Kingdom of Bhutan

TECHNOLOGY NEEDS ASSESSMENT AND BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT

ADAPTATION

"March 2013"

National Environment Commission
Royal Government of Bhutan

TECHNOLOGY NEEDS ASSESSMENT AND TECHNOLOGY ACTION PLANS FOR CLIMATE CHANGE ADAPTATION

Disclaimer

This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP Risoe Centre (URC) in collaboration with the Regional Centre (from the corresponding region), for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein is a product of the National TNA team, led by the National Environment Commission, Royal Government of Bhutan.

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FOREWORD

PRIME MINISTER

དཔལ་ལྡན་འབྲུག་གཞུང་།

Royal Government of Bhutan

28 March, 2013.

Foreword

Bhutan, with its commitment to preserve the natural environment, has been actively participating in the fight against one of the most pressing challenges of the current times, the climate change. The country has undertaken the Technology Needs Assessment process to identify, evaluate, and prioritize technologies that fit in the overall development context of the nation while allowing the country to adapt to and mitigate climate change. At the Conference of Parties (COP) 14 in 2008, the Poznań Strategic Programme on Technology Transfer was adopted as a step towards *scaling up the level of investment in technology transfer in order to help developing countries address their needs for environmentally sound technologies.* As part of this programme, in 2010, on behalf of Global Environment Facility (GEF), the United Nations Environment Programme (UNEP) started the implementation of Technology Needs Assessment (TNA) for 36 countries.

Taking forward its commitment at the international forums, I am pleased that the National Environment Commission (NEC) Secretariat has completed the Technology Needs Assessment for Climate Change (TNA) and that it led to the formulation of a Technology Action Plan (TAP) for implementation of the prioritized technologies for adaptation and mitigation. These initiatives fit in the larger scheme of things that we are pursuing for low-carbon and climate-resilient development and will contribute to the development of the 11th Five Year Plan of the country, to be finalized soon.

As a party to the UNFCCC, Bhutan is fully committed to developing and implementing policies, programmes and projects to address the many challenges posed by climate change. We have also adopted a new Economic Development Policy in 2010, which embraces the concept and principles of green economic development. We are now formulating a national strategy for low-carbon and climate-resilient development.

Application of collective knowledge and skills is crucial in developing solutions for combating the challenges of climate change. In this regard, I am encouraged to note that various stakeholders not only from government agencies, but also from the civil society and private sector have been involved in the TNA process and have contributed extensively in selecting the prioritized technologies, identifying the key barriers to technology development and deployment, preparing the Technology Action Plans for overcoming the identified barriers and identifying the implementable project ideas for each technology. I would like to commend all the individuals and organizations that have contributed to the TNA process particularly, the TNA Taskforce members, the respective government departments and agencies and the National Environment Commission for effectively leading this exercise.

I look forward to seeing the findings and recommendations of the TNA project feed into the national strategy for combating climate change in Bhutan.

Tashi Delek !

(Jigmi Y. Thinley)
Prime Minister, and
Chairman of NEC

PREFACE

Given Bhutan's vulnerability to the impacts of climate change, the nation has accorded climate change a high priority. The nation's commitment to remain carbon neutral while ensuring overall social-economic development reflects its vision to address the challenges of climate change and move towards a sustainable future.

The challenges of addressing climate change, particularly by developing and least developed countries have been recognized at various international forums. Technology transfer as a vital instrument to overcome these challenges has been identified by the UNFCCC in Article 4.5. Subsequently, the need and importance of technology transfer has been reiterated at various Conference of Parties (COP) of the UNFCCC. At COP 14 in 2008, the Poznań Strategic Program on Technology Transfer was adopted as a step towards *scaling up the level of investment in technology transfer in order to help developing countries address their needs for environmentally sound technologies.* As part of this programme, in 2010, on behalf of Global Environment Facility (GEF), the United National Environment Programme (UNEP) started the implementation of Technology Needs Assessment (TNA) for 36 countries.

Bhutan has undertaken the TNA process to identify, evaluate, and prioritize technologies that fit in the overall development context of the nation while allowing the country to combat climate change. The National Environment Commission Secretariat is the nodal agency for the TNA project and has constituted a TNA Task Force involving representatives from various sectors to provide inputs to the TNA project and most importantly in preparing the Technology Action Plan for identified technologies.

In the Part I of the TNA report, for each prioritized sub-sector in climate change adaptation and mitigation sectors one technology was prioritized based on a technology prioritization framework prepared through secondary research and rigorous stakeholder consultation. With a view of preparing the detailed technology action plans of the identified technologies, it was felt necessary to identify key barriers to technology development and deployment. The Barrier Analysis and Enabling Framework report, as part II of the TNA project, sets preliminary targets for diffusion of the prioritized technologies, identifies key barriers and suggests high level enabling measures that can address these barriers.

The entire process to set targets, identify barriers and enabling measures has been country-driven and highly consultative involving a number of stakeholders from various agencies in the government, civil society and private sector.

Ugyen Tshewang, PhD
Secretary
National Environment Commission

ACKNOWLEDGMENT

The National Environment Commission Secretariat (NECS) sincerely acknowledges the Global Environment Facility (GEF) for the financial support provided for the Technology Needs Assessment (TNA) project in Bhutan. We would also like to thank UNEP Risø Centre (URC) and Asian Institute of Technology (AIT) for their technical guidance during the course of the TNA. The NECS is particularly grateful to Mr. Gordon Mackenzie, TNA country coordinator for Bhutan, for coordinating all the activities between the NECS, AIT and URC.

We would like to thank all the TNA taskforce members for their valuable contribution in prioritization of sectors and technologies, and for their comments on the draft report.

Further, we express our sincere appreciation to Emergent Ventures India and Norbu Samyul Consulting for facilitating the TNA process and putting together the TNA report.

ABBREVIATIONS

BAFRA	Bhutan Agriculture and Food Regulatory Authority
DOA	Department of Agriculture
EVI	Emergent Ventures India
FYP	Five-year plan
GHG	Green house gas
IPCC	Intergovernmental Panel on Climate Change
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
JICA	Japan International Cooperation Agency
MOAF	Ministry of Agriculture and Forests
MCDA	Multi-criteria Decision Analysis
NABARD	National Bank for Agriculture and Rural Development
NAPA	National Adaptation Programme of Actions
NBC	National Biodiversity Centre
NEC	National Environment Commission
NECS	National Environment Commission Secretariat
NSC	National Seeds Centre
PGR	Plant Genetic Resources
RDC	Research and Development Centre
RNR	Renewable Natural Resources
SALT	Sloping Agriculture Land Technology
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	U.S. Agency for International Development

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Part II
Barrier Analysis and Enabling Framework Report

Executive Summary

In Part I of the TNA report, for each prioritized sub-sector in climate change adaptation one technology was prioritized based on a technology prioritization framework prepared through secondary research and rigorous stakeholder consultation. As a precursor to developing detailed technology action plans of the identified technologies, it is imperative that key barriers to technology diffusion should be identified which the technology action plan should address. AIthough key barriers in adoption of the adaptation technologies were duly considered by the TNA Task Force of Bhutan while prioritizing the technologies, in this report barriers that exist in diffusion of the technologies have been identified and an enabling framework for addressing these barriers have been outlined.

A two step process was followed for barrier analysis and enabling framework development for identified adaptation technologies in Bhutan. In the first step, secondary research was conducted in which Bhutan's policies and other feasibility studies were referred to for the identified technologies. In the second step, a stakeholder workshop was organized in Paro, Bhutan in which TNA Task Force members provided their inputs on key barriers and the enabling framework presented. Following this, focused sector specific roundtable discussions were held in Thimphu, Bhutan at NEC, with relevant experts to seek specific information on barriers and enabling measures for each technology.

The barrier analysis and enabling framework report primarily consists of setting preliminary targets for diffusion of the prioritized technologies and identifying key barriers and suggesting high level enabling measures that can address these barriers. A brief for each sub sector in adaptation is summarized below:

Agriculture

Development and promotion of drought and pest resistant varieties of crops had been selected as the appropriate technology measure in agriculture sector for adaptation. The chapter outlines the preliminary targets for the technology transfer and diffusion over the next five years which aims for identification, development and field trials of desired strains of economically important crops. Inadequate R&D facilities, lack of trained manpower and market barriers to adopting newly developed strains has been found to be the major constraints in technology adoption. Particular stress has been laid on favourable policies and capacity development including research and training of manpower to develop an enabling framework for technology diffusion.

Water

The primary focus of water resource sector in the face of accelerated climate change phenomenon is the development and adoption of technologies that result in efficient water use. For this purpose sprinkler and drip irrigation systems have been identified as potential technology. A preliminary five-year target has been set for pilot testing and scaling up of the technologies. The principle barrier that may be encountered in the technology adoption is the high cost of installation and maintenance, especially when considered for small farms and the lack of technical staff for designing and maintaining such systems. A number of enabling measures like financial incentives to farmers, training and capacity building have been conceived to help in the diffusion of this technology in Bhutan.

Natural disaster and infrastructure

In the Natural Disaster and Infrastructure Sector, the TNA identified climate-resilient farm roads as the prioritized technology. Lack of focus on developing climate resilient farm roads, over-ambitious targets relative to actual budgetary capacity and absence of skilled manpower were found to be the main barriers in adoption of the technology. Mainstreaming of climate change related issues in engineering sector, developing a strong network of local weather forecasting stations and moderation of targets as per actual budgetary capacity are some of the enabling measures advised for facilitating the technology diffusion.

Chapter 1. Agriculture sector

1.1. Preliminary targets for technology transfer and diffusion

In the agriculture sub-sector, development of drought and pest resistant varieties of crops has been prioritized as the top technology under the TNA process. The target for diffusion of this technology in Bhutan has been primarily based on the national strategy developed by the Ministry of Agriculture and Forests (MOAF). A country road map paper prepared by the Ministry ahead of the Bhutan Climate Summit 2011 identifies climate change as one of the major threats of food security in the country and thereby includes a National Food Security Program.

This program has an overall goal of:

- Ensuring availability of safe and quality food at affordable prices through increased production and diversification of food items by instituting efficient distribution net works and regulation of local supply and imports

Under this program, a Food Availability Program has been prepared with the goal of increasing crop production through development of improved varieties, breeds, and management technologies. One of the key strategies to achieve this goal is through evaluation and adoption of genetic resources resistant to biotic and a-biotic stresses including drought, pests and diseases. The country paper also includes a 10 year roadmap for the same. The roadmap includes specific targets for development of drought and pest resistant varieties.

