A ROADMAP AND STRATEGY FOR STRENGTHENING CLIMATE CHANGE RESEARCH IN BHUTAN 2021 – 2025

November 2020

Contents

Acronyms

ARDC:	Agriculture Research & Development Center, MoAF
AWS:	Automated Weather Station
BES:	Bhutan Ecological Society
BWP:	Bhutan Water Partnership
CARLEP:	Commercial Agriculture and Resilient Livelihoods Enhancement Program
CBS:	Center for Bhutan Studies
CERC:	Center for Environment & Climate Research, CNR
CLCS:	College of Language & Cultural Studies, RUB
CNR:	College of Natural Resources
CoE:	Center of Excellence, HRDC, DGPC
CRDS:	Center for Rural Development Studies, CNR
CSMA:	Center for Sustainable Mountain Agriculture, CNR
CST:	College of Science & Technology, RUB
DGPC:	Druk Green Power Corporation, DHI
DHI:	Druk Holding & Investments
DRER:	Department of Research & External Relations, RUB
GCBS:	Gedu College of Business Studies, RUB
GCIT:	Gyalpozhing College of Information Technology, RUB
GDP:	Gross Domestic Product
GLOF/s:	Glacial Lake Outburst Floods
GLORIA:	Global Observation Research Initiatives in Alpine Environment
HEROES:	Himalayan Environmental Rhythms Observation & Evaluation System, UWICER
HRDC:	Hydropower Research & Development Center, DGPC
IFAD:	International Fund for Agriculture Development
IPCC:	Intergovernmental Panel on Climate Change
JICA:	Japan International Cooperation Agency
JNEC:	Jigme Namgyel Engineering College, RUB
KGUMSB:	Khesar Gyalpo University of Medical Sciences of Bhutan
LDC:	Least Developed Country
MoAF:	Ministry of Agriculture & Forests
MoIC:	Ministry of Information & Communications
NAP:	National Adaptation Plan
NBC:	National Biodiversity Center, MoAF
NCCC:	National Climate Change Committee, NEC
NCHM:	National Center for Hydrology & Meteorology
NDC:	Nationally Determined Contribution
NEC:	National Environment Commission
RIGSS:	Royal Institute for Governance & Strategic Studies
RLDC:	Regional Livestock Development Centers, MoAF
RSPN:	Royal Society for the Protection of Nature
RUB:	Royal University of Bhutan
SCE:	Samtse College of Education, RUB
SDG/s:	Sustainable Development Goals
TWG:	Technical Working Group
UNDP:	United Nations Development Program
UNFCCC:	United Nations Framework Convention on Climate Change
UWICER:	Ugyen Wangchuck Institute for Conservation & Environmental Research

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Executive Summary

Climate change is unravelling rapidly in the Himalayas and impacting countries like Bhutan, whose socio-economic wellbeing is critically tied to climate sensitive sectors such as hydropower and agriculture. Melting glaciers, decreasing snow cover and changing monsoon patterns will further compromise Bhutan's socio-economic development.

Bhutan's population has almost doubled in the last forty years and is projected to reach 883,000 by 2047. There has been concurrent rise in per capita GDP, as well as associated CO^2 emissions.

Forests, covering about 71% of Bhutan's land area remove -8181.597 Gg CO_2e per year. Total GHG emissions in 2015 were estimated to be 3,750.563 Gg of CO_2e, while total sink capacity of forests was estimated to be 9,386.597 Gg of CO_2e.

The capacity of national and local institutions to address climate related challenges is impeded by lack of information and credible research. Bhutan's ability to remain carbon neutral and meaningfully address the challenges posed by a rapidly changing climate needs to be guided by sound science and reliable data.

Recognizing the scattered and incoherent approach to climate change research, the 2020 Climate Change Policy of Bhutan stipulates overarching guidelines to strengthen research and bring about coherence in approach and strategies.

This roadmap charts a way forward to strengthen climate change research in Bhutan by seeking delivery on five strategic imperatives:

- **Strategic Imperative I: Tackle issues which matter**
- Emphasis should be placed on understanding the full ramifications of climate change to enable design of effective mitigation and adaptation strategies. To focus research efforts, and to ensure value, research institutions, CSOs and constituent Colleges of RUB should prioritize research areas and frame execution plans.

  RUB and research institutions should enter into mutually beneficial and actionable MoUs with relevant Government agencies, and institutions of worth within the region and abroad.

- **Strategic Imperative II: Strengthen institutions and networks, inspire leaders and empower researchers**
- Institutions currently invested in research must be supported and strengthened at multiple levels, in terms of staff capacity, research financing, institutional facilities and credibility. Centers at constituent Colleges should take center stage and act as hubs for climate research, action, and engagement. High level workshops and leadership seminars aimed at coaxing leaders to bring about the required organizational and cultural change should be initiated and convened on an annual basis.

- **Strategic Imperative III: Operationalize a *Climate Research, Information, and Service Portal* (CRISP)**

- A web-based *Climate Research, Information and Service Portal* (CRISP), to hold and provide climate related data and relevant analysis should be set up. CRISP should also serve as a repository for all publications on climate change in Bhutan and provide information to guide researchers on administrative clearances required from multiple sectors.

- **Strategic Imperative IV: Mainstream and strengthen pedagogy, outreach and capacity building**

- Over the next three years, execute a string of priority capacity building programs to bring researchers and leaders up to speed on climate change science, mitigation and adaptation strategies and technologies, and financing frameworks. Annual forums for climate change research dissemination should be organized.

- **Strategic Imperative V: Establish the *Bhutan Science Foundation***

- To sustain funding for research, the Bhutan Science Foundation (BSF) should be established. BSF will be a vital and important addition to Bhutan's growing public benefit apparatus established to support basic and applied research to advance Bhutan's economic prosperity, social wellbeing, and ecological resilience.

1. Motivation & Objectives

Climate change is unravelling rapidly in the Himalayas and impacting countries like Bhutan, whose socio-economic wellbeing is critically tied to climate sensitive sectors. It is understood that no sector will be spared from the inevitable and damaging consequences of climate change. As such, climate change presents a clear and imminent danger to the socio-economic wellbeing and prosperity of Bhutan and countries across the world. In particular, it is noted that climate change will impact mountainous regions like the Himalayas to a greater extent[1]. Furthermore, vulnerable groups and people of lower income will bear a disproportionately larger brunt of the negative consequences of climate change.

Bhutan's economy is heavily reliant on hydropower and agriculture. Hydropower which accounts for almost 13% of Bhutan's GDP[2] (as of 2018), will be significantly impacted by changing monsoons, reduced snowfall and rapidly melting glaciers (Figure 1).

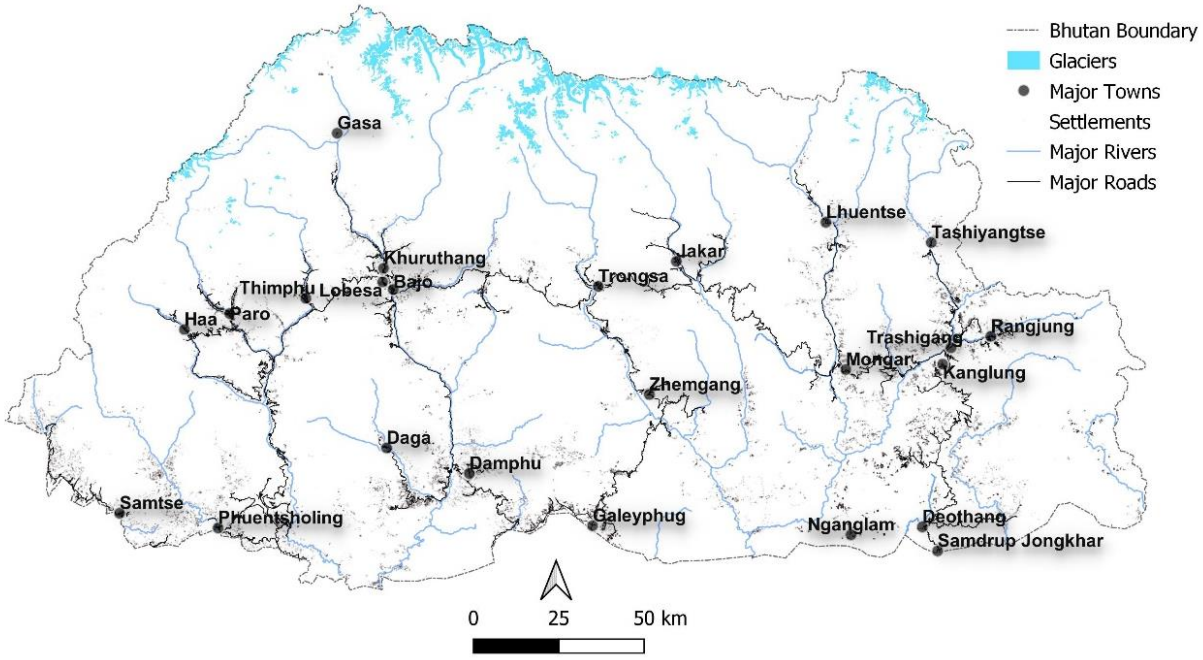

Figure 1. Glaciers in Bhutan

These melting glaciers also add to the risk from GLOFs (Glacial Lake Outburst Floods). Bhutan experienced GLOF events in 1957, 1960, 1968, and 1994. The 1994 GLOF event was the most destructive causing loss of life, damage to property, and endangering one of Bhutan's most precious heritage site, the Punakha dzong[3] (Figure 2). As of 2019, there are 17 potentially dangerous glacial lakes in Bhutan, with 9 of them in the Pho Chhu sub basin[4].

1 Wester, P., Mishra, A., Mukherji, A., & Shrestha, A. B. (2019). *The Hindu Kush Himalaya assessment: mountains, climate change, sustainability and people* (p. 627). Springer Nature.
2 Statistical Year Book 2018. National Statistical Bureau (www.nsb.gov.bt). Royal Government of Bhutan.
3 Watanbe, T., & Rothacher, D. (1996). The 1994 Lugge Tsho glacial lake outburst flood, Bhutan Himalaya. *Mountain Research and Development*, *16*(1), 77-81.
4 NCHM. (2019). Reassessment of Potentially Dangerous Glacial Lakes in Bhutan. NCHM. Royal Government of Bhutan. Thimphu, Bhutan.

Figure 2. Flood damage in and around Punakha dzong due to Lugge Tso GLOF (6 & 7 October 1994), sourced from Watanbe & Rothacher (1996)

In addition to risk from GLoFS, storms and freak weather incidences continue to take a significant toll on infrastructure and livelihoods. Tropical cyclones emanating from a warming Bay of Bengal continue to cause damage to property and agricultural land. In 2009, Cyclone Aila[5] caused damages to the tune of USD17 million[6]. Poor and rural populations remain the most vulnerable and bear the brunt of such disasters. The IPCC's Fifth Assessment Report[7] notes that increases in temperature and precipitation are likely to exacerbate the frequency and intensity of extreme events in South Asia.

Over 58% of Bhutan's population is directly supported by agriculture[8]. As of 2018, agriculture and livestock constituted 24% of Bhutan's GDP, with the forestry sector contributing 4%[9]. Climate change will burden[10] an already challenged sector by impacting yield, reducing available water, increasing weather related disasters for crops, and increasing incidences of pests, diseases and invasive species spread.

Only 18% of arable wetland, mostly for rice cultivation, are irrigated, while 61% of dryland remain without irrigation facilities. A majority of the 1307 existing irrigation schemes are open canal gravity fed systems. Such open systems have a conveyance efficiency of only about 30 – 40% and remain

5 Islam, M. R., & Hasan, M. (2016). Climate-induced human displacement: A case study of Cyclone Aila in the south-west coastal region of Bangladesh. *Natural hazards*, *81*(2), 1051-1071.
6 World Bank. (2015). Modernizing Weather, Water and Climate Services: A Road Map for Bhutan. Washington, DC 20433, USA
7 IPCC (Intergovernmental Panel on Climate Change). (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Cambridge, U.K.: Cambridge University Press.
8 Bhutan Agriculture Statistics 2018. Department of Agriculture. MoAF. www.doa.gov.bt
9 Statistical Year Book 2018. National Statistical Bureau (www.nsb.gov.bt). Royal Government of Bhutan.
10 Wheeler, T., & Von Braun, J. (2013). Climate change impacts on global food security. *Science*, *341*(6145), 508-513.

prone to significant water loss through seepage and evaporation. Programs on water harvesting, efficient conveyance system, water storage structures, use of groundwater, and modern irrigation technologies (drip, sprinkler) are infantile[11].

Water shortage will also impact livestock productivity, through decrease in fodder production, and degradation of pasture and rangelands.

Despite being a water abundant country, many settlements across Bhutan, both rural and urban, face acute shortages of water for drinking and irrigation. This shortage is being further exacerbated by water sources drying and reduction in stream flows. Decreasing snow cover[12] and changing monsoon patterns will further strain already water stressed parts of Bhutan.

Bhutan's population has almost doubled in the last forty years (Figure 3) and is projected to reach 883000 by 2047[13]. There has been concurrent rise in per capita GDP, as well as associated CO^2 emissions.

