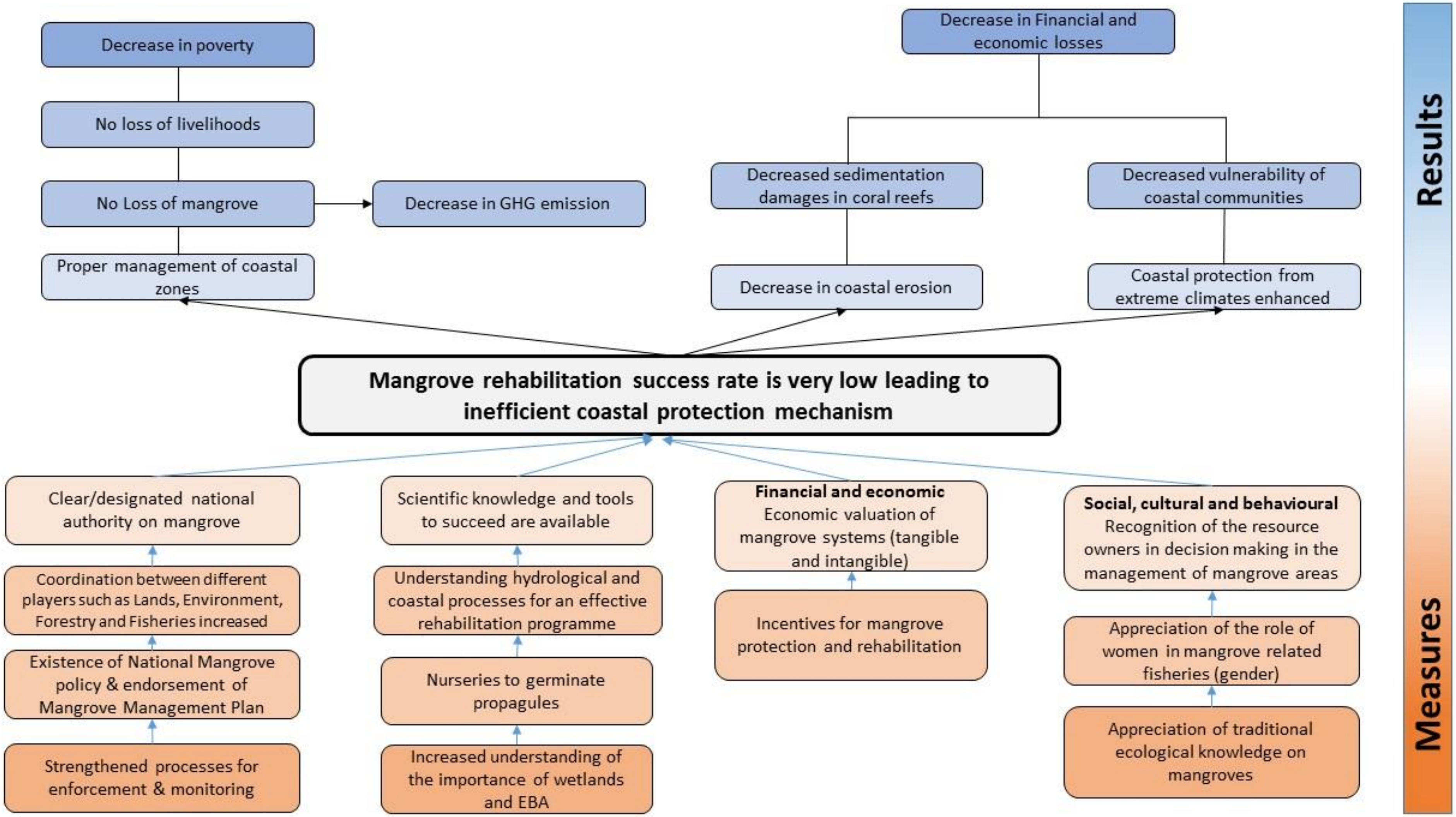
Annex III B: Objective Tree for INM



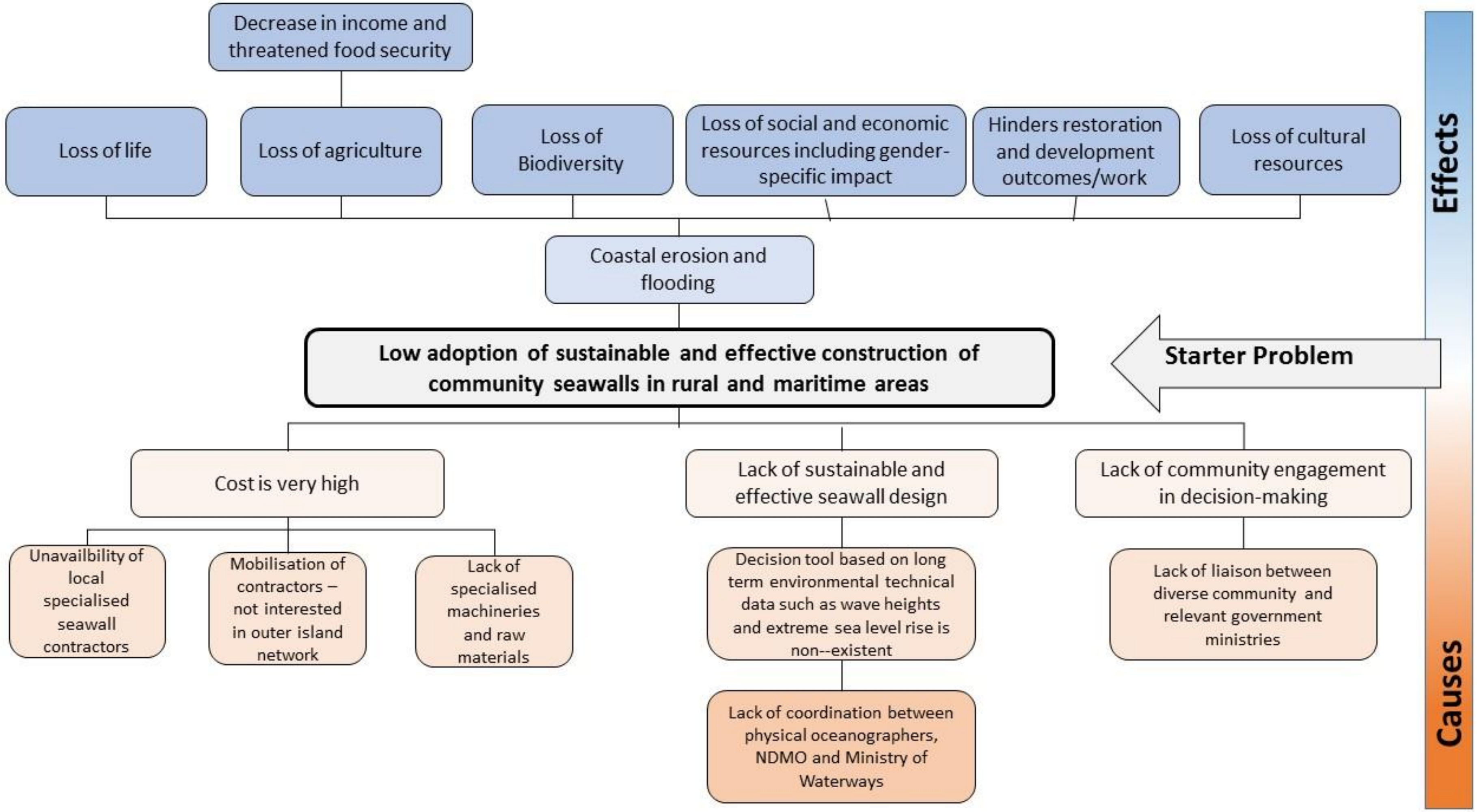
Annex IV A: Problem Tree