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IMPACT OF CLIMATE CHANGE AND RAPID URBANISATION ON THE ENVIRONMENTAL AND AGRICULTURAL SECTOR OF BHUTAN

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Introduction:

Bhutan is located on the Tibetan Plateau's southern edge. Like the other plateaus, the Tibetan plateau is also suffering from climate change. Since the year 2000, temperatures at Bhutan's 24 weather stations have risen by about 1 °C in summer and 2 °C in winter. From 2010 to 2039, the average annual temperature in Bhutan is anticipated to increase by 1 °C. Climate models predict a 3°C temperature increase during the monsoon, or rainy season. Air temperature variations in the winter and dry seasons are expected to increase by 3.5 °C.[1] Bhutanese people have depended on agriculture for centuries, and the agricultural output depends on glacial water, also known locally as "White Gold." The rate of glacier melting is accelerating because global temperatures are rising faster than we anticipated. Glaciers are melting quickly and abruptly, increasing the risk of catastrophic floods for those who live below the valley. Experts predict that all of Bhutan's glaciers will be entirely gone by 2025 as a result of rising global temperatures. Interestingly, Bhutan is situated in seismic zones 4 and 5, which are considered the most dangerous earthquake zones. Though accurate early earthquake prediction is impossible, most geologists predict a large earthquake in the Eastern Himalaya starting from Sikkim, Bhutan, and north-east India shortly after Turkey's recent earthquake.

Bhutan's population is almost entirely dependent on agriculture. Climate change has left its mark on agriculture as well. Climate change poses a severe threat to the sustainable development, standard of living, and means of subsistence of the Bhutanese people. The reasons for soil erosion and land degradation result in decreased land holdings. Manson is now

[1]WBG Climate Change Knowledge Portal (CCKP, 2021). **Climate Data: Historical.** URL: https://climateknowledgeportal.worldbank.org/country/bhutan/climate-data-historical

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acting quite erratically. Landslides and erosion also posed a hazard to important infrastructure and property during the Manson flash flood. The hydropower industry contributes significantly to national income. The looming repercussions of climate change, including glacier melting, altered rainfall patterns, and shifting river flows, have a detrimental influence on Bhutan's hydropower sector.

Objectives of the study:

The present study aims to accomplish the following two objectives:

1. To examine the impacts of climate change on the agricultural outputs of the small, landlocked state of Bhutan.
2. To highlight the rapid urbanisation and its impact on food and agriculture sector in Bhutan.

Methodology:

The entire research has been formulated within the historical and analytical methods of study. In using this methodology, care has been taken to avoid both the extremes of one-sided emphasis on objective conditions and subjective interpretation divorced from abstract historical reality. The work has been based on historical documents, and the data has been analysed in the context of the present global situation.

The study is based on both primary and secondary sources. Books, articles, journals, newspapers, and unpublished works have been referred to as secondary sources of information. The primary sources comprise various governmental and non-governmental documents, reports, and decisions; important state pronouncements and policy statements; parliamentary debates; as well as speeches and writings of prominent world statemen and leaders.

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Adverse effect on agricultural output

Bhutan's topography is unsuitable for farming because of its fragile mountains, despite the fact that the bulk of the nation's population depends on agriculture for a living. Challenges include low soil fertility, tiny landholdings, and frequent natural calamities. A 2°C temperature increase appears to raise the cultivating zone's height, permitting the introduction of low-temperature-sensitive crops at higher elevations. According to the ministry, only 13.5% of the total land area may be used for agriculture. In contrast to today's 5,130 km^2, the total area of agricultural land was only 3,700 km^2 in 1969. As a result, it is growing at a 0.72% annual rate. Presently, the total arable land area is only 2.93%.[2] Another factor contributing to the loss of agricultural land is urbanization. Bajo and Khuruthang are two brand-new settlements that have just been developed in Bhutan, with the majority of the labour taking place on valuable farmland. Government-approved plans for the cities of Bumthang and Trshiyangtse frequently incorporate agricultural land. Numerous wetlands were transformed into other types of property, according to the study produced by the Ministry of Agriculture. In Bhutan, "wetland farming" is the common name for the practice of growing rice on terraces. Wetland covers a total of 21% of agricultural land. Statistics for agriculture in 2016 show that 39% of potential dryland and 10% of potential wetland were left fallow.[3] More water is needed to grow rice than any other crop. As a result, rice farming is extremely vulnerable to the changing weather patterns brought on by global warming. From a socioeconomic perspective, Bhutan's three most significant crops are rice, maize, and potatoes. The primary food consumed by Bhutanese citizens is rice, closely followed by maize.