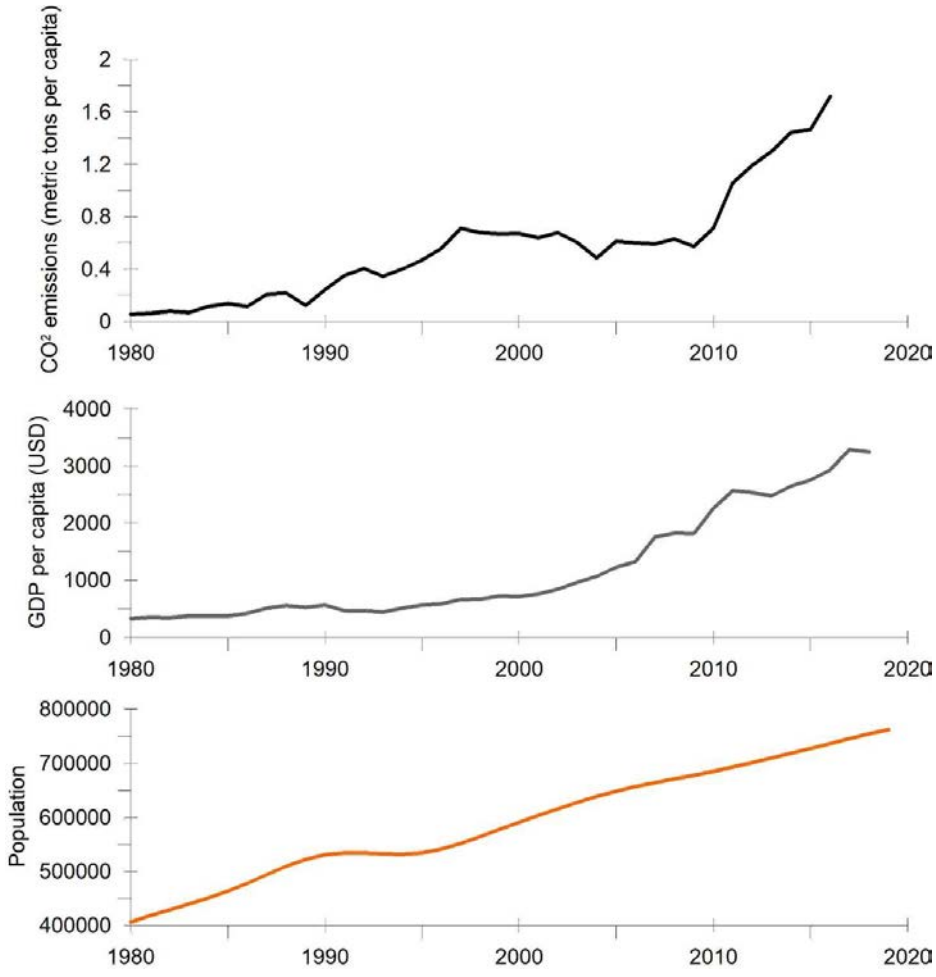

Figure 3. Population growth, rising per capita GDP and CO2 emissions (1980 – 2020). Data from https://data.worldbank.org/

11 MoAF. (2016). The Renewable Natural Resources Sector Adaptation Plan of Action (SAPA 2016). MoAF, RGoB. Thimphu, Bhutan. (http://www.moaf.gov.bt/download/Publications/The-RNR-Sector-Adaptation-Plan-Action-2016_FINAL.pdf)

12 Gurung, D. R., Kulkarni, A. V., Giriraj, A., San Aung, K., & Shrestha, B. (2011). Monitoring of seasonal snow cover in Bhutan using remote sensing technique. *Current Science*, 1364-1370.

13 NSB (2019). Harnessing Bhutan's Demographic Dividend. National Statistics Bureau. Royal Government of Bhutan.

Bhutan's rapid economic growth has also led to a boom in the construction sector, which currently accounts for 14% of Bhutan's GDP[14]. The construction sector is responsible for over 34% of Bhutan's energy related carbon emissions[15].

Rapid economic expansion coupled with population growth has also led to a significant increase in import of vehicles, and related consumption of fossil fuels. Fuel consumption, both diesel and petrol, have increased sixfold over the last indiction (2005 – 2019), while vehicle numbers have increased fourfold over the same period. See Figure 4.

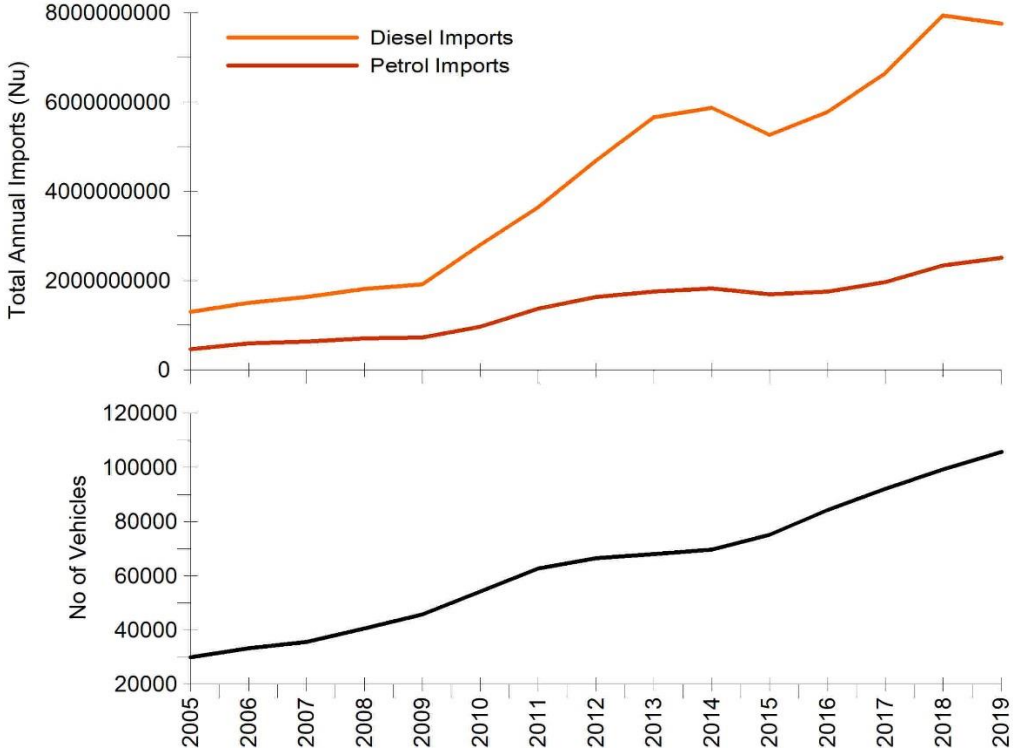

Figure 4. Growth in the number of vehicles and related increase in import of fossil fuels. Data from Bhutan Trade Statistics (www.mof.gov.bt)

This rapid upward consumption trajectory will mean that Bhutan's emissions will continue to rise unless mitigation measures are proactively pursued.

Today, forests (Figure 5), covering about 71% of Bhutan's land area[16], remove -8181.597 Gg CO_2e per year, by just the above ground biomass in forest trees[17]. Total GHG emissions in 2015 were estimated to be 3,750.563 Gg of CO_2e, inclusive of emissions from forestry and other land use. So far, Bhutan remains a net sink, since total sink capacity of forests is estimated to be 9,386.597 Gg of CO_2e in 2015.

14 Statistical Year Book 2018. National Statistical Bureau (www.nsb.gov.bt). Royal Government of Bhutan.
15 RGoB. (2019). Bhutan's 3rd National Communication to the UNFCCC – National Circumstances (DRAFT). National Environment Commission, Royal Government of Bhutan. Thimphu, Bhutan
16 Forests Facts & Figures 2019. Department of Forests & Park Services. Ministry of Agriculture & Forests.
17 RGoB. (2019). Bhutan's 3rd National Communication to the UNFCCC – National Circumstances (Draft). National Environment Commission, Royal Government of Bhutan. Thimphu, Bhutan.

In its Nationally Determined Contribution (NDC)[18], Bhutan aims to remain carbon neutral, building upon a commitment made in December 2009 during the UNFCCC COP-15 in Copenhagen, Denmark. This declaration for carbon neutrality is a manifestation of the moral obligation and commitment of every Bhutanese to be a champion of the environment, and by proxy, climate. This intent to champion environmental conservation finds expression under Article 5 of Bhutan's Constitution, which states that every Bhutanese is a custodian of the environment.

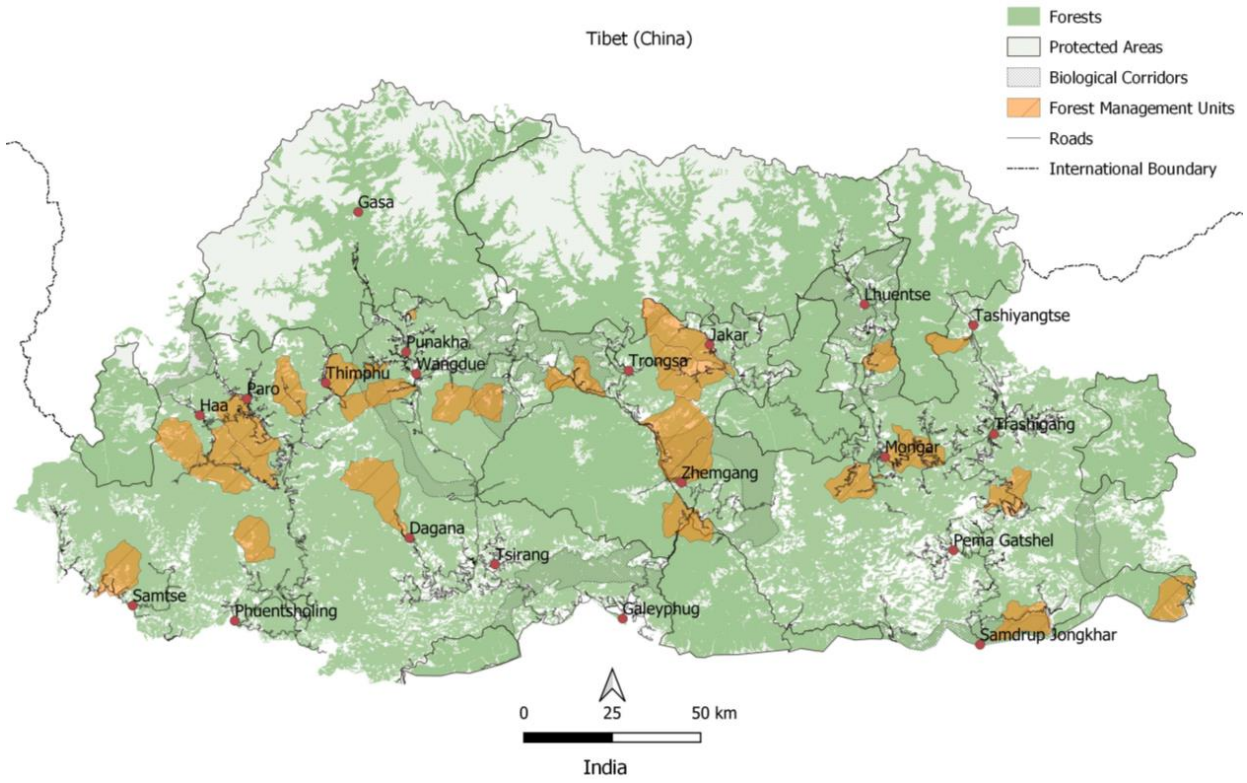

Figure 5. Forest cover, protected areas, biological corridors & forest management units

Bhutan's commitment to a low carbon development pathway[19], coupled with an economy which continues to be heavily tied to climate sensitive sectors, makes it clear that Bhutan needs to pay immediate and urgent attention to the nature and exigencies of a rapidly warming climate. Bhutan also recognizes that national efforts will have to be crafted and executed with an awareness and appreciation of, and for, regional and global developments within the spheres of emissions, adaptation, mitigation, technology, climate finance and capacity building.

The capacity of national and local institutions to address climate related challenges meaningfully is impeded by lack of information and credible research. Bhutan continues to build in-house core competency to understand the implications of climate change, peer into historical climate patterns, and forecast future trends. As Bhutan transitions, significantly so, to the status of a mid-level income country by 2023, it is imperative that climate change research, pedagogy, and outreach be strengthened in terms of execution capacity, institutional alignment, mainstreaming, ownership, outreach and impact.

18 (NDC ref needs to be added)
19 RGoB. (2012). National Strategy and Action Plan for Low Carbon Development. National Environment Commission, Royal Government of Bhutan. Thimphu, Bhutan.

Financial support will have to be guaranteed to ensure that research addressing the most urgent and critical issues are rigorously executed, and mechanisms should be instituted to assure that research results find expression in policy and praxis.

So far, within most institutions, including the RUB, research is still at a formative stage. RUB actively promotes research by according it high priority in its internal policies and research outputs have also been embedded within the University's performance management system. However, lack of funding and support systems with external agencies have hindered the University's progress.

Currently, Bhutan's investment in research is not even measured and may not be significant. Studies have demonstrated clear linkages between a country's economic development and investment in research[20]. Globally, as per estimates by the World Bank[21], average spending on research in 2018 was 2.27% of GDP, with South Korea and Israel investing the most, at almost 4.6% of their GDP.