Based on National strategy of MOAF and in line with plans of the ministry under the 11th Five Year Plan, the TNA consultations agreed on following targets for the technology:

- Develop and promote drought resistant rice varieties for low or wet subtropical zones during the period 2012-2018
- Develop and promote drought resistant varieties of spices (cardamom and ginger) for low or wet-subtropical zones during the period 2012-2015
- Develop disease resistant varieties of rice, maize, potatoes, spices and chilies and fodder for high and mid-altitude zones during the period 2012-2018

Work on the main staples of the country (rice and maize) has already been initiated. However the country aims to also target other important food crops such as wheat, barley, millets, buckwheat etc.

A general guide to in terms of crops and geographical area/districts and traits of crops required is provided in Table 1 below.

Table 1: Crops and geographical area to be targeted for diffusion and transfer of disease

Crops	Districts	Traits
Rice	Thimphu, Paro	Cold tolerance, Blast resistance
	Wangdue, Punakha, Tsirang, Dagana, Chukha,	Blast resistance, Sheath Blight resistance
	Samtse, Sarpang, Samdrupjongkhar	Drought tolerance, Blast resistance
Maize	Trashigang, Monger, Lhuntse, Yangtse, Samtse, Tsirang, Dagana, Pemagatshel	Disease (GLS, TLB) tolerance, high protein content
Wheat	Haa, Paro, Thimphu	Winter hardiness
	Punakha, Wangdue, Tsirang, Dagana	Rust resistance

Barley, buckwheat	Bumthang, Haa	Disease resistance
Millets	S/jongkhar, Sarpang, Samtse, Tsirang, Dagana	Rust resistance, High Yield

1.2. Barrier analysis and possible enabling measures for development of drought and pest resistant varieties of crops

1.2.1 General description of the technology

Breeding new and improved crop varieties enhances the resistance of plants to a variety of stresses that could result from climate change such as water and heat stresses and the emergence of new pests. Varieties that are developed to resist these conditions will help to ensure that agricultural production can continue and even improve despite uncertainties about future impacts of climate change. Breeding for improved performance under environmental stresses involves activities which accumulate favorable alleles (different forms of a gene) contributing to stress tolerance (Clements et al., 2011).

Development of new crop varieties requires both traditional knowledge in gene-pool as well as utilization of modern biotechnological processes like transgenic crops and molecular breeding. Conventional breeding requires the identification of genetic variability to drought among crop varieties and introducing this tolerance into lines with suitable agronomic characteristics. Although conventional breeding for drought tolerance have and continues to have some success, it is a slow process that is limited by the availability of suitable genes for breeding and largely limited to exploiting the existing genetic variation in crop plants and their very close relatives.

The development of tolerant crops by genetic engineering, on the other hand, requires the identification of key genetic determinants underlying stress tolerance in plants, and introducing these genes into crops. The physiological response of plants to water stress is accompanied by the activation of genes involved in the perception of drought stress and in the transmission of the stress signal. These set of genes are targeted for replication and amplification of their expression in the new breeds. A major reason for the relatively slow progress in conventional breeding responses to the stresses related to climate change arises from the fact that plant adaptations are not likely to be single gene changes and whole metabolic pathways are likely to be involved.

1.2.2 Identification of barriers for the technology

In order to identify barriers for technology development and diffusion, market maps were prepared for each technology. By this method, the group of experts discussed and exchanged information to build up a comprehensive picture of the elements of the existing system related to the development of the new technology. The relevant factors building this market included:

- Environment that allows the introduction of new technologies (such as legal, institutional, organizational, cultural, geographical, economic and social conditions ...)
- The relevant object in the system (such as manufacturers, wholesalers, retail dealers, consumers, households producers ...)
- Supporting services (such as finance, quality management, performance, standards, etc ...).

In the first step, secondary research was conducted in which Bhutan's policies and other feasibility studies were referred to for the identified technologies, based on which a market map was created. In the second step, a stakeholder workshop was organized in Paro, Bhutan in which TNA Task Force members provided their inputs on key barriers and the enabling framework. Following this, focused sector specific roundtable discussions were held

in Thimphu, Bhutan at NEC, with relevant experts to seek specific information on barriers and enabling measures for each technology.

However, market mapping was applied only for those technologies which are classified as consumer and capital goods. The detail of market maps for these categories of adaptation technologies are presented in the Annex 2.

Based on above methodology, for drought and pest resistant varieties of crops, financial and non-financial barriers have been identified.

1.2.2.1 Economic and financial barriers

The key barrier for research and development on drought and pest resistant varieties of crops in Bhutan is the huge investment costs required for setting of research laboratories and other institutions, for development of human resources and for knowledge transfer in the form of exchange programmes, collaboration with international laboratories and universities. The financial capacity of current institutions such the RNR RDCs is very limited to carry out the needed activities. Also, many new varieties of seeds need to be transferred from elsewhere into the country. These would then have to be tested on fields before they are distributed to farmers. All this involves enormous cost which has been identified as a significant barrier, hindering the introduction of this technology in the country. It was emphasized that there are large financial gaps and with needs for funds to undertake some vital activities.

1.2.2.2 Non financial barriers

a. **Institutional barrier:** Among the existing institutions, RNR Research and Development Centres (RDCs) are the oldest dealing with crop improvement research. The National Biodiversity Center (NBC), created in 1998, serves as the focal centre for Plant Genetic Resources (PGR) and conservation of biological resources. RNR RDCs under the Department of Agriculture are actively involved in development and utilization of crop genetic resources in field crops and horticulture. RDCs are assigned specific commodities such as rice, maize, fruits and vegetables to lead research and development of those commodities. RDCs also maintain small germplasm collections and tree mother blocks for their use. The National Seed Center (NSC) also handles large amount of crop germplasm including that of potato.

   However, though the country has a relatively well defined institutional structure in place looking at its seeds sector, amongst these institutions there is limited institutional and human resources capacity to carry out adequate research and development and more importantly extension activities. In addition, synergies amongst institutions are much desired.

b. **Policy, legal and regulatory barrier:** Bhutan's overall legal and regulatory framework is quite favorable towards R&D on crops specifically for developing new biotic and abiotic stress tolerant seed varieties. For instance, the Seeds Act has a clear objective to regulate import and export of agriculture seeds, prevent introduction of plants and diseases and to promote seed industry in the country aimed at enhancing rural income and livelihoods. Similarly, standards and guidelines have already been developed for seed production for implementation by the National Seed Centre. To ensure enforcement of the standards, the Bhutan Agriculture and Food Regulatory Authority (BAFRA) has been made the nodal agency. The IPR related issues are addressed by the Biodiversity Act of Bhutan. Thus there is no direct legal and regulatory barrier hindering the development, production and dissemination of new varieties.

   However, the task force members and sectoral experts pointed out that though there are different sets of policies/acts/regulations looking at various aspects of the agriculture sector, a comprehensive agriculture sector policy needs to be developed to act as an overall guidance document for the sector.

c. **Market barrier:** one of the biggest barriers is the access to new seeds of improved strains, especially for the farmers in the remote villages. Access is an issue largely due to tough topography of the country and is coupled with the limited capacity of the existing institutions to carry out effective dissemination. The Government appointed sales representatives for Geogs show less interest in promoting new varieties of cereals particularly rice due to their inexpensive nature, thereby lower commissions on them.

d. **Technical barrier:** methodologies used for developing new varieties are old and there is heavy reliance on institutes outside the country for germplasm. The research laboratories are outdated and there is a need for upgrading the equipment there. Inadequate manpower and technical skills in crop breeding and germplasm utilization remain a serious impediment. There is also a need to build institutional capacity within the country in the long run to be able to breed new varieties of seeds independently and domestically.

   There is also lack of awareness stakeholders engaged in germplasm development and utilization on recent technology trends and also international treaties and agreements such as Standard Material Transfer Agreements, Cartegena Protocol, and International Treaty on Plant Genetic Resources for Food and Agriculture ITPGRFA. Information dissemination and sensitization of the technical staff to these, could further R&D in the sector and development of more new varieties.

e. **Social and cultural and Behavioral barrier:** In Bhutan, farmers have been developing crop breeds traditionally for generations and hence they may be reluctant to adopt new varieties especially if they require different farming practices and additional investments. Also, the subsistence nature of farming along with small land holdings hinders large scale adoption of new technologies.

f. **Information and awareness:** there is in general a lack of awareness, education and information disseminated on new available technologies and their benefits to the farmers, which hinders its uptake. Also farmers often are not acquainted with the methods of multiplying new varieties of crops and have to buy the new varieties from the market again and again, the recurring cost of purchase of new varieties of these seeds dissuades farmers from adopting the new varieties, thereby preventing its widespread diffusion

1.2.3 Identified measures

Based on intensive discussions with experts, extensive secondary research as well as international experience a picture of an enabling environment for development and diffusion of the technology was drawn. Based on which enabling measures to overcome barriers for each group of factors as discussed above, were finalized by experts. The enabling measures as thought important are described below.

1.2.3.1 Economic and financial measures to overcome barriers to development and diffusion of drought and pest resistant varieties of crops

The new technology development would require huge capital costs to enhance the domestic research and development capacity. The domestic financial resources need to be supplemented by international sources to meet the targets.

Financial support needs to be sought for:

- Strengthening of research laboratories, universities and other institutions for R&D.
- Development of human resources and technical knowledge
- Knowledge transfer and exchange programmes

This could be done by establishing a seed development fund using both domestic and international funds. The fund can be provided in form of grant and debt for identified activities. The fund could be created under the Comprehensive Agriculture Development Policy.

1.2.3.2 Non financial measures

Various measures that could be introduced in Bhutan to overcome the non-financial barriers, these could include:

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Institutional strengthening:

- Strengthen the current institutions (such as NSC, RDCs etc) with human resources and required facilities for accelerating research and development for developing new varieties and preserving traditional varieties. This will help built human and technical capacity of institutes at the central and regional level. Built domestic capacity and ability to develop and produce new varieties domestically, without external dependence. Currently, there is too much of reliance on international germplasm and on conventional methods of crossing are practices domestically to produce new seeds.