[2]NSSC, PPD. **Bhutan land cover assessment 2010—technical report.** Thimphu: NSSC and PPD, Ministry of Agriculture and Forests; 2011.
[3]DoA. Agriculture statistics 2016.Thimphu: Information Management Section (IMS), Department of Agriculture, Ministry of Agriculture and Forests, Royal Government of Bhutan; 2016.

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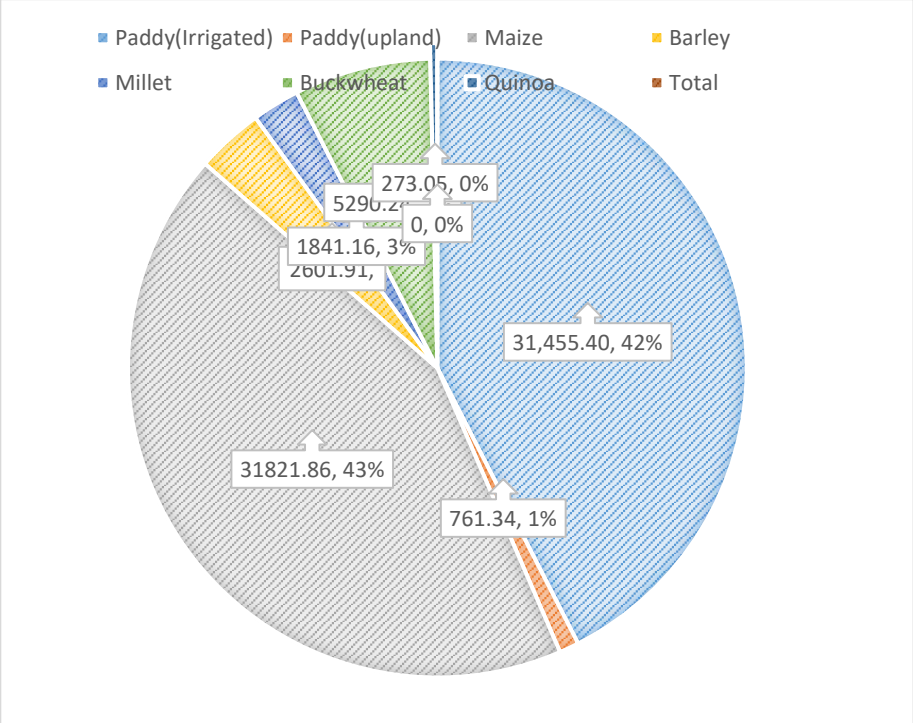
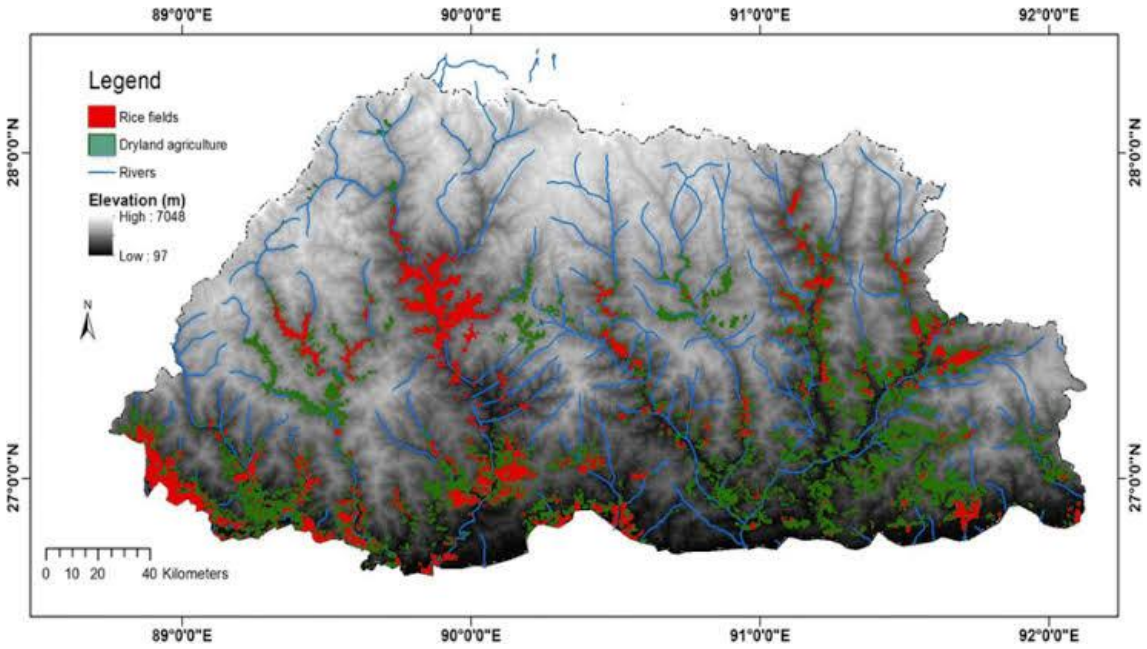
Table: 1