While Bhutanese society favors evidence-based policy and decision making[22], the culture of research is still weak, and frameworks to provision structural and fiscal incentives for research are infantile, even within institutions mandated to conduct research. Research efforts are further hindered by bureaucratic hurdles to accessing data and obtaining administrative clearances. There is also a perception that attention is not paid to research findings even when results are published. As such, there is an inherent, deep rooted, and systemic inertia stalling research progress.

Nevertheless, there is increasing acceptance and broad consensus that research must be strengthened, in general, and with regards to climate change in particular.

It is also noted that various agencies, both Government based and CSOs, engage in climate change research. It is acknowledged that such agencies will continue to conduct research in their own areas of concern and need to be supported. However, it seems propitious and opportune to leverage the scale, reach and capacity of the RUB to ramp up climate change research, pedagogy, and outreach.

The impacts of climate change are manifesting at an alarming rate across the world. And there are increasing calls for meeting the goals of the Paris agreement[23] and to limit global warming to less than 1.5°C. Bhutan's commitment and obligations to remain carbon neutral while admirable needs to be guided by sound science and reliable data. And research needs to inform both national and global climate policy and action. The need to build institutional capacity and accelerate the pace of climate research and action is therefore urgent.

20 Gumus, E., & Celikay, F. (2015). R&D expenditure and economic growth: new empirical evidence. *Margin: The Journal of Applied Economic Research*, *9*(3), 205-217.

21 https://data.worldbank.org/indicator/

22 As noted by participants at the *Consultation Meeting for the Development of Strategy and Roadmap for Climate Research in Bhutan (20 – 22nd July 2020, Metta Resort, Paro)*

23 https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement

1.1 Objectives

This roadmap document provides a framework for strengthening climate change research in Bhutan. Implementing the strategies outlined in the report will help meet the following objectives:

- Enhance and generate knowledge and information on climate change to support climate action
- Strengthen and streamline institutional mechanisms to support climate change research
- Strengthen capacity of national institutions to contribute significantly to climate change research
- Ensure that research efforts tackle issues that matter and are of value to practitioners and policy makers
- Provision ready and easy access to climate change research data and information for policy makers, decision makers, researchers, and stakeholders
- Generate locally feasible adaptation technologies and mitigation strategies
- Ensure that climate research financing is institutionalized, strengthened, and made available to researchers
- Build capacity to leverage opportunities arising from climate regimes and financing mechanisms to promote sustainable, green, and resilient pathway of 1.5°C

It will further ensure that research goals across sectors are aligned, and thereby lead to better delivery of impactful research results. Research will be increasingly viewed as vital and essential for framing strategies and meeting development goals.

1.2 Structure of the Report

Section 1, motivation and objectives, provides a brief overview of climate change issues with import for Bhutan. It lays out the need to strengthen the capacity of national institutions, outlines the objectives of the roadmap document, and spells out the general structure of the report.

Section 2, state of climate change research and key actors, surveys national institutions invested in climate change research. It reviews past initiatives, on-going programs, and assesses institutional mandates and interests. It identifies gaps, issues and challenges, and highlights research areas which need attention.

Section 3, the roadmap, spells out the principles and salient features of the roadmap document. It then provides **five strategic imperatives** to ensure value creation and strengthening of climate change research.

Section 4, action items and milestones, stipulates key activities which need execution in the next 3 years (2021 – 2023), and provides overarching milestones which need to be achieved.

Section 5, monitoring and evaluation, provides a framework to ensure that key milestones are reached. It identifies agencies which should monitor and evaluate the milestones proposed in this roadmap.

2. State of Climate Research and Key Actors

2.1. State of Climate Research, Policy Support & Mandates

Research in general and climate research in particular has been sporadic and lacks coherence. Each sector, depending on funds available, have been conducting one-off climate change related research projects, with no particular long-term goals and continuity plans. See Annexure 1 for a list of on-going and past climate related research projects.

Recognizing the scattered and incoherent approach to climate change research, the Climate Change Policy of Bhutan (2020)[24] stipulates a few overarching guidelines to strengthen research and bring about coherence in approach and strategies.

It calls on the Royal University of Bhutan (RUB) and other research institutions, in line with their respective mandates, to carry out needs-based research to support informed decision-making and the planning and implementation of climate change action.

The Policy also recognizes the need to increase public awareness and understanding on climate change. It further acknowledges the need to enhance the capacity of all relevant stakeholders and institutions, including local governments, community groups and beneficiaries. And it calls for a coherent and coordinated process to access support from international mechanisms for climate change capacity building.

The Policy reiterates the role of the National Environment Commission (NEC), chaired by the Hon'ble Prime Minister or his nominee as the highest cross-sectoral environmental policy and regulatory body responsible for coordinating all matters relating to the protection, conservation and improvement of the environment. The NEC is mandated to continue to function as the high-level National Climate Change Committee (NCCC), where it derives its mandate from the National Environment Protection Act of 2007, Water Act of 2011, Waste Prevention and Management Act of 2009, Environmental Assessment Act of 2000, and other directives of the government.

2.2. Climate Issues, Key Actors & Climate Change Research

2.2.1 Paleoclimatology, Climate Projections, Monsoons & the Cryosphere

The National Center for Hydrology and Meteorology (NCHM) is mandated to provide climate change data and weather information. The NHCM is also responsible for cryosphere research and is continuing to monitor and research the dynamics of Bhutan's glaciers[25]. The list below elaborates further on NCHM's focus areas.

Weather & Climate:

- Climate change projection
- Historical analysis of climate (paleoclimate[26])
- Weather forecasting and modelling

24 RGoB. (2020). *Climate Change Policy of the Kingdom of Bhutan*. Royal Government of Bhutan. Thimphu, Bhutan.
25 Glaciers were earlier monitored by the Department of Geology & Mines and work was mostly done in collaboration with JICA.
26 Krusic, P. J., Cook, E. R., Dukpa, D., Putnam, A. E., Rupper, S., & Schaefer, J. (2015). Six hundred thirty□eight years of summer temperature variability over the Bhutanese Himalaya. *Geophysical Research Letters*, *42*(8), 2988-2994.

- Seasonal forecasting and verification (Monsoons[27])
- Medium and extended range forecasting
- Regional climate modelling (currently being setup process)

Cryosphere:

- Glacier mapping and inventory
- Glacier monitoring program & assessment of potentially dangerous glacial lakes in Bhutan

Hydrology & Water:

- Flood modelling
- Flood hazard assessment and mapping
- Sedimentation
- Ground water and climate change impacts to hydrological regime

2.2.2 Agriculture, Livestock & Food

Given the importance of the agriculture sector, research within the MoAF is well institutionalized and the most mature. It executes its research and development mandate through a network of Agriculture Research and Development Centers (ARDC/s) spread across Bhutan (Figure 6 & Table 1).

As of now, there is no coherent framework for climate change research within the agriculture sector, albeit there are scattered efforts across the different ARDCs (Table 1).

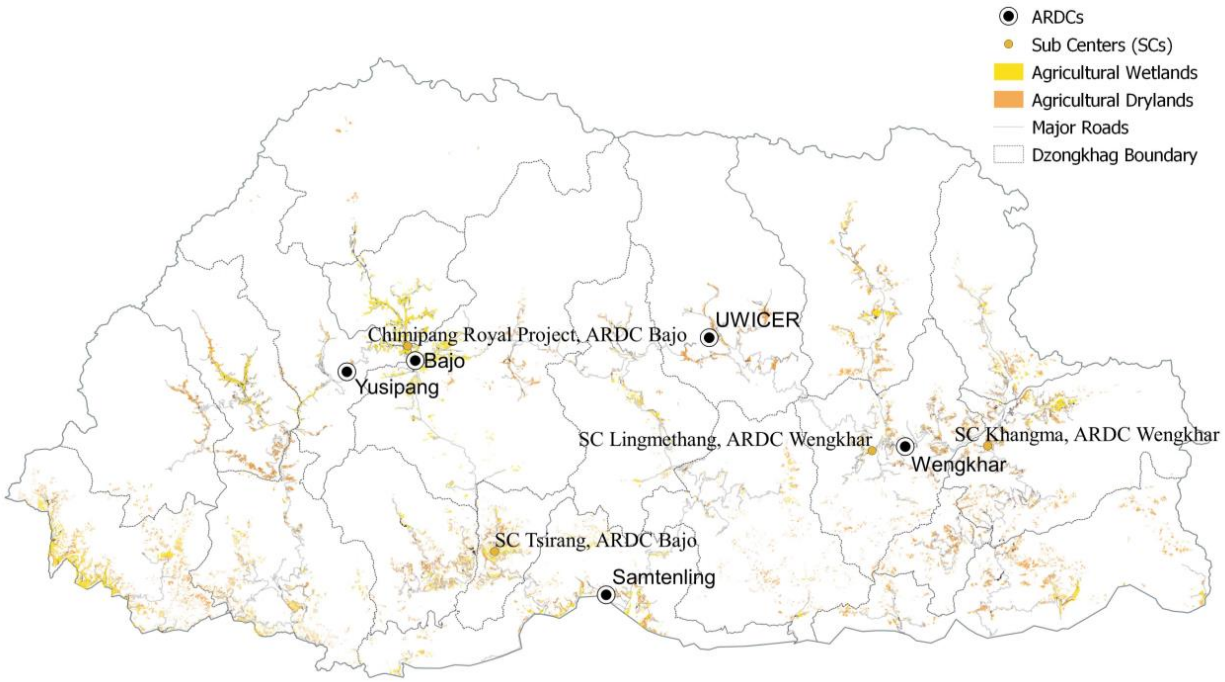

Figure 6. Location map of the Department of Agriculture's ARDCs, their sub-centers and UWICER under DoFPS

Under the Department of Livestock, the National Highland Research & Development Center in Bumtang specifically mentions climate change adaptation research for highlanders as one of their main thrust areas.

27 Sano, M., Xu, C., Dimri, A. P., & Ramesh, R. (2020). Summer Monsoon Variability in the Himalaya over Recent Centuries. In *Himalayan Weather and Climate and their Impact on the Environment* (pp. 261-280). Springer, Cham.

Table 1. Research agencies under the MoAF & focus areas

Department	Center/ Agencies	Focus Areas (initiatives related to climate change only listed)
Department of Agriculture:	ARDC, Yusipang	▪ Currently testing drought tolerant potato varieties
	ARDC, Bajo (with sub-stations at Tsirang and Chimipang Royal Project)	▪ Drought resistant trails for rice are on-going
	ARDC, Samtenling	
	ARDC, Wengkhar (with sub-stations at Lingmethang & Khangma)	▪ Heat resistant vegetable varieties are being trailed
Department of Livestock:	National Highland Research & Development Center, Bumtang	▪ Climate change adaptation research for highlanders
Department of Forests & Park Services	UWICER	▪ Dendrochronology for understanding paleoclimate
	Bhutan Tiger Center	▪ Impact of climate change on apex predators like the tiger[28]

The CNR[29] is also conducting climate change research with some bearing on food security and livelihoods (Box 1).

Box 1. Ongoing climate change research at the CNR

- Rainfall Pattern and Water Poverty and their Implication to Local Livelihoods in the Context of Changing Climate in Bhutan (ongoing till December 2020)
- Livelihood Vulnerability Approach to Assessing Farmers Vulnerability to Climate Change in central Bhutan (ongoing till December 2020).

2.2.3 Forests & Biodiversity

Research on forests and biodiversity are mostly carried out by the UWICER (Figure 6) based out of Bumthang under the DoFPS. The recently established Bhutan Tiger Center under the DoFPs is initiating research to understand the impacts of climate change on apex predators, like tigers.

The National Biodiversity Center (NBC) also has a stake in biodiversity research and holds the mandate to conduct bioprospecting and conserving genetic resources through their national gene bank initiative. NBC has partnered in the GLORIA initiative (Annexure 1) to track species range and composition shifts within alpine regions of Bhutan.

2.2.4 Water

Water being a resource of critical importance cuts across various sectors and many agencies have a stake and oversight responsibility[30]. The NEC is tasked with the overall mandate for

28 Personal communication with Dr. Tshering Tempa (PhD), Program Director of the Bhutan Tiger Center
29 https://www.cnr.edu.bt/
30 NEC (2016) National Integrated Water Resources Management Plan 2016. Royal Government of Bhutan. Thimphu, Bhutan

water resources governance, but implementation agencies spread across a spectrum of users, from drinking to irrigation to energy generation. Water can also be a source for vector borne diseases and floods. See Figure 7.

