Government of Nepal
Ministry of Forests and Environment

TECHNOLOGY NEEDS ASSESSEMENT FOR CLIMATE CHANGE ADAPTATION

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Technology Needs Assessment for Adaptation Technologies

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FOREWORD

Nepal is vulnerable to climate change. The rise in climate extreme events has already had an impact on the country's development gains. Several scientific findings predicted that the country would experience more intense impact of extreme events in the future, necessitating concrete climate change action.

In response to climate change, as a party to the United Nations Framework Convention on Climate Change, Nepal has undertaken several initiatives to ensure that our development pathway is resilient to climate change impacts. Nepal's National Climate Change Policy 2019 aimed to create a climate-resilient society by integrating adaptation and mitigation actions in vulnerable sectors. Nepal also developed a comprehensive National Adaptation Programme of Action (NAPA) that prioritized urgent and immediate adaptation actions in the country. This was supplemented by a framework on Local Adaptation Plans for Action, which paved the way for the country to localize climate change adaptation. Nepal is currently advancing its National Adaptation Plan process, which will define the country's medium- and long-term adaptation needs.

Adaptation to climate change impacts is a priority for Nepal which is well articulated in various policy instruments. Determining a suite of adaptation actions, however, poses a challenge given the country's limited knowledge of climate science, vulnerability, and risks. Regardless, identifying and/or implementing a set of innovative adaptive measures will aid in effectively addressing climate risks. In this regard, through a consultative process involving multiple stakeholders, promising adaptation technologies for the water, agriculture, and public health sectors in Nepal were identified. These technologies have the potential to reduce the negative effects of climate change in the short and long term, as well as contribute to climate-resilient development planning.

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Nepal is one of the world's most vulnerable countries to climate change, and adaptation actions are critical for minimizing climate change vulnerability. Nepal is already experiencing recurring climate-related disasters that are wreaking havoc on the country's socio-economic prosperity. In this regard, Nepal has developed appropriate policy and institutional mechanisms to incorporate innovative adaptation measures and technologies for responding to and adapting to the negative effects of climate change.

I anticipate that the Technology Needs Assessment for Climate Change Adaptation developed by the Ministry of Forests and Environment (MoFE), Government of Nepal, with assistance from the Global Environment Facility and the United Nations Environment Programme, will provide an opportunity to introduce, implement, and communicate prioritized adaptation technologies in a variety of sectors, including water, agriculture, and forestry.

I believe that implementing these prioritized adaptation technologies is appropriate for implementing climate-resilient development approaches at the local, provincial, and federal levels to reduce vulnerabilities and foster climate-resilient development. These prioritized adaptation technologies are the result of a rigorous consultative process at the national level with relevant stakeholders and experts.

I believe that adopting these technologies will improve the country's ability to adapt to the effects of climate change. As part of the Government of Nepal's efforts to ensure a climate-resilient society, I anticipate that national and international development partners will step in to provide financial and technical support to promote prioritized technologies. I would like to thank the member of the Technology Needs Assessment team who carried out this assessment on behalf of the Ministry of Forests and Environment. I am grateful to Climate Change Management Division Colleagues Dr. Arun Prakash Bhatta, Mr. Raju Sapkota, Ms. Srijana Shrestha, Ms. Shreejana Bhusal, Ms. Muna Neupane, Mr. Yam Prasad Pokharel, Mr. Ram Prasad Awasthi, Mr. Narayan Raymajhi, Mr. Som Nath Goutam, and Mr. Hari Krishna Laudari for their valuable inputs.

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ABBREVIATIONS

AFOLU	Agriculture, Forestry and Other Land Use
AIT	Asian Institute of Technology
Bt	*Bacillus thuringiensis*
Bti	*Bacillus israelensis*
CBS	Central Bureau of Statistics
CCMD	Climate Change Management Division
CDD	Consecutive Dry Days
CH4	Methane
CL	Confidence Level
CLOF	Cloud Outburst Flood
CO_2	Carbon Dioxide
CO_2 -eq	Carbon Dioxide Equivalent
COP	Conference of Parties
CRI	Climate Risk Index
CWD	Consecutive Wet Days
DoFRS	Department of Forest Research and Survey
DHM	Department of Hydrology and Meteorology
DoHS	Department of Health Services
EPA	Environment Protection Council
EST	Environmentally Sound Technology
FCHV	Female Community Health Volunteer
GDP	Gross Domestic Product
GEF	Global Environment Facility
GESI	Gender and Social Inclusion
Gg	Giga Tonnes
GHG	Greenhouse Gas
GLOFs	Glacial Lake Outburst Floods
GoN	Government of Nepal
HFC	Hydrofluorocarbon
HKH	Hindu Kush Himalayas
ICIMOD	International Center for Integrated Mountain Development
IMCCCC	Inter-Ministerial Climate Change Coordination Committee
IPCC	Intergovernmental Panel on Climate Change
JE	Japanese Encephalitis
KP	Kyoto Protocol
LAPA	Local Adaptation Plans for Action
LDOF	Landslide Dam outburst Flood
LULUCF	Land use, Land-use change and Forestry
MCCICC	Multi-stakeholder Climate Change Initiative Coordination Committee

MCDA	Multi-Criteria Decision Analysis
MoALD	Ministry of Agricultural Development
MoE	Ministry of Environment
MoEST	Ministry of Environment, Science and Technology
MoF	Ministry of Finance
MoFALD	Ministry of Federal Affairs and Local Development
MoFE	Ministry of Forests and Environment
MoHA	Ministry of Home Affairs
MoPE	Ministry of Population and Environment
MoST	Ministry of Science and Technology
MoSTE	Ministry of Science, Technology and Environment
MT	Metric Tonnes
N_2O	Nitrous Oxide
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NCCP	National Climate Change Policy
NDC	Nationally Determined Contribution
NEOC	National Emergency Operation Center
NHRC	Nepal Health Research Council
NPC	National Planning Commission
NTFPs	Non-Timber Forest Products
^oC	Degree Celsius
PC4	Provincial Climate Change Coordination Committee
PHC	Primary Health Care
PMU	Project Management Unit
RCP	Representative Concentration Pathways
RWH	Rain Water Harvesting
SDGs	Sustainable Development Goals
TNA	Technology Needs Assessment
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
US$	United States Dollar
USAID	United States Agency for International Development
VL	Visceral leishmaniasis
WECS	Water and Energy Commission Secretariat
WHO	World Health Organization

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EXECUTIVE SUMMARY

Nepal is experiencing warmer climate than before with maximum temperature increasing at higher rate than minimum temperature. Days and nights are getting warmer every year with fewer occurrences of cool days and cool nights. Annual Maximum Temperature is in increasing trend in the higher altitude than in the plains. Similarly, variation in the precipitation pattern is also observed with ever increasing intensity of precipitation while the number of rainy days is decreasing. Escalation of consecutive dry days is also clearly seen which signifies the extension of drought periods while the increasing very wet days symbols towards higher chances of landslides and floods. With the increasing impacts, the country is ranked as one of the most vulnerable to climate change indicating the need for assertive actions on climate change.

The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol envisage the need for development and transfer of environmentally sound technologies to developing countries in order to enable these countries to achieve progress in their development whilst limiting their greenhouse gas emissions and adapting to the impacts of climate change. The Government of Nepal, Ministry of Forests and Environment with the support of the United Nations Environment Programme acting as the Implementing Agency of the Global Environment Facility is preparing the Technology Needs Assessment as a part of the activities included in the UNFCCC and this report is part of it.

In Nepal the introduction and dissemination of new technologies is crucial in reducing the effects of climate change and in fostering climate resilience. Lack of appropriate technology and financial resources seriously impede Nepal's ability to implement adaptation options by limiting the range of possible responses. Adaptive capacity is likely to vary, depending on availability and access to technology at various levels - from local to national and in all sectors. There is a critical and urgent need to provide access to technology for adaptation at the regional, national, and local level, enabled by capacity-building and provision of new and additional funding to meet the costs of both integration of adaptation into the development process and stand-alone adaptation activities.

In an endeavor to identify and prioritize environmentally sound technologies that are in line with the social, economic and environmental development priorities of Nepal, stakeholder driven Technology Needs Assessment (TNA) was carried out. The overall process of TNA was set to prepare a detailed and representative description of portfolios of prioritized technologies that can contribute to achieve adaptation goals of the country and maximize the climate resilience of the people while identifying the barriers hindering the acquisition, deployment, and diffusion of prioritized technologies. Various stakeholders' workshops were organized which involved national experts from different governmental and non-governmental agencies. This led us to prepare the portfolios of technologies which included hardcore technologies from simple to advance along with other local management practices.

Stakeholder's workshop on sector prioritization finalized three sectors as the most vulnerable and highest priority to meet the immediate needs of the people and nation. They were water resources, agriculture and public health. Portfolio of technologies were prepared for each sector and preliminary short listing of the technologies was performed to screen the most potential technologies that behold the issues and concerns of the national development priorities and has potential to reduce climate change vulnerability. Thus, technology fact sheets were prepared and shared with the stakeholders in Stakeholders' workshop on technology prioritization. The following criteria were accepted after consultation process for prioritizing the technologies:

- Contribution to environmental development priorities
- Contribution to social development priorities
- Contribution to economic development priorities
- Ease of implementation
- Potential to maximize resilience of the sector

The criteria were listed after thorough desk research and then presented to the experts for further consultation and identifying the important and crucial development priorities. The technologies were scored and further weighted based on MCDA approach. Number of experts were involved in each sector for prioritization. The result was shared among the stakeholders and it was unanimously accepted. Finally, sensitivity analysis was performed to evaluate the outcomes of the technology prioritization workshop and as a result, following technologies were prioritized under Technology Needs Assessment:

S.N.	Sector / Technology	Availability/ Scale
1.	Water Resources Sector	
	Sprinkler irrigation	Short-term/small-scale
	Flood forecasting and warning	Short-term/medium-scale
2.	Agriculture Sector	
	Minimum tillage	Short-term/small-scale
	Organic Nutrient Management	Short-term/small-scale
3.	Public Health Sector	
	Drinking Water Quality Surveillance	Short-term/small-scale
	Bti	Short-term/small-scale

Although, the technologies listed above are based on the stakeholder consultation carried out during 2012/13, these are still relevant to the current climatic context of Nepal as the report has been updated as per the federal governance and recent national policies.

CHAPTER 1: INTRODUCTION

1.1 About the Technology Needs Assessment (TNA) Project

Nepal's economy largely depends on sectors such as agriculture and forestry, tourism, and water resources that are particularly vulnerable to environmental changes. Among such changes, climate change emerges as one of the most challenging threats that has repercussions on national development efforts and its economic base. Despite having only 0.4 percent of the total global population and being responsible for only 0.056 percent of total global GHG emissions in 2010/11 (MoFE, 2021), Nepal is disproportionately affected by climate change impacts.

Climate change is expected to result in increased frequency and severity of droughts, floods and other extreme weather events adding to stress on water resources, food security, health, infrastructure, and in overall development of the country. Thus, adapting to the changing climate has become fundamental to safeguard the climate vulnerable communities and ecosystems in Nepal.

The effects of climate change are observed and noticed in different key economic sectors of the country. The magnitude and intensity of disaster events are found increasing over the years and taking a toll of lives and damaging huge swaths of properties across the country. Impacts of climate change have been observed in the country's Gross Domestic Product (GDP) as well. An estimated direct costs of climate variability are found to be equivalent to 1.5-2.0 percent of Gross Domestic Product (GDP) per year in Nepal based on 2013 prices (MoSTE, 2014a).

Adapting to climate change requires finance and technology. Documentation of local/international technologies and innovation on natural resource management and improvement on these innovations and technologies through participatory approach is imperative while adapting to climate change. In line with this, the United Nations Framework Convention on Climate Change (UNFCCC) in its articles have specifically outlined the need of technology development and transfer more comprehensively. Article 4.5 of the UNFCCC identifies technology transfer as a key mechanism for addressing climate change, and requires developed countries to support technology development and utilization in developing countries. In order to operationalize Article 4.5, Parties agreed to introduce a mechanism known as Technology Needs Assessment (TNA) for climate change. Over the years, the importance of TNA was emphasized at various Conferences of Parties (COPs) of the UNFCCC. At COP 7 in Marrakech, November 2001, the international community took the decision to encourage developing country Parties "to undertake assessments of country-specific technology needs, subject to the provision of resources, as appropriate to country-specific circumstances". The COP 13 (Bali, December 2007) further reinforced the importance of TNA. The Bali Plan of Action, an outcome of COP 13, emphasized enhanced actions and provision of financial resources to enable technology development and transfer. At COP 14 (Poznan, December 2008), the Poznan 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. At the

COP 15 (Copenhagen, December 2009) the future establishment of a Technology Mechanism was suggested "…to accelerate technology development and transfer in support of action on adaptation and mitigation that will be guided by a country-driven approach and be based on national circumstances and priorities". The Paris Agreement speaks of the vision of fully realizing technology development and transfer for both improving resilience to climate change and reducing GHG emissions. It establishes a technology framework (Article 10, Para 4) to provide overarching guidance to the Technology Mechanism.

Enhanced mitigation and adaptation roadmap under the UNFCCC require acceleration in the development, deployment, adoption, diffusion, and transfer of environmentally sound technologies among all Parties, particularly from Annex II Parties to non-Annex I Parties, in order to avoid the lock-in effects of non-environmentally sound technologies on developing countries. Mitigation and adaptation are integral components of combating climate change and should be given equal treatment. Compared with mitigation, which is an arduous task to be implemented over a longer time horizon, the need for adaptation is more real and urgent to Nepal.

Concurrent with the growing international impetus on developing and using technologies for mitigation of, and adaptation to climate change, Nepal, as a party to the UNFCCC, Kyoto Protocol and Paris Agreement, and adhering to the international processes and mechanisms, initiated a process of preparing a Technology Need Assessment Report for the country in 2009. The TNA was undertaken in order to identify, evaluate and prioritize technology means for adaptation and prepare action plan that will enable to achieve development equity and environmental sustainability, and to follow climate resilient development pathway.

The Government of Nepal, Ministry of Forests and Environment (MoFE) with the support of the United Nations Environment Programme (UNEP) acting as the Implementing Agency (IA) of the Global Environment Facility (GEF) has prepared the Technology Needs Assessment (TNA) as part of the activities included in the United Nations Framework Convention on Climate Change.

1.1.1 National Circumstance on Climate Change

Nepal's Initial National Communication was submitted to the UNFCCC in 2014. The inventory was undertaken for the base year 1994/95 which reveals a net GHG emissions of 39265 Gg CO_2-eq. Agriculture sector was found to be the largest emitter (69.3%), followed by LULUCF (20.6%). For the Second National Communication, the inventory was undertaken for the base year 2000/01 which reveals that 13447 Gg CO_2-eq was emitted from Nepal. The third GHG inventory suggests a net GHG emissions of 28166.06 Gg CO_2-eq from Nepal in the base year 2010/11 (MoFE, 2021).

Table 1: Greenhouse Gas Source and Sink of Direct Gases in 2010/11 (in Gg)

Sector, Sub-sectors	Emission/Sink of Direct Gas (Gg)				
	CO_2	CH_4	N_2O	HFC*	CO_2-eq
TOTAL	**-11195.02**	**1259.61**	**26.37**	**0.01**	**28166.06**
1 Energy	**4678.22**	**354.9**	**4.03**	0	**14751.66**
- Energy Industries	2.38	0	0		2.38
- Manufacturing Industries and Construction	2237.34	0.04	0.06		2256.22
- Transport	1708.92	0.27	0.08		1739.51
- Others (Commercial/Institutional, Residential, Agricultural)	729.58	354.59	3.89		10753.55
2 Industrial Processes and Product Use	**355.4**		**0**	**0.01**	**368.4**
3 AFOLU	**-16231.43**	**882.36**	**21.12**		**12121.33**
- Livestock		705.49	0.09		17664.07
- Land (Forest)	-17077.81				-17077.81
- Land (Non-forest)	35.39				35.39
- Aggregate Sources and Non-CO2 Emissions Sources on Land (3C)	810.99	176.87	21.03		11499.68
4 Waste	**2.36**	**22.35**	**1.22**		**924.67**
Memo Items					
International Bunker	**172.51**				
Biomass Combustion for Energy Production	**23,499**				

(Source: Nepal's Third National Communication to the UNFCCC, 2021)

With regards to temperature, the analysis of trends from 1971 to 2014 shows that the country is witnessing an increase in average annual maximum temperature by 0.056ºC. In addition, the annual precipitation trend in majority of high mountain districts is decreasing with higher rate in the east. Among five physiographic regions, precipitation is in decreasing trend mainly in High Mountains and High Himalayas in all the seasons (DHM, 2017). In terms of extreme indices, the precipitation extremes are found to be increasing (Karki, et al., 2017). Furthermore, the climate change scenarios suggest that average annual precipitation will increase by 2-6 percent by 2030 and by up to 12 percent by 2050. It is expected that the precipitation will increase in all seasons, except the pre-monsoon season, which is likely to see a decrease of 4-5 percent by 2030. The projections indicate that the mean annual temperatures could increase by 1.3-1.8°C by the 2050s, with the highest increases in the high mountain regions followed by Tarai. Along with this, an increase in warm days and nights and decrease in cold days and nights are predicted. Extremes are also expected to occur more frequently, with an increase in very wet and extremely wet days (MoFE, 2018a).