Total cereal production in 2020



Agricultural Statistics, 2020, RSD/MoAF



Map shows the scattered agricultural land along the river basins and foothills.

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Cropland is shared among the siblings in accordance with Bhutanese tradition. It is mostly to blame for Bhutan's population expansion and agricultural land's quick fragmentation. In Bhutan, it has recently led to a rapid rural-urban migration as people look for new occupations. Citizens are currently permitted to acquire up to 25 acres of land under the rules that the royal government has already established. This amply demonstrates how Bhutan's land's potential for production is constrained.

Bhutan's low population and land protection have so far protected it from the degree of environmental and human health damage observed in surrounding countries. Other implications of global warming, such as altered precipitation patterns, shifting growing zones, more severe weather, and deteriorating air and water pollution, are all likely to worsen.

According to the analysis of gross national happiness, some farmers plant rice early, which has an impact on when they can produce other crops and how much water they have available. The World Wildlife Fund survey cites other farmers who live in mountain towns as saying that temperatures have risen over the previous 15 years. This is generally advantageous because farms at higher altitudes may now grow eggplants, beets, cabbage, cauliflower, and chilies.

Soil erosion and land degradation

Bhutan's mountainous ecology, which is geologically vulnerable, and rugged, steep terrain make it susceptible to several sorts of land degradation and soil erosion. According to Yeshey Dorji, the former minister of agriculture and forests in Bhutan, land degradation is becoming a severe issue for the state. He also noted that overreliance on forest resources, inadequate irrigation systems, subpar agricultural methods, urbanisation, industrial development, a lack of environmental safeguards in infrastructure, etc. were some of the

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principal factors for local land degradation.[4] Land degradation is a serious concern for Bhutan, according to the National Environment Strategy (NEC 1998) and the Bhutan Vision 2020 document, because the country's topography and altitude limit the amount of agricultural land that can be utilized. There may be widespread in-situ and physical soil deterioration in the country. Among the visible indications of land degradation are landslides, gullies, sheet erosion, rill erosion, topsoil capping, and mass soil wasting.

In addition to its consequences for agriculture, land degradation is a significant environmental concern for the state. Another major issue in Bhutan is soil erosion. Soil erosion causes about 8.6 metric tonnes of soil per acre to be lost, especially during the wet season.[5] By cultivating sloped terrain, using insufficient soil conservation techniques, overgrazing animals, obtaining fuel wood in an unsustainable manner, and starting forest fires, agriculture and forestry operations contribute to soil erosion. A report on soil erosion and land degradation was recently made public by the Royal Government of Bhutan. The research highlights the significance of minimising fertiliser consumption in order to boost production on limited land resources. As a result, soil starts to degrade chemically and lose nutrients. It is one of the key reasons why they won't be able to achieve the RGoB's 2020 objective of turning their country completely organic.

Traditional farming practices lose 8.6 metric tonnes (MT) of soil per hectare (3.48 MT/acre) to erosion, particularly during the rainy season (DoA, 2010). Landslides on roads, agricultural land, and other infrastructure, which cause financial harm and endanger people's lives, are a continuous and significant concern in Bhutan. On the other side, instances of extreme rainfall make the issue worse.

[4] **Combating land degradation in the country: The Bhutanese(Newspaper),** OCTOBER 22 2019 https://thebhutanese.bt/combating-land-degradation-in-the-country/

[5] **Bhutan climate+change** (2016): Handbook, Bhutan Media and Communications, Thimphu, Bhutan. http://lib.icimod.org/record/32399/files/icimodBhutanClimate016.pdf

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Environment and growing urbanisation

In 2019, urban regions were home to 41.61% of Bhutan's population. Thimphu and Phuentsholing are the only real cities in Bhutan. With a population of over 1.5 million, Thimphu is one of the Asian cities with the fastest-rising populations. Two other urban canters are Phuensholing and Paro. With a nationwide population growth rate of around 1.1 percent per year in 2019, migration from rural to urban areas has greatly boosted the urban population over the past 20 years. In terms of family relocation, the data that is currently available indicates that business or education are the main drivers of urban migration.