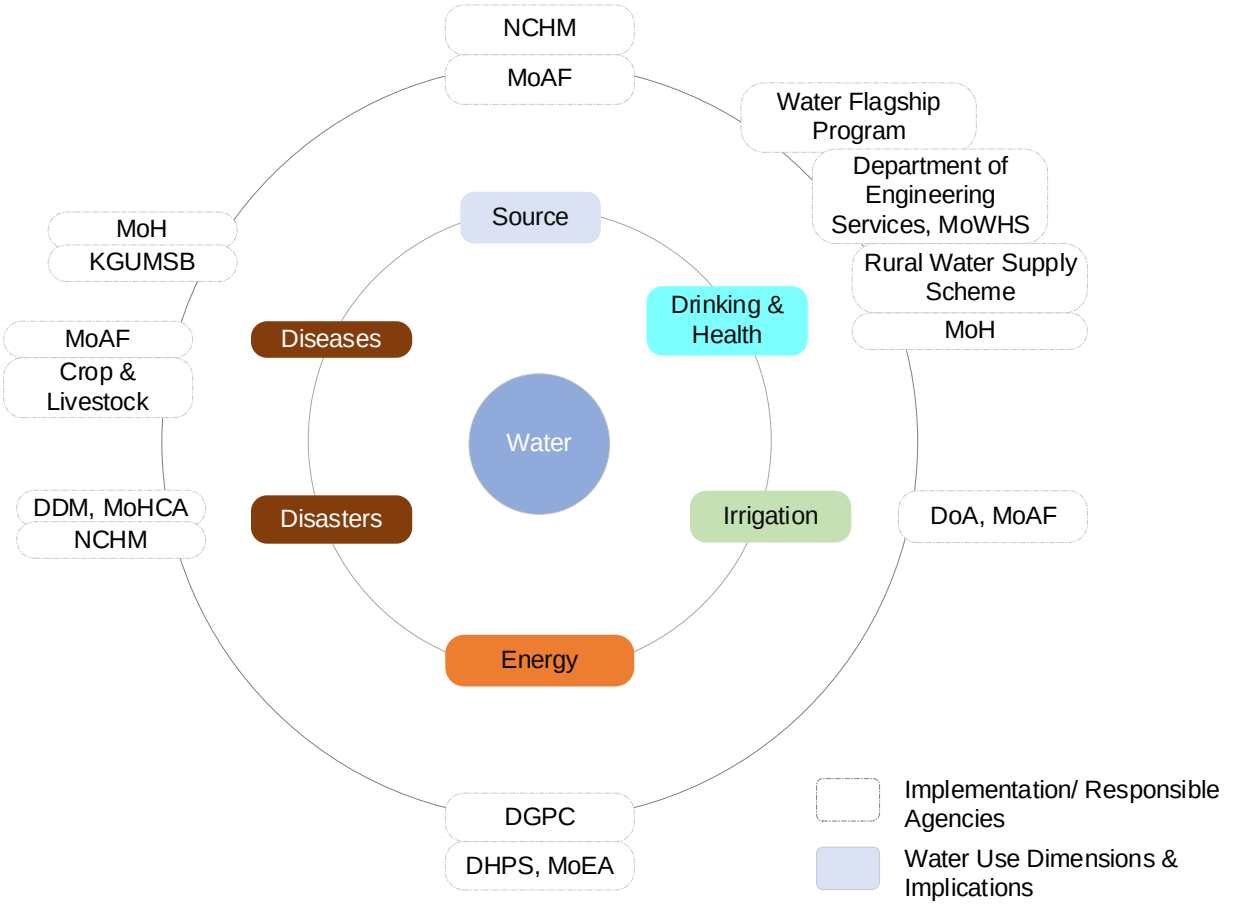

Figure 7. The cross-cutting nature of the water means the intersection of multiple interests. There is no dedicated institution for conducting research on water related issues.

To enhance cooperation across sectors, the Bhutan Water Partnership (BWP) has been in operation since the early 2000s and is currently hosted under the Royal Society for the Protection of Nature (RSPN). The BWP however is not carrying out any research.

Given the intersecting interests of many actors and dispersed governance structure, research on water has been lacking and the impacts of climate change on water resources has not been addressed. This leaves ample room for institutions to collaborate and redress this shortfall.

2.2.5 Energy

Bhutan's economy is heavily reliant on hydropower, which in turn is dependent on the hydrology of Bhutanese rivers. Climate change raises uncertainties and increases risks for the hydropower sector. Given that hydrology, sedimentation, and the resilience of hydropower infrastructure are of prime importance to the DGPC, it has established its own Hydropower Research & Development Center (HRDC) which operates 3 Centers of Excellence (CoE): a) Condition Based Monitoring; b) Automation, Control and Protection; c) Civil & Geotechnical Engineering; and d) Hydraulics. The CoE for Hydraulics is tasked to provide river discharge and generation forecasts.

There is also increasing recognition that Bhutan needs to diversify its energy sources not only to buffer the impacts of climate change on the hydropower sector, but also as a means of creating employment through the promotion of renewables.

The Center for Renewables and Sustainable Energy Development (CRSED)[31] under the College of Science & Technology (CST), RUB intends to research on and promote renewables. There are further opportunities for cross and multi-agency collaboration since CSOs like BES are also actively pursuing and committed to the promotion of renewables in Bhutan[32].

2.2.6 Health

Bhutan is witnessing increasing incidences of mosquito-borne diseases such as chikungunya fever and dengue, parasitic diseases such as leishmaniasis, lymphatic filariasis and onchocerciasis, and tick-borne diseases, which may exhibit changes in transmission intensity or shifts in their geographical ranges due to the impact of climate change[33, 34].


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Dengue and Chikungunya outbreak in P/ling and Samtse

July 20, 2019

Post Views: 438

Phuentsholing General Hospital has reported of more than 100 cases of dengue fever until yesterday this month.

The hospital saw most of the cases this week. Due to increased number of patients, the hospital had to keep extra trollies outside the emergency rooms to cater to those who couldn't avail the beds. The number of cases dropped by the end of the week.

Chief medical officer, Dr Thinley Pelzang said that preventive measure of thermal fogging started about five days ago. "We want to advise people to avoid mosquito bites," the doctor said.

He said people should keep their surroundings clean and cover breeding sites.

Phuentsholing has consistently seen dengue fever cases in the last five years. The highest was reported in 2016 with 857 positive cases but no casualties were reported. It was the year Phuentsholing received heavy rainfall.

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Basic protective measures against the new coronavirus: WHO
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Conference
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COVID -19
COVID Bhutan News
COVID new and Update
COVID-19 Update
Editorial
Fighting Fake News
Forum
hello
home

Figure 8. A Kuensel article from July 2019 reporting on dengue and chikungunya outbreak in Phuentsholing & Samtse[35]

Although there is no dedicated climate change research program on health, the Khesar Gyalpo University of Medical Sciences Bhutan (KGUMSB) is taking stock of such incidences and preparing to assess what new risks are likely to emerge due to climate change.

31 https://cst.edu.bt/index.php/en/research-3/research-center/cdsed
32 https://kuenselonline.com/mou-to-widen-the-energy-supply/
33 Rocklöv, J., & Dubrow, R. (2020). Climate change: an enduring challenge for vector-borne disease prevention and control. *Nature Immunology*, *21*(5), 479-483.
34 McMichael, A. J., Campbell-Lendrum, D. H., Corvalán, C. F., Ebi, K. L., Githeko, A., Scheraga, J. D., & Woodward, A. (2003). *Climate change and human health: risks and responses*. World Health Organization. Geneva, Switzerland.
35 https://kuenselonline.com/dengue-and-chikungunya-outbreak-in-p-ling-and-samtse/

2.2.7 Transport & Industry

Bhutan's aspiration to remain carbon neutral and to pursue a low carbon development pathway will depend critically on what kind of innovation occurs within the transportation and industries sector[36]. The transportation sector is a significant contributor of GHG emissions (about 424.75 Gg of CO_2e) along with the industrial processing and product use sector accounting for 796.423 Gg of CO_2 e emissions, about 21.23% of the national net emission[37].

Research leading to innovative policy and promotion of viable technologies is needed to ensure carbon neutrality of the transport and industry sector. Currently, there are no academic institutions dedicated to the study of transport and industries in Bhutan.

2.2.8 Climate Related Disasters

GLOFs remain a real and immediate risk to many of Bhutan's infrastructure and agricultural land. With rise in temperatures, there is also increasing risk from forest fires, weather storms and flash floods.

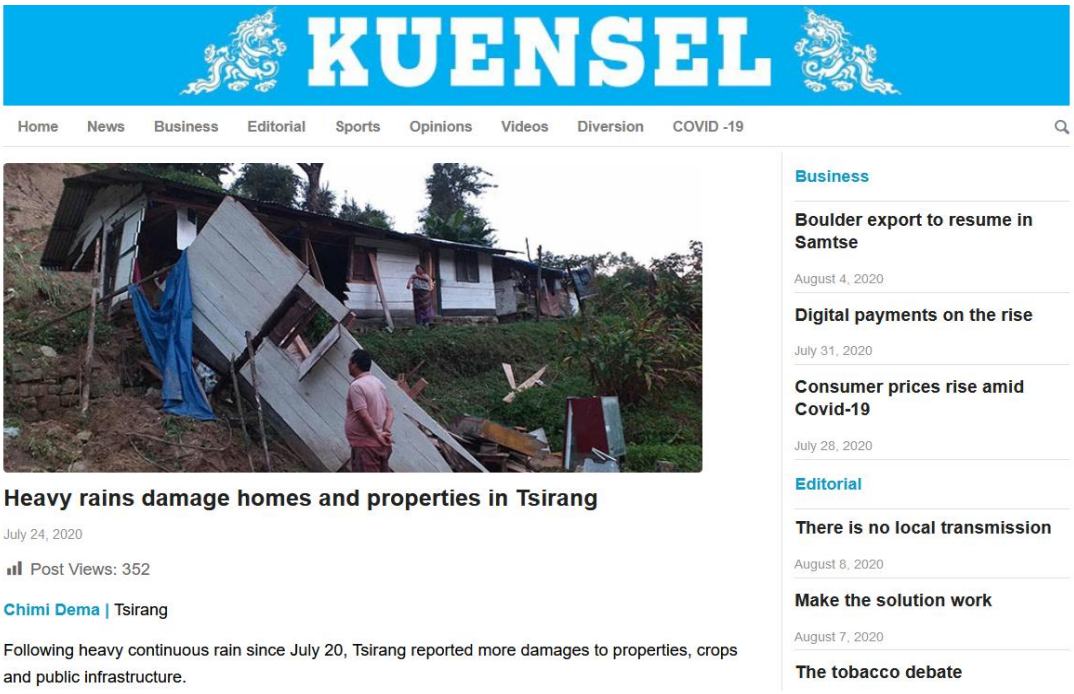

Figure 9. A Kuensel article reporting damage from heavy rains (20 – 23 July, 2020) in Tsirang[38]

While the NCHM is tasked with providing early warning and operates a network of early warning systems across Bhutan, there is no dedicated institution to research what climate change means for Bhutan in terms of loss and damage, risks and disasters.

The Center for Disaster Risk Reduction and Community Development Services (CDRRCDS)[39] under the CST under RUB can upscale research activities on climate change and disasters in collaboration with the Department of Disaster Risk Management under the Ministry of Home and Cultural Affairs.

36 Newman, P., & Yangka, D. (2018). Bhutan: Can the 1.5° C agenda be integrated with growth in wealth and happiness?. *Urban Planning*, *3*(2), 94-112.
37 RGoB. (2019). Bhutan's 3rd National Communication to the UNFCCC – National Circumstances (DRAFT). National Environment Commission, Royal Government of Bhutan. Thimphu, Bhutan
38 https://kuenselonline.com/heavy-rains-damage-homes-and-properties-in-tsirang/
39 https://cst.edu.bt/index.php/en/research-3/research-center/cdrrcds

2.2.9 Climate Finance

Currently, using mechanisms afforded by the Bhutan Climate Change Policy, the NAP process and NDCs, the NEC in partnership with the UN and other agencies source funding for climate mitigation and adaptation programs. Most assessments for both the NAP and the NDC formulations are carried out on a need basis and not tied to any particular long-term climate change research being carried out in Bhutan. There are also no studies on the efficacy and impact of climate finance and the projects which have been executed.

There is, however, acknowledgement, that climate financing and future climate related projects will need to allocate funds to support climate change research. And research in turn will have to address the efficacy and impact of such funds and influence the way funds are secured, governed, and disbursed.

3. The Roadmap – Creating Value & Strengthening Impactful Research

3.1 Principles & Salient Features

This roadmap is crafted on the following principles and salient features to render and chart a way forward which is of significant value to a wide array of actors.

- Climate change is acknowledged as a clear, present, and imminent danger to Bhutan's socio-economic wellbeing and prosperity.
- Up scaling research initiatives by empowering and capacitating national institutions are considered a key imperative and of strategic value to Bhutan as we adapt to a changing climate.
- The scale, strength and relevance of individual institutions are acknowledged and weighed, with the intent of leveraging and capitalizing on strengths and the opportunities therein.
- Strategies are proposed to reduce redundancies, improve synergies, and promote coherence.
- Strategies encourage networking and advocates for the adoption of common goals by establishing mechanisms and frameworks which allows for definition of common intent and deliverables, and to take stock of impact and value.
- Proposed mechanisms are intended to bridge current gaps and break systemic inertia which constrain research execution, impact, and opportunities.

Furthermore, the roadmap document is a product of multiple stakeholder consultations and reflects a distilled synthesis of ideas and proposals from a wide range of stakeholders.

3.2 Strategic Imperatives

3.2.1 Strategic Imperative I: Tackle Issues Which Matter

Bhutan's socio-economic wellbeing is dependent on sectors which are tied to the vagaries of climate and weather. The issues surrounding hydropower and agriculture are twinned to the availability of water, a resource which is inextricably tied to climate.