for Mangrove Rehabilitation



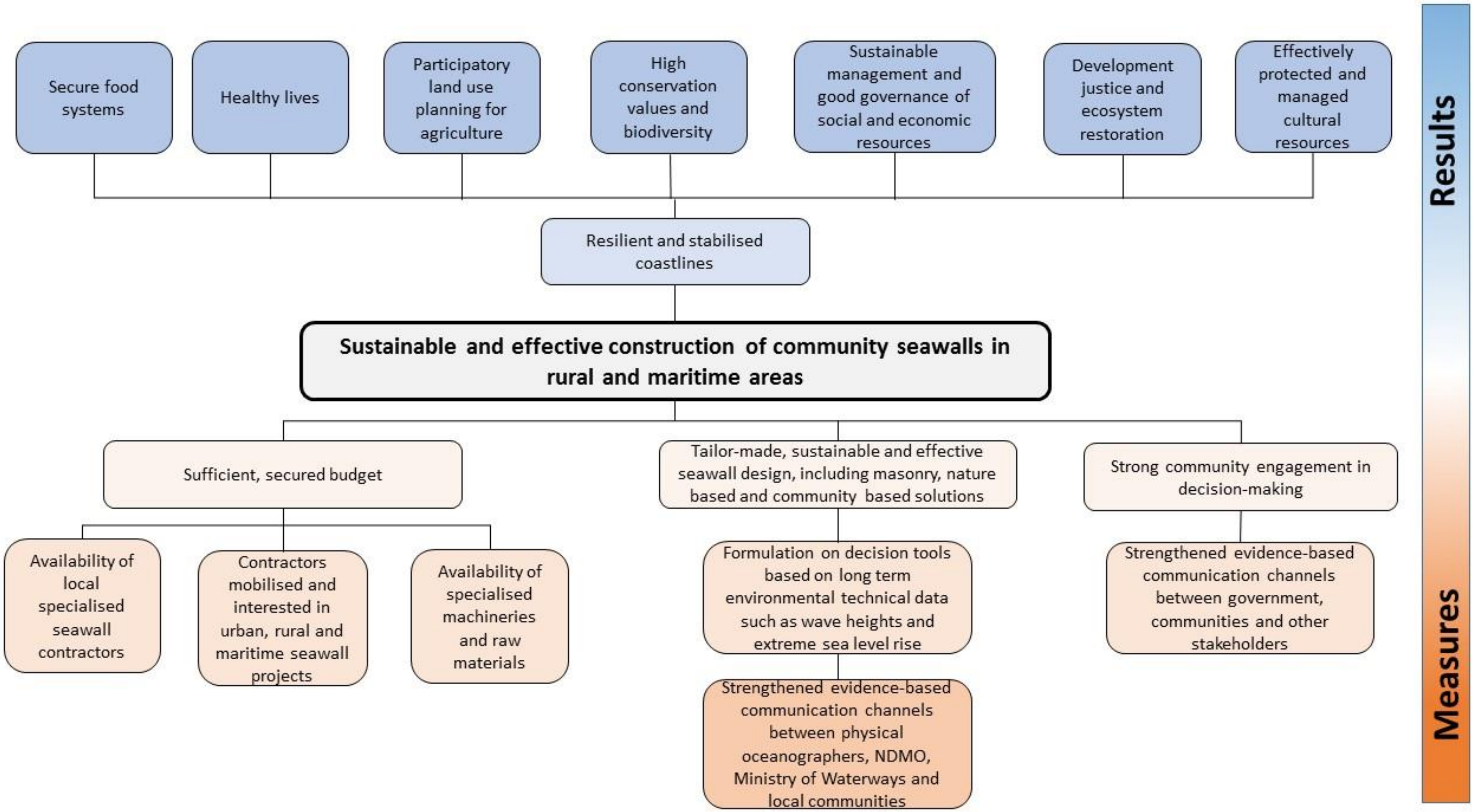
Annex IV B: Objective Tree for Mangrove Rehabilitation