  This can be ensured by:

  - Hiring the relevant technical experts in key institutes including BAFRA, National Seed Centre, Technology Release Committee and RDCs
  - Identifying equipments/lab requirements, of the institutions for development of technology
  - Establishing required facilities either through tie-ups with domestic suppliers or international technology suppliers
  - Acquisition of latest required lab equipments to further research in related areas
  - Training and other skill development measures for staff in institutes mentioned above
  - Collaboration with regional and international research institutes with the RDCs under DoA by
    - Establishing tie-ups
    - Defining scope of tie-ups
    - Promoting exchange of experts on exchange programmes
- Capacity building of RDCs to undertake extension services for diffusion of seeds. Currently, the existing institutional capacities are limited to undertake large scale production and dissemination for these varieties to farmers. Capacity of RDCs can be built by:
  - Designing and conducting training and capacity building pogrammes for RDCs and outreach centres focusing on sales representatives and extension officers
  - Developing extension and communication materials for the training programmes by Hiring consultants or using in-house resources
  - Undertaking exposure visits for extension officers sensitizing the existing and new officers to benefits of new technology

Building Market support:

- Strengthening of the current community based model and upscaling new models for production of seeds. The seed production part has been a major challenge in Bhutan. A well defined community based model will ensure large scale production of improved seeds and also build confidence of farmers in these varieties based due to farmer's direct involvement. This could be ensured by formation and strengthening of community groups by RDCs with support from their outreach centres in different geographical regions for specific crops.
- Undertake pilot projects and field testing of new varieties. It is important to test the technologies before a large scale roll out to farmers. This will help make modifications, if required, based on learnings of the pilot before a large scale roll out. This will potentially consist of:
  - Identifying sites for pilots and field testing
  - Identifying institutions for conducting the pilots

- Seeking source of funding these pilots
- Implementing pilots
- Monitoring the pilots
- Drawing lessons from pilot applications of the drought and pest resistant varieties

Policy, legal and regulatory

- Strengthen the current Seeds Rules and Regulation of Bhutan to also focus on other crops in addition to rice and maize. It is also important to bring to focus through policies and regulation, research and development on GM crops. Strengthening of these policies would go a long way in creating an enabling environment in development and dissemination of such varieties of crops. The policy structure is in place, but it needs to be strengthened to assist focus on development and dissemination of these varieties.
- A comprehensive agriculture development policy, an overall policy for the agriculture sector, would ensure a combined vision for the sector and avoid overlap of responsibilities between different departments and agencies.

Information and awareness creation

- 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:
  - Designing of awareness campaign for farmers
  - Clearly identifying elements of such campaign
  - Developing content of relevance to farmers for such campaigns
  - Collaborating with village level bodies for proper dissemination of information and conducting such a campaign
  - Broadcast media
  - Including successful case studies to sensitize farmers

Chapter 2. Water resources sector

2.1 Preliminary targets for technology transfer and diffusion

The major thrust areas for technology adaptation for combating effects of climate change on water resources is the adaptation of efficient irrigation technologies that will not only be effective in the scenario of increasingly erratic water availability but also be appropriate for intensive agriculture and horticulture methods being envisaged as a means of attaining food security and self-sufficiency in Bhutan.

Efficient irrigation system with focus on the use of drip and sprinkler irrigation system to optimize the use of water for irrigating its cash crops and horticultural crops has been shortlisted as potential technologies for the climate change adaptation for the water resources sector. The National Irrigation Policy of Bhutan also aims "***to strengthen technical support services and to develop, promote and disseminate new practices, innovation and technologies that are environmentally sustainable, appropriate, manageable and affordable"*** and in the process introduce and support such technologies as drip and sprinkler irrigation. The Department of Agriculture has budgeted about Nu 50 million over three years for the transfer and diffusion of the technologies.

The Department has initiated a Decentralized Rural Development Project under the World Bank funding with the objective of demonstrating and promoting drip and mini-sprinkler irrigation technologies to the farmers for cash crop production.

Demonstration plots for sprinkler irrigation tentatively selected through Decentralized Rural Development Project funding (Nu. 5 million) (USD 0.09 million) are provided in Table 2 below:

Table 2: Tentative sites for demonstration of drip and sprinkler irrigation

S No.	Site/location	Target Crop	Dzongkhag
1.	Choekor	Vegetables	Bumthang
2.	Kabjisa	Chili & beans	Punakha
3.	Deothang	Orange	S/Jongkhar
4.	Phangyul	Vegetables/tomato	Wangdue
5.	Patshaling/Gosaling	Citrus	Tsirang
6.	Thangna, Drujeygang	Citrus	Dagana
7.	Phobjikha	Potato	Wangdue

Nu. 5 million (USD 0.09 million) has been allocated for this activity through the DRDP project funding for 2011-2012 FY. 7 sites spread across the country. Each site will have an area of 2-5 acres.

It is being proposed to expand the project to include more sites for demonstration of the technology.

In addition to this ongoing demonstration projects, the Department of Agriculture (DOA) is in the process of finalizing the targets and objectives for irrigation as part of the 11th FYP process. The TNA process and consultation with experts, as well, highlighted following as the targets for new irrigation systems in line with 11th FYP targets. These include:

- Increased area under irrigation by installing new irrigation systems for horticulture (cash) crops, target is to increase the area by 300 hectares under new irrigation systems from December 2013 to March 2018.

2.2 Barrier analysis and possible enabling measures for efficient irrigation systems

2.2.1 General description of the technology

Efficient irrigation methods or technologies include the advanced irrigation systems like sprinkler irrigation and drip irrigation. Sprinkler irrigation is a type of pressurized irrigation that involves applying water to the soil surface using mechanical and hydraulic devices that simulate natural rainfall. The goal of irrigation is to supply each plant with just the right amount of water it needs. Sprinkler irrigation is a method by which water is distributed from overhead by high-pressure sprinklers on risers or moving platforms. Today a variety of sprinkler systems ranging from simple hand-move to large self-propelled systems are used worldwide.

Drip irrigation is based on the constant application of a specific and calculated quantity of water to soil crops. The system uses pipes, valves and small drippers or emitters transporting water from the sources (i.e. wells, tanks and or reservoirs) to the root area and applying it under particular quantity and pressure specifications. Managing the exact moisture requirement for each plant, the system significantly reduces water wastage and promotes efficient use. Compared to sprinklers systems which can provide 75 per cent efficiency, drip irrigation can provide as much as 90 per cent water-use efficiency (Tanji and Kielen, 2002 in Clements et al., 2011).

2.2.2 Identification of barriers for the technology

As part of the TNA process, group of experts in Bhutan, discussed and exchanged information to build up a comprehensive picture of the entire existing system elements related to the development of new technology. The relevant factors building this market include:

- Environment that allows the introduction of new technologies (such as legal, institutional, organizational, cultural, geographical, economic and social conditions ...)

- The relevant object in the system (such as manufacturers, wholesalers, retail dealers, consumers, households producers ...)

- Supporting services (such as finance, quality management, performance, standards, etc ...).

Based on this picture, Bhutan TNA Taskforce members and other stakeholders identified existing problems in the system, from which barriers were found for each technology.

In the first step, secondary research was conducted in which Bhutan's policies and other feasibility studies were referred to for the identified technologies, based on which a market map was created. In the second step, a stakeholder workshop was organized in Paro, Bhutan in which TNA Task Force members provided their inputs on key barriers and the enabling framework. Following this, focused sector specific roundtable discussions were held in Thimphu, Bhutan at NEC, with relevant experts to seek specific information on barriers and enabling measures for each technology.

However, market mapping was applied only for those technologies which are classified as consumer and capital goods. The detail of market maps as well as problem trees for these technologies categories of adaptation technologies are presented in the Annex 2.

Based on above methodology, for drip and sprinkler irrigation technology, financial and non-financial barriers have been identified.

2.2.2.1 Economic and financial barriers

The key economic barrier identified for the implementation and diffusion of sprinkler and drip irrigation is the high costs of these systems as compared to traditional irrigation methods.

A study in India indicates INR 23900[1] (USD 430) as cost of investment for 1 hectare sprinkler irrigation system (National Bank for Agriculture and Rural Development (NABARD), 2007). Similarly, depending on the crop, the cost of drip irrigation may vary from INR 17000 (USD 306) to over a lakh (USD 1800) per hectare as given in Table 3.

Table 3: Unit cost of drip irrigation

S No.	Crop/Fruit	Spacing (m)	Cost in INR/Ha (USD/Ha)
1.	Coconut	8×8	23790 (USD 429)
2.	Sapota/Mango	10×10	17030 (USD 307)
3.	Oranges/ Guava	6×6	28010 (USD 504)
4.	Pomegranate	4.5×2.7	32010 (USD 576)
5.	Grapes	2.7×1.8	54370 (USD 979)
6.	Banana	1.8×1.5	73010 (USD 1314)
7.	Sugarcane	[(0.75+1.25) ×0.15] lateral spacing- 2.25	60440 (USD 1088)
8.	Vegetables	0.6×0.45	103020 (USD 1865)
9.	Mango	5×5	32060 (USD 577)
10.	Litchi	6×8	42000 (USD 756)

Source: NABARD, 2007

As per experts in Bhutan, the cost of these systems in Bhutan is almost double of those in India. And these costs are much higher than those for traditional systems in Bhutan. Such high costs are certainly unaffordable by Bhutanese farmers practicing mostly subsistence agriculture.

Further, access to credit for farmers is another barrier identified for the technology. At present, rural banks in Bhutan such as the Bhutan Development Bank provide loans to farmers at a rate of interest as high as 13%, making it extremely difficult for farmers to avail these loans. In scenario of high costs, lack of any fiscal support and limited access to finance makes the diffusion of these technologies particularly difficult in the country.

2.2.2.2 Non financial barriers

The following were identified as the primary non-financial barriers:

a. **Technical:** The acute shortage of professionals in the country is a major impediment for the development and diffusion of irrigation programs such as those concerned with drip and sprinkler irrigation. Irrigation infrastructure development activities at the Dzongkhag and Geog levels are implemented by few civil engineers who lack technical knowledge and skills in irrigation and agronomy, and are overburdened with other civil construction activities. The lack of professionals and adequate staff particularly dealing and familiar with drip and sprinkler irrigation techniques acts as a major impediment. This coupled with poor efficiency of existing infrastructure for irrigation there is a severe lack of needed experience to design and maintain new systems with very few engineers. The institutions and their human capacity are further constrained to cater to after sales service needs of such systems.

[1] The currency conversion rate of Indian Rupees (INR) and Bhutan Nu is 1.0

b. **Policy, Legal and regulatory:** environment in the country is not particularly supportive to encourage individual irrigation systems. There is no special focus in current policies on promoting individual irrigation systems, most are focused only on community based models.