Bhutan's low carbon development aspirations will have significant bearing on the way we design our transportation systems and build our homes and cities. Climate change also means that we will grapple with increasing incidences of diseases and disasters.

Understanding the full ramifications of climate change with an intent to design effective mitigation and adaptation strategies, and influencing climate change discourse and financing, will matter most and be of consequential value as we move ahead. See Figure 10.

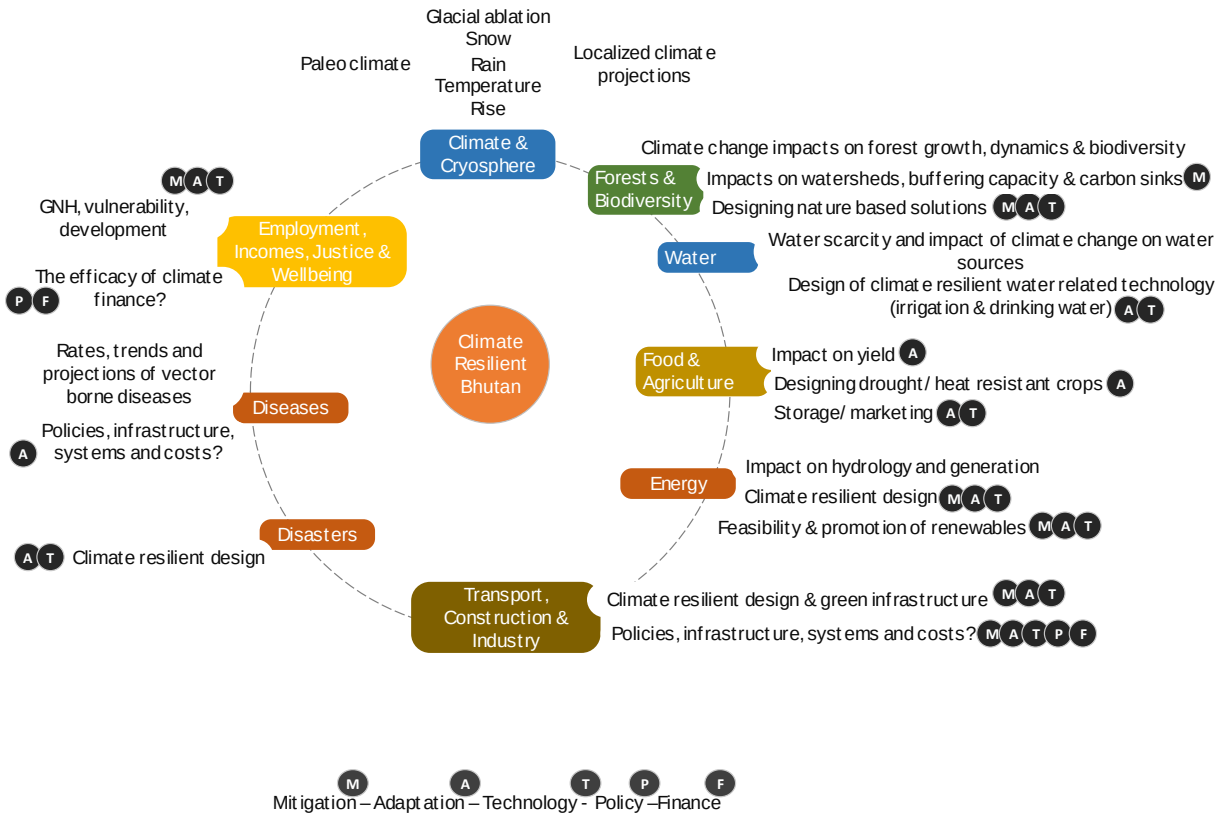

Figure 10. General delineations of enquiry along broad themes which are of pressing and consequential concern to building a climate resilient Bhutan

To focus research efforts and to ensure meaning and value, research institutions, CSOs and constituent Colleges of RUB should prioritize research areas and frame execution plans. Tentative costs and timelines for priority research areas should be estimated. These execution plans should be made openly available once the *Climate Research, Information and Services Portal* (CRISP)[40] is operationalized.

Such an exercise will ensure transparency, promote collaboration, and avoid redundancies. Most importantly, in line with aspirations drawn up in the Climate Change Policy, it will allow and enable a coherent and coordinated process to access support from international mechanisms for climate change research and capacity building.

All plans should be prepared with the intention, particularly for RUB, to substantially add to understanding the social, economic, and ecological ramifications of climate change in Bhutan and the region in the next decade.

Alignment of this intent is important to ensure that limited research funds are used for impact. Figures 11, 12, 13, 14, 15, 16, 17, 18 and 19 illustrate pressing research issues, relevant institutions which might address these research questions, and a possible timeline for delivery.