Climate change in Nepal is already leading to an erratic weather patterns, unpredictable rains, reduced snowfall at high altitudes, and recurrent droughts. The Hindu Kush Himalaya Assessment Report by International Centre for Integrated Mountain Development (ICIMOD) states the impacts of climate change could be far worse if global efforts to curb climate change fails. Furthermore, the report shows that even if global warming was limited to 1.5°C by 2100, there would be a 1.8°C rise in temperature in other parts of the world and up to 2.2°C in the mountains due to elevation dependent warming, a phenomenon where mountains experience rapid changes with rise in temperature. In addition to this, it states that Himalayas could lose two-thirds of their glaciers by 2100 affecting more than 240 million people that depend directly on the Hindu Kush Himalayas (HKH) for their lives and livelihoods (Wester et al., 2019).

Climate change is a global phenomenon and not a single sector is aloof from its severe impacts; however, the degree of impact is not proportionally distributed across all the sectors such as agriculture, water resources, forest and biodiversity, human health, disasters and others. Agriculture is the most important sector in Nepalese economy as it is the major source of income (almost 35% of GDP) and employment (more than 60% of economically active population). Agricultural land occupies 28 percent of the total land area of Nepal (of which 21% is cultivated and 7% uncultivated); forest area is about 40 percent and pasture cover 12 percent (CBS, 2013). However, a recent study by FRTC (2019) revealed that cultivated land occupies 21.88 percent of total land. This indicates the recent increment in crop land area in Nepal. Cultivation practices in about 40 percent of the arable land is dependent on rainfall which is largely dependent on the weather condition and this already provides the glimpse on the severity of climate change impacts on costs of production, farm revenues, income, consumption and GDP.

Climate change has increased vulnerability on forests and biodiversity as well. Increased variability and timing of precipitation, and rise in temperature have profound impact on the entire forest ecosystem. Change in flowering and fruiting season, reduced availability of NTFPs, less grass and forest fire are already evident in many parts of the country.

The changing climate has serious health impacts due to incidences of heat waves and cold waves. The records of heat stroke, heat rash, bronchitis, Japanese encephalitis, malaria and Kala-azar show the evidence of the climate change. Similarly, Nepal is prone to multitude of climate-induced disasters such as floods, flash floods, glacial lake outburst floods and landslides. The severity of these disasters is likely to increase as the extreme precipitation is increasing and this will ultimately lead to considerable increase in the vulnerability of the communities. Despite impacts of climate change in every sector, agriculture, water resources and health are the national priority sectors facing higher consequences due to climate change.

1.2 Existing national policies on climate change adaptation and development priorities

Climate Change Initiatives in Nepal

Nepal’s vulnerability to climate change impacts-combined with high levels of poverty and inequality has driven climate change adaptation as a key priority for the government of Nepal

(MoFE, 2020). Consequently, the government of Nepal established dedicated institutions and introduced and implemented policies, strategies and programs that support, promote and facilitate climate change adaptation at national and sub-national levels.

After the ratification of the UNFCCC on May 2, 1994 and its entry into force on July 31, 1994, Nepal paved the way towards addressing climate change impacts in the country by establishing the Environment Protection Council 1992 and Nepal Environmental Policy and Action Plan 1993. Along the way, Nepal formulated Environment Protection Act 1996 and Environment Protection Rules 1997 as a precursors of climate change policies, which were updated and revised in 2019 following the new governance structure of the country. Under Chapter 4 of the Environment Protection Act 2019, the climate change concerns are reflected which are related to providing information on climate change impacts and risk on the communities and ecosystems; development and implementation of adaptation plans by the federal, provincial and local governments, implementation of mitigation actions, climate change impact and risk management and carbon trade. This embarks the legal entitlement of the climate change issues in Nepal.

Since 2002, the Government of Nepal recognized climate change as an emerging issue when the 10th Plan (2002-2007) acknowledged the influence of weather on overall economic performance (Agrawala et al., 2003). In 2004, Nepal prepared its Initial National Communication that provided an overview of the national circumstances on climate change including that of national greenhouse gas emission inventory, vulnerability, impact and adaptation.

Institutionalizing of climate change agenda started in 2009, when the Climate Change Council, headed by the Prime Minister, was established for high-level coordination and policy guidance on climate change in the country. Climate change agenda was on highest national priority as reflected in country's action. The country organized Cabinet Meeting at the base of the Mount Everest, Kalapathhar to garner support and raise awareness on the importance of the mountains as well as vulnerability of least developed countries like Nepal in a rapidly changing climate. In 2010, Nepal established the Climate Change Management Division within the Ministry of Science, Technology and Environment so as to coordinate the climate change related initiatives in Nepal. The Adaptation Section is one among five sections within this division that undertakes adaptation related work. In the same year, the country endorsed the National Adaptation Programme of Action (NAPA) and started implementing adaptation actions at the local level. The Multi-Stakeholder Climate Change Initiative Coordination Committee was also formed as a platform for involvement of multiple stakeholders in climate action. As part of supporting in the NAPA implementation, Nepal introduced a novel initiative of localizing climate change adaptation through the Local Adaptation Plans for Action (LAPA) framework in the year 2012. Furthermore, Nepal's readiness to address climate change amplified after the introduction of the climate change budget code in 2013. This initiative aimed to identify climate change related financing, based on a system using three indicators as highly relevant, relevant and neutral. Alongside these policy processes, Nepal started several adaptation projects in the country through the funding support from bilateral and multilateral organizations. In October 2016, Nepal submitted its Nationally Determined Contribution (NDC) with elements of adaptation and mitigation incorporated into the document which was revised and updated in the year 2020 with specific targets on climate change adaptation along with mitigation. Furthermore, Nepal started the National Adaptation Plan formulation process in 2016 to identify the medium-and long-term adaptation needs of the country, which is still ongoing at present. In 2017, Nepal produced a report on 'Sustainable Development Goals: Status and Roadmap for 2016 to 2030 highlighting the major issues and challenges that the country needs to reckon within pursuit of the SDGs. The report has identified several indicators as part of achieving the targets under Goal 13 of the Sustainable Development Goals, which focuses on climate action. By 2030, the country is targeting to have climate change adaptation plans developed and implemented in 120 Rural Municipalities, while also developing 170 climate smart villages, 500 climate smart agriculture farms and climate change curricula in all the schools of Nepal (NPC, 2017).

After the promulgation of the new constitution in 2015 and the starting of federal governance system in Nepal, the government realized the need for revision and amendment of policy instruments to suit the new governance structure. Accordingly, the revision process started. In the year 2019, Nepal updated its climate change policy which aim to 'contribute to the socio-economic development of the country by building resilience of social, economic and ecological systems through integrated planning of climate change adaptation and mitigation actions (MoFE, 2019). The policy has identified Agriculture and Food Security, Forests, Biodiversity and Watersheds, Water Resources and Energy, Rural and Urban Settlements, Industry, Transport and Physical Infrastructures, Tourism, Natural and Cultural Heritage, Water, Sanitation and Hygiene and Disaster Risk Reduction and Management as a major thematic area. Climate Finance, Gender and Social Inclusion, Awareness and Capacity Building and Research, Technology Development and Promotion are cross cutting themes of the policy.

The 15th Plan produced in 2019 is considered as a foundation plan to achieve the long-term vision *Prosperous Nepal, Happy Nepali* and considers climate change as important issue for Nepal to achieve the long-term vision. Therefore, the 15th Plan includes a separate section on climate change, which outlines a vision to develop a climate resilient society through increasing adaptive capacity and mitigating the negative impacts of climate change. The plan also put forward the following objectives:

- Reduce the impacts of climate change as per the Paris Agreement and build adaptive capacity
- Implement environment friendly, clean energy and green development concept for climate change mitigation
- Access available international finance and technology through the mechanisms under the Paris Agreement for climate change mitigation and adaptation and distribute the funds equitably.

Further to bolster the coordination on climate change in the country and at all levels of government, the country has established different coordination mechanism in 2020. At the federal level, an Inter-Ministerial Climate Change Coordination Committee was established to effectively coordinate on climate change issues across sectors and ministries which is chaired by the Ministry of Forests and Environment. At the Province level, a Provincial Climate Change Coordination Committee is established to steer and guide climate change issues and activities among different stakeholders.

The table below summarizes key policy initiatives of government of Nepal in response to climate change:

Table 2: Climate Change Policy Initiatives

Policy Initiatives	Focus
National Adaptation Programme of Action (NAPA), 2010	The NAPA identified nine urgent and immediate climate change adaptation priority programmes related to six thematic sectors (agriculture, forest biodiversity, water resources, health, infrastructure, and disaster). The first comprehensive government response to climate change, the NAPA also specified a coordination mechanism and implementation modality for climate change adaptation programmes in Nepal.
National Framework for Local Adaptation Plans for Action (LAPA), 2011	The LAPA framework was developed by the Government of Nepal as an operational instrument to implement NAPA prioritized adaptation actions. Its goal is to integrate climate adaptation and resilience into local and national planning, and to incorporate the four guiding principles of being bottom-up, inclusive, responsive and flexible. The aim of the LAPA is to integrate climate adaptation activities into local and national development planning processes, and to make development more climate-resilient.
Climate Resilient Planning Tool, 2011	The National Planning Commission (NPC) developed a climate resilience framework to guide the country in implementing development plans. It recommends methods, tools and approaches for guiding climate-resilient planning.
Climate Change Budget Code, 2013	The budget code is developed in accordance with the 11 criteria identified to assess whether the budget is directly, indirectly or neutral to climate change.
National Adaptation Plan, 2016 (ongoing)	NAP in Nepal is being formulated to reduce vulnerability to the impacts of climate change by building adaptive capacity and resilience; and facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programmes and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate. NAP will identify adaptation and resilience milestone to be achieved in the short-term (by 2025), medium-term (by 2030) and long-term (by 2050).

Sustainable Development Goals Status and Roadmap: 2016-2030	The roadmap proposed key actions to strengthen resilience and adaptive capacity to climate- related hazards and natural disaster such as to have climate change adaptation plan, put forward the idea of climate smart villages and climate smart farming as well as climate change education in schools.
Environment Protection Act, 2019	The Environment Protection Act (EPA) incorporated the provisions related to climate change in Chapter 4 which legalize the periodic study and assessment of climate change impacts in the country and prepare adaptation plan thereof by the federal, provincial and local government on the need basis. Additionally, among other, the act provides a basis for enactment of necessary policies and technical standards for the development of technology in the sectors identified.
15th Plan (2019/20-2023/24)	The plan considered conservation and promotion of natural and resilient development as one national strategy whereas climate change is considered as one of the cross-cutting sectors with a vision to develop a climate resilient society through building climate change adaptive capacity and reducing the negative impacts of climate change
National Climate Change Policy, 2019	The goal of this Policy is to make contribution to socio-economic prosperity of the nation by building a climate resilient society. This Policy has the following objectives: a) Enhance climate change adaptation capacity of persons, families, groups and communities vulnerable to and at risk of climate change. b) Build resilience of ecosystems that are at risk of adverse climate change impacts. c) Promote green economy by adopting the concept of Low Carbon Emission Development. d) Make judicious mobilization of international financial resources for climate change adaptation and mitigation. e) Make research, technology development and information service delivery related to climate change effective. f) Integrate the climate change issues into policies, strategies, plans and programs of all State levels and clusters. g) Mainstream gender equality and social inclusion (GESI) into climate change adaptation and mitigation programs.
Second Nationally Determined Contribution, 2020	The Second Nationally Determined Contribution (SNDC) target to have climate-resilient and gender-responsive adaptation plans in all the 753 local governments by 2030. Furthermore, the SNDC has specifically outlined the timeline for the NAP update (every 10 years) and National level vulnerability and risk assessment (every 5 years). Additionally, a national strategy and action plan on Loss and Damage (L&D) associated with climate change impacts is expected to prepare by 2025 under the SNDC adaptation targets.

Technology Development and Transfer in the National Climate Change Policy 2019

The National Climate Change Policy, 2019 has identified ‘Research, Technology Development and Expansion’ as one of the cross-cutting themes and has outlined a policy as ‘climate change related study, research and technology development and expansion will be encouraged’ To implement this policy thirteen strategies and working policies were put forwarded among which four strategies are directly related to the technology development. These are:

(a) Development and use of climate-friendly traditional and nature-based technologies will be promoted.
(b) Technologies will be developed for reduction of black carbon and greenhouse gas emission induced by water, land and air pollutions.
(c) Emphasis will be laid on the participation of private sector to carry out research and technology development related to climate change adaptation and mitigation.
(d) Technology development action plan will be prepared and implemented by carrying out need assessment of technologies related to climate change adaptation and mitigation.

CHAPTER 2: INSTITUTIONAL ARRANGEMENT FOR THE TNA AND STAKEHOLDERS' INVOLVEMENT

2.1 National TNA team

The MoFE is the focal point to the UNFCCC and several other multilateral environmental agreements. The main aims of the Ministry are i) promote the sustainable development, ii) protect the natural environment, iii) create the clean and Healthy environment through conserving the life-support elements, iv) help to attain the goal of poverty alleviation through environment related research activities, v) encourage the involvement of intellectuals creating opportunities to contribute to environment protection and promotion and vi) coordinate and implement the adaptation and mitigation related projects to minimize the negative impacts of climate change.

To achieve the mentioned aim, the Ministry is supported by the Environment Protection and Climate Change Management National Council envisioned by the Environment Protection Act 2019, under the chairmanship of Right Honorable Prime Minister, one vice-chair and 17 other members as shown in Table 3. The Council is responsible for providing high level coordination, guidance and direction, as required to the Ministry and other bodies to continue integrating matters relating to the environment and climate change into the long-term policies, plans and programs, and also provide policy guidance to the Provincial and Local levels with regards to environmental protection and climate change. It also initiates, coordinates and/or manages economic resources for environmental protection and climate change.

Table 3: Composition of the Environment Protection and Climate Change Management National Council

Right Honorable Prime Minister	Chair
Honorable Minister for Forests and Environment	Member
Three Ministers of the Government of Nepal designated by Prime Minister	Member
Honorable Chief Ministers of all the Provinces	Member
Honorable Member (Environment), National Planning Commission	Member
Two Professors (including one women) in Forests and Environmental Science	Member
Three Persons (including two women) nominated by Chairperson from among the persons with expertise in the field of forests and environment	Member
Secretary, Ministry of Forests and Environment	Member Secretary

Institutional arrangement of the TNA project

The implementation of the TNA project in Nepal involved the participation of multiple government agencies, research institutions (both public and private), and non-governmental organizations. The Figure 1 shows the institutional arrangements of the TNA project.

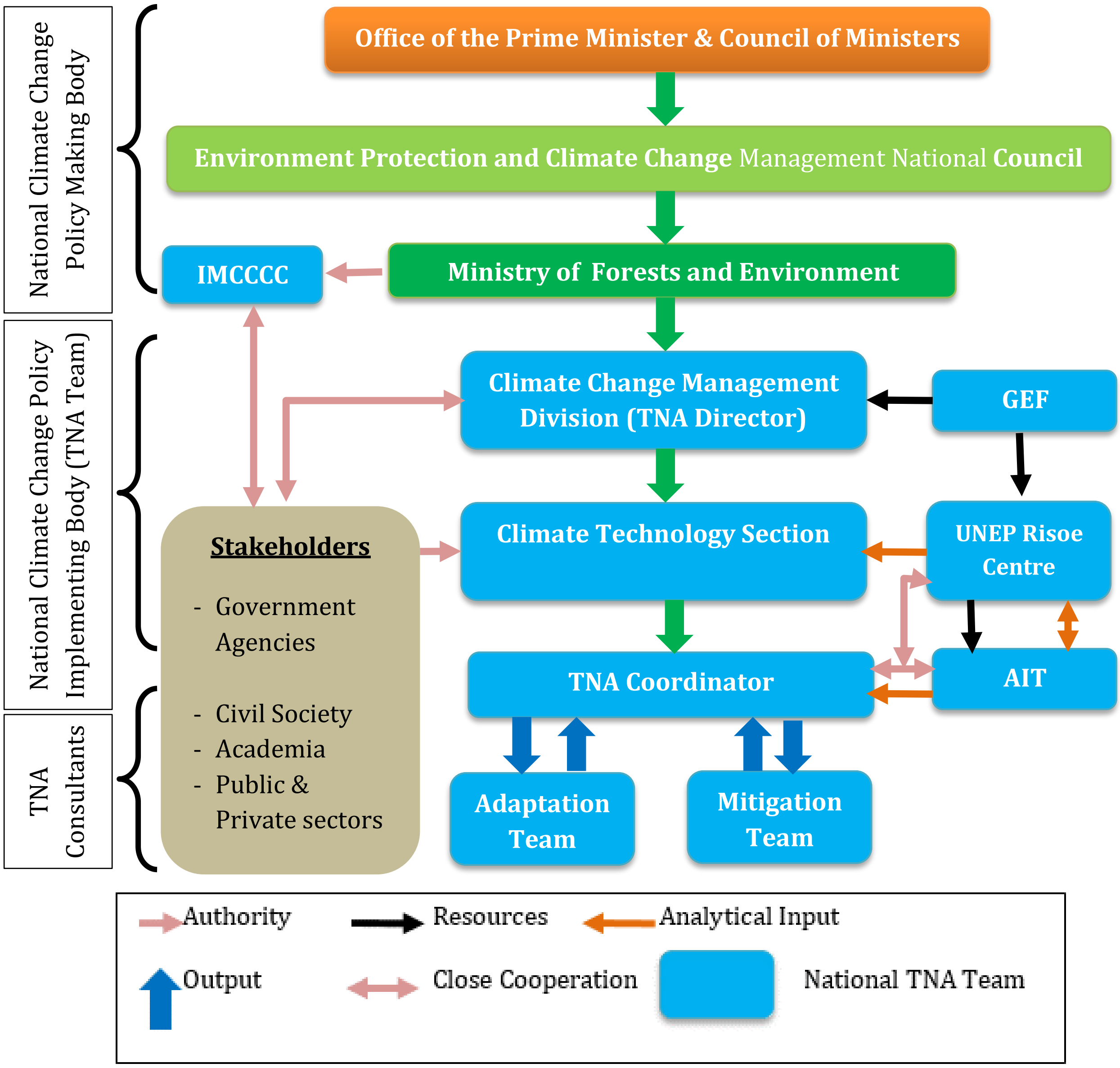

Figure 1: Institutional Arrangement of the TNA Project

The National Supervising Agency: Environmental Protection and Climate Change Management National Council.