   In addition given the high costs of these systems, lack of any fiscal incentives in form of tax exemptions or subsidies further discourages farmers in switching to new technologies.

c. **Market:** currently there are no dealers dealing with new technologies and equipment. This is largely because there has been no demand for such systems; thereby the supply could not be developed. Most of these systems are currently being imported from India. No after sales support to these systems further reduces their uptake.

d. **Social, cultural and behavioral:** Water sharing in Bhutan is currently governed by traditional community regulations which are difficult to break, specifically for some areas. Since number of uses will increase, as a result of these technologies, this is likely to create problems.

   The subsistence nature of agriculture reduces the viability of these systems. For this technology to be viable it is essential for agriculture to be commercial in nature. In addition there is also an observed general resistance to new technologies from farmers, being used to old traditions and practices.

e. **Information and awareness:** due to limited institutional capacity both at research as well as implementation level for new irrigation systems, there is real dearth of information on better water management techniques, including drip and sprinkler. This lack of information translates into lack of awareness both at the level of researchers, engineers, farmers of new technologies and associated costs and benefits.

f. **Institutional Barrier:** Water management research suffers from shortage of professionals to work on new techniques, leading to a rather slow development and diffusion of new technologies such as drip and sprinkler. As well as implementation of irrigation system suffers due to lack of enough technical staff as Dzonkghag and Geog level.

   In addition, existence of different agencies under different ministries collecting information and researching on water issues further exacerbates the problem of information sharing.

2.2.3 Identified measures

2.2.3.1 Economic and financial measures

One of the primary ways by which the existing financial barriers for the transfer and diffusion of sprinkler and drip irrigation system could be overcome is the introduction of financial incentives to overcome the high costs associated with these systems. Financial support is essential in short term to enhance uptake of these technologies by commercial farmers and understand the benefits. Such support will also ensure that the pilot projects are replicated on large scale in different parts of the country. In long term once the business case is established such support can be phased out.

Financial incentives could be provided by introducing a scheme on installation of drip/sprinkler irrigation. Such a scheme could provide certain percentage of the total cost of the installation of the irrigation systems as capital subsidy and remaining amount could be sourced through low interest debts and farmer contributions. The subsidy could be provided through a special fund created for promotion of micro irrigation schemes.

Further, at present the loans available to farmers through rural banks such as the Rural Development Bank are offered on high interest thus making them expensive for farmers to avail. In order to improve the access to finance of farmers one of the essential financial measures would be to provide loans to farmers at lower rates of interest

through rural and agricultural banks. For this, rural and agricultural banks providing such loans could be identified. The Banks accordingly, could be sensitized on the importance of development and dissemination of the technology. Further incentives could be provided to Banks to provide such loans by introducing re-financing and credit risk guarantee schemes.

2.2.3.2 Non financial measures

Various measures that could be implemented in Bhutan to overcome some of the impending non-financial measures are:

Strengthening institutional support and building technical capacity

Strengthen the current institutions in terms of human resources and technical expertise. It is Important to overcome the shortage of professionals and strong institutions in Bhutan and promote effective development, management and implementation of micro irrigation programs and activities. This could be done by:

- Assessing the resource requirements in different level of institutions with enhanced focus on local and regional level institutions such as RDCs, Extension officers, Dzongkhag Agriculture Sector, and Dzongkhag Engineering Sector.
- Designing and conducting training programs on irrigation and water management in order to develop irrigation professionals and engineers in the identified institutions
- Designing institutional structure for smoother implementation of micro irrigation schemes. Such structures could include setting up of specific cells in the existing nodal agencies at central, regional and local levels. These cells/units could be responsible for planning, approval, administration, technical support, implementation and monitoring and evaluation.

Information and awareness generation

Introduce training, capacity building programmes and awareness campaigns on drip and sprinkler irrigation techniques for district engineers, regional RDCs engineers, farmers and extension agents. It is important to introduce training and capacity building programmes as there is lack of skilled personnel for installation and operation of such technologies. Such programmes will built capacity and also enhance the confidence of the manpower in the technology. This could be done by:

- Reviewing and assessing needs of existing technical staff and farmers
- Developing support plans and programs for training and capacity building for installation and operation and maintenance of the irrigation systems
- Organizing study visits to India and Israel as well as participating in technology exhibitions in other countries
- Using the Media (print and A/V) to sensitize on issues of water management and role of such technology in better water management

Building market support

Undertake pilot projects for technology demonstration and modification. It is important to undertake the required research and test the technology through pilots, in way to suit the local conditions of Bhutan. This is particularly important as there is a risk of damage to the installations during winters for example.

Also given Bhutan's topography and the fact that it is difficult to operate such systems on sloping land, it is crucial to undertake pilots before widespread roll outs of the systems.

Following activities could be undertaken for designing and implementing pilots:

- Evaluate lessons and learning's from pilot projects implemented in past or currently ongoing e.g. pilot projects being implemented under the DRDP program funded by the World Bank
- Identify sites for pilot projects across regions in Bhutan
- Design pilot specifying type of micro irrigation technology (drip or sprinkler), cash crop, target community, funding required, expected water saving and increase in productivity
- Design implementation framework specifying role of institutions at central, regional and local level
- Develop strategy for communication and outreach to disseminate project findings among various stakeholders including policy makers and farmers

Chapter 3. Natural Disaster and Infrastructure Sector

3.1 Preliminary targets for technology transfer and diffusion

Under this sector, the TNA identified 'climate-resilient road development' as the top priority technology. Among all road types, farm roads were identified as the ones that required this technology the most. While all roads in general are vulnerable to climate change in Bhutan, it is the farm roads that are most vulnerable among all road types. This is largely because they are constructed with rudimentary planning and engineering works as a result of limited financial and human resources available for building such roads.

The Road Master Plan (2007-2027), produced by the Ministry of Works and Human Settlement, reflects a national target of 2,654.4 km of dzongkhag roads (formerly feeder roads), 537 km of inter-dzongkhag highways, and 794 km of national highway. The master plan does not project any target for farm roads. This has been left to Department of Agriculture, Ministry of Agriculture and Forests (DoA, MoAF). At the time of writing the barrier analysis and enabling framework report, the DoA, MoAF was in the process of formulating the plan and target for farm roads for the oncoming 11th Five-Year Plan (June 2013-July 2018).

The overall goal will be to make entire country's road network climate-resilient. In the short-term (over the next five years), the 11th Five-Year Plan target for farm roads can be taken as the target for diffusion of this technology. For pilot projects to implement and demonstrate the full-range of climate-resilient farm road development technology, 15-20 km of farm roads in each dzongkhag is proposed for the next five-years, coinciding with the 11th Five-Year Plan period. This translates to a national target of 300-400 km of farm roads over a period of five years.

3.2 Barrier analysis and possible enabling measures for transport management systems

3.2.1 General description of the technology

Climate-resilient road development technology refers to a set of technological measures that take into account local climate conditions and vulnerabilities in planning, design and construction. The most effective method of making roads climate-resilient is to anticipate and fully consider climate change impacts during the planning stage and integrate resilience measures in the design using local climate information in combination with geophysical information.

The measures to make roads climate proof are generally classified in the following categories[2]:

Engineering and structural measures: Under these measures the technologies typically include the following:

- Slope stabilization structures such as dry stone wall, gabion wall and jute bag wall. The choice of the structure is dependent on the gradient of the road and road construction materials;
- Paving of roads with durable materials;
- Proper alignment of new roads to avoid vegetative loss, steep gradient and fragile terrain;
- Improved drainage systems to avoid erosion of road materials. The drainage system includes side drainage and cross drainage structures such as cascades, small check walls, culverts and causeway;
- Improved planning of roads with proper cross section and standard dimensions.

[2] http://www2.adb.org/Documents/RRPs/CAM/42334/42334-01-cam-oth-03.pdf

Bio-engineering measures: This involves the use of vegetation, either alone or in conjunction with civil engineering structures[3] such as small dams, wall and drains to manage water and debris thereby reducing instability and erosion on slopes[4]. Bio-engineering measures are also taken during earthwork and excavation activities of road construction. These include among others spreading of top soil, broadcasting seeds, grass slips and seedling of local plants. Typical bio-engineering methods include the following:

Grass Planting- Grass seed is spread or alternatively grass is hand-planted in lines across the slope. This results in slope stabilization by armouring and reinforcing of slopes.

Shrub and Tree Planting- Shrubs or trees are planted at regular intervals on the slope which later create a dense network of roots in the soil supporting the slope.

Brush Layering, Palisades and Fascines- In this system, woody cuttings are laid in lines across the slope usually following the contour which form a strong barrier, preventing the development of rill, and trap material moving down the slope. The system catches debris, armours and reinforces the slope.

Composite Systems- A range of composite systems are also used including live check dams, vegetated stone pitching and planted geo-textiles later supplemented by the vegetation. The composite systems reinforce the soil thereby stabilising the slopes.

Integration of local climate and geologic information in planning and design: This is a critical aspect of climate-resilient road development and will influence the choice and design of civil work structures and bioengineering measures to be put in place.

As a terminology, climate-resilient road development is being introduced recently but conceptually it is not completely new to the country. It has to certain extent existed in the form of "environment-friendly road construction", or EFRC in short, a concept and term that has been in circulation in the country's road construction parlance since 1999. EFRC concept was adopted as an integral component of the Rural Access Project, started in 1999-2000 with funds from World Bank and technical support of the Netherlands Development Organization (SNV). The Rural Access Project has covered more than 250 km of rural roads using EFRC approach and practices. EFRC has also been employed in road projects supported by the Asian Development Bank. These include completed projects, namely Road Improvement Project and Road Network Project I, and the ongoing Road Network Project II. These projects collectively cover more than 550 km of dzongkhag roads and highways.

During the course of stakeholder consultations for the Technology Needs Assessment and Technology Action Plan, it was inferred that EFRC was somewhat of a misnomer as road construction can never be environment-friendly but can only go to the extent of employing practices and measures to minimize adverse environmental impacts. 'Climate-resilient road development' was identified as a more suitable terminology for the TNA and TAP.

3.2.2 Identification of barriers for the technology

As part of the TNA process, group of experts in Bhutan, discussed and exchanged information to build up a comprehensive picture of the entire existing system elements related to the development of new technology. The relevant factors building this market include:

- Environment that allows the introduction of new technologies (such as legal, institutional, organizational, cultural, geographical, economic and social conditions ...)

- The relevant object in the system (such as manufacturers, wholesalers, retail dealers, consumers, households producers ...)

- Supporting services (such as finance, quality management, performance, standards, etc ...).