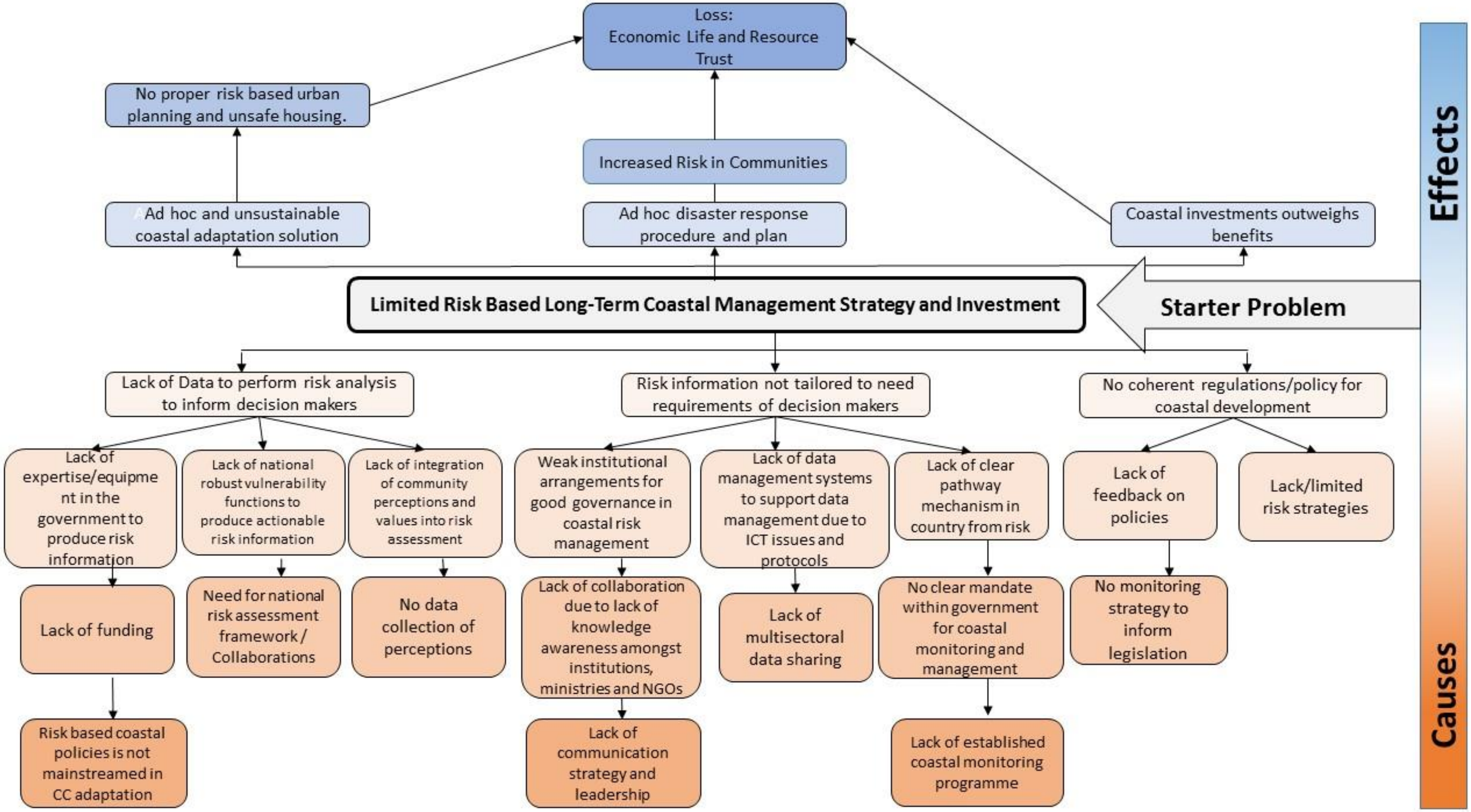
Annex V A: Problem Tree for Construction of Seawall with Groynes



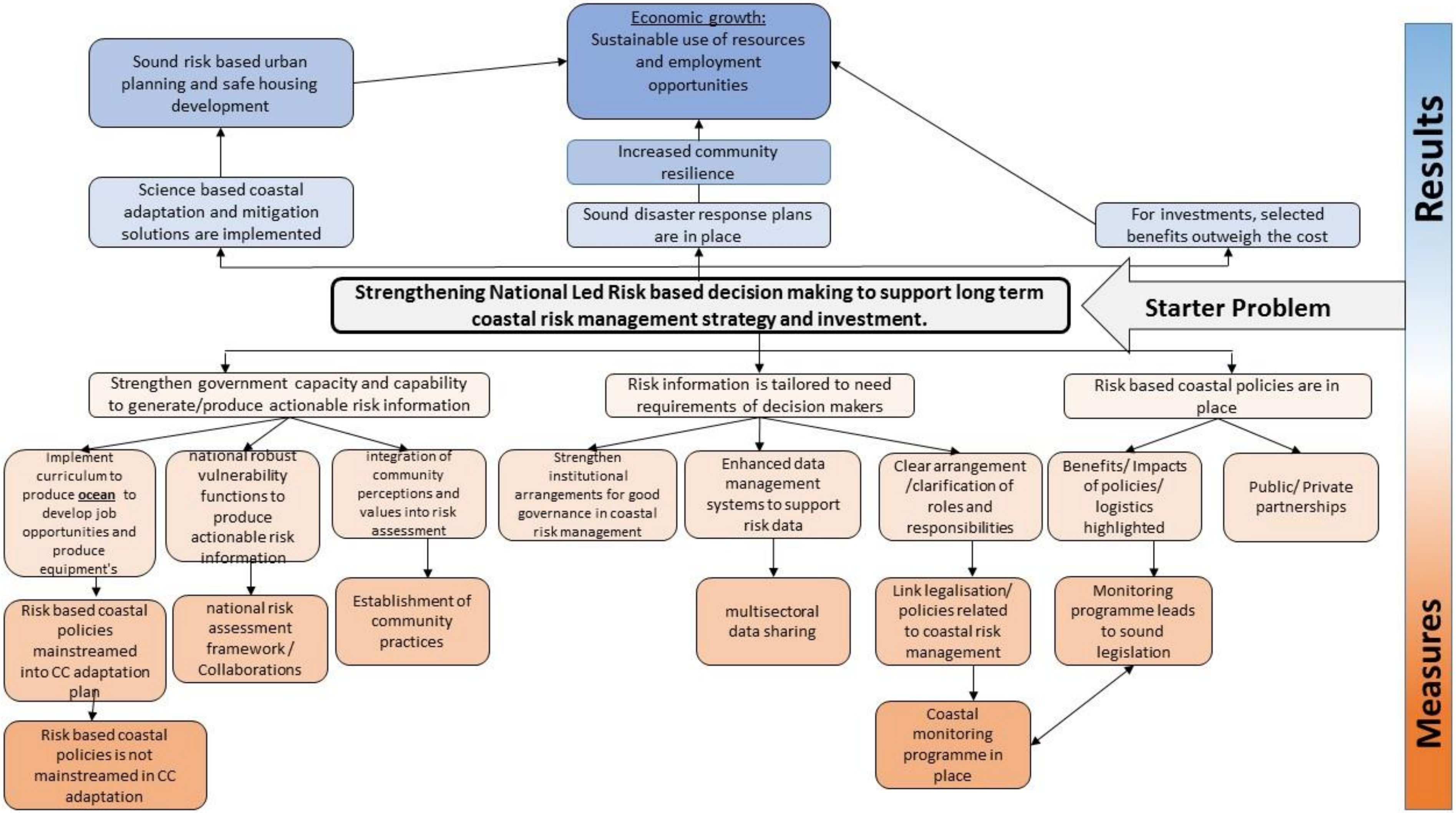
Annex V B: Solution Tree for Construction of Seawall with Groynes



Annex VI A: Problem Tree for Flood Hazard and Risk Assessment Mapping



Annex VI B: Objective Tree for Flood Hazard and Risk Assessment Mapping



Annex VII: List of stakeholders consulted

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