National Coordination Institution/Executing Agency: Ministry of Forests and Environment.

Climate Change Management Division: The whole TNA process was led by Climate Change Management Division, Ministry of Forests and Environment (Previously Ministry of Science, Technology and Environment)

Project Management Unit (PMU): The PMU composed of Project Director and Project Coordinator. The supporting staffs are utilized from Second National Communication for executing the activities. The Unit is responsible for reporting the TNA progress to the Ministry, and coordinating UNEP and AIT as well.

National Project Coordinator, National TNA team and Consultants

The project is coordinated by Under Secretary (Technical) and chief of Climate Technology Section at CCMD.

The TNA Consultant Team comprised two groups of experts: mitigation and adaptation. The team included members familiar with national development objectives and sector policies, better insights in climate change science, and potential climate change impacts, adaptation needs and mitigation options of climate change technologies. The experts are from policy-making institutes and organizations with responsibility to undertake TNA activities such as research, analyses, and synthesis in support of the TNA exercise.

The cooperation of UNEP Risoe Center and AIT

UNEP Risoe Center and AIT experts provided their valuable guidance in devising the whole process of technology needs assessment. With the support of Ministry, they provided two days training to the Mitigation and Adaptation team experts in defining the whole TNA process, MCDA tool, workouts of other countries and the documents to supplement the TNA report of Nepal. Time to time communication with AIT and UNEP facilitated the progress of TNA and helped to bring the report to this shape and size. Besides, the inception workshop was supported by UNEP team.

2.2 Stakeholder Engagement Process followed in TNA

The whole TNA process envisages stakeholders as the major contributor towards the preparation of the TNA. Hence every step involved large share of consultation with the stakeholders for making valuable decisions in finalizing the report. The roster of stakeholders involves policy-making governmental agencies (the then Climate Change Council, Ministry of Irrigation, Ministry of Science, Technology and Environment, Ministry of Forest and Soil Conservation, Ministry of Agricultural Development, Ministry of Physical Planning Works, National Planning Commission, Water and Energy Commission Secretariat, National Women Council and Ministry of Home Affairs)[1], research institutes and centers (ICIMOD, Institute of Engineering, Institute of Agriculture and Animal Sciences, Department of Hydrology and Meteorology, Forest Action Nepal, College of Applied Sciences and Alternative Energy Promotion Center), and public and private organizations (National Federation of Environmental Journalist, USAID, Confederation of Nepalese Industries, Trust-Nepal, Great-Nepal, and ADB).

[1] After the promulgation of new constitution in 2015, there has been a reform in the administrative system of the government with a change in the ministry portfolio.

The PMU, National Consultant Team and stakeholders cooperated in the overall TNA process. The stakeholders were informed about the process and objectives of TNA activities in the inception workshop held in presence of UNEP official:

- ❖ The national team, after completing necessary studies (national priorities, plans, policies and strategies) and establishing appropriated marking criteria for selection of sectors and sub-sectors, consulted with PMU for stakeholder consultation in assessing the priority sectors/ sub-sectors. The findings of the national team were thus shared with all stakeholders in the prioritization workshop. The suggestions and comments were collected and incorporated in the sector prioritization report.
- ❖ PMU organized technology prioritization workshop after necessary consultation with the experts. Long list of technologies was shared among the stakeholders and thorough iterative discussion following MCDA approach, the technologies were prioritized.

Throughout the TNA process, these core bodies interacted and discussed to carry out assessment in an objective fashion in identification, assessment and selection of climate appropriate technologies. The national team received enthusiastic support from stakeholders in completing the requirement of TNA and sectoral data in meeting the objectives of TNA.

2.3 Scope and Limitation of the Report:

The report was prepared during 2012/13 through a consultative process involving various stakeholders in identifying the adaptation technologies in the prioritized sectors viz. water resources, agriculture and public health. Though the report has been prepared long ago, the report could not be published earlier due to some administrative reasons. Now, after undergoing a revision and making necessary changes considering a current climate change context of the country, the report has been finalized. The adaptation technologies that are identified in the report are based on the consultations from that period. However, these technologies are still relevant and applicable in the current climatic context.

CHAPTER 3: SECTOR SELECTION

3.1 An overview of expected climate change and impacts, sectors vulnerable to climate change

The state of the current and projected circumstances of climate change in Nepal, an overview of the sectors that are identified by the National Climate Change Policy 2019 as vulnerable sectors to changing climate is presented below.

3.1.1 Current Climatic Variability

Temperature Trend[2]:

All Nepal maximum temperature analysis shows positive trend of 0.056oC per year. Maximum temperature trend is significantly positive for all seasons, except in Tarai in winter season. The highest significant positive trend (0.12oC/yr) is found in winter season in Manang district.

All Nepal annual minimum temperature trend is also positive (0.002°C/yr). Seasonal and annual minimum temperature trends, though majority are insignificant both at district and physiographic levels, shows positive trends in lower elevation and negative in the higher elevation. At the district level, significantly highest positive trend (0.046°C/yr) is observed in Dolpa district in monsoon and significantly highest negative trend (-0.076°C/yr) in Humla district in winter.

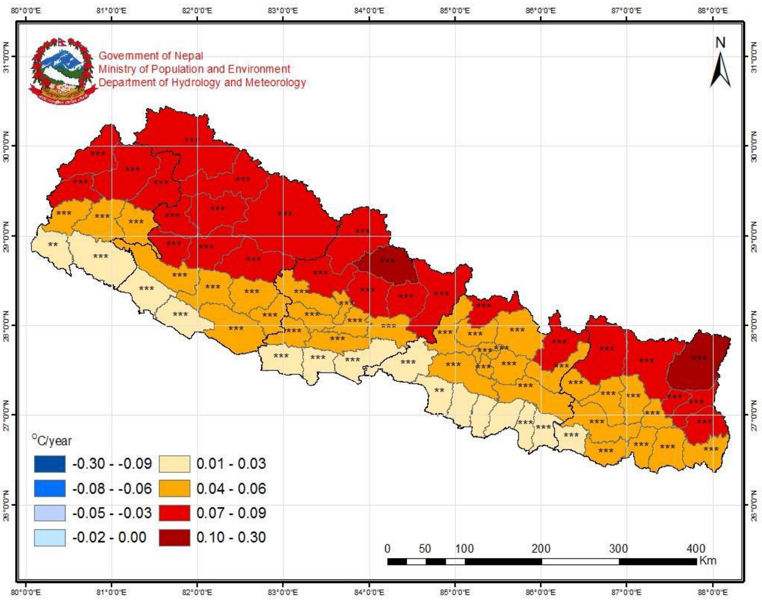

Figure 2: Annual maximum temperature trends in the districts of Nepal

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[2] The information on Climate Variability is sourced from the report published by Department of Hydrology and Meteorology in 2017.

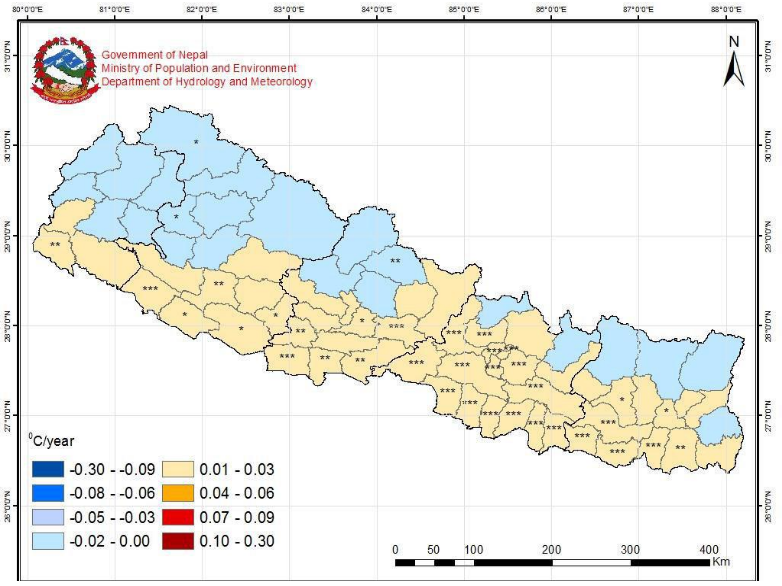

Figure 3 Annual minimum temperature trends in the districts of Nepal

Precipitation Trend:

Annual precipitation is decreasing in majority of high mountain districts with higher rate in the east. Among five physiographic regions, precipitation is in decreasing trend mainly in High Mountains and High Himalayas in all the seasons. The pre-monsoon and monsoon precipitation show significant trends only in few districts while winter and post-monsoon precipitation trends are insignificant in most of the districts. The highest significant positive monsoon precipitation trend is observed in Syangja (9.0 mm/yr). The winter precipitation trend shows increasing trend in Tarai, Siwalik and middle mountains while it is in decreasing trend in High Mountains and Himalayas.

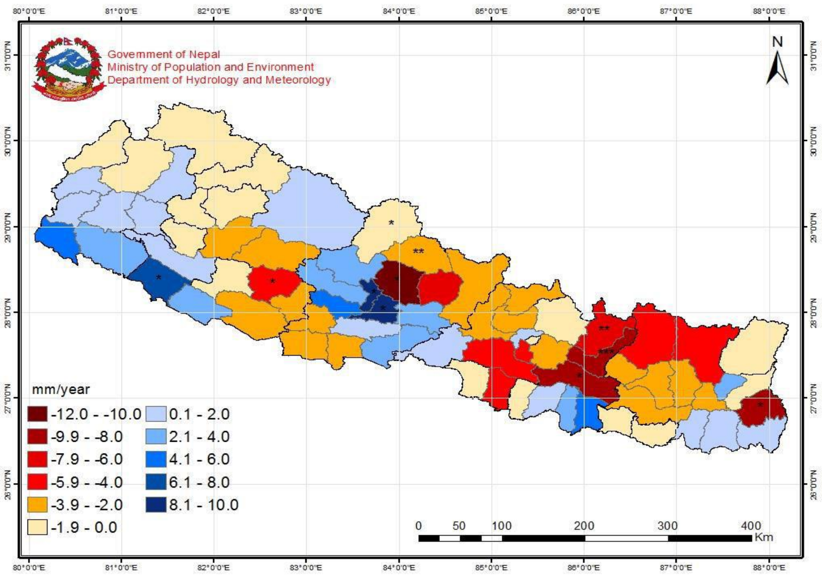

Figure 4: Annual precipitation trends in the districts of Nepal

Extreme Climate Trends:

An analysis of the extreme climate trends shows significant extreme precipitation trend in north-western and northern districts only whereas the extreme temperature shows significant trends in majority of the districts. Warm days, warm nights and warm spell duration were found to be in increasing trends where as cool days were found to be in decreasing significantly in majority of the districts. The cool nights showed mixed signal (increasing in the northern and north-western and decreasing in the south-eastern districts).

Table 4: Extreme climate indices trend in Nepal

Extreme Climate Indices	Trend pattern/regions
Number of rainy days	Increasing significantly, mainly in the northwestern districts and trends are insignificant in other districts
Very wet days	Decreasing significantly, mainly in the northern districts and trends are insignificant in other districts
Extremely wet days	
Consecutive wet Days	Increasing significantly in the northern districts of Karnali Province, central part of Gandaki Province and Province No. 1, however the trend is insignificant
Consecutive dry Days	Decreasing significantly, mainly in the northwestern districts and trends are insignificant in other districts
Warm days	Increasing significantly in majority of the districts
Warm nights	Increasing significantly in majority of the districts
Warm spell Duration	Increasing in majority of the districts
Cool days	Decreasing in majority of the districts
Cool nights	Increasing in the northwestern significantly and decreasing in the southeast significantly
Cold spell duration	Increasing significantly only in the FWDR districts and trends are insignificant in other districts

(Source: DHM, 2017)

3.1.2 Projected Climate Change[3]

Climate is expected to be warmer and wetter in the future periods, except for a decrease in pre-monsoon season (MoFE, 2018b). Extreme Indices related to temperature and precipitation suggest that more extreme events are likely in the future. This is expected to affect different sectors, such as water, energy, biodiversity, agriculture, human health, and physical infrastructures.

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[3] Climate Change Scenarios for Nepal for National Adaptation Plan (NAP), Ministry of Forests and Environment, Kathmandu

Temperature Projection

The temperature is projected to increase for all seasons in future. Mean temperature could increase by 0.92-1.07ºC in the medium-term period and 1.3-1.8ºC in the long-term period. The highest temperature increase is projected for the post-monsoon seasons for both medium and long term.

Table 5: Projected range of multi-model ensemble mean change in temperature (ºC) of Nepal for different seasons in three time periods with respect to reference period

Change in temperature (ºC)						
Seasons	**2016-2045**	**2036-2065**	**2071-2100**	**2016-2045**	**2036-2065**	**2071-2100**
	RCP 4.5			**RCP 8.5**		
Winter	1.0	1.5	2.1	1.2	2.0	4.0
Pre-monsoon	0.7	1.0	1.2	1.0	1.6	3.4
Monsoon	0.8	1.1	1.4	0.8	1.5	3.0
Post-monsoon	1.3	1.8	2.5	1.4	2.4	4.5
Annual	**0.92**	**1.3**	**1.72**	**1.07**	**1.8**	**3.58**

Source: MoFE, 2018b

The annual mean temperature is projected to increase by 0.95ºC in the medium term and 1.36ºC in the long term for RCP 4.5 for High Mountains and by 1.11ºC in the medium term and 1.87ºC in the long term for RCP 8.5 for Tarai.

Precipitation Projection

Average annual precipitation is likely to increase by 2-6 percent in the medium-term period and by 8-12 percent in the long-term period. It is expected that precipitations will increase in all seasons, except the pre-monsoon season, which is likely to see a decrease of 4-5 percent in the medium-term period. The post-monsoon season will have the highest increase in precipitation with respect to the reference period, possibly going up by 6-19 percent in the medium-term and 19-20 percent in the long-term. Projections about precipitation in the future have a large degree of uncertainty, greater than temperature projections.

Table 6: Projected range of Multi-model ensemble mean change in precipitation (%) in three time periods for different seasons

Change in precipitation (%)						
Seasons	**2016-2045**	**2036-2065**	**2071-2100**	**2016-2045**	**2036-2065**	**2071-2100**
	RCP 4.5			**RCP 8.5**		
Winter	-5.8	13.6	24.4	7.2	5.0	20.9
Pre-monsoon	-5.0	-7.4	-7.8	-4.0	4.2	-3.1
Monsoon	2.7	9.4	12.4	7.8	13.6	27.1
Post-monsoon	18.6	20.3	16.5	6.0	19.0	22.9
Annual	**2.1**	**7.9**	**10.7**	**6.4**	**12.1**	**23**

Extreme Indices Projection

Extreme indices related to temperature and precipitation suggests that more extreme events are likely to occur in the future. Extremely wet days (P99) are expected to increase at a higher rate than very wet days (P95). This entails 'more water-related hazards' are likely to occur in the future. Consecutive Dry Days (CDD) is likely to increase under Representative Concentration Pathways (RCP 4.5) scenario but are projected to decrease under RCP 8.5 scenario. Similarly, Consecutive Wet Days (CWD) are projected to decrease under RCP 4.5 and increase under RCP 8.5 scenarios. Both the warm days and nights are projected to increase in the future whereas both the cold days and nights are likely to decrease.

Table 7: Projected range of multi-model ensemble mean change in extreme temperature indices (days) in Nepal in two time periods with respect to reference period

Indices	Mean annual days in the reference period (1981-2010) [Days]	2016-2045 (Days)	2036-2065 (Days)	2016-2045 (Days)	2036-2065 (Days)
		RCP 4.5		**RCP 8.5**	
Warm Days	36.5	23.9	32.3	26.4	46.1
Warm Nights	36.5	30.5	43.3	30.5	59.6
Warm Spell	17.6	19.3	26.2	27.6	43
Cold Days	36.5	-15.4	-19.3	-20.5	-27.5
Cold Nights	36.5	-15	-19.7	-19-9	-27.3
Cold Spell Duration	20.3	-10.5	-12.9	-11.2	-14.8

Table 8: Projected range of multi-model ensemble mean change in extreme precipitation indices (days) in Nepal in two time periods with respect to reference period

Indices	Mean annual days in the reference period (1981-2010)	2016-2045 (Days)	2036-2065 (Days)	2016-2045 (Days)	2036-2065 (Days)
		RCP 4.5		**RCP 8.5**	
Very Wet Days	18.1	0.3	2.2	2.2	3.4
Extremely Wet Days	3.5	0.9	1.4	1.0	2.1
Rainy Days	166.4	-3	-1.7	-1.6	-0.8
Consecutive Dry Days	45.3	2.7	1.1	-0.7	-1.3
Consecutive Wet Days	78.1	-3.3	-1	2.5	1.7

Source: MoFE, 2018b

3.2 Overview of the Sectors Vulnerable to Climate Change

3.2.1 Agriculture and Food Security

Nepal is an agrarian country. More than 66 percent of the total population and nearly 80 percent of the total households (3.4 million) are involved in agricultural production which contributes to about 27 percent in the gross domestic production (CBS, 2014; MoF, 2019). The total agricultural land of the country is 4,243,160 ha (29.7% of total area) with per capita availability of 0.082 ha (MoALD, 2014). About 21 percent of the land is cultivated, of which 54 percent has irrigation facilities and only 0.68 ha per household land holding size. Over 50 percent farmers are small holders usually with less than 0.5 ha where agriculture sector contributes to 50 percent to their household income.