[3] http://himachal.nic.in/hpridc/RandD.pdf
[4] http://www.scidev.net/en/features/landslide-victory-bioengineering-in-nepal.html

Based on this picture, Bhutan TNA Taskforce members and other stakeholders identified existing problems in the system, from which barriers were found for each technology.

In the first step, secondary research was conducted in which Bhutan's policies and other feasibility studies were referred along with the literature available on web for the identified technologies, based on which a market map was created. In the second step, a stakeholder workshop was organized in Paro, Bhutan in which TNA Task Force members provided their inputs on key barriers and the enabling framework. Following this, focused sector specific roundtable discussions were held in Thimphu, Bhutan at NEC, with relevant experts to seek specific information on barriers and enabling measures for each technology.

However, market mapping was applied only for those technologies which are classified as consumer and capital goods. The detail of market maps as well as problem trees for these technologies categories of adaptation technologies are presented in the Annex 2.

Based on above methodology, for farm roads, financial and non-financial barriers have been identified.

3.2.2.1 Economic and financial barriers

The main barrier for climate-resilient farm roads is the huge upfront costs for detailed planning and design, entailing not only well-trained personnel but also advanced survey and engineering equipment, and use of robust construction materials. The Rural Access Project has projected an additional capital cost of 20-30 percent for roads using EFRC approach and practices. Integrating climate-resilience measures will further raise the cost of building roads. Whilst environmental codes of practice exist for road construction, they are generally not applied unless environmental management costs are built in as in the case of specially funded projects, such as those by the World Bank and Asian Development Bank, where environmental and social safeguards are conditional for securing funds. According to the Guidelines for Farm Road Development, Nu 3 million (around USD 57,000) is estimated for construction of each km of farm road integrating basic environmental measures[5]. In practice, that kind of budget is very rarely available for farm road construction. Furthermore, in sites where climate and geophysical conditions are more difficult than the normal Bhutanese conditions, even Nu 3 million per km is reportedly far from adequate[6].

3.2.2.2 Non financial barriers

The following were identified as the key non-financial barriers:

a. **Institutional Barrier:** A key institutional issue is the poor coordination and line of communication between the Department of Agriculture/ Ministry of Agriculture and Forests and the Dzongkhag Administrations, where the Dzongkhag Engineers are based work-wise. The Dzongkhag Engineers are responsible for field-level planning, supervision and monitoring of farm roads development. They are appointed and technically guided by the Ministry of Works and Human Settlement, and administratively managed by the Dzongkhag Administrations. They have no clear institutionalized working linkages with the Department of Agriculture. As a result, coordination between the two agencies has been poor and this has among other things impacted proper implementation of farm road development guidelines and technical standards.

   Most dzongkhag engineering sections are short-staffed and ill-equipped to carry out proper planning and design of farm roads, and monitor construction work. This constraint is further exacerbated by the lack of knowledge and skills among the private contractors to carry out environment-friendly/ climate-resilient road construction.

   Another major institutional issue is the role of Dzongkhag Administrations in environmental assessment and environmental clearance. Currently, farm roads are planned by Dzongkhag Engineers and Dzongkhag Agriculture Officers, environmental assessment and collation of information for environmental clearance

[5] Project Appraisal Document of Second Rural Access Project in Bhutan by World Bank, 2006.
[6] Stakeholder consultation session for TAP for climate-resilient farm road development, 10th October 2012, NECS conference hall.

are done by Dzongkhag Environmental Officers, followed by review of application for environmental clearance by the Dzongkhag Environment Committees (which is coordinated by the Dzongkhag Enviornmental Officers, chaired by the Dzongdags, and members include Dzongkhag Engineers and Dzongkhag Agriculture Officers along with other relevant dzongkhag sector heads). So, the entire procedure of planning, environmental assessment, review, and environmental clearance is housed within a single agency, i.e. the Dzongkhag Administration. This presents a great risk of 'conflict of interests' and undermining the purpose and value of environmental assessment and environmental clearance, which is a crucial procedural framework for ensuring that recommended technical and environmental standards are implemented in the development of farm roads.

b. **Policy Barrier:** Currently, there is no national road development policy. The road master plan (2007-2027) which exists focuses on operational plans and targets for dzongkhag (feeder) roads, inter-dzongkhag highways, and national highway and does not feature other road types. The Road Act 2004 advocates that roads need to be constructed in environmentally sound manner but it lacks comprehensive provisions on how this will need to be implemented.

   There is no policy or legal provision for compensation/ land substitution for acquisition of private land to build farm roads. As a result of this policy gap, acquisition of private land for farm road construction is a major impediment. Where private landowners do not consent to part away with their land, farm roads have to be realigned sometimes through difficult and fragile terrain, which are vulnerable to soil erosion and landslides.

c. **Social, Cultural and Behavioral Barrier:** Developing climate-resilient farm roads will require meticulous planning and implementation of construction standards, and additional funds than what is normally available. However, public demand for farm roads is enormous. Consequently, ambitious targets for farm roads have been set in the ongoing 10th Five-Year Plan (July 2008-June 2013). These are, in most dzongkhags, not commensurate with the implementation capacity. Nonetheless, due to relentless public demand and consequent political pressure, the attempt is to build more and more farm roads with limited human and financial resources.

   Furthermore, there is the misconception that climate-resilient or environment-friendly roads are very expensive and beyond the financial means of a country like Bhutan with scarce budget. While upfront costs are high by about 20 to 30 percent than conventional roads, the additional capital costs are nullified over a period of 7-9 years due to low recurrent costs for maintenance and monsoon restoration work. In fact, over the long term, climate-resilient roads would become far less expensive than those built without climate-resilience and adequate environmental measures. In addition, there are many co-benefits – for example, less occurrence of road blocks, reduced travel time, reduced soil erosion and sedimentation of farmlands and water bodies, and improved public service delivery. There is, however, no country-specific evidence providing quantified data of comparative costs and benefits of climate-resilient roads, which can be used to sensitize the stakeholders, and inform investment decisions.

d. **Technical Barrier:** Environmental codes of practice for roads and highways were developed in 2002, and are inadequate in terms of outlining specific practices for planning and designing climate-resilience in roads. The Guidelines for Farm Road Development 2009 is also deficient when it comes to technical standards for climate proofing of farm roads.

   Field interventions that demonstrate the full range of climate-resilient farm road development technology are also limited. Thus, there is insufficient basis on the ground for developing cases for replication and scaling-up.

   A major technical barrier is also the unavailability of local meteorological data for use in planning and designing farm roads. This is largely due to the limited network of meteorological stations. This barrier will be significantly addressed through support from the Japanese International Cooperation Agency and NAPA/GEF/LDCF for strengthening the national meteorological system, which includes upgradation of existing weather stations and establishment of additional weather stations for real-time weather monitoring, forecasting, and early warning of extreme weather events. Detailed formulation of projects

for support from JICA and from NAPA/GEF/LDCF is ongoing and the projects are scheduled to come through in 2013.

3.2.3 Identified measures

3.2.3.1 Economic and financial measures

It is recommended the budget for farm road development be rationalized in accordance with the technical standards required for climate-resilience. In this respect, the following activities are proposed:

- Review existing costs and budget for farm road development in relation to the recommended technical standards for farm roads, incl those required for climate-resilience, and come up with specific recommendations;
- Convene inter-agency meetings/ workshops to discuss the review findings and implementation of recommendations;
- Produce and disseminate farm road budgeting guidelines for implementation together with the technical standards.

3.2.3.2 Non financial measures

The following measures are recommended to address the non-financial barriers associated with environment-friendly/ climate-resilient roads:

Institutional Measures

Inter-agency coordination and working linkages need to be developed and strengthened, in particular between the Engineering Division, Department of Agriculture/ Ministry of Agriculture and Forests. To achieve this, the following activities are proposed:

- Review existing institutional arrangements for farm road development, analyze the gaps and come up with recommendations for strengthening coordination and institutional linkages;
- Convene inter-agency meetings/ workshops to discuss the review findings and implementation of recommendations;
- Incorporate the recommendations in the Farm Road Development Guidelines.

Institutional capacity of the Engineering Division of DoA/MoAF and Dzongkhag Engineering Sectors will also need to be strengthened. This would involve: staff training for DoA/MoAF and Dzongkhag Engineers; equipment support to the Dzongkhag Engineering Sectors; review of existing staffing structure for engineering works at dzongkhag and development of dzongkhag staffing plan for engineering works based on the scale and nature of work; and deployment of engineering staff according to the dzongkhag staffing plan for engineering works

Policy Measures

Climate-resilience mainstreaming in road development policies and guidelines requires to be enhanced. This will require a review to examine to what existing policies and guidelines relevant to road development address climate-resilience aspect and come up with specific recommendations to comprehensively integrate this aspect in the policies and guidelines.

There is also the need for clear policy/ legal provisions with regards to compensation/ land substitution for private land acquisition for farm roads. It is proposed that a review be carried out to examine the policy/ legal framework for land acquisition and come up with recommendations to address the issue of compensation/ land substitution for private land acquisition for farm roads

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Information and Awareness

Information and country evidences to support the case for climate-resilient farm road development need to be developed. To do so, it is proposed that case studies be carried out to examine and highlight comprehensive (economic, social and environmental) costs and benefits of climate-resilient farm roads vis a vis roads that do not integrate climate-resilient measures and environmental standards.

Using the case studies as country evidences, conduct sensitization, advocacy and awareness-building activities for the following (but not limited to) target audiences: (a) policy-makers; (b) parliamentarians; (c) dzongkhag administrations; (d) gewog administrations. In addition, the case studies can be used to produce a video to highlight the various adverse impacts of poorly-built farm roads and the importance and benefits of climate-resilient farm roads, and broadcast it through TV.

Technical Measures

To demonstrate the full range of climate-resilient farm road development technology, pilot projects are proposed. This will entail selection of pilot sites using multiple criteria, including poverty reduction, population size, and climate impacts. It is proposed that the full-range of climate-resilient farm road development technology be implemented in pilot sites at the rate of 15-20 km per dzongkhag. Targets may include both new farm roads as well as existing farm roads that require to be improved for climate-resilience.

Concurrently, activities will need to be undertaken to strengthen the technical know-how and skills among various people who will have a role in the planning, design and construction of climate-resilient farm roads. This will involve dissemination of technical know-how and skills through training and provision of knowledge resources (toolkit, handbook, reference materials, etc). Target audience for dissemination of technical know-how and skills include private contractors, private engineers, site supervisors and machine operators (Government staff not included here as they can be covered through staff training mentioned as part of institutional strengthening measures).