40 Elaborated under Section 3.3.4, Strategic Imperative IV to operationalize CRISP

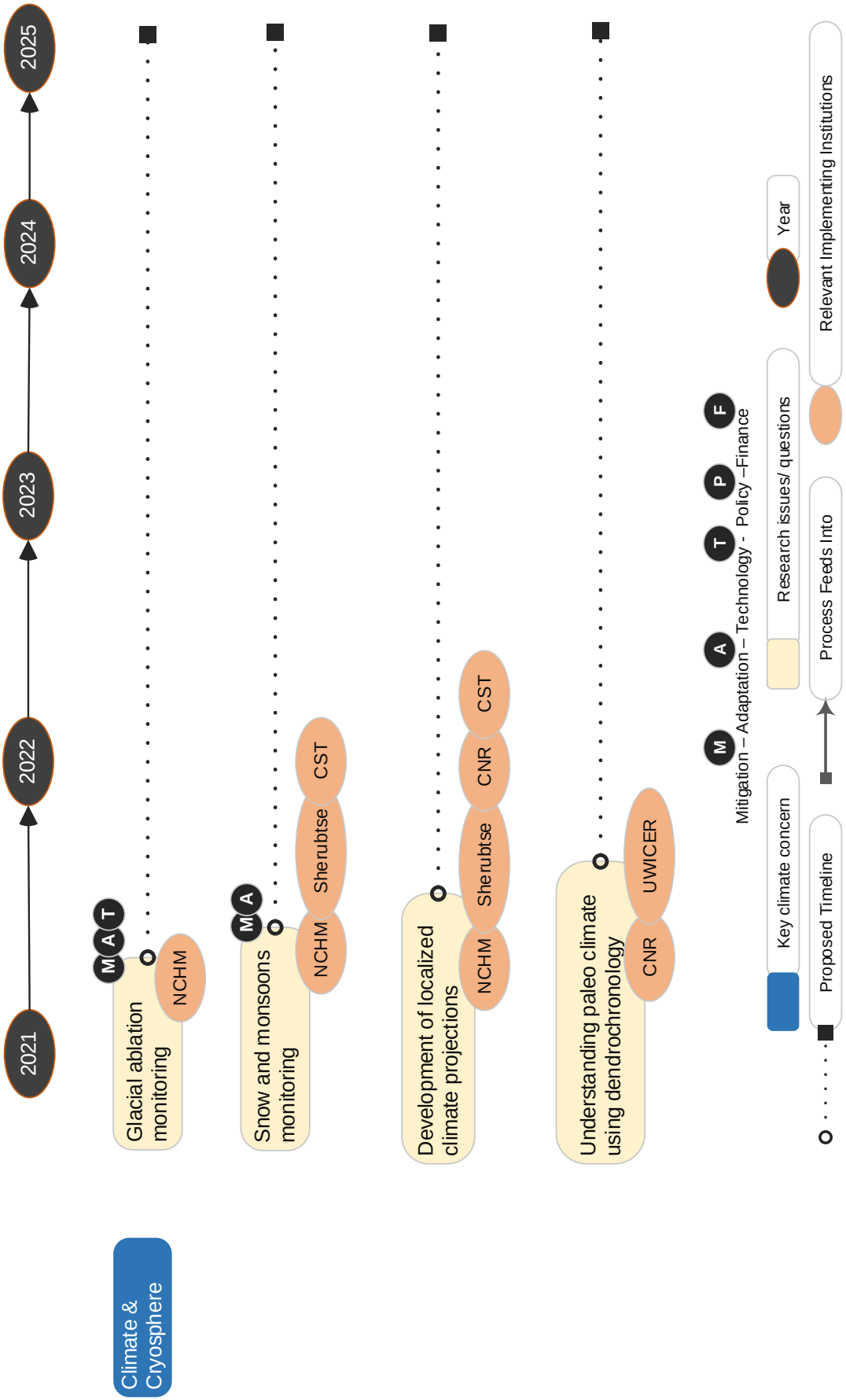

Figure 11. Cryosphere, monsoons, and snow related research imperatives

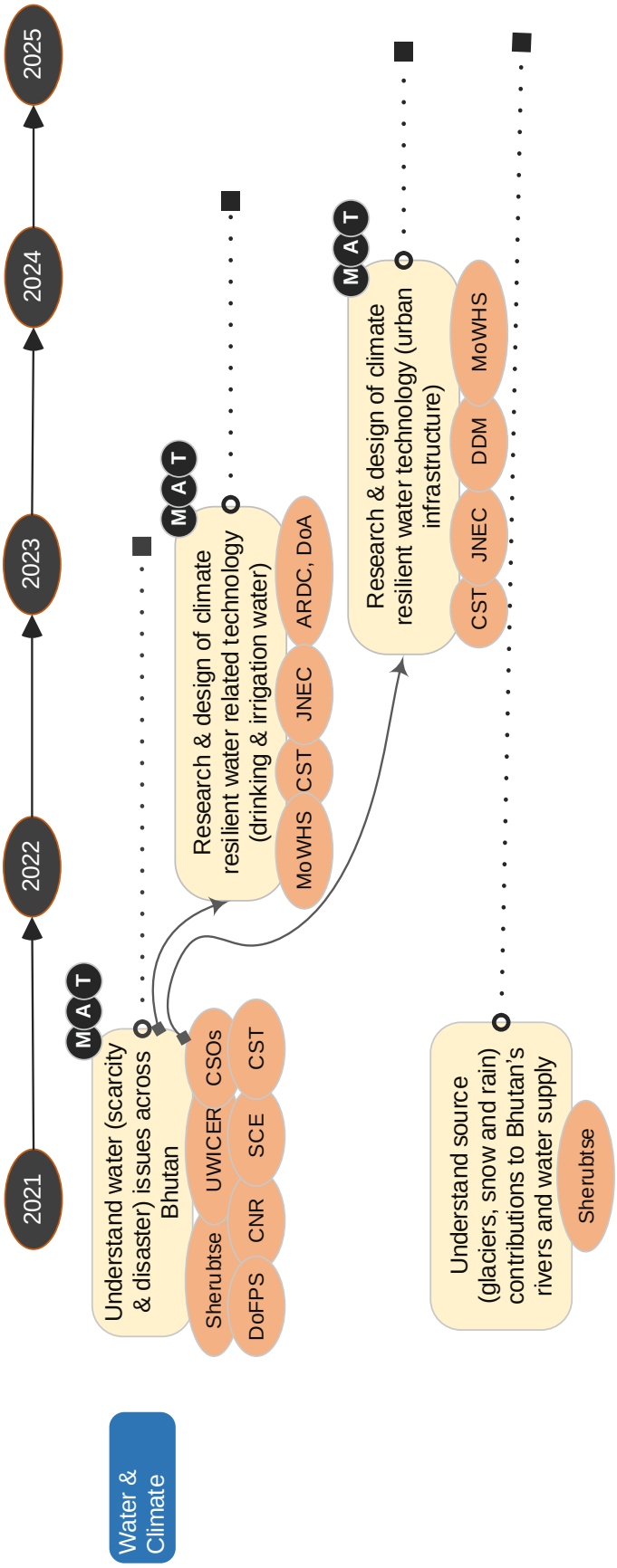

Figure 12. Climate research issues related to water

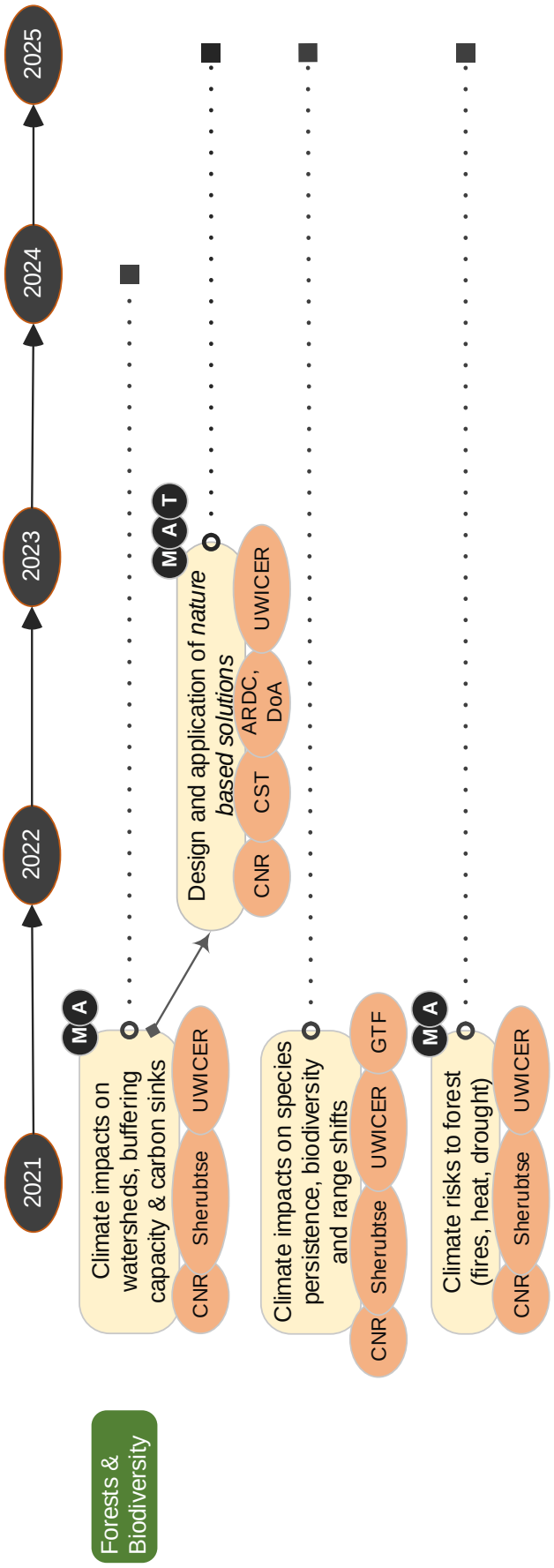

Figure 13. Climate research issues related to forests and biodiversity

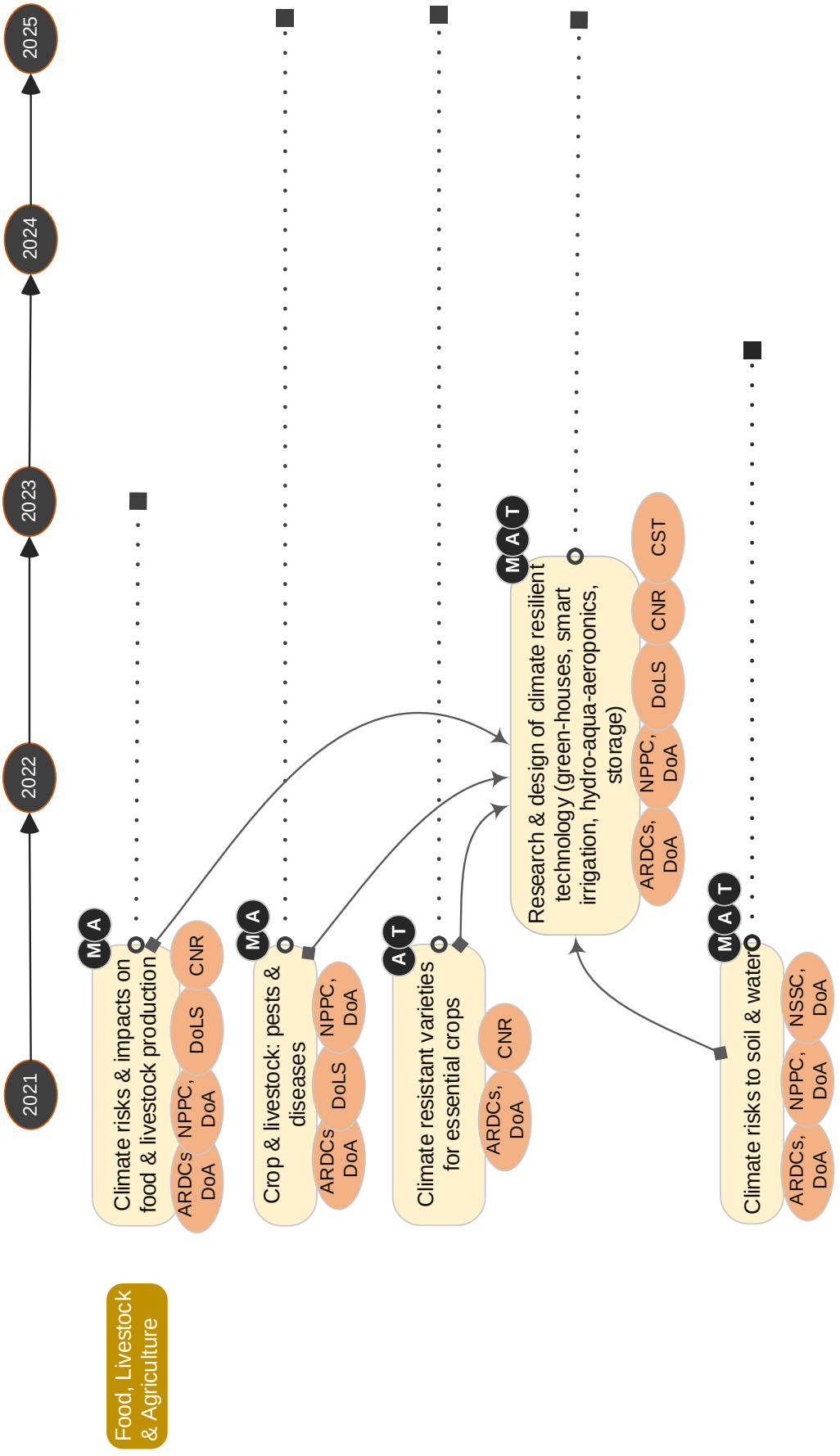

Figure 14. Climate research issues related to food, agriculture, and livestock

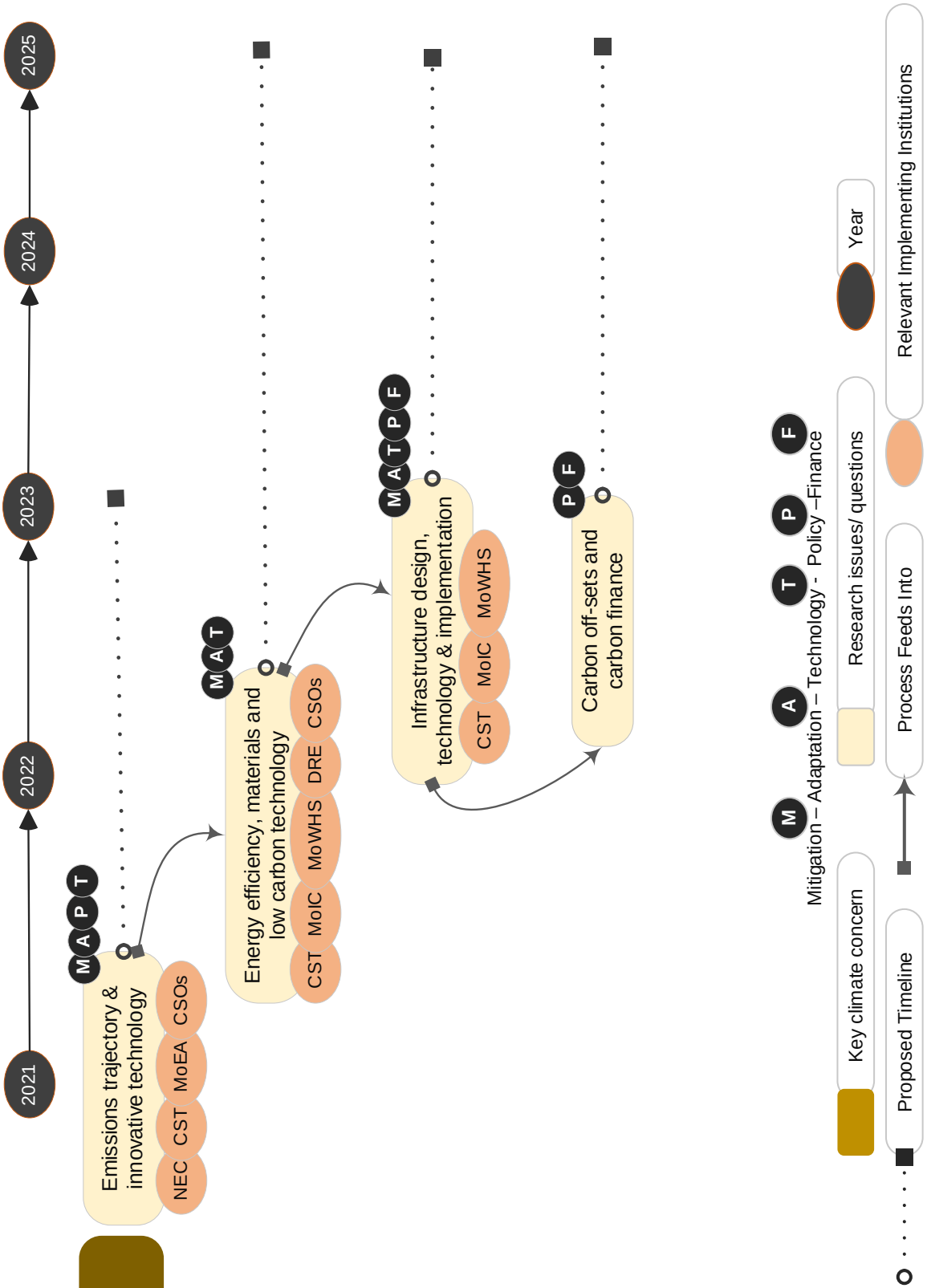

Figure 15. Climate research issues related to transport, construction, and industry