The country's agriculture sector is a mix of crop and livestock farming which is characterized by higher level of diversification in terms of climatic and geographic variations. Its agricultural biodiversity means it can produce a wide range of crops (cereals, pulses, oilseed crops, fruits, vegetables and other cash crops) at different locations throughout the country.

As farming is mostly traditional in nature for meeting the daily household food requirement, cash income from agriculture is very limited. Most of the farmers with low cash income find difficulties to buy modern agricultural inputs like chemical fertilizers and improved seeds. With the limited affordability and availability of chemical fertilizers, 80 percent of the farmers integrate livestock and poultry in their crop farming to meet milk and meat requirements and to supply manure in lieu of chemical fertilizers. The livestock are also used for draft power instead of machines thus reducing the need for fossil fuel in agriculture. Most of the farmers use their own home saved seeds for cereal crops. Though 80 percent of the crop area is covered by five cereal crops, agriculture is integrated by blending all basic need products such as cereals, pulses, oilseeds, vegetables, fruits and cut flowers, livestock, poultry, fisheries, honey production, silk production and even agro-forestry.

Crop production is dominated by rice covering more than 43 percent of total cropped area of cereals, maize covering 27.7 percent, wheat 20.4 percent, millet 7.6 percent followed by other minor crops like buckwheat and barley (MoALD, 2020). Rice is the main staple food in Nepal followed by wheat. As maize can thrive in a wide range of temperatures from tropical to temperate, it is grown in areas of varying temperature. Maize is planted less in Tarai region partly due to rice preference and water logging problem.

The livestock and poultry in the village areas are generally grown as the free-range system of rearing. In recent years, some confined poultry farming is coming up mainly in the peri-urban areas. The livestock also contribute raw materials to the manufacturing sector such as wool, meat and dairy products and some primary products such as leather and bristle for export.

The major cash crops are oilseed, potato, tobacco, sugarcane, jute, cotton, and rubber. Cardamom, ginger, garlic, turmeric, silk cocoons, honey and mushroom are also cultivated in copious amounts. Among the commonly cultivated crops in Nepal, rice, buckwheat, soybean, foxtail millet, and mango have higher genetic diversity as compared to other food crops (MoALD, 2017). Nepal is also famous for orthodox tea, large cardamom, turmeric and zinger. Aquaculture is popular in the southern Tarai flat land and river systems originating mostly from the Himalayas harbor indigenous fish species. Most Nepalese farmers grow diversified crops in order to hedge against erratic and uncertain weather and other unfavorable agronomic conditions.

The table below provides an information in regards to the area in hectare and production in Metric Tonnes of the major cereal and cash crops in Nepal.

Table 9: Area and production of Major Cereal and Cash Crops in Nepal

Cereal Crop	2074/75 (2017/18)		2075/76 (2018/19)	
	Area (ha)	Production (Mt)	Area (ha)	Production (Mt)
Paddy	1469545	5151925	1491744	5610011
Maize	954158	2555847	956447	2713635
Wheat	706843	1949001	703992	2005665
Millet	263497	313987	263261	314225
Buckwheat	10296	11472	10311	11464
Barley	24648	30510	24409	30550
Cash Crops				
Oil seeds	224595	245867	260307	280530
Potato	195173	2881829	193997	3112947
Sugarcane	78609	3679508	71625	3557934
Jute	7507	11159	7285	10585
Cotton	120	125	97	99
Rubber	555	296	476	249

Although more than 70 percent of the workforce is involved in agriculture, the sector generates only around one third of the country’s GDP. Therefore, the development of agriculture sector is key for the development of national economy.

3.2.2 Forests, Biodiversity and Watershed Conservation

Forests is one of the prominent natural resources of Nepal which covers 44.74 percent of the total land area. Out of the total forests area, 37.80 percent lies in Mid Mountain, 32.25 percent in High Mountain and High Himal, 23.04 percent in Chure and 6.90 percent in Tarai (DFRS, 2015).

About 23.23 percent of the country's land is a protected land area which has 20 protected forest areas. By Province, the Karnali Province occupies highest forest area whereas the Province 2 occupies the lowest forest area. Among protected forest areas, Gandaki Province occupies the highest 45.8 percent and Province 2 occupies the lowest 10.5 percent. A total of 118 different ecosystems have been identified in Nepal, including 112 forest ecosystems, four cultivation ecosystems and one water body ecosystem and one glacier/snow/rock ecosystem. Majority of the ecosystems are found in the mid-mountains and in the high mountains. The total carbon stock in Nepal's forest is estimated as 105.97 million Tonnes (176.95 t/ha) (DFRS, 2015).

Nepal is rich in biodiversity and is regarded as a hotspot for some locally and globally important plant and animal species. The diverse climatic and topographic conditions have also favored maximum diversity of agricultural crops, their wild relatives and animal species. It occupies about 0.1 percent of the global area, but harbors 3.2 percent and 1.1 percent of the world's known flora and fauna, respectively. About 5.2 percent of the world's known mammals, 9.5 percent birds, 5.1 percent gymnosperms and 8.2 percent bryophytes are reported in Nepal. A total of 284 species of flowering plants, 160 animal species and 14 species of herpetofauna are reportedly endemic to Nepal (MoSTE, 2014a). Biodiversity in Nepal is closely linked to the livelihoods and economic well-being of most Nepalese people.

3.2.3 Water Resources

Nepal has abundant water resources. Water is regarded as the key strategic natural resources having the potential to be the catalyst for all round development and economic growth of the country. There are about 5358 lakes (NLCDC, 2009), 6000 rivers and rivulets that flow through Nepal generally reaching their maximum flow in July-August and declining to their minimum in February-March (WECS, 2002). About 78 percent of the average flow is available in four major river basins, 9 percent in the medium basins and 13 percent in the smaller southern rivers of the Tarai.

The major source of flow of the river; the snow, and ice area is around 23 percent of the total area (MoPE, 2004). According to the 2001 Glacier Inventory of Nepal, there were 3252 glaciers covering an area of around 5324 square kilometers (Mool et al., 2001), which in 2010 was reported as 3808 glaciers covering a total area of 3902 square kilometers ((ICIMOD, 2010).

The inventory of glacial lakes and identification of potentially dangerous glacial lakes in Koshi, Gandaki, and Karnali river basins of Nepal, the Tibet Autonomous Region of China, and India report in 2020 found 3,624 glacial lakes located in the three basins, of which 2,070 lakes are in Nepal which are large enough to cause a glacial lake outburst flood (GLOF). Of the identified 47 potentially dangerous glacial lakes in the Tibetan Autonomous Region (TAR), China, Nepal and India, 21 are located in Nepal (Bajracharya et al., 2020).

The development of Nepal's water resources could generate hydroelectric power, furnish water for irrigation, and supply water for domestic and industrial uses.

Irrigation Potential and Development

Irrigation is the largest water use sub-sector affecting the life of many people involved in agriculture. Irrigation has been given due importance in yearly and five-year national development plans. Given the importance of irrigation and large investments already made and planned for the future, the effectiveness of water delivery and its ultimate sustainability are of major concern. The Water and Energy Commission Secretariat indicates that many schemes have not reached their planned level of productivity and are not sustainable, financially as well as technically (WECS, 2002).

Most of the schemes in Nepal are supply oriented whose objectives are to distribute irrigation water to the maximum number of farmers. Additionally, most irrigation schemes are run-of-river type carrying a high sediment load. Out of 2.641 million hectares of total arable agricultural land till FY 2017/18, 1.473 million hectares of land has irrigation facility. However, due to lack of availability of sufficient amount of water in the source and delayed implementation of the projects of water transfer and multi-purpose water reservoir projects, only 33.0 percent areas of irrigated land have irrigation facility throughout a year.

3.2.4 Health, Drinking Water and Sanitation

Health care system in Nepal is based on Primary health care (PHC) which was adopted after Alma Ata Declaration. There are 4515 health institutions in the country including 125 hospitals and 384 Ayurvedic hospitals and pharmacies. Altogether 203 Primary Health Care Centers, 3805 Health Posts (HPs) are also providing health services in the country. These services are further supported by 2640 Doctor, 20653 Nurse/Auxiliary Nurse Midwife, 14347 Health Assistant and 52000 Female Community Health Volunteers (FCHVs) (MoF, 2019).

Health sector development has been a priority of the Government of Nepal. However, the country still faces many challenges regarding the health issues, such as poverty, illiteracy, inadequate health services and difficult geography. Nepal has also initiated the National Health Insurance Policy 2071, which is at present expanded to 42 districts. From this insurance scheme, a total of 610 thousand people have been registered out of which 6.7 percent belong to extremely poor group.

The 2011 Nepal Living Standards Survey reports that 38 percent of rural households do not have access to a health post or sub-health post, and that 66 percent do not have access to a public hospital within 30 minutes of reach from their home. Overall, Nepal's rural populations take a mean of 135 min to access a health post or sub-health post (CBS, 2011). The government has set a target to provide health service to all country's inhabitants within 30-minute walking distance. This health accessibility pattern is varied remarkably among the three ecological regions. For instance, the Tarai has relatively better access to given health services than other two regions. The major climate sensitive diseases for TNA as per Nepalese context are as follows:

Vector Borne Diseases

Vector borne diseases including encephalitis, *Japanese Encephalitis (JE)*, leishmaniasis, malaria and Kala-azar (Visceral leishmaniasis) seem to have occurred in the warmer districts of Nepal. The most common species of malaria parasite are *Plasmodium vivax* and *P. falciparum* (DoHS, 2010).

Table 10: Trend of Vector borne diseases in Nepal (last five year)

Disease	Year					
	2070/71	2071/72	2072/73	2073/74	2074/75	2075/76
Dengue	302	134	1527	2111	811	3424
Kala-zar /Leshmaniasis	-	220	250	235	239	228
Malaria	-	-	991	1128	1187	1065

Source: http://edcd.gov.np/news/download/dengue-kalaazar-and-malaria-trend-update

The first outbreak of dengue occurred in Nepal in 2006. The cross-sectional entomological survey conducted in 2006 identified the presence of Aedes aegypti in 5 major urban areas of Tarai region bordering with India, i.e., Biratnagar (Morang), Birganj (Parsa), Bharatpur (Chitwan), Tulsipur (Dang) and Nepalganj (Banke). Similarly, the entomological survey conducted in Kathmandu valley in 2009 has revealed the presence of Aedes aegypti in Kathmandu (Gautam et al., 2009). Previously A. aegypti was not recorded in Nepal. One of the reasons for increasing the disease and geographical spread may be due to climate change. The increased temperature due to climate change may create conducive environment to mosquitoes breeding. The egg laying capacity decreases if the monthly mean temperature decreases from 16.5ºC. If the average temperature decreases below 14ºC mosquito will not lay eggs. For instance, the people of Dhading (Hill) district have felt that the mosquitoes are shifting to higher altitudes in this district where there was previously no occurrence of mosquitoes (MoSTE, 2014b).

Water Borne Diseases

In Nepal, water shortage is one of the causes for poor sanitation and water-washed diseases like skin disease, worm infestation, eye infections, etc. Limited and poor-quality drinking water is responsible for spreading water borne diseases like typhoid, diarrhea, dysentery, cryptosporidiosis, giardiasis, amoebiasis, gastritis and infectious hepatitis. The water sources such as springs, rivers and groundwater are drying-up due to exposure to extreme heat. Available studies indicate that torrential rainfall events transport terrestrial microbiological agents into drinking water sources, resulting in outbreaks of these infectious diseases.

Nepal faces a high number of water-borne diseases such as diarrhea, dysentery, typhoid, gastroenteritis and cholera. But with the increasing access to basic sanitation facilities (99% of the total population have access to basic sanitation facilities) and basic water supply facility (88% have access to basic water supply facility), these diseases now rank lowest in the top ten diseases in

Nepal. However, in some urban centers and rural areas, these diseases are spotted on a yearly basis primarily because of water contamination at source.

The healthcare organizations in the country show that incidence of diarrheal diseases per 1000 new cases children under 5 years of age has increased consistently from 131 in 1995 to 498 in 2011, while the case fatality rate has decreased remarkably from 0.6/1000 new cases in 1996 to 0.01/1000 new cases in 2011. Further, there is a record of morbidity with an average of over 3.3 episodes per child. Likewise, trend of typhoid fever increased, from over 400 cases in 2001 to nearly 1000 cases in 2005. A hospital record in 2005 showed a close relationship between temperature and precipitation, and typhoid cases; both climatic phenomena have risen during four months (June-September) and meanwhile typhoid cases of children under 5 years of age ranged from 270 to 193 per 1000 new cases, which were among the highest, while in the winter months, the cases have lowest along with low temperature and rainfall. A total of 282 people died in May--August 2009 due to the outbreak of diarrhea and cholera in the mid-western development region of Nepal which was mainly due to the consumption of contaminated water and poor sanitation. Many of the local water sources have been dried up due to longer droughts (DoHS 2011).

3.2.5 Rural and Urban Settlements

Nepal is one of the fastest urbanizing country and Kathmandu is the fastest urbanizing city in South Asia. According to the census data and list of municipalities, urban population has increases from 9.2 percent in 1991 to 17.1 percent in 2011 to 58.4 percent in 2017[4]. The urban growth in Nepal is characterized by an increase in the number of municipalities, an expansion in the urban area and rapid increase in the population in recent years. Increase in urban settlements in the country is primarily due to the rural to urban migration triggered by the availability of certain infrastructures such as health facility, education and jobs.

Generally, settlements with less than 10000 population with a population density of 10 persons per hectare, and lacking in basic facilities in the country is considered as rural settlements in Nepal. Rural settlements in Nepal are often poor and deprived of basic facilities. In general, poverty pressures in Tarai and Hills are similar, but extremely high in the Himalayan region. Rural Poverty level (27.43%) is still higher than urban poverty (15.46%). In 2011 census, 83 percent of the total population live in rural areas, however, at present larger portion of population lives in urban areas but still the absolute poverty is high in rural areas as compared to the urban areas.

Climate change poses significant threats to the social fabric of Nepalese towns and cities, and to urban and strategic infrastructure (MoE, 2010). Increased climatic variability and change is likely to pose greater threats to the settlements. The ever-booming urbanization, unplanned cities, haphazard construction, inferior building quality and dense population are major issues for climatic vulnerability. Human encroachment in the river banks and open spaces further impede the mobility

[4] Ministry of Federal Affairs and Local Development (www.mofald.gov.np)

during disasters such as floods and earthquakes.

Urban poor populations are at higher risk as they lack social safety nets and often reside in marginal lands that are prone to disasters. National Adaptation Programme of Action to Climate Change or NAPA report states that vulnerability of urban poor communities is augmented by vulnerable settlement locations, social determinants of health and impacts of climate change.

3.2.6 Disaster Risk Reduction and Management

A combination of rough topography, steep slopes, active seismic zone and intense impact of monsoon rains makes Nepal extremely vulnerable to disaster impacts. Nepal is one of the global 'hot spots' for natural disaster in terms of high mortality risk from multiple hazards like landslides, floods, glacial lake outburst floods (GLOFs) and droughts. Every year, the disaster events claim large number of lives and cause significant economic loss.

A total of 22,372 disaster events have been recorded during the period of 1971-2015. Hence, annually Nepal is exposed to about 500 disaster events (MoHA, 2017). A total of 6,381-small and large disaster incidents were reported in 2017 and 2018 as per the National Emergency Operation Center (NEOC) record which claimed the lives of 968 people, with an additional 3,639 injury cases affecting 27,256 families (MoHA, 2019). The disaster incidents records of NEOC explains that Province No. 1 was affected the most with highest number of loss of lives, while Province No. 2 faced the highest amount of financial loss. Province No. 1 and Province No. 2 witnessed more than 200 lives claimed by disasters. Bagmati Province, Gandaki Province and Lumbini Province bear the loss of more than 100 lives during this period, whereas 80 and 47 people lost their lives due to disasters in Karnali and Sudurpaschim Province respectively.

In the present context, weather-related extreme events like excessive rainfall, longer drought periods, landslides and floods are increasing both in terms of magnitude and frequency. The changed intensity and amount of monsoon rains positively correlate with the increase in water-induced disasters like floods and landslides.

Water Induced Disasters

Water-induced hazards are a major cause of disasters in Nepal. Current climate variability and extreme events lead to major impacts and economic costs. Floods associated with monsoon rains top the list of disasters, and lead to loss of lives and major property and infrastructure damages (MoPE, 2017). Landslides, river bed variations (resulting subsequent shifting and degradation), debris flow and flooding are main water-induced disasters in Nepal. The country is highly vulnerable to recurrent floods and landslides. The Nepal Himalayas comprises a geologically active zone where instability due to tectonic activity and ongoing erosion is everywhere apparent. These factors, combined with peculiar meteorological conditions where the rainfall and river flow vary tremendously in both time and space, make the landscape vulnerable to water-induced disasters such as floods, landslides, slope failures and debris flow.

In addition to these natural processes, development activities and increasing population have caused further vulnerability and destabilization of land resources. This includes human activities such as deforestation, cultivation of marginal lands, road building in hills and mountains, and encroachment of flood plains. The water-induced disasters, thus, have been occurring more frequently in recent times.