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Annex I. Market Maps and Problem Trees

A proposed method for technology innovators to find barriers and problems is by mapping market. By this method, the group of experts discuss and exchange information to build up a comprehensive picture of the entire existing system elements related to the development of new technologies. The relevant factors that are mainly considered include:

- Environment that allows the introduction of new technologies (such as legal, institutional, organizational, cultural, geographical, economic and social conditions ...)
- The relevant object in the system (such as manufacturers, wholesalers, retail dealers, consumers, households producers ...)
- Supporting services (such as finance, quality management, performance, standards, etc ...).

Based on this picture, Bhutan TNA Taskforce members and other stakeholders identified existing problems in the system, from which barriers were found for each technology.

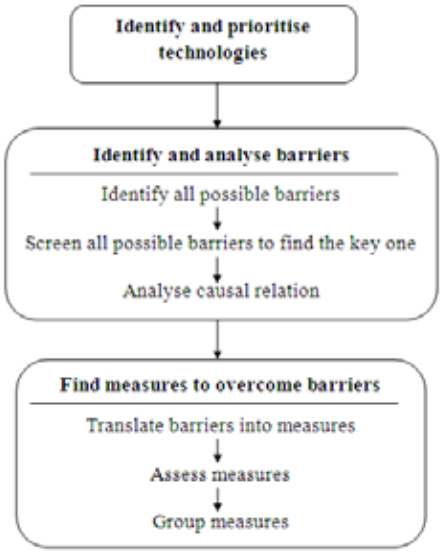
The market mapping is only applied for technologies which are classified by consumer and capital goods. For adaptation technologies, there are no technologies of capital goods categories, and there are 2 technologies of consumer goods categories such as the drought and pest resistant varieties of crops and drip and sprinkler irrigation techniques.

For example, for technology of drought and pest resistant varieties, the market chain includes development, production, extension agencies, extension agents at each Gangkho and consumer/farmers.

Next, the main related-market chain factors in the transfer and diffusion process of new technology are defined as: geographical conditions, cost, production cycle, infrastructure etc. On the basis of identified barrier, we can also provide some solutions to overcome the barrier such as identifying possible areas of conversion, pilot demonstration or researching to develop technology that can suitable for many localities. Or for cost factor, whether technology needs high investment or not and if the investment is high, this will be an obstacle for farmer for adopting the technology. Therefore, cost is also considered as a barrier. Accordingly, one of the solutions given is: setting up of the funds ... Similarly other barriers are determined and the solutions overcoming barriers are also given in parallel in the transfer and diffusion of this new technology.

Specific market map for each adaption technology is presented below respectively. Following that, maps of analysing framework condition for them are shown in parallel.

The Figure below presents the process used for arriving at the final list of barriers and enabling measures.



Annex I

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Identifying and analysing barriers and finding measures to overcoming barriers

Logical Problem Analysis (LPA) tool has been used to identify and analyse the barriers for each technology across the sectors of adaptation, as well as for finding measures to overcome the identified barriers. The LPA enabled to arrange the observed problems into a hierarchy of causes and effects, with each problem being linked to causes and effects and creating a multi-level cause and effect pathways to form a problem tree. The problem trees have been prepared based on discussions held with Bhutanese sector experts and TNA taskforce members. Similarly for identifying and analyzing the enabling measures, measure result relations were discussed, to arrive at enabling measures for each technology.

Problem trees for the three technologies under adaptation are presented below.