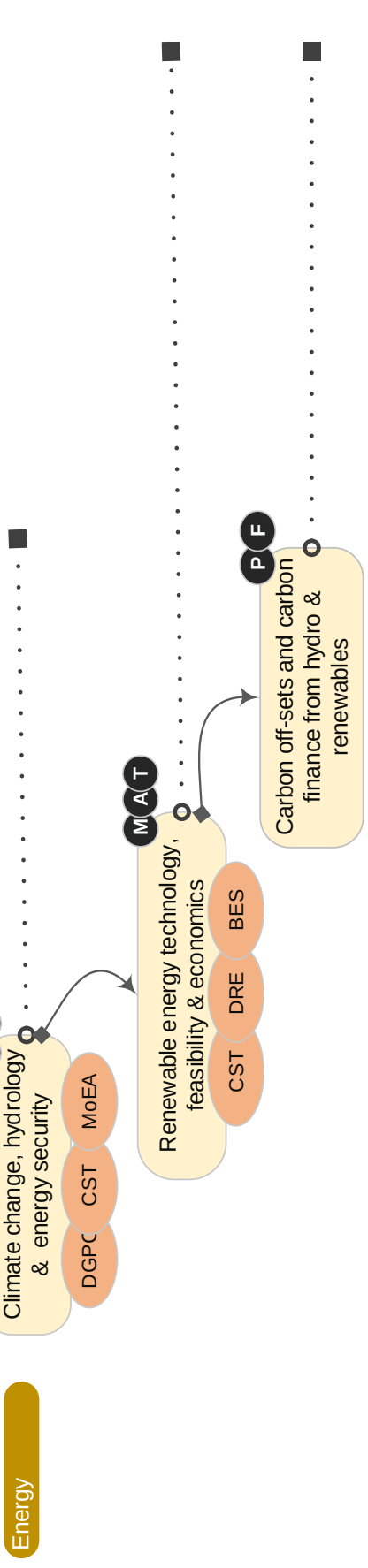

Figure 16. Climate research issues related to energy

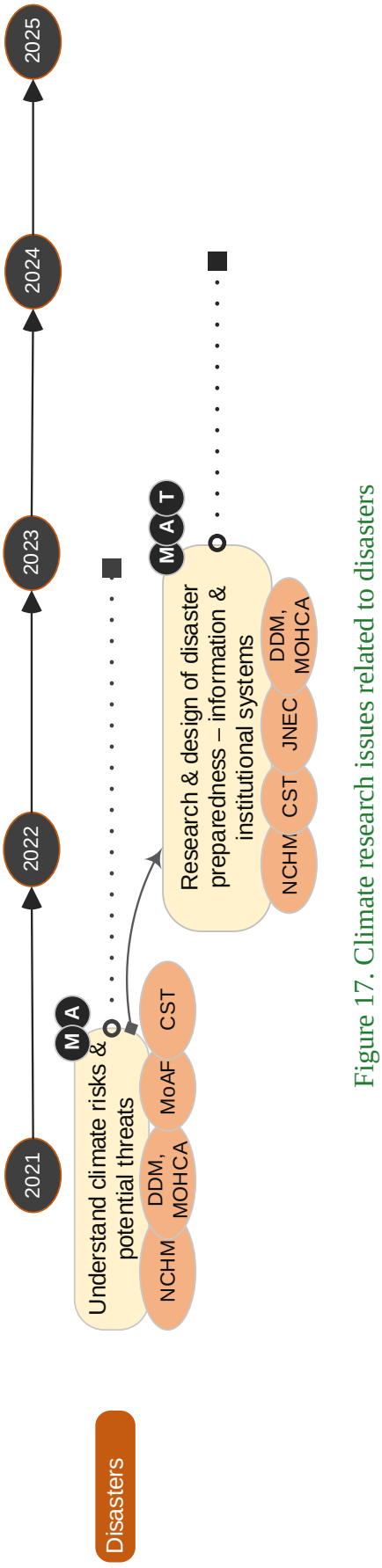

Figure 17. Climate research issues related to disasters

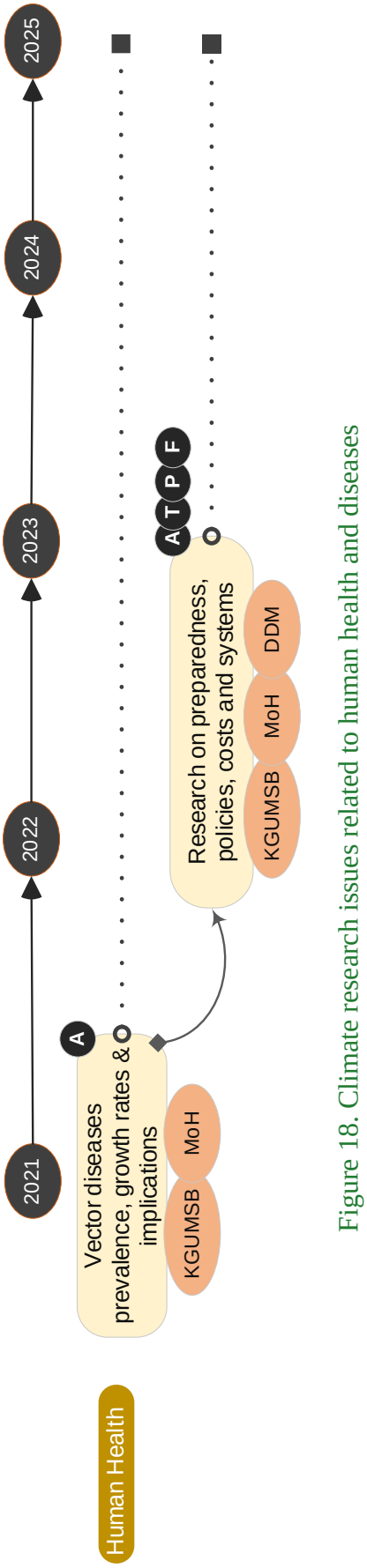

Figure 18. Climate research issues related to human health and diseases

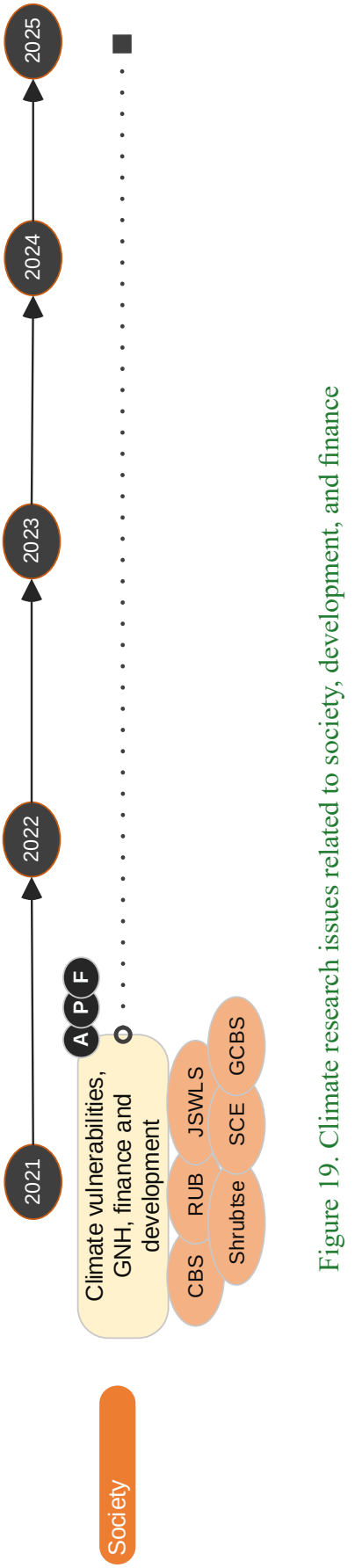

Figure 19. Climate research issues related to society, development, and finance

Proposed research should aim to influence design, institutional structures, and climate policy architecture. Research findings should feed into adaptation and mitigation proposals.

Research gaps, such as our lacuna in the understanding of snow[41] and water scarcity, and adaptation technologies which can offset negative impacts, should be frontloaded, and accorded priority.

To ensure relevance of research to stakeholders, an annual platform should be designed and implemented to support an iterative process where research feeds into practice, and practitioners can take stock of impact, and help define the next set of research issues which need tackling. This can take the form of annual national level seminars. The NEC should provide support for this multi-stakeholder initiative.

3.2.2 Strategic Imperative II: Strengthen Institutions & Networks, Inspire leaders & Empower Researchers

Research does not feature as a strategic priority for Bhutan as yet. However, there is increasing consensus that science, research, and innovation, has to feature prominently within mainstream discourse as Bhutan continues to develop.

Institutions currently invested in research have to be supported and strengthened at multiple levels, in terms of staff capacity, research financing, institutional facilities and credibility.

The strength and institutional mandate of RUB – and KGUMSB for health – should be harnessed and deployed to full effect (See Figure 20). Similarly, research institutions under the MoAF and other agencies including CSOs should be supported.

In particular, it is noted that RUB has the institutional mandate and reach across disciplines and harbors the required manpower to effect transformational impact on climate change research. Furthermore, RUB is not constrained by the institutional burdens associated with a regular Government agency. As such, RUB should be able to deliver faster, be responsive to changing needs, and proactively acquire opportunities.

41 Vano, J. A. (2020). Implications of losing snowpack. *Nature Climate Change*, *10*(5), 388-390.

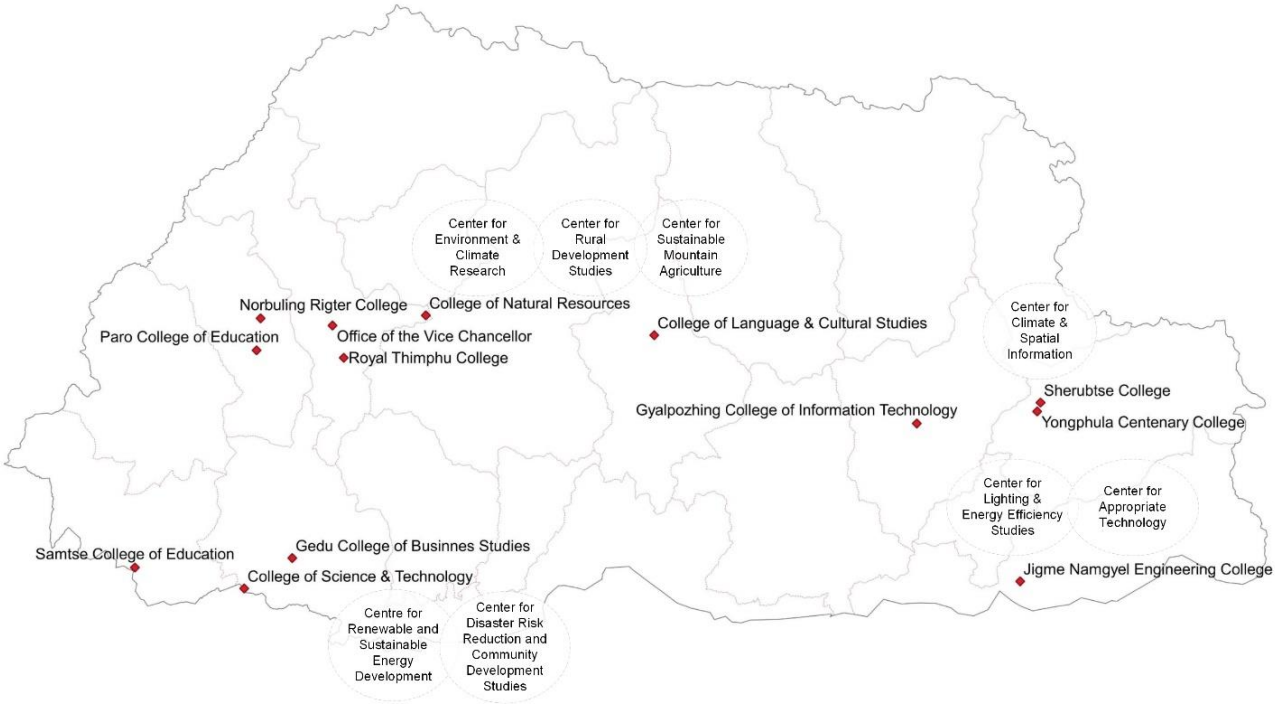

Figure 20. Constituent Colleges of the Royal University of Bhutan and their Centers

Centers at constituent Colleges should take center stage and act as hubs for climate research, action, and engagement.

RUB also needs to increasingly view and adopt research as an institutional core competence and strength, with guaranteed benefits for faculty who produce stellar research outputs.

Leaders within the RUB, KGUMSB and research institutions should be persuaded to support and promote research. High level workshops and leadership seminars aimed at coaxing leaders to bring about the required organizational and cultural change should be initiated and convened on an annual basis.

Researchers in turn will have to be supported through access to dedicated research funds, particularly for addressing urgent climate change issues. Capacity building programs to enhance analytical and writing skills should be mainstreamed within annual programs and convened on a regular basis.

Teaching load should be examined to determine whether time can be freed for research. Researchers should be encouraged to network and forge strategic partnerships with stakeholders within mainstream Government agency, CSOs and partner academic institutions.

To ensure research relevance and credibility, RUB and research institutions should enter into mutually beneficial and actionable MoUs with relevant Government agencies and institutions of worth in the region and abroad. These MoUs should be enable research issues of mutual interest[42] to be collaboratively addressed. Such an exercise will ensure stakeholder buy in through proactive engagement, and to some degree, allow researchers to influence policy and design.

42 RUB should provide a template stipulating key elements which should feature in the MoUs

College Centers should publish annual climate related data analytics and reports. For instance, the CST in collaboration with CNR and the DDM could produce an annual report on all disasters in Bhutan and report the toll which climate related disasters wreck on our agriculture, services, and infrastructure. All such reports could then be published both on the respective websites of Colleges and the proposed CRISP (See 3.2.3 below) platform. Such reports which are not yet covered by the NSB will serve as important data sources for researchers and policy makers alike.

3.2.3 Strategic Imperative III: Operationalize a Climate Information, Research & Services Portal (CRISP)

Research initiatives are hampered by bureaucratic hurdles to accessing climate related data and obtaining administrative clearances.

A web-based *Climate Research, Information and Service Portal* (CRISP), to hold and provide climate related data and relevant analysis should be set up. CRISP should also serve as a repository for all publications on climate change in Bhutan and provide information to guide researchers on administrative clearances required from multiple sectors.

Contingent on clearance from data providers, the following datasets to facilitate climate change research will be of value and should be made available through the portal:

- Climate data and data from weather stations[43]
- Geo-spatial data on landuse, infrastructure (roads, bridges, public facilities), administrative delimitations, and geographical features (rivers and glaciers)

To ensure that climate data from the portal is only used for scientific analysis and not to predict and forecast weather, climate data on the portal maybe be uploaded with a time lag of a few months. It should also be made explicit, with a disclaimer, that only weather information provided by NCHM should be treated as valid and official.

CRISP can also serve as a repository for all publications on climate change in Bhutan and provide information to guide researchers on administrative clearances required from multiple sectors.

NEC should initiate discussions on CRISP, formulate operational modalities, assess overlaps with ongoing information repository initiatives, estimate fund requirements and concretize operational plans.

3.2.4 Strategic Imperative IV: Mainstream & Strengthen Pedagogy, Outreach & Capacity Building

Credible research findings should positively influence policy and practice, and an individual's construction of world views and narratives[44].

Over the next three years, execute a string of priority capacity building programs to bring researchers and leaders up to speed on climate change science, mitigation and adaptation strategies and technologies, and financing frameworks. **Annexure 2** provides a list of priority capacity building programs to be executed over the next three years.

43 There are some openly available weather data from the UWICER HEROES project
44 van der Linden, S., Leiserowitz, A., & Maibach, E. (2018). Scientific agreement can neutralize politicization of facts. *Nature Human Behaviour*, *2*(1), 2-3.

Annual forums for climate change research dissemination should be organized. Frameworks such as the Annual Research Symposium of BES should be utilized and supported. Such fora should be used as venues to ensure that research findings influence policy, design and decision-making. In turn, policy and decision-makers should use such fora to influence the agenda and direction of research.

Each research institutions should prepare its own communication and outreach strategy within the next 2 years. Research organizations should proactively use CRISP to disseminate all climate research outputs.

Existing regional partnerships, such as the Himalayan Universities Consortium[45], and global networks, such as the LDC University Consortium on climate change[46], should be used for sharing and cross-fertilization of ideas and solutions.

A systematic and regular review of RUB curriculum should be conducted to ensure that the latest climate change findings and innovate pedagogical approaches are adopted. This will increase climate literacy and support for climate action.

3.2.5 Strategic Imperative V: Establish the Bhutan Science Foundation

Currently, the Royal Government has accorded approval for the RUB to maintain and operate a Research Endowment Fund. Funding proposals are entertained from all interested individuals and research agencies and not limited to RUB.

The endowment totals Nu. 9.55 million as of 31st October 2020. However, the utility and scale of the fund is limited due to the rigid operational modalities imposed by Government norms and regulations.

Within constituent Colleges, the RUB also stipulates each College to allocate 2% of its annual revenues for the purposes of research. No assessment is available yet on how much this amounts to on an annual basis, and how much is spent on research. Additionally, RUB Colleges also actively source grants from outside donor agencies.