In Nepal, devastating floods are triggered by different mechanisms which can be classified into five major types: i) continuous rainfall and cloudburst (CLOFs), ii) glacial lake outburst floods (GLOFs), iii) landslide dam Outburst floods (LDOFs), iv) floods triggered by the failure of infrastructure, and v) sheet flooding or inundation in lowland areas due to an obstruction imposed against the flow (Dixit, 2003; Khanal, 2005).

In between 2017 and 2018, Nepal faced a number of disaster events including floods and landslides. These incidents resulted in the loss of hundreds of lives and billions of Nepalese rupees. The table 11 summarizes the loss and damage due to water induced disaster events in Nepal in the year 2017 and 18. As can be seen from the table 11, floods, landslides, and fires are the major hazards for Nepal which are expected to increase in future.

Table 11: Damage and losses of disaster incidents in Nepal in the year 2017 and 2018

Damage and losses of disaster incidents										
S.N.	**Incident**	**No. of Incident**	**Death**			**Injured**	**Affected Family**	**Houses destroyed**		**Estimated Losses (NR)**
			Male	Female	Total			Partial	Complete	
1	Flood	418	128	55	183	61	16196	14424	286	60,944,400
2	Landslides	483	96	65	161	182	1083	149	328	191,662,000
3	Lightning	432	87	72	160	551	618	23	14	14,687,000
4	Fire	3973	74	76	150	557	6027	549	3234	6422638013
5	Cold Wave	48	26	22	48	0	48	0	0	-
6	Heavy Rainfall	342	8	22	30	84	538	193	252	89,415,160
7	Wind Storm	254	7	12	19	84	1527	763	301	51,447,998
8	Snow Storm	2	10	0	10	0	10	0	0	-
9	Avalanche	1	1	0	1	0	1	0	0	-
10	Hailstone	3	0	0	0	0	127	2	0	457,000

Source: (MoHA, 2019)

3.2.7 Tourism, Natural and Cultural Heritage

Nepal is known for its natural beauty. Snowcapped mountains, the stunning landscapes, breathtaking trekking experiences, cultural diversity, traditions and lifestyles makes this country unique and a loved destination for the tourism activity. Tourism industry is a growing potential sector for the country's economic development which is contributing about 7.5 percent of the country's total GDP, slightly above 7 billion[5]. Tourism sector possess great potential in increasing income sources through creating employment and reducing income and employment disparities. The country has 20 protected areas, out of which 10 are national parks, 3 wildlife reserves, 6 conservation areas and 1 hunting reserve. There are 10 natural and cultural heritage sites listed by UNESCO as a world heritage sites in Nepal out of which 8 are cultural heritage sites. Richness in cultural and natural diversity makes Nepal a beautiful tourism destination.

Nature based tourism is the main tourism type in Nepal. Large number of foreigners visit Nepal for trekking purposes, mountaineering and exploring the country's rich cultural diversity. Tourism sector is one of the sensitive sectors to climate change as the tourism activity largely depend on the flows of services provided by ecosystems which are sensitive to climate change. With the increasing temperature and extreme events in the country, tourism is affected badly.

3.2.8 Industry, Transport and Physical Infrastructure

Industry sector contributes to 15.2 percent of the total GDP of the country (NPC, 2020). Different types of industries are in operation in Nepal that includes; Agro and Agro Forestry based, construction, energy based, information technology, manufacturing, mineral, service and tourism. As of 2018, there are total of 7967 industries all over the country. Bagmati Province has higher number of industries in the country. Of the different industry, agro and agro forestry, energy, and tourism-based industry are sensitive to the climate change impacts as these sectors are directly related to climate parameters. Furthermore, majority of the large industries in Nepal are located in the southern plain of Nepal, which is vulnerable to riverine flooding.

Transport sector is one of the key priority sectors of Nepal. At present, road construction is at the top of the development plan followed by development of physical infrastructures for electricity generation, telecommunication and irrigation.

Increased climatic variability and change is likely to pose greater threats to the development infrastructures. Climate change is likely to result in increased damage to buildings, energy services, telecommunications, transport structures and water service. Wide array of social, institutional, political, economic and cultural factors may be affected resulting into dislocation of quality of life and safety of communities.

[5] Ministry of Finance, Economic Survey Report 2017

3.3 Sector Prioritization

National climate change vulnerability and adaptation issues were initially reviewed through national literatures on development issues and priorities, government plans, national agendas, and periodic plans. Based on the literature review, the team of adaptation experts consulted with different research institutes and government agencies regarding the development priorities in the verge of climate change. Thus, the following list of sectors were identified initially and shared with the stakeholders for sector prioritization:

i. Water resources
ii. Agriculture and Food Security
iii. Forest and Biodiversity
iv. Public Health
v. Urban Settlement and Infrastructure
vi. Climate Induced Disaster

3.4 Process and Criteria of Prioritization

The consortium of experts for each sector were visited by the Adaptation team to purview the sensitivity and adaptive capacity in different sectors and areas of Nepal. In doing so, the experts were asked to mark the degree of sensitivity and adaptive capacity in each sector with an objective to identify and prioritize the sector for defining the way forward for TNA-Adaptation technologies. The team visited several experts from different fields namely agriculture, water resources, public health, urban settlement and infrastructure, and forests and biodiversity. The sectoral vulnerability to climate change is given below in Table 12.

Table 12: Sectoral vulnerability to Climate Change

Climate change impacts	Vulnerable sectors
Increased Temperature	Agriculture and food security Forestry Ecology and biodiversity Water resources Urban settlements and infrastructure Energy Public health
Change in rainfall pattern	Agriculture and food security Water resources Public health Climate induced disaster

Climate change impacts	Vulnerable sectors
Flood, water loss and erosion	Agriculture Forestry Ecology and biodiversity Water resources Energy Transportation Infrastructure
Reduced precipitation	Agriculture Forestry Ecology and biodiversity Water resources Energy (hydropower) Public health

For assessment and identification of the priority sectors, four criteria were defined and agreed:

- **Economic contribution:** contribution of the sector to the national economic development, expressed by the GDP share of the sector;
- **Social contribution:** contribution of the sector to the job market, poverty alleviation, improving cultural life and human health, etc.;
- **Environmental development contribution:** highlighting the implications of the sector for the development of soil, water resources, air, landscape and biodiversity, etc.
- **Reduction of vulnerability to climate change:** opportunities to reduce economic loss and environmental damage through application of adaptation technologies.

National Stakeholders' Consultation Workshop was organized on 17th August, 2012 with participation from various sectors. The adaptation team shared the impacts and associated vulnerabilities of each sector to the stakeholders. Taking into account of economic, social and environmental development priorities including vulnerability reduction potential of the sectors, the following rating scheme was applied for sector prioritization:

- 0: no benefit
- 1: faintly desirable
- 2: fairly desirable
- 3: moderately desirable
- 4: very desirable
- 5: extremely desirable

As a result, the performance matrix for prioritizing has been identified using MCA method as shown below in Table 13:

Table 13: Scoring for sector prioritization

Sectors	Social Priority	Economic Priority	Environmental Priority	Reduction of Vulnerability	Total Benefit
Agriculture and Food Security	5	5	3	5	18
Water resources	4	5	4	4	16
Public Health	4	4	3	3	15
Forest and Biodiversity	3	3	4	3	13
Urban Settlement and Infrastructure	4	2	3	3	12

In order of priority, the sectors, viz Agriculture, Water Resources and Public Health were identified. Furthermore, sub-sectors namely Niche-based Farming and Resource Management under agriculture sector and Irrigation Management and Disaster Preparedness under water resources sector were unanimously accepted. Similarly, in Public Health sector, Water-Borne Disease and Vector-Borne Diseases were selected for technology prioritization

3.5 Vulnerability assessment of selected sectors in changing climate

A. Water Resources

Water Resources system is very sensitive to climate change. Although climate change is a global phenomenon, its impact on local hydrology is considerable. Hydrological seasons in Nepal can be categorized in three different groups: (a) dry pre-monsoon season (March-May) with almost no rain; (b) rainy monsoon season (June-September); and (c) post-monsoon season (October-February) with little rain. Specific discharges of Nepalese river are not uniform for all the rivers and vary randomly. Climate change will significantly increase the intra-annual variability of stream flow (Agrawala et al., 2003).

The rising temperature trends and the projection of rising temperature have direct impacts on water resources and hydropower. The variations in climate phenomena have resulted in accelerated melting of glaciers, formation of glacial lakes in the mountain valleys and expansion of existing glacial lakes (Gardelle et al., 2011) in Nepal Himalaya. Rise in temperature attributes to the increasing risk of GLOFs, run-off variability, sediment loading and evaporation.

Changing climatic conditions may affect the operational plan of existing hydropower system, which are built based on historical records of climate patterns, and therefore, impacts on energy supply. Initially, the electricity generation potential may increase with the rise in temperature, and then gradually decline (NDRI/PAC/GCAP, 2017).

A study on annual discharge of three major river basins (Koshi, Gandaki and Karnali) indicates that discharge in these major basins is decreasing annually but contrary to this fact, annual discharge in southern basins is in increasing trend (MoSTE, 2014b). Furthermore, the study concludes that there will be reduction in electricity generation of existing plants considerably in future because of the changing climate variability. An increase in the maximum average temperature by 0.06°C per year would increase the theoretical hydropower potential by 5.7 percent by 2030 but it would then decrease and be down 28 percent by the end of the century (MoE, 2010).

Primarily, the impacts of climate change on water resources are:

- Increased risk of GLOF
- Increased run-off variability
- Increased sediment loading
- Increased evaporation

Climatic variability and associated hydrological variability are likely to result in high vulnerability for the overall energy system, and cause high economic impacts. Electricity operators are expected to face large financial costs from low flows, high floods and sediment load and geo-hazards (NDRI/PAC/GCAP, 2017).

B. Agriculture Sector

Agriculture (including livestock, fisheries and agroforestry) in Nepal is highly vulnerable to climate change due to diverse risks of natural disasters associated with rugged terrain and steep topography and tectonically active geology. Marginality of a large proportion of farmers towards small size land holding, limitedly available irrigation, low level income, limited institutional capacity and greater dependency on climate-sensitive natural resources renders the degree of agrarian vulnerability higher (Regmi and Adhikari, 2007).

Climate change is expected to cause substantial reductions in yields, for example, in South Asia, up to 10 percent for millet and maize (Lobell et al., 2008). In the case of Nepal, the rain fed system, due to its dependence on the changing monsoon pattern and timing, is susceptible to declining crop productivity (MoSTE, 2014a).

The temperature rise will negatively impact rice and wheat yields in Tarai and tropical part where these crops are already being grown closer to their temperature tolerance threshold. Understanding the potential impact of climate change on agriculture in Nepal is critical for two reasons. First, the existing system of food production is highly climate sensitive because of its low level of capital and technology. Second, agriculture is the main source of livelihood for the majority of the population. If agricultural production is adversely affected by climate change, the livelihoods of the even greater number of people will be at risk. In summary, the impacts of climate change in agriculture and food security are:

- Declining crop, fisheries and livestock production

- Impact on subsistence farming, which is more vulnerable to erratic monsoon rains and floods
- Decline in the production of winter and spring crops because of temperature and precipitation anomalies
- Decline in rice and wheat yields, with serious implication on food security for a large section of the population, particularly in the western region
- Loss of local and traditional crop varieties, leading to negative impacts on food and nutrition security

Climate change may cause a decrease in the supply of water and soil moisture during the dry season, which would exacerbate stress on the available water supplies and increase the need for irrigation. Changes in precipitation and temperature caused by climate change will impair the efficiency of externally applied inputs, such as fertilizers, and this will have a negative impact on food production.

The farmers of Nepal will suffer from the effects of climate change and their adaptation costs. The farmers are likely to face three types of the costs of the climate change, namely, direct impact, indirect impact, and adaptation costs (Pant, 2011) as described below:

- ❖ Direct costs from the effects of climate change on crop production, livestock production, and risks of natural hazards.
- ❖ Indirect costs from the effects of climate change on socioeconomic conditions and lost opportunities for their advancement of the living conditions.
- ❖ Costs of adaptation incurred to keep themselves away from or minimize the negative effects of the climate change.

C. Public Health

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR5) has indicated that climate change impacts on human health will be multi-fold. A number of adverse public health impacts are expected to worsen in climate-related disasters such as storms, floods, landslides, extreme heat, drought, and wildfires (IPCC, 2014). Climate change is likely to exacerbate already existing health problems, and bring additional impacts on health and mortality. Scant availability and bad quality of water damages personal hygiene and health. Lack of clean drinking water could increase the frequency and spread of diarrheal diseases, and increasing droughts will exacerbate malnutrition and associated disorders. There is also the possibility of pollen-related allergies (Boyd and Juhola, 2009). The health of people is affected adversely particularly during the dry season because of lack of water supply to be used for sanitation and hygiene (WASH).

In Nepal, there is an increasing trend in vector-borne and waterborne diseases in both rural and urban areas, often with a shift to higher altitudes (Badu, 2013). The incidence of vector-borne diseases such as malaria, Kalazar (Visceral leishmaniasis), and Japanese Encephalitis, and water- and food- borne diseases such as diarrhea, dysentery, typhoid, cryptosporidiosis, giardiasis, amoebiasis, gastritis, jaundice, and infectious hepatitis have been increasing with the rise in temperature. A study in 2009 after the outbreak of diarrheal diseases, which claimed more than 240 people's lives in the Western Hills, found that the outbreak is attributed in part to water shortage, which was due to winter drought and delayed onset of the summer monsoon. In addition to disease, there is also an increasing trend in health-related hazards as a result of the impacts of climate-induced disasters. The quality of the existing water sources that supply drinking water is deteriorating mainly because of the poor source protection and drainage system, inadequate sanitation coverage and poor wastewater treatment plants.

Dhimal et al. (2017) identified following climate change risk in health, drinking water and sanitation sector in his study.

- Greater risk of injury, disease and death, owing to more intense heat waves, cold waves and forest fires
- Increased risk of undernutrition, resulting from diminished food production in resource-poor regions
- More negative health consequences from lost work capacity and reduced labour productivity in vulnerable populations
- Increased risk of vector-borne, waterborne and foodborne diseases, especially in mountain areas, and leading to perennial occurrence in the lowlands
- Increase in cardiorespiratory diseases, owing to higher ambient air pollution and haze in urban areas, resulting from climate change
- Increase in mental health problems, owing to extreme climatic events such as droughts, floods and landslides
- Modest reductions in cold-related mortality and morbidity in the highlands, owing to fewer cold extremes
- Increased morbidity and mortality related to cold waves in the southern Tarai lowlands
- Reduced disease-transmission capacity of vector insects in the Tarai, owing to higher temperatures exceeding their thermal thresholds.

CHAPTER 4: TECHNOLOGY PRIORITIZATION FOR THE WATER RESOURCES SECTOR

4.1 Climate Change Vulnerability and Existing Technologies and Practices in water resources sector

Climate change may cause a decrease in the supply of water and soil moisture during the dry season, which would exacerbate stress on the available water supplies and increase the need for irrigation. Changes in precipitation and temperature caused by climate change will impair the efficiency of externally applied inputs, such as fertilizers, and this will have a negative impact on food production. Similarly, the striking incidences of increasing climate extreme events such as increase in intensity of precipitation along with the shrinkage of glaciers at faster rate is likely to impend greater intensity of disasters.

Balance between water availability and demand is imperative for the farmers as they are solely dependent on the available water resources for cultivation. As the majority of the population are farmers, year-round irrigation system will aid the economic activities and thus the livelihood. Hence, water efficient technologies are imperative to reduce the sensitivity of the farmers towards rain-fed agricultural practices. Besides, technology should be accessible as the cost of the technology largely determines poor farmers' capability to afford the technology.

Similarly, farmers, poor and disadvantaged people are at greater risk as their livelihood or shelter is along the flood zones. Early warning of the impending disaster can save the lives and properties of these people. The situation demands the flood forecasting system that can detect the flood warning and aware the people residing downstream well in advance.

4.2 Adaptation Technology Options and Their Main Adaptation Benefits

4.2.1 Bore hole/ Tube well irrigation

Technology description

Increasing access to groundwater is a key strategy for irrigation during droughts and dry spells. Therefore, drought relief programs in rural areas typically incorporate drilling or deepening of tube wells and/or boreholes. Tube wells consist of a narrow, screened tube or casing driven into a water-bearing zone of the subsurface. A hand-powered or automated pump is used to draw water to the surface or, if the casing has penetrated a confined aquifer, pressure may bring water to the surface. The salient features of tube wells include:(1) plastic or metal casing (usually100-150 mm diameter); (2) in unconsolidated soils, a "screened" portion of casing below the water table that is perforated; (3) a "sanitary seal" consisting of grout and clay to prevent water seeping around the casing; and (4) a pump to extract the water.

Contribution to Adaptation

A warmer climate is highly likely to result in more frequent droughts. Deep tube wells, usually defined by engineers as those that penetrate at least one impermeable layer, generally have much greater resilience to drought than traditional water supplies including springs, hand dug wells and surface water sources. In many regions, groundwater is the only perennial source of water supply.

4.2.2 Sprinkler Irrigation

Technology description

Sprinkler Irrigation is a method of applying irrigation water which is similar to rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air and irrigated entire soil surface through spray heads so that it breaks up into small water drops which fall to the ground. Sprinklers provide efficient coverage for small to large areas and are suitable for use on all types of properties. It is also adaptable to nearly all irrigable soils since sprinklers are available in a wide range of discharge capacity.

Contribution to Adaptation

This technology is very important at the brink of climate change as it utilizes the water resources effectively and efficiently. It is for almost all field crops like Wheat, Gram, Pulses as well as Vegetables, Cotton, Soya bean, Tea, Coffee, and other fodder crops. The most important thing about this technology in relation to country's physiography, it can be used in sloppy hill areas as well where less water can irrigate the field with effective utilization of fertilizer and soil.