Urbanisation has strained the city's housing stock, infrastructure, and land, which has had an impact on the environment. Future urbanisation is predicted to proceed at a rapid rate due to the influx of migrants from rural areas. It is anticipated that more than half of the population will reside in cities by the end of this decade. The urban environment in Bhutan is fairly small. The main environmental issues caused by urbanisation are water pollution, air pollution, issues with waste management, a lack of available land, and particularly the loss of agricultural land. The issue of air pollution has grown significantly in urban areas. Poor urban air quality is mostly caused by an increase in automobile emissions, fugitive dust from newly constructed sites and unpaved roads, home wood burning for fuel, bitumen heating along road building sites, and waste burning in satellite towns due to insufficient trash management. Table 11(a) shows the rise in car ownership in Bhutan from 1997 to 2018. Between 2016 and 2017, there were 9.18 percent more automobiles on the road, more than doubling since 1997. In 1995 and 1996, the emissions of 1060 vehicles were examined to determine the state's pollution requirement.[6] The survey

[6]Tashi Tenzin, Karchung K., Karma Norbu, Sangay Wangmo, and Pema Zangmo.**"Estimation of energy content in municipal solid waste of Bhutan and its potential as an alternate power source,"** Environment Conservation Journal, 2021.

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found that 66% of gasoline-powered cars and 96% of diesel-powered cars did not adhere to emission guidelines. According to the survey, the majority of cars lack altitude adaptation features, and imported fuel of low quality increases vehicle emissions. CO_2 emissions (metric tonnes per person) rose from 0.4 in 2000 to 1.4 in 2019, according to data from the World Bank.

Table: 2(a)

Number of vehicles (Road Safety Transport Authority (RSTA, Thimphu)