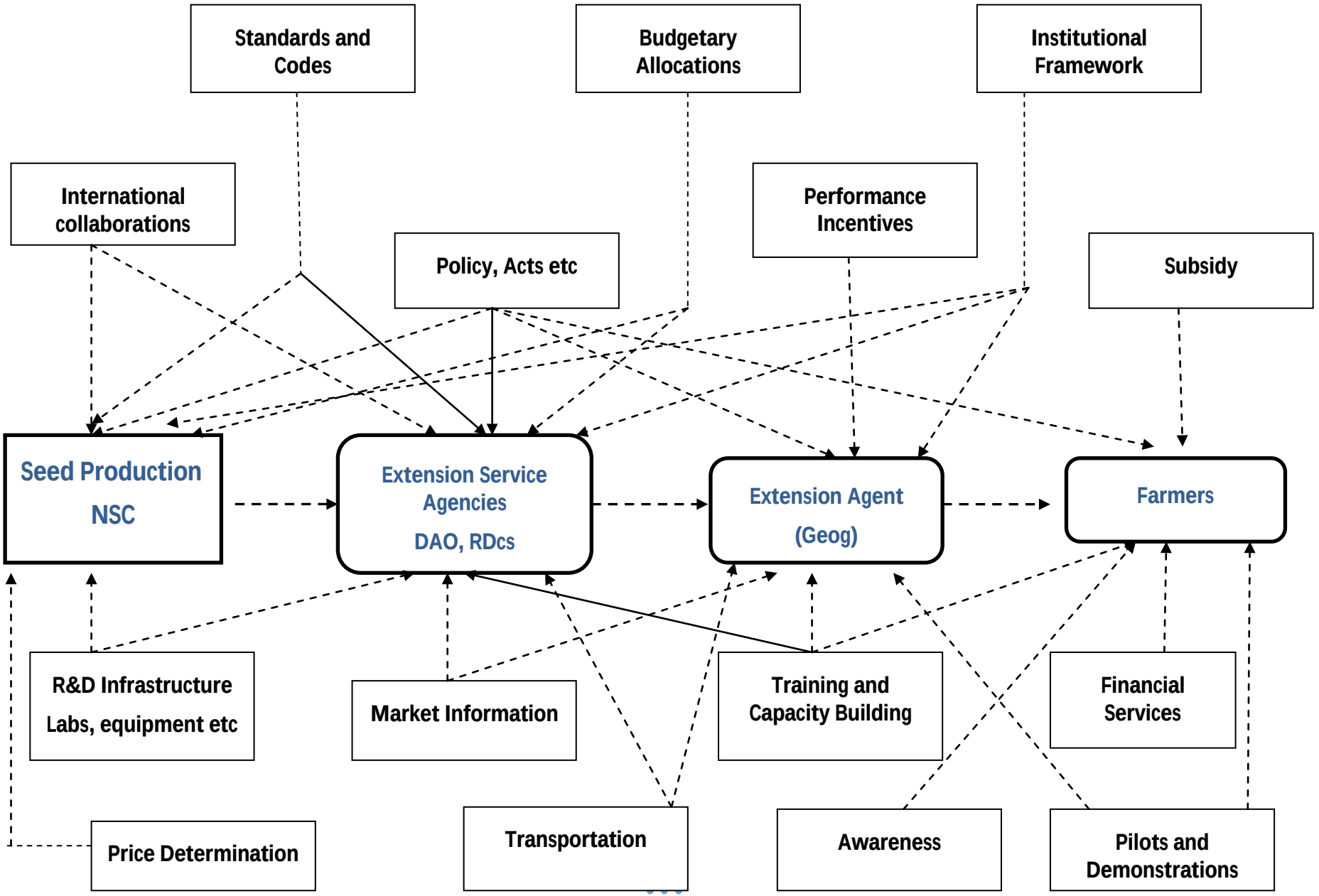

Figure 1: Market Map for Drought and Pest Resistant Varieties of Crops

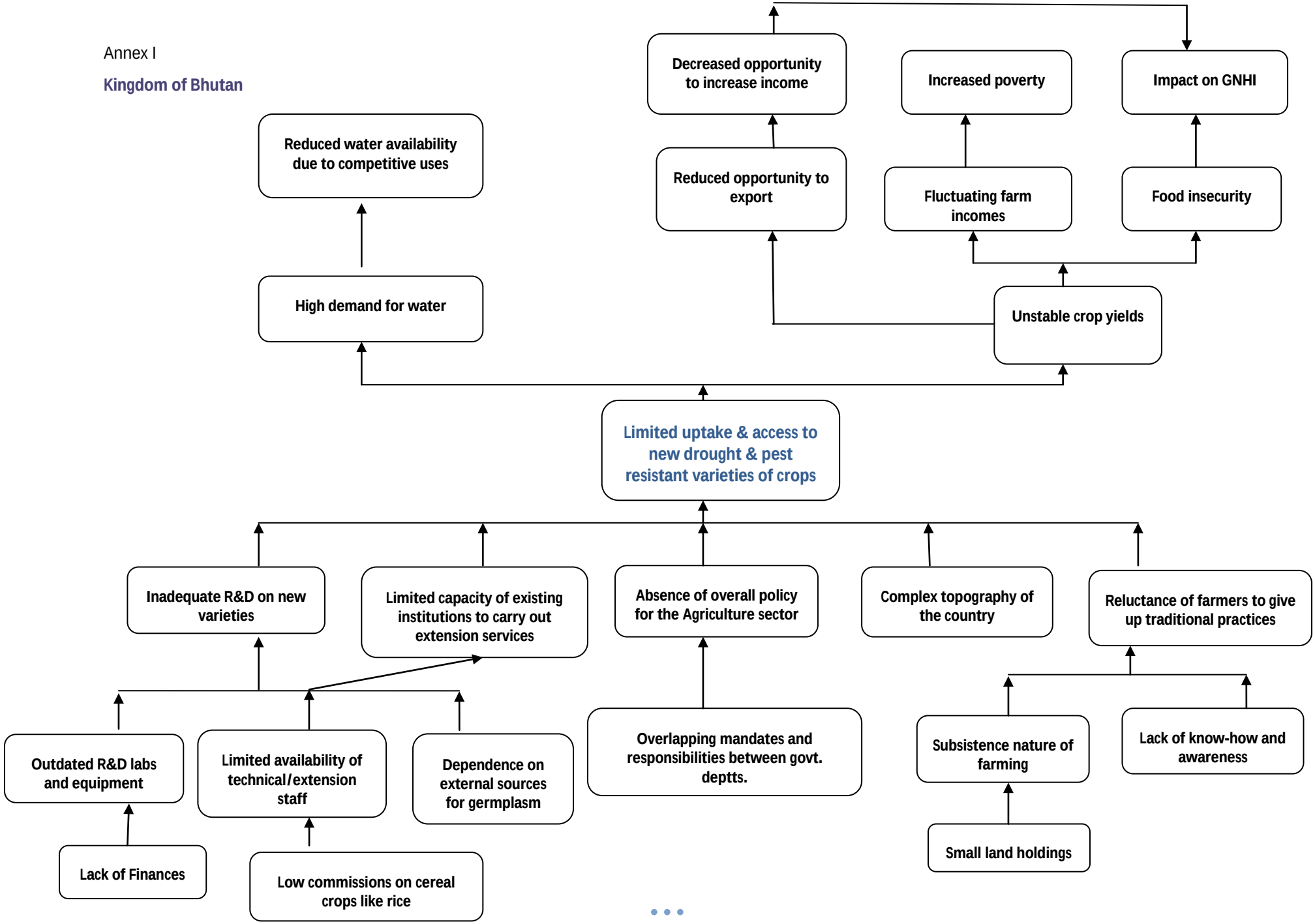

Figure 2: Problem Tree for Drought and Pest Resistant Varieties of Crops

Annex I

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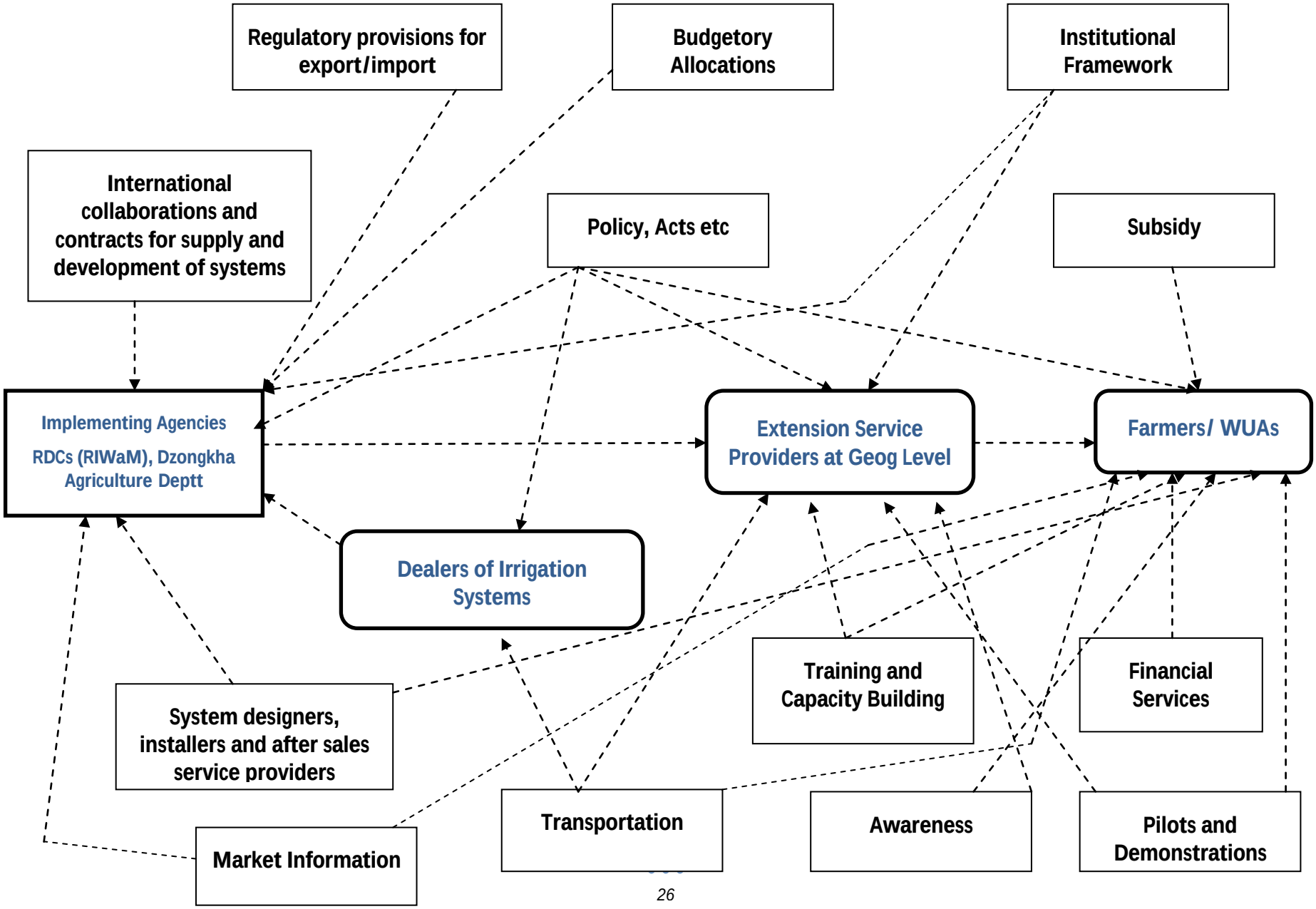