4.2.3 Water leakage management

Technology Description

Leakage in distribution systems is a major problem for irrigation. A minor leak of four liters per minute would likely continue for years before it was noticed, resulting in the loss of over two million liters per year. Detection and repair of small leaks in a distribution system are critical functions of system operation and maintenance. Leak management methods can prevent or reduce leakage volume and leak detection technology can improve the ability of water utilities to respond quickly and repair leaks.

Water audits are typically conducted by monitoring water inputs, flow throughout the distribution system, these are used to quantify losses and identify zones with high leakage.

Contribution to Adaptation

Proper utilization of available resources is the greatest necessity of today's world. Securing the water leakage can contribute greater relief to the water scarcity problem. Indirectly, it can supplement the availability in water stressed regions as well. Besides the contribution to balance water availability, demand and supply is achieved to some extent.

4.2.4 Flood forecasting and warning

Technology Description

It involves the detection of the flood warning level in the upper basin which triggers either the siren or alarm message to the authorized personnel of the basin such that preparedness activities can be initiated in advance to mitigate the losses of lives and properties. In this technology, telemetric system is involved in which the water level in the river is continuously measured with battery fed detecting instruments.

This type of technology is beneficial in basins where rainfall-runoff relationship has been established and flood danger level has been assessed. Once this information is available, flood forecasting can be issued for timely alert.

Contribution to Adaption

With increase in the extreme precipitation events, there is greater possibility of weather induced floods and resulting losses of lives. In today's context, 29 percent of total loss of lives and 43 percent of total loss of properties account to water induced disasters alone. Hence, this technology can have added advantage in adapting to the burgeoning impact of climate change on flood events and save the essential lives.

4.2.5 Bio-engineering

Technology Description

Soil bioengineering combines mechanical, biological, and ecological concepts to arrest and prevent shallow slope failures and erosions. Vegetative plantings are conventional plantings of grasses, forbs, and shrubs used to prevent surface erosion. Soil bioengineering utilizes live plant parts to provide soil reinforcement and prevent surface erosion. In soil bioengineering systems, the installation may play the major structural roles immediately or may become the major structural component over time. Live staking, live fascines, brush layers, branch packing, and live gully repair are soil bioengineering techniques that use stems or branch parts of living plants as initial and primary soil reinforcing and stabilizing material. When these vegetative cuttings are placed in the ground, roots develop and foliage sprouts. The resulting vegetation becomes a major structural component of the soil bioengineering system in upland slope protection and erosion reduction.

Contribution to Adaptation

Studies have shown that extreme precipitation events have been increasing. At such condition, heavy downpour can trigger the landslides and other soil erosion. Annually, the victims of landslides are increasing across the country and this can further escalate as the global warming worsens. This technology combines the indigenous knowledge of plant varieties with the surface control mechanisms, and hence ultimately contributes to the resilience of communities to similar disasters.

4.2.6 Permeable spurs

Technology description

A permeable spur is a pervious structure projecting from the stream bank into the channel. Spurs are used to deflect flowing water away from, or to reduce flow velocities in critical zones near the stream bank, to prevent erosion of the bank, and to establish a more desirable channel alignment or width. The main function of spurs is to reduce flow velocities near the bank, which in turn, encourages sediment deposition due to these reduced velocities. Increased protection of banks can be achieved over time, as more sediment is deposited behind the spurs. Because of this, spurs may protect a stream bank more effectively and at less cost than revetments. Furthermore, by moving the location of any scour away from the bank, partial failure of the spur can often be repaired before damage is done to structures along and across the stream.

Spurs are generally used to halt meander migration at a bend. They are also used to channelize wide, poorly defined streams into well-defined channels. The use of spurs to establish and maintain a well-defined channel location, cross section, and alignment in braided streams can decrease the required bridge lengths, thus decreasing the cost of bridge construction and maintenance.

Contribution to Adaptation

Tarai belt of Nepal is more prone and vulnerable to flood like events. Since the flood plain is suitable for agricultural farming, many of the cultivation and settlements are near or on the flood plains. Spurs can prove to be beneficial as the cost-effective tool for improving resiliency of communities towards natural disasters like floods.

4.3 Criteria and process of technology prioritization

Criteria of technology prioritization

The whole process of technology prioritization was driven based on the contribution of the technologies towards sustainable development goals and to adaptation in light of climate change. A wider group of experts and stakeholders were involved in finalizing the criteria on which the assessments were based. The following criteria have been identified to be applied for prioritization of adaptive technologies:

- Contribution to environmental development priorities;
- Contribution to economic development priorities;
- Contribution to social development priorities;
- Ease of application;
- Potential to maximize resilience of the sector.

A comprehensive explanation for the above-mentioned criteria is provided below:

Contribution to environmental development priorities (C1)

Climate change is a serious challenge to sustainability, but not an insurmountable one. Hence, in an endeavor to prioritizing the technologies, the issues like water quality and its availability, ecosystem conservation and protection, protection of lives and properties, etc. should be addressed. Similarly, it should focus on health-related aspects of disaster by implementing preparedness and disaster management initiatives in rural areas.

The prioritization of the technology should be in line with the sustainable environmental development and thus maximize environmental improvement of the country. The technology should be able to offer environmental opportunities in reducing the ill-effects of climate change.

Contribution to economic development priorities (C2)

The technology should envisage agriculture growth creating opportunities for farms and other enterprises while safeguarding the environment and achieving food security. It should be in line with improving the livelihood of the people and also improve national balance of payment. Besides, active participation of private sector is to be promoted.

The impacts of climate change, and the vulnerability of poor communities to climate change, vary greatly, but generally, climate change is superimposed on existing vulnerabilities. Climate change will further reduce access to drinking water, negatively affect the health of poor people, and will pose a real threat to food security. Livelihood choices are limited to the poor communities and hence during the prioritization of the technology, economic opportunities that the technology can offer should be greatly taken into account.

Contribution to social development priorities (C3)

The combined effects of global warming may have particularly harsh effects on people and society through impacts on a number of different factors such as social, cultural, and natural resources. Climate change could affect human health, infrastructure, and transportation systems, as well as energy, food, and water supplies. This may slow down economic development and poverty reduction, and make it harder to achieve the Sustainable Development Goals. Hence, the technology should contribute towards reducing the impacts on the society and thus promote job opportunities, urban and rural development, healthy living condition, and reduce risks associated with disasters.

Ease of application (C4)

Larger percentage of the population lies under the minimum education level and poverty still strives across the country. Livelihood activities are still focused on the traditional practices from antiquity.

Hence, the technology to be adopted should be contextual which explains the ease of handling, accessible, repairable, market potential, and higher benefits in comparison to costs of the technology.

Potential to maximize resilience of the sector (C5)

As the developing countries have the fewest resources and the least capacity to prepare for, plan for, and withstand climate change crisis, the prioritized technology should have potential to catalyze attention, funding and action to promote resilience to climate change at regional and local levels. Improving resilience to climate change is a priority for ensuring the long-term effectiveness of development programs and investment in poverty eradication and sustainable development.

Process

Technology Fact Sheets (TFSs) for pre-selected technologies were prepared by the adaptation team and shared with the stakeholders. These TFSs provided the background information of technologies and enabled stakeholder groups to prioritize technologies. The technologies were then scored on a scale of 0-100 by a stakeholder group, consisting of 15 experts. The experts were asked to score technologies from the range 0-100 in TNA Table (0 means least preferable and 100 means best preferable option). The best and least preferred options were identified and scored first, and then other options were scored in between these two extreme values. The average value of scores has been taken into account (Table14).

Table 14: Scoring results for technologies

Technologies	C1	C2	C3	C4	C5
Sub-sector: Irrigation					
Sprinkler Irrigation System	91	81	90	80	86
Borehole/Tube well Irrigation System Management	43	41	37	82	68
Leakage Management	42	47	50	33	32
Subsector- Water Induced Hazards					
Flood Forecasting and Warning	70	72	83	72	78
Bio-engineering technique	63	54	62	67	61
Use of Permeable Spurs	45	38	41	13	33

Once all the options have been scored within the technology category, the criteria were weighted. This is needed as scores applied to one criterion are independent of the others. Assessment of weights for each criterion involved the stakeholders concerns as it provided opportunity to determine relative importance of each criterion.

In assessing weights, there were different opinions of experts involved in the analysis process. As a result of fruitful debates on the degree of importance of different criteria, normalized weights for each criterion have been provided as following:

- Contribution to environmental development priorities -25 percent weightage
- Contribution to economic development priorities -20 percent weightage
- Contribution to social development priorities -20 percent weightage
- Ease of application -15 percent weightage
- Potential to maximize resilience of the sector -20 percent weightage

The weights mentioned above are the normalized weights. The swing weights provided to the respective criterion C1-C5 are 100, 80, 80, 60 and 80 respectively. In each sector, technologies were scored and weighted for each criterion and arranged in priority order (Table 15). The more the score was, the higher the rank was.

Table 15: Weighting results for technologies

Technologies	C1	C2	C3	C4	C5	Overall weighted
Sub-sector: Irrigation						
Sprinkler Irrigation System	22.75	16.2	18.0	12.0	17.2	86.15
Borehole/Tube well Irrigation System Management (IVM)	10.75	8.2	7.4	12.3	13.6	52.25
Leakage Management	10.5	9.4	10	4.95	6.4	41.25
Subsector- Water Induced Hazards						
Flood Forecasting and Warning	17.5	14.4	16.6	10.8	15.6	74.9
Bio-engineering technique	15.75	10.8	12.4	10.05	12.2	61.2
Use of Permeable Spurs	11.25	7.6	8.2	1.95	6.6	35.6

4.4 Result of technology prioritization

The stakeholder's workshop organized on 4th January, 2013 finalized the prioritization of the technologies under two thematic sub-sectors namely irrigation and water-induced hazards. The prioritized technologies are sprinkler irrigation, and flood forecasting and warning.

Lastly, sensitivity analysis was conducted to assess the robustness of the results relative to the weights and scores applied and other uncertainties. Analysis provided by experts proved that the priority measures for each selected sub-sector are also priority measures according to all the experts. Analysis showed that, for most measures, the experts' judgement did not vary significantly. The list and assessment of prioritized adaptation technologies in water resources sector is shown in Table 16.

Table 16: List and assessment of prioritized adaptation technologies in water resources sector

Availability/scale	Technology	Adaptation potential in 20 years	Estimated investment cost
Short-term/ small-scale	Sprinkler irrigation	High	US$ 600-US$2500/ha (depending on the type of materials used and the amount of labor contributed by rural producers)
Short-term/ medium-scale	Flood forecasting and warning	High	US$ 175000/basin (for basin size<1000sq km, however the cost differs widely depending on the level of sophistication of monitoring and forecasting technologies.

CHAPTER 5: TECHNOLOGY PRIORITIZATION FOR THE AGRICULTURAL SECTOR

5.1 Climate Change Vulnerability and Existing Technologies and Practices in Agriculture Sector

Agriculture is the largest economic sector involving more than 66 percent of the total population and nearly 80 percent of the total households and sharing about 27 percent in the GDP as explained earlier. A heavy reliance on agriculture makes Nepal's economy very sensitive to climate variability (World Bank, 2002). With the dependency on agriculture, over 80 percent of all water in Nepal is used for irrigation. Higher temperatures, increased evapotranspiration and decreased winter precipitation may bring about more droughts in Nepal (Alam, 2004). In addition, many rivers may face highly variable flows due to climate change impacts. Increased variability in flows would severely impact irrigation and thus livelihoods of majority of farmers. The production of cereal crops and cash crops will be affected by the increasing temperature and uncertainty in the precipitation.

It is important that enhancing plant productivity, quality, health and nutritional value and/or building crop resilience to diseases, pest organisms and environmental stresses through minimum tillage, proper crop residue management and appropriate crop rotation are to be addressed to improve the living condition of farmers. As livelihood of the larger population of Nepal is dependent on agriculture, economic proliferation based on improved agricultural yields becomes necessity.

5.2 Adaptation Technology Options and their main adaptation benefits

5.2.1. Integrated Farming System

Technology Description

Integrated farming means the mixing of diverse components (different crops and animals) in the farm. Integrated farming aims to ensure food security while at the same time diversifying sources of income from a variety of agricultural activities that can be carried out by a single household. Integrated farming provides opportunities for combining traditional agricultural activities together and, at the same time, minimizes the risk of failure due to climatic uncertainty.

Contribution to Adaptation

Integrated farming technology contributes to adaptation to climate change by providing the farmers approach to various options to face the uncertain weather conditions associated with the increased climate vulnerability. It gives more stable output because if one component fails to produce goods and services, another may complement the loss.

5.2.2. Conservation Agriculture (Minimum Tillage)

Technology Description

Minimum tillage is a method aimed at reducing tillage to the minimum necessary for ensuring a good seed bed rapid germination satisfactory stand and favorable growing condition. It denotes the reduction of number of operations by planting directly after harrowing without any other intervening cultivation which are usually carried out to give a fine seed bed. The technology is imperative as it increases organic carbon and improves soil structure. Besides hydraulic conductivity of soil is enhanced and thus infiltration of soil. It also reduces soil compaction.

Contribution to Adaptation

As the technology itself requires less human power and it has better yield than other conventional approaches, it can improve the adaptive capacity of farmers. Besides the technology reduces the risk from drought, reduces tillage costs and limits soil erosion.

5.2.3. Biochar

Technology Description

Biochar is the solid remains of any organic material that has been heated to at least 250°C in a zero-oxygen or oxygen-limited environment, which is intended to be mixed with soils. It is a carbon-rich solid product of thermal stabilization of organic matter that is safe and potentially beneficial when stored in soil. A large fraction of the carbon in biochar resists degradation and can sequester carbon in soils for hundreds to thousands of years, providing a potentially powerful tool for mitigating anthropogenic climate change.

Contribution to Adaptation

Biochar can increase soil fertility, increase agricultural productivity and provide protection against some foliar and soil-borne diseases. Besides, it also supports the carbon storage and thus mitigating the anthropogenic climate change.

5.2.4. Organic Nutrient Management

Technology Description

Organic agriculture/farming is a system of agriculture that encourages healthy soils and crops through such practices as nutrient recycling of organic matter (such as compost and crop residue), crop rotations, proper tillage and the avoidance of synthetic fertilizers and pesticides. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved[6]. As stated in the report of FAO, organic agriculture enables ecosystems to better adapt to the effects of climate change (FAO, 2011).

[6] International Federation of Organic Agriculture Movements (IFOAM) General Assembly, 2008

Contribution to Adaptation

This technology emphasizes closed nutrient cycles, biodiversity and effective soil management providing the capacity to mitigate and even reverse the effects of climate change. Besides this organic nutrient management decreases fossil fuel consumption by 33 percent and carbon sequestration take CO_2 out of the atmosphere acting as the most effective strategies for mitigating CO_2 emissions.

5.2.5 Cultivation of Stress tolerant crop/varieties

Technology Description

One of the main focuses of international research for adaptation to climate change is the search for a new generation of crop varieties (UNFCCC, 2006). Development of new varieties those are more resilient to higher temperatures and water shortages with a new cultivation method (Christiansen et al., 2011) seems imperative. Fortunately, farming communities have considerable experience of coping with adverse climatic events, such as droughts, floods, and with salinity. And also, on the whole, agricultural systems are fairly flexible. So, if farmers have access to the right information and tools, they should be able to make necessary adaptations on their own (UNFCCC, 2006).

Contribution to Adaptation

Such types of improved crop varieties enhance the resistance of plants to a variety of stresses resulting from climate change which include water and heat stress. This technology gives the continuum to agriculture production despite uncertainties about future impacts of climate change.

5.2.6. Mixed cropping

Technology Description

Mixed cropping agriculture is growing of two or more crops simultaneously in the same field providing the benefit of balance input and out go of soil nutrients, to keep down weeds and insect pest, to resist climate extremes and overall enhancing the productivity of crop.

Contribution to Adaptation

This technology provides insurance against crop failure due to abnormal weather conditions. It contributes to reduction in climate change effecting by providing greater food security, maintaining soil fertility by recycling, preserving soil nutrients.

5.3 Criteria and process of technology prioritization

National development priorities in light of changing climate are the essential driver for the assessment of the technologies that can contribute towards climate change adaptation. Wider group of stakeholders were involved in defining the criteria for technology prioritization under current national concerns and priorities. The following criteria have been identified and applied for prioritization of adaptive technologies as described in Chapter 4 section 4.3:

- Contribution to economic development priorities;
- Contribution to social development priorities;
- Contribution to environmental development priorities;
- Ease of implementation;
- Potential to maximize resilience.

Process

Technology Fact Sheets (TFSs) for pre-selected technology were prepared by the adaptation team and shared with the stakeholders. These TFSs enabled stakeholder groups to prioritize technologies. The technologies were then scored on a scale of 0-100 by a stakeholder group, consisting of 15 experts. The experts were asked to give a score from 0-100 in TNA Table (0 means least preferable and 100 means best preferable option). The best and least options were identified first and issued in order from 100-0, then scores for other options were given in between these extreme values. The average value of scores has been taken into account (Table 17).

Once all the options have been scored within the technology category, the criteria were weighted. This is needed as scores applied to one criterion are independent of the others. Assessment of weights for each criterion involved the stakeholder's concerns as it provided opportunity to determine relative importance of each criterion.