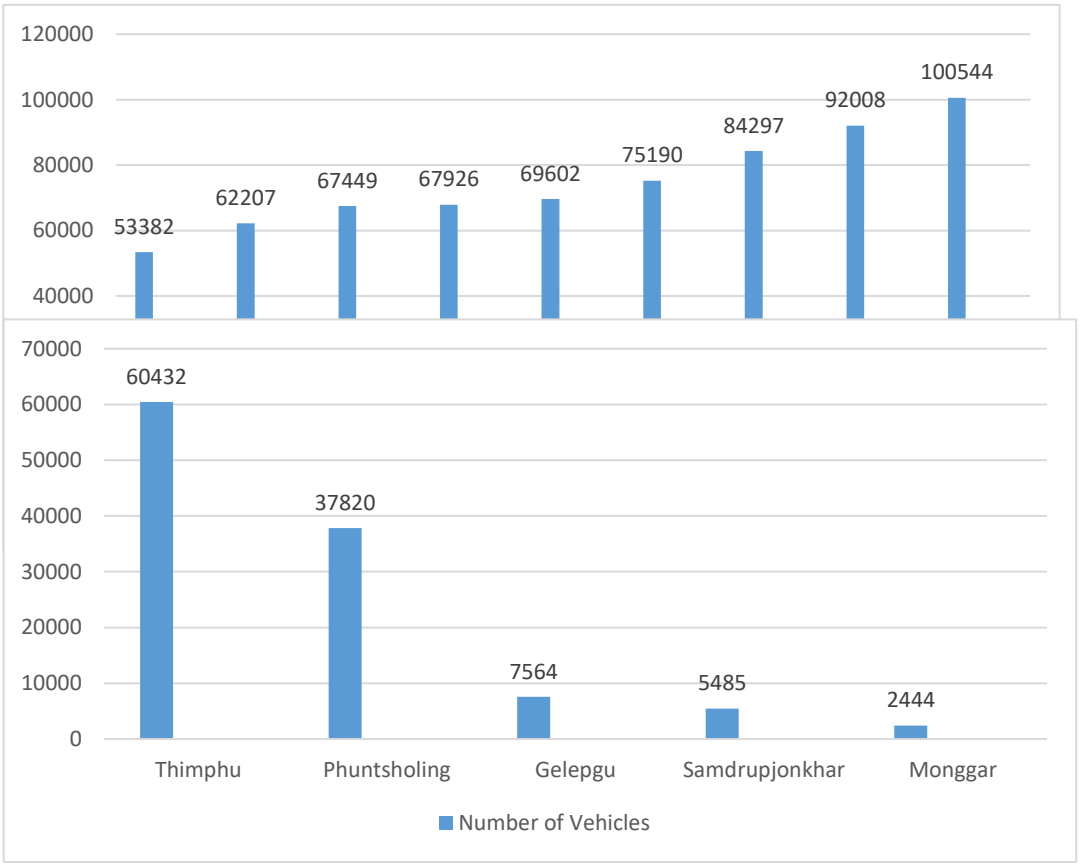

Table: 2(b)

As of March 31, 2021, the total number of motor vehicles, RASTA

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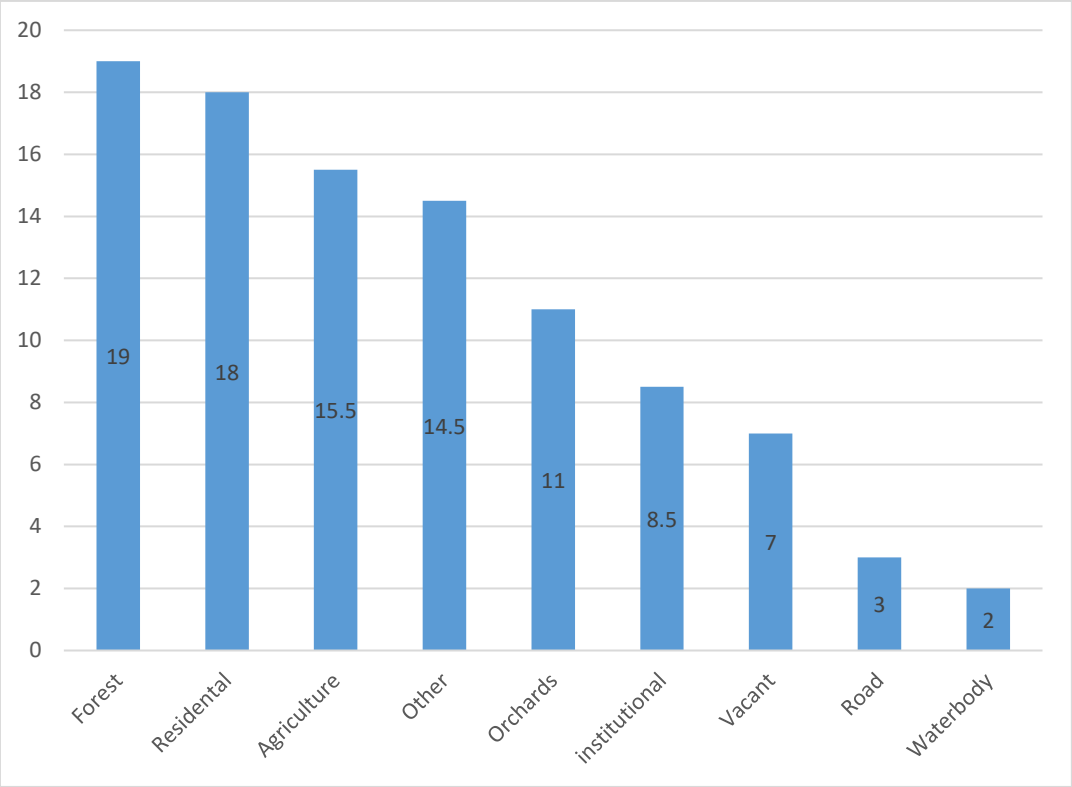
Table: 2(c)

Land Use Pattern in Thimphu



Source: Derived from Thimphu Structure Plan 2000-2027

Table: 11(d)

CO_2 emissions (metric tons per capita)