Research within institutions outside of RUB are mostly funded by the RGoB and donor assisted projects and programs. A notable exception is the UWICER which has its standalone 'endowment fund' to support research and education.

Given the rapid pace of climate change, a mechanism to provide funding for critical research is required.

To provide and sustain funding for research, the Bhutan Science Foundation (BSF) should be established. The BSF should be accorded the mandate to manage and oversee the research endowment fund which is currently under the keep of the RUB. The Royal Government should commit an annual contribution for the upkeep of the BSF, and the BSF in partnership with the RUB, KGUMSB and other partners should raise funds to support critical research.

45 https://www.huc-hkh.org/
46 http://www.luccc.org/

BSF will be a vital and important addition to Bhutan's growing public benefit apparatus established with the intent to support basic and applied research to create knowledge that supports the present and transforms the future. Sustained support for critical research will promote the nation's security by advancing Bhutan's international standing and repute, and contribute to economic prosperity, social wellbeing and ecological resilience.

The BSF may be overseen by a Government appointed Board, who in turn will appoint a Director to oversee staff and day-to-day administration. Operational and policy priorities will be guided by a National Science Board comprised of eminent individuals representing various subject areas and domain expertise.

The RUB should prepare a concept note to initiate discussions and kick start the process of operationalizing BSF. To support the institution of BSF, RUB should also spearhead the development and adoption of a National Research Policy in discussion with the GNHC.

4. Action Items & Milestones

4.1 Action Items for the Next 3 Years (2021 – 2023)

2021:

- RUB Colleges, KGUMSB and research institutions should formulate research plans around key climate change concerns. NEC should facilitate this.
- These research plans should be translated into project proposals. Funding for such proposals could be sought independently or as part of bigger proposals being developed by relevant agencies. Furthermore, these projects should align with national plans, programs, policies, and priorities.
- RUB Colleges should initiate discussions on MoUs with relevant Government agencies.
- Five MoUs[47] should be explored, initiated, and entered into as soon as possible:

    - A MoU between Sherubtse College, CNR, UWICER & NCHM on understanding paleoclimate and monsoons using dendrochronology and other methods
    - A MoU between KGUMSB and the MoH to initiate, upscale and mainstream climate change research within the health sector
    - A MoU between the CRSED, CST and the DRE to engage and empower the CST to fulfill, where appropriate, the research needs of DRE
    - A MoU between the CDRRDCS, CST and the DDM, MoHCA to fulfill, as appropriate, the research needs of the DDM
    - MoU between MoWHS, MoAF, JNEC and CST to research and promote climate resilient infrastructure and design for buildings and irrigation

- Further MoUs with reputed international climate research institutions that will help build capacity of national institutions and address key climate issues should be explored and entered into.
- NEC should support discussions on CRISP, formulate operational modalities, estimate fund requirements, develop proposals, and source funds.
- RUB should prepare a concept note and framework for the Bhutan Science Foundation which should be circulated for discussion with Government and academia.
- RUB should prepare a concept note on a National Research Policy in discussion with the GNHC.
- RUB College Centers either independently or in collaboration with relevant agencies should organize 2-week long ‘climate data’ camps for:

    - Climate projections, emissions, and adaptation scenario development
    - Climate impacts on agriculture and hydropower
    - Climate impacts on health

- RUB College Centers should organize 1-week long ‘science write’ camps.
- RUB, NEC and partners should organize and convene high level policy seminars (half day) for organizational change and effective leadership. The high-level forum should also provide a platform for policy makers and academics to take stock of research findings

47 Additional MoUs should be entered into depending on need and potential to add value

and define future priorities. A mechanism to institutionalize this annual platform should be agreed upon and endorsed for implementation. Existing mechanisms, as that of the annual research symposium conducted by BES should be utilized.

- RUB should carry out periodic curriculum reviews and Colleges should engage students in climate change research.
- College Centers, KGUMSB and research institutions should prepare research communication and outreach strategies.

2022:

- RUB Colleges, KGUMSB and research institutions should sign MoUs with relevant Government agencies, regional and international partners.
- NEC should initiate the design and operationalization of CRISP.
- RUB and GNHC should ensure that discussions on the National Research Policy and the Bhutan Science Foundation are continued and that proposals continue to get refined and concretized.
- Key research on pressing climate issues should be initiated within RUB Colleges, ARDCs and relevant agencies.
- RUB College Centers should continue to provide 2-week long 'climate data analysis and writing' camps.
- RUB, NEC and partners should continue to organize and convene high level policy seminars (half day to a day) for organizational change and effective leadership.
- RUB, NEC and BES should continue to organize and provide high level fora for policy makers and academics to take stock of research findings and define future priorities. The forum should add onto existing frameworks at the individual College/ research institution level to disseminate climate change research findings.
- RUB, NEC and partners provide a string of capacity building programs to bring researchers and leaders up to speed on climate change science, mitigation and adaptation strategies and technologies, and financing frameworks.
- RUB should continue to carry out periodic curriculum reviews (RUB) and engage students in climate change research.

2023:

- GNHC, nudged by RUB, should ensure that a National Research Policy for Bhutan gets adopted.
- The NEC should operationalize and launch CRISP.
- RUB College Centers should continue the 2-week long 'climate data analysis and writing' camps.
- RUB, NEC and partners should continue the annual high-level policy seminars (half day to a day) for organizational change and effective leadership.
- RUB, NEC and BES should continue the annual research symposium to provide a platform for policy makers and academics to take stock of research findings and define future priorities.
- RUB, NEC and partners provide a string of capacity building programs to bring researchers and leaders up to speed on climate change science, mitigation and adaptation strategies and technologies, and financing frameworks.

4.2 The Milestones

We stipulate eight overarching milestones to track progress and assess whether the aspirations outlined within the roadmap document are being realized.

Milestone 1: In the next decade, from now to the close of 2030, Bhutanese institutions produce a comprehensive corpus of research findings which will:

a. Further our understanding of paleoclimate, rates of climate change and allow for localized climate projections for Bhutan (and the region possibly);
b. Lead to development and implementation of adequate mitigation and adaptation strategies and actions;
c. Bring forth innovative clean and green technologies to ensure sustainable economic growth, conservation of our environment and secure the well-being of Bhutanese society; and
d. Significantly contribute to global discourses on climate change by providing local insights on limiting warming to less than 1.5˚C.

Milestone 2: By 2022, respective Colleges and institutions with a mandate to further climate change research enter into actionable MoUs with relevant Government agencies, CSOs, regional and international institutions and agree to deliver on collaboratively identified research issues. These MoUs will help promote and institutionalize research while also increasing ownership and support for research.

Milestone 3: By 2023, Centers at RUB constituent colleges to have mainstreamed and convened annual 'Climate Change Data Analysis and Writing Camps' with the intent to upgrade analytical skills of researchers.

Milestone 4: By 2023, operationalize a functional and dynamic[48] climate data[49] and research portal (CRISP) which is publicly accessible.

Milestone 5: By 2021, mainstream and institutionalize a high level[50] mechanism and forum[51] to take stock of research programs and define research and information needs on an annual basis. Government and client agencies should be encouraged to define research questions and assess the relevance and utility of research findings produced by academia.

Milestone 6: By 2025, establish the 'Bhutan Science Foundation' with clear strategies for resources mobilization, governance, and fund allocation.

Milestone 7: By 2023, a string of capacity building programs executed to bring researchers and leaders up to speed on climate change science, mitigation and adaptation strategies and technologies, and financing frameworks.

Milestone 8: By 2030, RUB to offer a wide range of undergraduate and research-based MSc and PhD programs related to the environment and climate change.

48 Dynamic here referring to the expectation that such a system and its components would be regularly updated
49 Facilitate uploading and free sharing of all data which is open to the public with proper clearance from responsible agencies
50 Participation from Government agencies should be guaranteed from at least one Chief Level officer or upwards (Directors & Specialists) who not only have an in depth understanding of critical issues within their sectors and are able to articulate their research needs and concerns, while also assuring that research findings will be examined for policy and implementation purposes.
51 The Annual Research Symposium organized by the Bhutan Ecological Society offers an opportunity to host such a forum effectively across multiple stakeholders and agencies.

5 Monitoring & Evaluation

Strengthening of climate change research and ensuring impact will require the engagement of a range of stakeholders, entering into mutually beneficial partnerships, and successful implementation of key strategies. It is imperative that the RUB and the NEC provide leadership and assume catalytic roles in ensuring that key objectives are met and that milestones are achieved.

Table 2 outlines milestones, the year by which the milestone should be reached, and the institutions which should monitor progress to ensure that goals are achieved.

Table 2. Milestones, time frames and institutions responsible for monitoring progress

No	Milestones	By When/ Interval	Who Should Monitor Progress?
1	Respective Colleges and institutions with a mandate to further climate change research will enter into actionable MoUs with relevant Government agencies, CSOs, regional and international institutions.	By the end of 2022	RUB
2	Centers at RUB constituent colleges to have mainstreamed and convened annual 'Climate Change Data Analysis and Writing Camps'.	By the end of 2023	RUB
3	Provide a string of capacity building programs to bring researchers and leaders up to speed on climate change science, mitigation and adaptation strategies and technologies, and financing frameworks.	By the end of 2023	RUB
4	Operationalize a functional and dynamic climate data and research portal (CRISP).	By the end of 2023	NEC
5	Mainstream and institutionalize a high-level mechanism and forum to take stock of research programs and define research and information needs on an annual basis.	By the end of 2021	RUB
6	Establish the 'Bhutan Science Foundation'.	By the end of 2025	RUB
7	RUB to offer a wide range of undergraduate and research-based MSc and PhD programs related to the environment and climate change	By the end of 2030	RUB
8	From now to the close of 2029, Bhutanese institutions produce a comprehensive corpus of climate change research results.	Annually through an annual research forum	NEC & partner institutions

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Annexure 1. A list of past and on-going climate change research initiatives[52]

Project:	What?
GLORIA[53]:	Global Observation Research Initiative in Alpine Environments. A monitoring plot was established at Jumolhari in 2010 with the NBC.
CHARIS[54]:	Contribution to High Asia Runoff from Ice & Snow. A US-AID funded project beginning in 2012 concluded in March 2019, covering 8 Asian countries had Sherubtse College as collaborators from Bhutan. The project assessed the role of glaciers and precipitation (snow and rain) on the hydrology of the mountains of High Asia.
HEROES[55]:	Himalayan Environmental Rhythms Observation and Evaluation System managed by the UWICER. A network of 20 AWMS and phenology monitoring systems covering a gradient of altitudes and spread across 20 schools throughout Bhutan.
Dendrochronology:	The UWICER, DoFPS with the Lamont-Doherty Earth Observatory, Earth Institute of the Columbia University have been carrying out dendrochronology research in Bhutan[56]. The CNR also has a dendrochronology program.
Agriculture:	Heat tolerant vegetables are being trailed at the ARDC Wengkhar under the IFAD supported CARLEP project. And the Potato Program under ARDC Yusipang is currently testing 20 climate resilient potato clones[57].
Loss & Damage:	The UWICER conducted the first 'Loss & Damage' study[58] in Bhutan in 2012.

52 This is not an exhaustive list
53 www.gloria.ac.at
54 http://nsidc.org/charis/
55 www.heroes.gov.bt
56 Krusic, P. J., Cook, E. R., Dukpa, D., Putnam, A. E., Rupper, S., & Schaefer, J. (2015). Six hundred thirty-eight years of summer temperature variability over the Bhutanese Himalaya. Geophysical Research Letters, 42(8), 2988-2994.
57 Personal communication with Dr. Yadunath Bajgai at the ARDC, Yusipang
58 Kusters, K., & Wangdi, N. (2013). The costs of adaptation: changes in water availability and farmers' responses in Punakha district, Bhutan. International Journal of Global Warming, 5(4), 387-399.

Annexure 2: A list of priority capacity building programs[59]

Capacity Building Program	Relevant National Coordinating Agency
Understanding the physical basis of climate change	NCHM
Climate change modelling and projections	NCHM
GHG emissions inventory and low emissions technology	NECS
Climate vulnerability and risk assessment	NECS
Climate change mitigation – challenges and opportunities	NECS
Climate change adaptation – challenges and opportunities	NECS
Climate change and water availability - projections, adaptation and technology	UWICER
Climate resilient water infrastructure	CST & JNEC
Climate resilient infrastructure (roads, urban buildings and systems)	CST & JNEC
Ecosystem based adaptation/ nature-based solutions to climate change	UWICER, CNR, RSPN & BES
Climate change and food security (crop modelling, climate resilient crop production, livestock management, climate smart technologies)	DoA and DOLS, MoAF
Climate change, forests, and biodiversity	UWICER & BES
Climate change and health	KGUMSB
Climate change and socio-economic development (modelling the socio-economic impacts and cost-benefits of climate change)	NSB
Climate change and gender	GNHC
Climate change financing (accessing, green bonds, inclusive green financing)	GNHC & MOF
Leadership and design thinking in an era of rapid (climate) change	RIGSS, RIM, RCSC and GNHC
Geopolitical implications and developmental impacts of climate change	RIGSS

59 This list has been proposed, refined, and endorsed by the NEC constituted TWG members for climate change during a TWG consultative meeting held in Paro on the 22nd of October 2020