Table 17 Scoring results for technologies in agriculture sector

Technologies	C1	C2	C3	C4	C5
Sub-sector: Resource Management					
IFS	57	42	57	50	50
Conservation Agriculture (Minimum tillage)	64	65	63	64	70
Biochar	43	32	36	54	32
Sub-sector: Niche based farming					
Organic Nutrient Management	39	39	57	58	84
Cultivation of stress tolerant crop varieties	36	57	53	50	50
Mixed cropping	39	26	34	45	42

In assessing weights, there were different opinions of experts involved in the analysis process. As a result of fruitful debates on the degree of importance of different criteria, normalized weights for each criterion have been provided as following:

- ❖ Contribution to environmental development priorities - 25 percent weightage
- ❖ Contribution to economic development priorities - 20 percent weightage
- ❖ Contribution to social development priorities - 20 percent weightage
- ❖ Ease of application - 15 percent weightage
- ❖ Potential to maximize resilience of the sector - 20 percent weightage

In each sector, technologies were scored and weighted for each criterion and arranged in priority order (Table 18). The more the score was, the higher the rank was.

Table 18: Weighting results for technologies in agriculture sector

Technologies	CW1 25%	CW2 20%	CW3 20%	CW4 15%	CW5 20%	Overall weighted score
Sub-sector: Resource Management						
IFS	14.25	8.4	11.4	7.5	10.0	51.55
Minimum tillage	16.0	13.0	12.6	9.6	14.0	65.2
Bio charcoal	10.75	6.4	7.2	8.1	6.4	38.85
Sub-sector: Niche based farming						
Organic Nutrient Management	9.75	7.8	11.4	8.7	16.8	54.45
Cultivation of stress tolerant crop varieties	9.0	11.4	10.6	7.5	10.0	48.5
Mixed cropping	9.75	5.2	6.8	6.75	8.4	36.9

5.4 Result of technology prioritization

The stakeholder's workshop organized on 4th January, 2013 finalized the prioritization of the technologies under two thematic sub-sectors namely resource management and niche-based farming. The prioritized technologies are minimum tillage, and organic nutrient management.

Lastly, sensitivity analysis was conducted to assess the robustness of the results relative to the weights and scores applied and other uncertainties. It showed that, for most measures, the experts' judgement did not vary significantly. The list and assessment of prioritized adaptation technologies in agricultural sector is given below in Table 19.

Table 19: List and assessment of prioritized adaptation technologies in agricultural sector

Availability/scale	Technology	Adaptation potential in 20 years	Estimated investment cost
Short-term/small-scale	Minimum tillage	High	US$ 488/ha
Short-term/small-scale	rganic Nutrient Management	High	US$ 290/ha

CHAPTER 6: TECHNOLOGY PRIORITIZATION FOR PUBLIC HEALTH SECTOR

6.1 Climate Change Vulnerability and Existing Technologies and Practices in Public Health Sector

The climate change has differential impacts on human health due to different levels of vulnerability of the people. There are huge spatial and temporal variations of climatic elements in Nepal. The impacts of climate change on health have been observed through the changes in average temperature, precipitation and extreme weather events. These changes have brought direct and indirect impacts on human health.

Based on existing database and observation, the health impacts due to climate change are summarized into three groups: (a) Extreme weather-related health impacts such as heat wave causing heat stress in Tarai region of Nepal where average summer temperature remain above 30°C. The consequences are hyperthermia, heat stroke, heat exhaustion, heat syncope, heat cramps, and heat rash. Similarly, cold wave in different parts of the country including Tarai region in winter causes respiratory problems such as cough, throat infection, chronic obstructive pulmonary disease (COPD), bronchitis, asthma, pneumonia, chronic bronchitis and others like rotavirus diarrhea, skin diseases etc. (b) Vector borne diseases including Japanese Encephalitis (JE), malaria and Kala- azar (Visceral leishmaniasis) seem to have occurred in the warmer districts of Nepal. The cases of Dengue have also been observed in the selected districts of Nepal. (c) Diarrheal disease shows a definite seasonal pattern in a year. The trend of diarrhea morbidity has been in increasing trend despite several government intervention programs.

Some weather conditions are conducive for spreading of water borne and vector borne diseases. There are serious concerns that increased climate variability in combination with increased population density and inadequate sanitation could augment the occurrence of these diseases in Nepal. Under the scenario, it is important that the climate change adaptation address the issues and support in building healthy nation.

6.2 Adaptation Technology Options and their main adaptation benefits

6.2.1. Drinking Water Quality Surveillance

Technology

At national level water quality contamination is very common throughout the year and intensity of contamination is higher during monsoon period. Diarrheal epidemics occur every year in some parts of the county. National water quality standard with 27 parameters is available. For water quality surveillance, laboratory, equipment and trained human resource for analyzing all the required parameters at district level are required. The lack of drinking water quality surveillance at district level is due to lack of resources and laboratory.

Contribution to Adaptation

Climate change is being experienced by the weather extremities especially increased temperature. The water resources are directly or indirectly affected by climate change which has been seen in decrease in water quality and quantity of the existing water supplies. On the other hand, this change temperature is very much favorable to the aquatic microorganisms to replicate faster and to enhance their virulent effects as water borne diseases to human beings. Water quality surveillance is an assessment tool concerned with whether water quality supplied by the government to the people has complied with the National water quality standards or not. If it has not complied with the national standards, then no doubt the diarrheal disease will always be in increasing trend.

6.2.2. Rain Water Harvesting

Technology description

Rain Water Harvesting (RWH) is a simple and accessible technology to fulfill the water quantity gap in most of the places including Nepal. To maintain basic hygiene and sanitation condition, adequate amount of water is required. If the available amount of water is not adequate, then basic sanitation cannot be maintained and results to high morbidity and mortality due to diarrheal disease. The amount of water with the exiting sources is decreasing which is more severe during dry season. RWH can be one of the best options to collect and store water obtained during rainy season for use in dry season. Thus, properly managed RWH increases per capita water use and improves hygiene and sanitation condition and reduces water borne diseases among the communities. The RWH involves collection, store, management and use of rainwater by individual households and there are few if any institutional requirements. However, storage containers usually show economies of scale. Therefore, groups of households can often benefit by directing rainfall to one or larger shared storage containers.

Contribution to Adaptation

The fulfillment of water quantity deficit depends on the volume of the container and internalization of severity of the problem by the users. Due to the climate extremity decrease of water volume especially during dry season is increasing. Rain water harvesting is one of the adaptation options to combat water scarcity. It is most suitable for hill areas of Nepal.

6.2.3. Healthcare liquid waste management

Technology description

Water borne disease is the most common diseases in Nepal. It is preventable disease if proper hygiene and sanitation are maintained. Liquid waste generated from most of the healthcare organizations are directly discharged into nearby water bodies or municipal sewerage which ultimately mix with the nearby rivers. Healthcare waste contains high concentration of pathogenic microorganisms and if not treated properly, then it distributes all pathogens where it is being directly discharged into the water bodies. It is observed in most of the places that local communities use nearby water sources without caring their quality of water for different domestic activities such as cleaning, washing and gardening. The ignorance of using contaminated water for different domestic activities may be one of the causes of water contamination at consumption points resulting high water borne diseases in Nepal. Depending on the types of treatment plants adopted two type of treatment plants are recommended based on the Nepalese experience (a) Reed bed treatment plant (Biological TP) (b) Anaerobic digester

Contribution to Adaptation

Treatment plant can provide multiple benefits such as reduction in water borne diseases, quality of life enhanced, productivity increased and aesthetic value of the surroundings increased. Treated water helps to reduce the burden of water scarcity. Similarly, due to improved environment of the hospital Nosocomial infection of the hospitalized patient decreases and hospital stay will be shortened.

6.2.4. *Bacillus thuringiensis israelensis*

Technology description

Bacillus thuringiensis (Bt) is a naturally occurring bacteria in the soil throughout the world. It is one of the microbial insecticides used in widespread. The strain of *Bacillus thuringiensis israelensis* (Bti) has been isolated to kill mosquito larvae. Bti acts on the mosquito larvae by producing proteins that reacts with the cells of the gut lining of susceptible insects and paralyzes the digestive system of the infected insects stopping feeding within hours and ultimately die. To control mosquito larvae, Bt formulation containing israelensis strain are placed into the standing water of mosquito breeding sites. For these applications, Bti usually is formulated as granules or solid, slow-release rings or briquettes to increase persistence. The quantity of Bti use is determined by the size of the water body.

Contribution to Adaptation

Vector borne disease is climate sensitive disease. Despite the government's multiple efforts of curative and preventive measures such as treatment, insecticide spray, insecticide impregnated bed-nets etc. the types, coverage and mortality and morbidity due to vector borne diseases are in increasing trend. The Bti is an environmentally friendly technology. Unlike most insecticides, Bti does not have a broad spectrum of activity, so they do not kill beneficial insects. Therefore, Bti integrates well with other natural controls. Bti is essentially nontoxic to people, pets and wildlife. It is well tested and more than two decades global experience of assessing its effectiveness.

6.2.5. Bed nets

Technology description

Insecticide-treated bed nets (ITNs) are one of the most effective methods of reducing main-vector contact in intra and peridomiciliary transmission of vector borne diseases. The principle of ITNs is to act as 'baited traps' with the odor of the sleeper as bait, alongside a deterrent and repellent effect. Bed nets can be a useful means even for Visceral leishmaniasis (VL) control if finer mesh (>40 holes/cm2) are produced as sandfly proof bed nets. The effectiveness of bed nets to prevention of parasite transmission depends on mesh size, behaviour of the vector in terms of biting habits, and on sleeping habits.

Contributions to Adaptation

Bed net is acting as barrier between vector and human beings. Community is aware of different types of bed nets. It can be easily acceptable to all groups in the community. The contribution of bed net use to the climate change adaptation is related to the behavior change communication of the individual, households and at the community level.

6.2.6. Reduce polluted stagnant water bodies

Technology description

Stagnant polluted water bodies provide good environment for vector breeding. Increased temperature has supported fast breeding of the vectors and resulting high chances of vector transmission and diseases. Haphazard open drainage and stagnant water bodies especially in the Tarai region are the avenues for vector borne diseases aggravated by climate change (temperature rise).

Contribution to Adaptation

It is the preventive measure which requires hardware as well as software. Drainage coverage, gradient maintenance in the drainage and proper exist point in the drainage system contribute in the adaptation to vector borne diseases.

6.3 Process and Criteria of technology prioritization

National development priorities in light of changing climate are the essential driver for the assessment of the technologies that can contribute towards climate change adaptation. Wider group of stakeholders were involved in defining the criteria for technology prioritization under current national concerns and priorities. The following criteria have been identified and applied for prioritization of adaptive technologies as described in Chapter 4 section 4.3:

- Contribution to economic development priorities;
- Contribution to social development priorities;

- Contribution to environmental development priorities;
- Ease of implementation;
- Potential to maximize resilience.

Process

Technology Fact Sheets (TFSs) for pre-selected technology were prepared by the adaptation team and shared with the stakeholders. These TFSs enabled stakeholder groups to prioritize technologies. The technologies were then scored on a scale of 0-100 by a stakeholder group, consisting of 15 experts. The experts were asked to give score from 0-100 in TNA Table (0 means least preferable and 100 means best preferable option). The best and least options were identified first and issued in order from 100-0, then other options were scored in between 100 and 0. The average value of scores has been taken into account (Table 20).

Table 20: Scoring results for technologies in health sector

Technologies	C1	C2	C3	C4	C5
Sub-sector-Diarrheal disease					
DWQS	52	54	75	75	75
HCLWM	82	67	61	72	72
WASH	34	43	55	38	46
Sub-sector- Vector borne disease					
Mosquito Nets	62	57	41	50	62
Bti	64	74	61	59	70
RSWB	59	42	47	54	63

Once all the options have been scored within the technology category, the criteria were weighted. This is needed as scores applied to one criterion are independent of the others. Assessment of weights for each criterion involved the stakeholders concerns as it provided opportunity to determine relative importance of each criterion.

In assessing weights, there were different opinions of experts involved in the analysis process. As a result of fruitful debates on the degree of importance of different criteria, normalized weights for each criterion have been provided as following:

- Contribution to environmental development priorities - 25 percent weightage

- Contribution to economic development priorities - 20 percent weightage
- Contribution to social development priorities - 20 percent weightage
- Ease of application - 15 percent weightage
- Potential to maximize resilience of the sector - 20 percent weightage

In each sector, technologies were scored and weighted for each criterion and arranged in priority order (Table 21). The more the score was, the higher the rank was.

Table 21: Weighting results for technologies in health sector

Technologies	CW1 25%	CW2 20%	CW3 20%	CW4 15%	CW5 20%	Overall weighted score
Sub-sector-Diarrheal disease						
DWQS	20.5	13.4	12.2	10.8	14.4	71.3
HCLWM	13.0	10.8	15.0	11.25	15.0	65.05
WASH	8.5	8.6	11.0	5.7	9.2	43.0
Sub-sector- Vector borne disease						
Mosquito Nets	15.5	11.4	8.2	7.5	12.4	55.0
Bti	16.0	14.8	12.2	8.85	14.0	65.85
RSWB	14.75	8.4	9.4	8.1	12.6	53.25

6.4 Result of technology prioritization

The stakeholder's workshop organized on 4th January, 2013 finalized the prioritization of the technologies under two thematic sub-sectors namely diarrheal disease and vector borne disease. The prioritized technologies are Drinking Water Quality Surveillance, and *Bacillus thuringiensis israelensis* (Bti).

Lastly, sensitivity analysis was conducted to assess the robustness of the results relative to the weights and scores applied and other uncertainties. Analysis provided by experts proved that the priority measures for each selected sub-sector are priority measures according to all the experts. Analysis showed that, for most measures, the experts' judgement did not vary significantly. The list and assessment of prioritized adaptation technologies in Public health sector is given below in Table 22.

Table 22: List and assessment of prioritized adaptation technologies in Public health

Availability/scale	Technology	Adaptation potential in 20 years	Estimated investment cost
Short-term/small- scale	Drinking Water Quality Surveillance	High	US$1,25,000 (in 5 district)
Short-term/small- scale	Bti	High	US$ 1,00,000

CHAPTER 7: SUMMARY AND CONCLUSIONS

7.1 Summary and Conclusion

Under the framework of Technology Needs Assessment-adaptation technologies as per the guidance provided by TNA handbook, National TNA team reviewed the country's development priorities and adaptation essentials including ease of implementation and potential to maximize resilience of the sectors. As a result, three priority sectors/sub-sectors were identified and relevant technologies were prioritized. The list of prioritized technologies that have potential to improve the resilience towards climate change is summarized in the Table 23 below.

Table 23: List of prioritized technologies to adapt to climate change

S.N.	Sector / Technology	Availability/ Scale
1.	Water Resources Sector	
	Sprinkler irrigation	Short-term/small-scale
	Flood forecasting and warning	Short-term/medium-scale
2.	Agriculture Sector	
	Minimum tillage	Short-term/small-scale
	Organic Nutrient Management	Short-term/small-scale
3.	Public Health Sector	
	Drinking Water Quality Surveillance	Short-term/small-scale
	Bti	Short-term/small-scale

7.2 Way forward

Nepal is at present formulating National Adaptation Plan (NAP) for the medium-and long-term considering the sectors identified by the National Climate Change Policy 2019. The NAP is identifying adaptation measures to address the future climate risks in each of the sectors. In this context, the adaptation technologies that are identified under this assessment through an extensive participatory approach could be further reviewed in the current climatic condition and prioritized for their interventions through NAP. Additionally, NAP process is expected to devise adaptation measures and strategies in each of the sector through a participatory approach for which this assessment report could be an important source. Apart from this, the NAP process could also identify more technologies that are feasible and important in the present context to address the exacerbating impacts of climate change in each of the sectors.

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ANNEX 1: TECHNOLOGICAL FACT SHEETS FOR SELECTED TECHNOLOGIES

1. Technology Fact Sheet for Sprinkler/drip Irrigation System

Sector	Water Resources
Sub-sector	Irrigation
Technology Name	Sprinkler /drip Irrigation System
Technology Characteristics	
Introduction	Systems of pressurized irrigation, sprinkler or drip, can improve water efficiency and contribute substantially to improved food production. Sprinkler irrigation is a type of pressurized irrigation that consists of applying water to the soil surface using mechanical and hydraulic devices that simulate natural rainfall. These devices replenish the water consumed by crops or provide water required for softening the soil to make it workable for agricultural activities. 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, sprays or guns mounted on risers or moving platforms. Today a variety of sprinkler systems ranging from simple hand-move to large self-propelled systems are used worldwide.
Size of beneficiaries group	From individual small size land to large size land with operated by user groups
Institutional and organizational requirements	A whole range of institutional conditions must be understood before sprinkler irrigation technology selection can be made. These include land tenure issues, water rights, and financial incentives by government and taxation. Large-scale irrigation schemes will usually form part of national policy and could be harnessed to support national employment initiatives. Where the sprinkler irrigation type is not available nationally, foreign imports or government-supported stimulation of national manufacture will be required alongside investment in training for design, installation and maintenance. Coordination with public or private authorities in charge of water management will be crucial and could be facilitated through the establishment of a committee of irrigation users. At a local level, social organization for the participatory monitoring of water resources and quality could provide a key monitoring tool. Whichever method is selected, developing regulations for the distribution and allocation of water would provide an important mechanism for conflict resolution. Whether a large or small-scale intervention, farmer involvement in the development stages of a sprinkler irrigation project is recommended to help ensure social acceptance and technical success.