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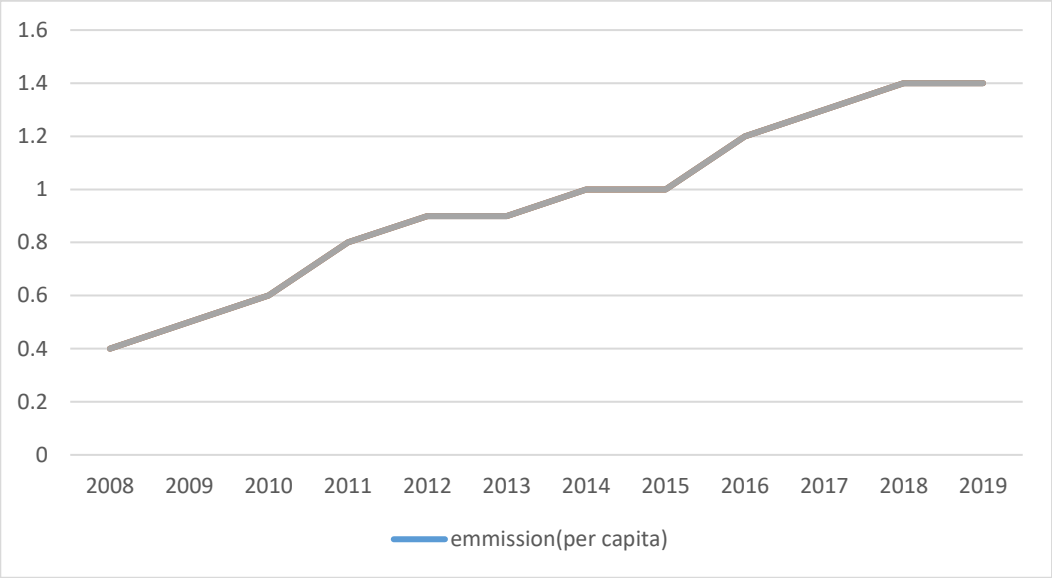

Source: world Bank data

Table: 2 (e)

Environment data (Carbon emission) from recent years

Indications	Source	Ministry	2017	2018	2019	2020	2021
CO_2 emissions (000 Tons)	UNFCC reports	NEC	1559560	1559560	1559560	1559560	1559560
CO_2 / capita emissions (000 Tons)	UNFCC Reportl	NEC	2.14	2.12	2.10	2.08	2.06
Kg CO_2/ $1GDP(PPP)	UNFCC Report	NEC	N/A	N/A	N/A	N/A	381310.51

Population expansion, migration from rural to urban regions, and shifting consumer behaviour all contribute to serious problems with solid waste disposal in metropolitan areas. Between 75 and 80 percent of the waste produced in the state is domestic rubbish, which makes up the majority of waste production. A recent national survey indicates that Bhutan generates 172.15 metric tonnes of garbage every day. The average amount of trash produced each day is 0.23 kg; however, recent figures indicate that this amount may have significantly grown. Due to the lack of a national inventory, information on the production, collection, and disposal of

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municipal solid waste is not available at the national level. By 2027, the capital city of Thimphu, which currently produces 99 metric tonnes per day of solid trash, is predicted to produce 124 metric tonnes.

Landslides and flash floods

Due to its rugged topography and delicate geology, Bhutan is susceptible to flash floods, particularly in its eastern and southern foothill regions. Due to rising rainfall intensity and the earlier start and finish of the monsoon, flash floods have become more frequent and severe over the past several decades. In Bhutan, landslides are a frequent occurrence and are closely related to flooding. Bhutan's infrastructure and agricultural land are primarily centred along drainage basins that are particularly susceptible to riverine flooding brought on by intense monsoon rains and glacial melt.[7] The frequency of floods has increased since 1999.[8] The World Resources Institute's AQUEDUCT Global Flood Analyzer predicted that floods in Bhutan would affect 7,700 people in 2010 and have a $33 million annual impact on GDP.[9] The Samtse province and the country's central and north-western areas are particularly at risk for flooding. The nation's GDP has decreased nationwide by 0.36% as a result of the direct and indirect consequences of flooding.[10]

Table: 3(a)

Key Natural Hazard Statistics for 1980-2020

Serial Number	Year	Kind	Number of people Affected
1.	1985	Epidemic	247
2.	1992	Epidemic	494

[7]World Bank Group (2020). Global Facility for Disaster Risk Recovery. Bhutan. URL: https://www.gfdrr.org/bhutan

[8]Dupchu, K. **Compendium of Climate and Hydrological Extremes in Bhutan since 1968.** Thimphu. 2018. Available online:https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/campendium.pdf. (Accessed on 25 November 2020).

[9]WRI (2018) **AQUEDUCT Global Flood Analyser.** URL: https://floods.wri.org/#

[10]Dupchu, K. **Compendium of Climate and Hydrological Extremes in Bhutan since 1968.** Thimphu. 2018. Available online:https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/campendium.pdf. (Accessed on 25 November 2020).