Figure 3: Market Map for Drip and Sprinkler Irrigation Systems

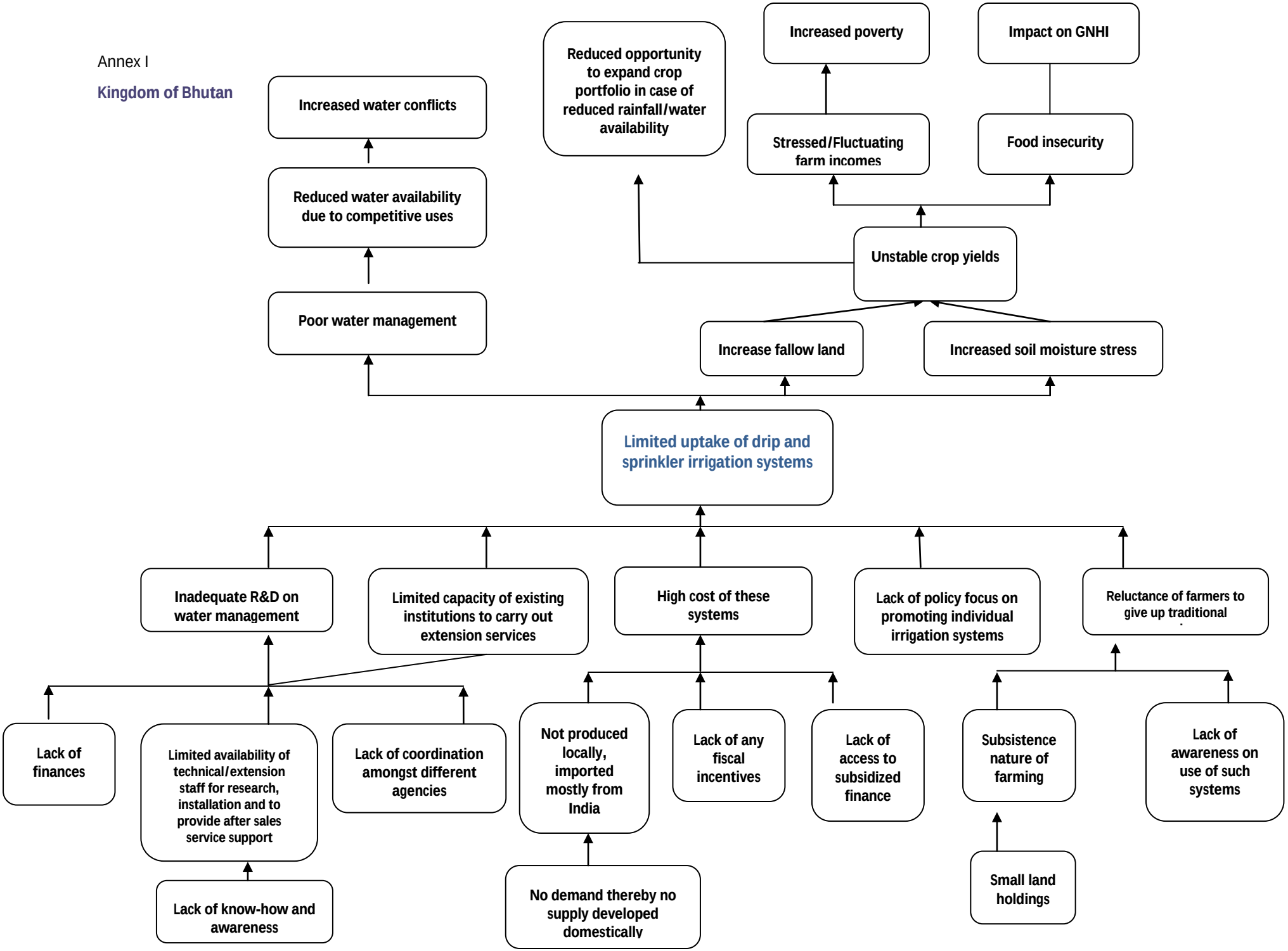

Figure 4: Problem Tree for Drip and Sprinkler Irrigation Systems

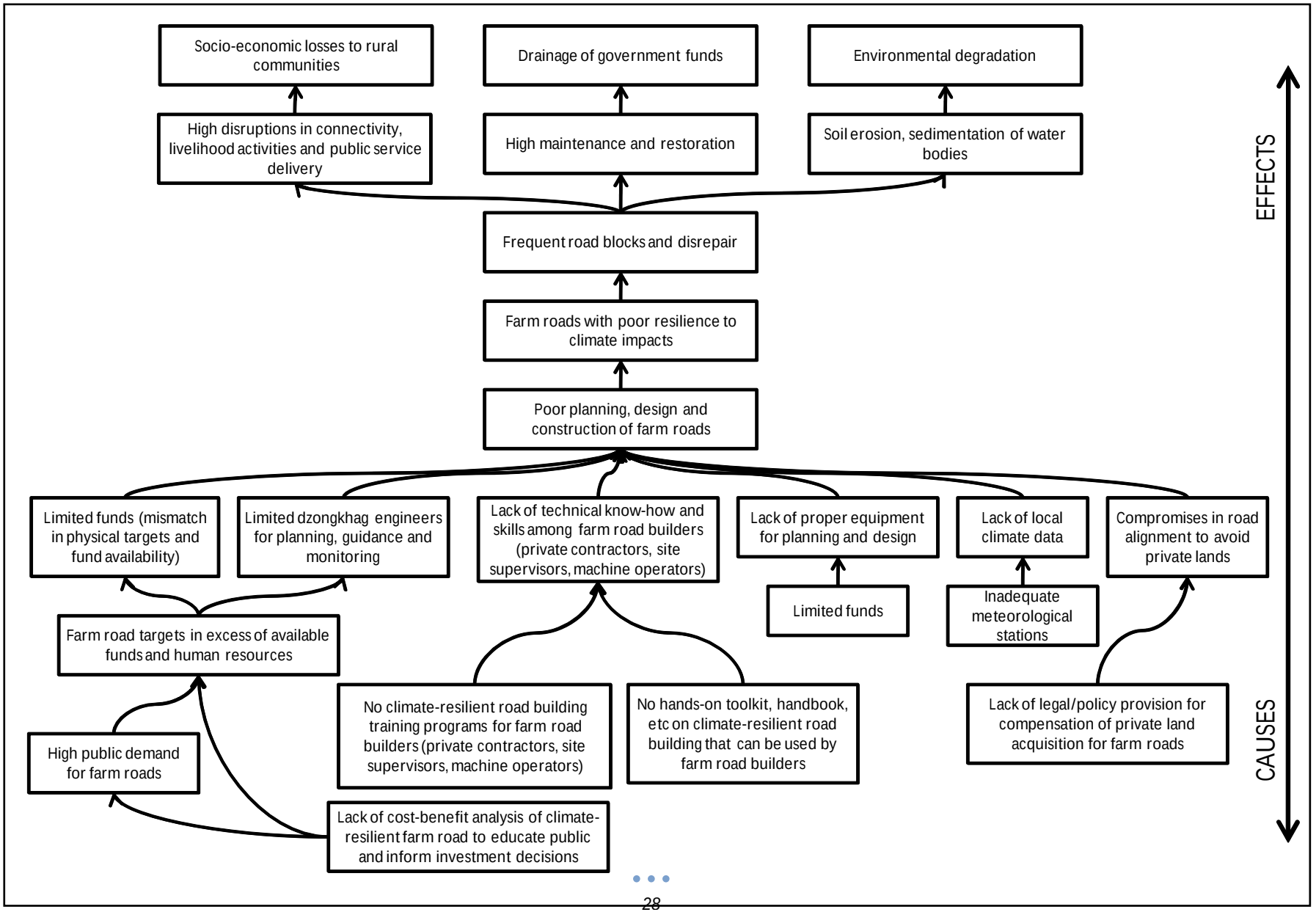

Figure 5: Problem Tree for Climate-Resilient Farm Road Development

Annex II. List of Stakeholders involved and their contacts

Several stakeholders were consulted in the process of preparation of the current Barrier Analysis Report. The list of stakeholders consulted along with their contacts is provided below.

S. No.	Name	Organization	Type of Consultation	Topics consulted for
1.	Birkha B. Chhetri, General Secretary	Association of Bhutanese Industries	Roundtable discussions and one on one interview	Industries
2.	Chhimi Dorji, Deputy Executive Engineer	Department of Hydro Meteorology Services	Roundtable discussions and one on one interview	Water, Agriculture
3.	Chhimi Rinzin, Chief Agriculture Officer	Department of Agriculture	Roundtable discussions	Agriculture
4.	Dawa Chogyel, Deputy Chief Environment Officer (EU-DOI),	Ministry of Economic Affairs	Roundtable discussions	
5.	G K Chhopel, Chief, Water Resources Division	National Environment Commission Secretariat	Roundtable discussions and one to one interview	Water
6.	Tek Nath Kararia, Civil Engineer	Thimphu Thromde	Roundtable discussions	Waste
7.	Gyembo Tenzin, Deputy Executive Engineer	Department of Agriculture	Roundtable discussions	Agriculture
8.	Jigme Nidup, Senior Environment Officer	National Environment Commission Secretariat	Roundtable discussions	Farmroads
9.	K. P Bhandari, DGM (plant)	SKW Tashi Metals	Roundtable discussions	Industries
10.	Karma Pemba, Chief Transport Officer	Road Surface and Transport Authority	Roundtable discussions and one to one interview	Transport
11.	Karma Tshethar	Department of Agriculture	Roundtable discussions	Agriculture
12.	Kunzang Choden, Senior Research Officer	Council of RNR Research in Bhutan	Roundtable discussions and one to one interactions	Water, Agriculture

13.	Nima Dorji, Engineer	Department of Agriculture	Roundtable discussion	Water, Agriculture
14.	Namgay Thinley, Deputy Chief Horticulture Officer	Department of Agriculture	Roundtable discussion	Agriculture
15.	Prem P. Adhikari, Senior Transport Officer	Road Safety and Transport Authority	Roundtable discussion	Transport
16.	Sherab Jamtsho, Deputy Executive Engineer	Department of Renewable Energy	Roundtable discussion	Industries
17.	Subarna Sharma, General Manager	Ugen Ferro Alloy Pvt Ltd	Roundtable discussion	Industries
18.	Tashi Dorji, Head of Administration	SKW Tashi Metals	Roundtable discussion	Industries
19.	Tashi Wangdi, Senior Manager	Bhutan Ferro Alloys Ltd	Roundtable discussion	Industries
20.	Tenzin Khorlo, Chief Environment Officer	National Envrionment Commission Secretariat	Roundtable discussion	Waste
21.	Thinley Dorji, Chief, Compliance Monitoring Division	National Environment Commission Secretariat	Roundtable discussion	
22.	Trashi Namgyel, Hydromet Officer	Department of Hydro Meteorology Services	Roundtable discussion	Water
23.	Tshering Yangchen, Assitant Environment Officer	Thimphu Thromde	Roundtable discussion	Waste
24.	Yeshey Penjor	Independent consultant	Roundtable discussion and one to one interview	Waste
25.	Tshering Wangchuk, Program Officer		Roundtable discussion	
26.	Tshewang Lhamo, Environment Officer		Roundtable discussion	

Annex III. Policy Factsheets

POLICY: Name of Policy	**The Seeds Act of Bhutan**
Date Effective:	17 July 2000
Date Ended:	-
Unit:	**CC**
Country:	Bhutan
Year:	2000
Policy Status:	**In force**
Agency:	Department of Agriculture, Ministry of Agriculture and Forests.
Policy Type:	-
Policy Target:	-
URL:	http://www.nationalcouncil.bt/wp-content/uploads/2011/02/Seeds_En_00.pdf (accessed on 3 August 2012)
Description:	This is an Act to regulate import and export of agricultural seeds, to prevent introduction of plant pests and diseases and to promote seed industry in the country aimed at enhancing rural income and livelihood. The Seed Rules and Regulations of Bhutan, 2006 has been developed to implement the provisions contained in this Act.

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POLICY: Name of Policy	**Renewable Natural Resources (RNR) Research Policy of Bhutan**
Date Effective:	2012
Date Ended:	-
Unit:	**CC**
Country:	Bhutan
Year:	2012
Policy Status:	**In force**
Agency:	Ministry of Agriculture and Forests.
Policy Type:	-
Policy Target:	-
URL:	http://www.moaf.gov.bt/moaf/?wpfb_dl=593 (accessed on 17 August 2012)
Description:	During the 10th Five Year National Development Plan, RNR research policy has been put squarely on the negotiating table. Policymakers' are particularly demanding: § a clarification of the purposes of RNR research and its role in development; § an efficient and competitive national RNR research initiative in which public spending is well justified, and clients pay for some services and undertake some of the research; § RNR research program that is in line with the national philosophy of Gross National Happiness and sustainability; § RNR research programme that aspires to improve existing products while creating new RNR products and new uses for RNR commodities; § RNR research system that supports mainly commercial rather than subsistence clients to take their place in competitive national and global markets; § RNR research system that provides measured responses to the challenges of environmental and natural resources degradation, climate change and threatened biodiversity. The RNR Research Policy of Bhutan responds to the demand in the 10th Five Year Plan and beyond to determine the progress that the research system has made in meeting the objectives set forth in these new areas, and to provide guidance on the management and conduct of RNR research.

	In doing so, the policy focuses on new ways to coordinate, prioritize, plan and programme, organize, finance, manage and implement RNR research to prepare the system and its clients for the challenges of the 21st century.

POLICY: Name of Policy	**National Irrigation Policy**
Date Effective:	NA
Date Ended:	-
Unit:	**CC**
Country:	Bhutan
Year:	1992
Policy Status:	In force
Agency:	Department of Agriculture, Ministry of Agriculture and Forests
Policy Type:	-
Policy Target:	-
URL:	Hard and soft copies available with Department of Agriculture, Ministry of Agriculture and Forests
Description:	The National Irrigation Policy has been framed in order to lay the foundation for a sustainable approach to irrigation development through the effective participation of the Water Users. The Policy covers the whole process of irrigation development, beginning with selection through to operation and maintenance, lays down procedures for Government assistance conducive to establishing sustainable irrigation development. The fundamental proposition of the Policy is that farmers should take on responsibility for operation and maintenance with a sense of community ownership of the system. For this, the approach underlying all stages of development will be participatory, or rather farmer-centered and the initiative of the premise of the policy remains with farmers with supports from Government. The policy requires water beneficiaries associate themselves in an organization as Water User Association, an autonomous organization. The policy deals with new construction and rehabilitation of schemes, which have no previous assistance provided under the terms of the policy.

POLICY: Name of Policy	**The Road Act of the Kingdom of Bhutan**
Date Effective:	2004
Date Ended:	-
Unit:	**CC**
Country:	Bhutan
Year:	2004
Policy Status:	**In force**
Agency:	Department of Roads, Ministry of Works and Human Settlement, Royal Government of Bhutan.
Policy Type:	-
Policy Target:	-
URL:	www.dor.gov.bt/Publication/**Road**%20Act.pdf (accessed on 28 August, 2012)
Description:	This Act establishes powers and responsibilities of various agencies for road planning, design, construction and maintenance at the central, dzongkhag, geog and municipal levels. The Act also provides the framework for setting technical standards and requirements for road construction and maintenance. Section 4(1)(h) gives the Department of Roads (DoR) the mandate to adopt and promote environment friendly road construction (EFRC) techniques. Section 7(2) requires that all road construction and maintenance works conform to environmental considerations, geological stability considerations and preservation of agricultural lands.
POLICY: Name of Policy	Environmental Assessment Act of Bhutan
Date Effective:	2000
Date Ended:	-
Unit:	CC
Country:	Bhutan
Year:	2000

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Policy Status:	In force
Agency:	National Environment Commission, Royal Government of Bhutan.
Policy Type:	-
Policy Target:	-
URL:	www.nec.gov.bt/clearance/EAdoc/EA%20Act%202000.pdf (accessed on 28 August, 2012)
	The Act requires that environmental concerns are fully taken into account when formulating, renewing, modifying and implementing any policy, plan or program as per regulations that may be adopted within the appropriate provision of the Act. It makes environmental clearance mandatory for any project or activity that may have adverse impact on the environment, and is especially applicable to projects that concern infrastructure development and natural resource use such as roads, hydropower, mines and industries, where land degradation and pollution concerns are generally considerable. To support implementation of the legislation, environmental assessment guidelines are in place for key sectors, including roads.