Disadvantages	The main disadvantages associated with sprinkler systems are related to climatic conditions, water resources and cost. Even moderate winds can seriously reduce the effectiveness of sprinkler systems by altering the distribution pattern of the water droplets. Likewise, when operating under high temperatures, water can evaporate at a fast rate reducing the effectiveness of the irrigation. Although sprinkler irrigation can help farmers to use water resources more efficiently, this technology relies on a clean source of water and therefore may not be suited to areas where rainfall is becoming less predictable. Implementation costs are higher than that of gravity-fed irrigation systems and large labour force is needed to move pipes and sprinklers in a non-permanent system. In some places such labour may not be available and may also be costly. Mechanized sprinkler irrigation systems have a relatively high energy demand.
Capital Cost	
Cost to implement adaptation options	The cost of installing a sprinkler system suitable for a family production unit ranges from US$ 600 to US$ 2500 per hectare, depending on the type of materials used and the amount of labour contributed by rural producers. Affordable Micro Irrigation Technologies (AMITs) are low cost and low-pressure systems with the same technical advantages as conventional micro-irrigation system, however the technology is packaged and marketed as kits suitable for small fields (25 m^2 to 4000 m^2). The AMIT has the specific advantage of being affordable, and easy to understand; they also have rapid pay back, divisibility and expandability.
Development impacts, indirect benefits	
Reduction of Vulnerability to Climate Change, indirect	Sprinkler irrigation technology can support farmers to adapt to climate change by making more efficient use of their water supply. This is particularly appropriate where there is (or is expected to be) limited or irregular water supply for agricultural use. The sprinkler technology uses less water than irrigation by gravity, and provides a more even application of water to the cultivated plot. Additionally, sprinkler irrigation can reduce the risk of crops freezing due to colder than usual temperatures. More frequent and intense frosts are already impacting on crops as a result of climate change. During the night, the motion of the sprinklers and the application of rain-like water droplets can reduce the stress on crops caused by a sharp decrease in temperature.
Economic benefits	
Employment	Job creation in monitoring, maintenance etc. of the system.
Investment	It is not unusual for such alternative system schemes in developing countries to be heavily funded by international civil society organizations and banks
Social benefits	
Learning	Training elements from capacity building
Health	Enhance food security
Income	Good income generation from cash crops

Environmental benefits	Reduce erosion and water logging
Local context	
Opportunities and Barriers	- Sprinkler irrigation is a versatile technology suitable for application in a wide range of contexts, can be implemented at small or large scale and with either low-cost or more sophisticated components. This technology can be employed in conjunction with other adaptation measures such as the establishment of water user boards, multi-cropping and fertilizer management. - Possible barriers to implementation include lack of access to finance for the purchase of equipment, lack of local skills for design, installation and maintenance of the system and lack of nationally/locally available component parts. A low level of public awareness of or concern for the importance of sustainable water management and use could also be a barrier to the exploration of sprinkler irrigation technology as a climate change adaptation option.
Market Potential	The technology is small-scale, proven and less capital-intensive. It has market potential nationwide.

2. Technology Fact Sheet for Flood Forecasting and Warning

Sector	Water Resources
Sub-sector	Water Induced Hazards
Technology Name	Flood Forecasting and Warning
Technology Characteristics	
Introduction	Detect and forecast threatening flood events so that the public can be alerted in advance and can undertake appropriate responses to minimize the impact of the event. Because of their ability to drastically reduce property losses and loss of life, flood warning services may be seen as a cost- effective means of mitigating flood hazards.
Size of beneficiaries group	Communities in flood prone areas
Institutional and organizational requirements	A flood warning system is not a standalone response to minimization of the impacts of flooding. An early warning system should be coupled with emergency planning measures, such as the provision of evacuation routes and flood shelters, and should also contain an awareness raising element. Actions can take place on a local level, involving larger organizations, with superior resources, knowledge and know- how may still prove beneficial in improving the quality of warning messages from the warning systems. Better still, by working together with neighboring countries that may also operate flood warning systems, it may be possible to obtain more complete and timely meteorological data, better dissemination of warnings and improved responses.
Disadvantages	A flood warning system is not sufficient on its own to reduce risk; people's reactions to warnings - their attitude and the nature of their response - has an important bearing upon the effectiveness of a warning system System inaccuracies may lead to complacency if previous warnings were unfounded, or fear by causing unnecessary anxiety
Capital Costs	
Cost to implement adaptation options	The costs of implementing flood warning systems are expected to differ widely, depending on the level of sophistication of monitoring and forecasting technologies.
Development impacts, indirect benefits	

Reduction of vulnerability to climate change, indirect	Reduction in human casualties Reduction in physical damage to property, infrastructure and economic output
Economic benefits	
Employment	Job creation in monitoring, maintenance etc. of the system
Investment	It is not unusual for flood warning schemes in developing countries to be heavily funded by international civil society organization
Social benefits	
Learning	Training elements from capacity-building
Health	Reduce loss of life
Income	Reduce property losses
Local Context	
Opportunities and Barriers	- It is possible to implement flood warning systems together with other adaptation measures, as part of an integrated flood risk management plan. - Disbelief of the warnings can be a problem. - The approach also requires significant volumes of detailed information to be collected and analyzed in order to detect flood threats. It needs significant investment in equipment and training
Market Potential	Non-market

3. Technology Fact Sheet for Resource Management: Minimum Tillage

1. Technology characteristics	
Sector	**Agriculture**
Technology Name	**Resource Management: Minimum tillage**
Introduction	- Tillage is becoming costly in the context of rising fuel price and lack of labor - Tillage takes a long turn over time between two crops especially between rice and wheat - It becomes late for wheat planting if to wait for field to be ready - Late sown wheat always suffers by the hot wind in late winter/early spring - Ploughing is also responsible for mineralization of organic matter to destroy the soil structure and - There are means and ways to establish the crop in time without tilling the field without reducing the yield - Minimum tillage method of wheat and rice planting is such technique
Institutional requirements	Nepal Agriculture Research Council (NARC) is taking the lead to promote this technology in rice-wheat areas
Beneficiaries	All the farmers, especially engaged with rice and wheat farming will be benefitted from this technology
O and M	Seeding cum fertilizer machine are preferable which costs
Disadvantages	Majority of the rice-wheat farmers are not very familiar with the technology yet.
2. Capital costs	
a. Cost to implement adaptation options	- The technology needs machine - Training the farmers to operate the machine is essential - Start in five districts in first phase - The total cost for one machine is NRS.30000
b. Additional cost to implement	Additional cost per machine is 10000/year and 10000 to train the farmers in cluster
Development impacts, indirect benefits	
Reduction of vulnerability to climate change, indirect	Health of soil maintained, cost of production reduced, and the quality of the life of the farmers enhanced.
Economic benefits	

Employment	More farmers will be attracted to the new technology with reduced cost of production and engage in such system of crop establishment
Investment	Investment in machine is needed and rich may invest on it
Public and private expenditures	Reduce public and private expenditures in land preparation
Development impacts, indirect benefits	
Social benefits	
Income	Increased through reduced cost of cultivation.
Knowledge	Knowledge on the new way of crop establishment increased
Health	Not much impact but less field work in land preparation
Environmental benefits	It reduces GHG emissions through decreased use of fossil fuels in field preparation and by increasing carbon sequestration in soil
Local Context	
Opportunities and Barriers	- Ensures the cost-efficient food production. - Less priority is given to this technology. - NARC has promoted the technology with seed cum fertilizer drill among the farmers. - Unavailability of machines in time may also appear as barrier
Market Potential	The technology has good market potential as farmers are loving the technology.
National status of technology	Technology is already present in research stations and many farmers know about it.
Time frame	The technology is already in use sporadically in some areas of the country and can be scaled up anytime.
Acceptability to local stakeholders	Not many people have accepted it due to lack of appropriate machines and government take the responsibility and commitment to help in this regard.

4. Technology Fact Sheet for Organic Agriculture

Technology characteristics	
Sector	Agriculture
Technology Name	Niche based farming: organic agriculture
Subsector GHG emission (megatons CO2-eq)	Not applicable
Background/Notes, Short description of the technology option sourced from ClimateTech Wiki, Seminars, etc.	Organic agriculture/farming is a system of agriculture that encourages healthy soils and crops through such practices as nutrient recycling of organic matter (such as compost and crop residue), crop rotations, proper tillage and the avoidance of synthetic fertilizers and pesticides (IASA, 1990). Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved (IFOAM, 2008). As stated in the 2002 report of FAO, organic agriculture enables ecosystems to better adapt to the effects of climate change.
Implementation assumptions, How the technology will be implemented and diffused across the subsector?	There is a challenge in making this agricultural system popular among the farmers due to its forgotten values and infancy of its movement in Nepal. National mainstream research and development approach is still chemical dominated. However, it is estimated that about 26% of agriculture in the country is still organic and in recent years it is getting popularity among the farmers, scientists and policy makers. The organic way of life is slowly becoming less of a passing trend and more of lifestyle, for an increasing number of people. It is hoped that the system will get momentum in near future. However, supportive policies and programs are still to be made and enforced.
Reduction in GHG emissions	The system has good potential to reduce the GHG especially nitrous oxide as there in no use of chemical fertilizers.
Impact Statements-How this option impacts the country development priorities	

Country social development priorities	- Improved nutrition: one of the aims of organic agriculture is to produce healthy and nutritious food using local resources. It is claimed that the widespread adoption of organic agriculture could result in rural revitalization, regional self-sufficiency in food production. Recently, National Adaptation Plan of Action (NAPA) to climate change (2010) has mentioned organic farming as one of the adaptation strategies to climate change. - Social cohesion: Organic agriculture not only has technical dimension but also social including the tradition and science. Production of healthy food by optimal use of local resources including human resources is the key to its success. Mutual help respect and benefit sharing are always the key elements of agriculture.
Country economic development priorities	- Efficient use of plant and animal resources: Organic farming promotes, manages and enhances biodiversity which offers more beneficial interactions among the components, higher resource use efficiency higher associational resistance, higher nutrient cycling and mineralization, better microclimatic regimes, less risks to farmers and more possibilities of conserving wider agro-biodiversity. - Efficient use of human and capital resources: There is a big under or unemployment problems in rural households. The proposed agricultural system will generate employment opportunity in the villages promote efficient utilization of household members
Country environmental development priorities	- Reduced air pollution: There is less emission of GHG in organic system because of recycling of plant materials, use of biogas and no use of chemical fertilizers consequently, reduced risk of climate change and associated negative impacts on humane welfare - Biodiversity conservation: Since biodiversity in its fullest sense is the key to the success of organic agriculture, its conservation is ensured by several means.
Other considerations and priorities such as market potential	Nepal is already in international market with such organic products as tea, coffee, essential oils and herbs. However, quality of the products is becoming more and more sensitive matter. Accredited laboratories are essential if to continue with international market. There is a dire need of developing local market for organic products as well. Hygiene and adulteration problems are also defaming the products.
Costs	

Capital Costs	Technology on plant/soil nutrition and plant protection is of paramount importance in making organic agriculture popular in the country. For this, initiation of robust research and development system is essential in the NARC and academia. Government is already spending some amount of money for subsidy to organic input producers and for certification. But there is no budget in technology development. It needs about 10 million rupees/year
Operational and maintenance costs	Operation costs are assumed to be 5% of total capital costs per year. It means 10.05 million rupees in second year and with 5% increment in each consequent year.
Cost of GHG reduction	Not applicable in this context

5. Technology Fact Sheet for Drinking Water Quality Surveillance

Sector	Health
Sub-Sector	Public Health
Technology Name	Drinking Water Quality Surveillance
Scale	Small-Scale
Availability	Available
Technology to be included in prioritization?	Yes
Background/Notes, Short description of the technology options	At national level water quality contamination is very common throughout the year and intensity of contamination is higher during monsoon period. Diarrheal epidemics occur every year in some parts of the county. National water quality standard with 27 parameters is available.

Nepal's Drinking Water Quality Standards

Group	Parameter	Unit	Maximum Concentration
Physical and chemicals	Turbidity	NTU	5 (10)**
	pH		6.5-8.5*
	Color	TCU	5 (15)**
	Taste and Odor		Would not be Objectionable
	Total Dissolved Solids	mg/l	1000
	Electrical Conductivity	µc/cm	1500
	Iron	mg/l	0.3 (3)**
	Manganese	mg/l	0.2
	Arsenic	mg/l	0.05
	Cadmium	mg/l	0.003
	Chromium	mg/l	0.05
	Cyanide	mg/l	0.07
	Fluoride	mg/l	0.5-1.5*
	Lead	mg/l	0.01
	Ammonia	mg/l	1.5
	Chloride	mg/l	250
	Sulphate	mg/l	250
	Nitrate	mg/l	50
	Copper	mg/l	1
	Total Hardness	mg/l	500
	Calcium	mg/l	200
	Zinc	mg/l	3
	Mercury	mg/l	0.001
	Aluminum	mg/l	0.2
	Residual Chlorine	mg/l	0.1-0.2*
Micro Germs	E-Coli	MPN/100 ml	0
	Total Coli form	MPN/100 ml	95 % in sample

	Sources: Environment statistics of Nepal 2008, Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics, Nepal
Implementation assumptions	- The technology for the drinking water quality surveillance is set of laboratory equipment and chemicals for the measurement of the above-mentioned parameters of the drinking water. - MOHP is responsible for drinking water quality surveillance as per the drinking water quality standard 2005. - Unavailability of financial resources, trained manpower and laboratories at district levels may pose challenge in managing and effectively implementing this technology throughout the country.
Adaptation Benefits	Water quality surveillance is an assessment tool to check the water quality supplied by the government to the people. Non-compliance to the national standard will, no doubt, keep the diarrheal disease incidences always in increasing trend. Compliance to the water quality standards will definitely minify the cost spent in curing and will greatly improve health status of locals.
Impact Statement	
Country social development priorities	- Productive and quality life restored. - Awareness on drinking water quality surveillance and its importance in public health increased. - Means and ways to improve the water quality are explored and implemented. - Health of community enhanced. - Hygiene and sanitation quality increased.
Country economic development priorities	**Employment:** - Creation of jobs to support drinking water quality surveillance. - Tourism sector foster **Reduction in Expenditures:** - Reduce public and private expenditures in curing water borne diseases.
Country environmental development priorities	**Reduction of vulnerability to climate change, indirect:** - Decline in water borne diseases, quality of life enhanced, productivity increased and aesthetic value of the surroundings increased. - Point source and non-point source for communicable disease will be identified.
Other considerations and priorities	- Need for water treatment plants identified - With the treated water the burden of clean water scarcity reduced
Cost	

Capital Costs	- Laboratory facilities (equipment and chemicals) for the analyses of the parameters indicated in the NWQS - Technical human resources for each laboratory in the districts - Start in five districts in first phase - US$ 50,000*5=US$ 250,000 (Five districts) - Additional cost per unit ≈ USD 200 per village for awareness program based on the surveillance result
Operational and Maintenance costs	Operation costs are assumed to be 35% of total capital costs per year. The maintenance costs are assumed to be 5 % of the capital cost.

6. Technology Fact Sheet for *Bacillus thuringiensis (Bti)*

Sector	Health
Sub-Sector	Public Health
Technology Name	*Bacillus thuringiensis israeliensis* (Bti)
Scale	Small-Scale
Availability	Available
Technology to be included in prioritization?	Yes
Background/Notes, Short description of the technology options	Malaria, dengue, filariasis, Japanese encephalitis and leishmaniasis are the main vector-borne diseases in Nepal. Integrated Vector Management (IVM) is a process for managing vector populations to reduce or interrupt transmission of disease. *Bacillus thuringiensis* (Bt) is a naturally occurring bacteria in the soil throughout the world. It is one of the microbial insecticides used in widespread. The strain of Bt israelensis (Bti) has been isolated to kill mosquito larvae. Bti acts on the mosquito larvae by producing proteins that reacts with the cells of the gut lining of susceptible insects and paralyzes the digestive system of the infected insects stopping feeding within hours and ultimately die. To control mosquito larvae, Bti formulation containing israelensis strain are placed into the standing water of mosquito breeding sites. For these applications, Bti usually is formulated as granules or solid, slow-release rings or briquettes to increase persistence. The quantity of Bti use is determined by the size of the water body.
Implementation assumptions	There is a little or no challenge of managing and popularizing this technology in the community with different economic condition and knowledge.
Adaptation Benefits	Bti do not have a broad spectrum of activity, so they do not kill beneficial insects. Therefore, Bti integrates well with other natural controls. Bti is essentially nontoxic to people, pets and wildlife. It is well tested and more than two decades global experience of assessing its effectiveness.
Impact Statement	
Country social development priorities	- Productive and quality of life restored. - Knowledge on Bti (*Bacillus thuringiensis israeliensis*) and its importance in public health increased. - Health of community enhanced.

Country economic development priorities	**Employment:** - Creation of jobs if Bti are cultured and raised locally. - Tourism sector foster **Reduction in Expenditures:** - Reduce public and private expenditures in curing water borne diseases.
Country environmental development priorities	Reduction of vulnerability to climate change, indirect: Reduction in vector borne diseases, quality of life enhanced, productivity increased and aesthetic value of the surroundings increased.
Other considerations and priorities	Prevent from mosquito bites and reduce the vulnerability of the people. A total of 86% (≈22 million people) from the 65 districts of the country are vulnerable. Similarly, the number and frequency of hospitalized patients greatly reduced and hospital stay shortened.
Cost	
Capital Costs	US$ 1,00,000
Operational and Maintenance costs	Operation and maintenance costs are assumed to be 25% and 5% of total capital costs per year respectively.

ANNEX 2: LIST OF STAKEHOLDERS

Consultation Workshop on TNA Considering Adaptation Technologies and TNA Considering Mitigation Technologies

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ANNEX 3: PHOTOGRAPHS

STATKEHOLDERS DURING CONSULTATION WORKSHOP ON TNA CONSIDERING ADPTATION TECHNOLOGIES

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