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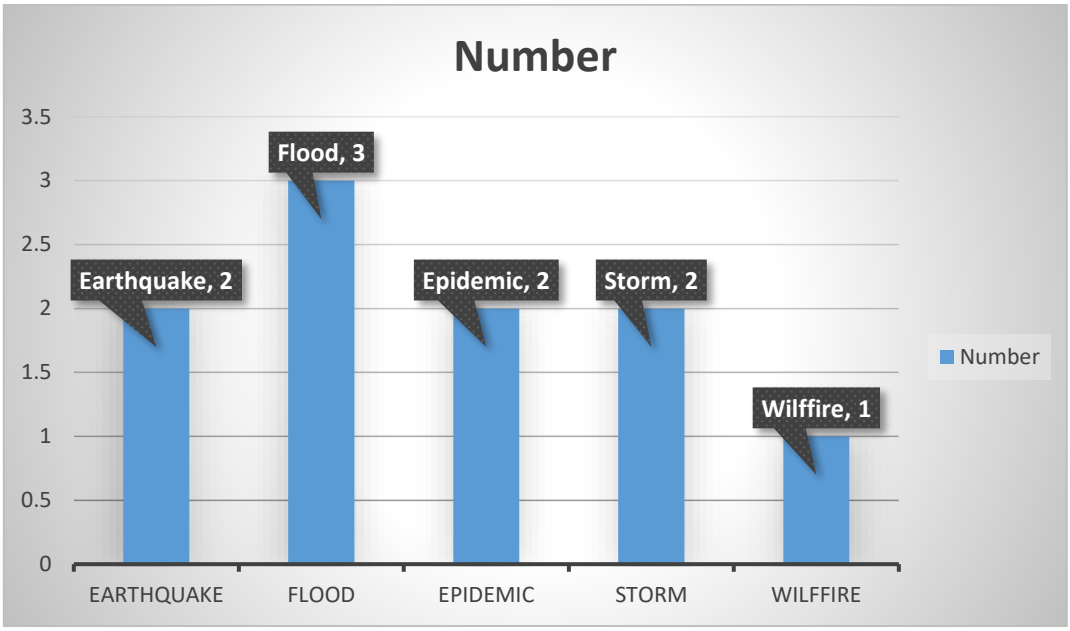
3.	1994	Storm	65,000
4.	2000	Flood	1,0000
5.	2009	Earthquake	12
6.	2011	Earthquake	20,016

Source: World Bank Data

Table: 3(b)

Average Annual Natural Hazard Occurrence (1980-2020)



Source: World Bank Data

In May 2009, one of the deadliest tragedies to ever strike Bhutan was brought on by the cyclone Aila, which had its origins in the Bay of Bengal. The Thimphu Meteorology Department reports that the 24-hour period of record-breaking rainfall, which might have reached 76 mm, was one of the highest in the previous five years (UNDP 2009–2011). Rivers and streams flooded to dangerous flood levels as a result of the flooding caused by the rain. In reality, river monitors in the Punatsangchhu area show that Storm Aila increased the river's water flow over that of the 1994 GLOF.

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The Department of Agriculture and the Ministry of Agriculture and Forestry jointly released reports stating that in 2010, landslides and flash floods destroyed about 2000 acres of agricultural land, displacing 4165 people across 20 dzongkhags, as well as farm roads and irrigation canals, displacing 529 households. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) from 2007 predicted that tropical cyclones would get stronger, with greater peak wind speeds and heavier precipitation.

Tropical storms

Tropical storms were first reported in the local paper in 1994, and every year since then, incidences of windstorms have been reported. In Bhutan, particularly before the monsoon season, windstorms have recently become more intense and frequent. In lower Trashigang, 249 rural dwellings sustained damage in April 2008 due to windstorms. 148 families were impacted in Lumang Gewog, which was the area most badly hit. Kangpara, Khaling, Thrimshing, Sakten, and Shongphu each had one affected family. In addition, the windstorm caused damage to eight school structures, four lhakhangs, and one forest office.

The Department of Agriculture and Ministry of Agriculture and Forestry's 2011 project file indicates that in recent years, farmers have experienced an increase in the frequency of rain and windstorms. In 2010, hail and windstorms destroyed a variety of staple crops, including maize, rice, potatoes, chilies, buckwheat, and others, injuring more than 5000 acres of agricultural crops. 432 residences suffered wind damage in 2019, according to a report co-published by the Department of Home and Cultural Affairs and the Department of Disaster Management.

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Table: 4

Most Violent Topical storms since 2020

Date	Storm Name	Wind speed(max)	Diameter (max)	Air pressure (mbr)	Area(affected)
21-05-20	AMPHAN	241 km/h	222 km/h	920	About 163 km south of Phunsholing
27-05-21	YAAS	119 km/h	259 km/h	974	About 486 km southeast of Samtse in Samchi
06-12-21	JAWAD	65 km/h	130 km/h	997	About 542 km south of Samtse in Samchi
25-10-22	SITRANG	83 km/h	241km/h	994	About 305 km south of Samdrup Jonkhar

Source: National Centers for Environmental Information of NOAA

Pests and diseases

Climate change will cause pests and diseases to proliferate in formerly uninhabited areas due to the anticipated upward trend. Bhutan has seen an increase in pests and diseases as a result of the changing climatic circumstances.

Bhutan also has a high incidence of a few health conditions related to the environment. Climate change increases the danger of vector-borne illnesses like malaria and dengue fever, which have become major public health concerns in countries like Bhutan, according to a 2010 report by the National Environment Commission. Bhutan's malaria pandemic is largely caused by rain and warming temperatures. Bhutan experienced a substantial rise in malaria cases between 1965 and 1994, going from 518 to 39,852.[11] Bhutan is experiencing a rise in the

[11]Lai, A. T., Lin, I. C., Yang, Y. W., & Wu, M. F. (2012).**Climate change and human health.** *Journal of Internal Medicine of Taiwan*, 23(5), 343–350. https://doi.org/10.3329/jssmc.v8i1.31495

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infectious disease dengue, which was first discovered there in 2004. Bhutan presently experiences a high incidence of dengue during the monsoon season.[12] Dengue fever, a deadly viral disease, has emerged. Since its discovery in Bhutan in 2004, dengue fever has spread widely throughout the monsoon season.

Disappearing springs

One of Bhutan's main sources of water for consumption and survival, springs, appears to be decreasing. Due to the increasing frequency of these occurrences, particularly during the prolonged dry season, both rural economies and people's means of subsistence are in peril. Due to persistently dry winters and an increase in springs drying up, there is a severe lack of water in Bhutan's eastern and southern regions. This is true despite Bhutan having one of the largest water resources in the region—109,000 cubic metres of water per person.

The poorest populations have been hardest hit by climate change's effects. They have trouble accessing both clean water for drinking and water for irrigation. As a result of farms being abandoned and some farmers moving to cities in search of better prospects, food availability is negatively impacted, and vulnerable populations are put in danger.

[12]Division, A., & Bureau, N. S. (2012).**Bhutan's Glaciers Meltdown As a result of the induced spread of infectious diseases as a result of changing environmental circumstances, the incidences of vector-borne diseases are expected to rise as people relocate to higher elevations as a result of global warming. The management of vector-borne diseases is being impacted in Bhutan by rising temperatures. Temperature, precipitation, humidity, and other odd meteorological conditions all directly affect the transmission of malaria, either preventing it or facilitating it. A Ministry of Health report from 2010 details the growth and survival of parasites and vectors. Bhutan has recently experienced, Threats and the Need for Joint Response Mechanism.**http://www.nsb.gov.bt/publication/files/pub9ib9100uu.pdf

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Conclusion:

The principle of environmental protection is not new to the Bhutanese people or government. Strong conservation policies have been implemented by the Bhutanese royal government for more than a century, and the country's legal framework has developed to support the sustainable management, conservation, and use of biological resources. National development, as determined by a special statistic known as gross national happiness, is facilitated by national conservation policies and legislation. The preservation of the environment is a major threat to GNH. 60% of the country's territory must be kept forested, according to Bhutan's new democratic constitution.

In order to increase the nation's food security, policies in the renewable natural resource sector are important. Bhutan's well-thought-out conservation strategy, which aids the country in managing its natural resources, improving rural income, and creating the best employment opportunities, benefits a segment of the population.

It won't be far off in the near future, but it will have an effect on subsequent generations. They feel really satisfied since they are aware that what they are doing is the right thing to do. They are, however, deeply disappointed when the more developed economies that could afford to do so decide against doing so. Bhutanese people consider themselves to be a tiny fraction of all humankind. The global map shows that greenhouse gases can transcend international boundaries without a passport or visa. There would be less discussion of climate change now if more developed countries took steps similar to those taken by Bhutan.