



ISSN:2582-8169

# “RELATIONSHIP BETWEEN LAND USE AND CLIMATIC CHANGE: A CASE STUDY OF 24 PGS (S), WEST BENGAL”

<sup>1</sup> Madhuchhanda Dhole <sup>2</sup> Sheetal Topno

<sup>1</sup> Research Scholar <sup>2</sup> Assistant Professor

Department of Geography

Ram Krishna Dharmarth Foundation (RKDF) University, Ranchi

Received: 16<sup>th</sup> January, 2023;

Revised: 11<sup>th</sup> February, 2023

Accepted: 17<sup>th</sup> May 2023

**Abstract:** After COVID-19 pandemic, anti COVID vaccination is an important tool to combat COVID- 19 health hazard. In early time India government lead by Prime Minister Modi adopted Neighbour hood first policy. India's vaccination drive to the neighboring country Strengthen said policy. India manufacturing two vaccines (Covaxine and Covishield) by indigenous Indian Pharmaceutical Company. By these two vaccines India also included into five major anti Corona virus vaccine producing countries with US UK Russia and China. India's vaccination exporting policy to neighbour friend help Them to overcome COVID-19 pandemic. India's vaccine Maître programmed provides Vaccination to Bangladesh, Sri Lanka, Nepal, Myanmar, and Bhutan. The decision of Providing vaccine to neighbouring countries is a showcase to maintain faithful Commitment to the Neighbourhood first policy (NFP), which was declared by PM Modi. All Stakeholder of neighbouring country like Bangladesh Nepal and Bhutan Express their Thanks to India for this live saver attempted. Vaccine diplomacy by Indian government Increases role of India in International politics in south Asia and world. My present paper is an attempt to India's vaccination diplomacy with special interest to neighbouring countries in the light of PM Narendra Modi's Neighbourhood First Policy.

**Keywords:** *Causes, Climatic Change, Consequences, Global Warming, Land Use Change*

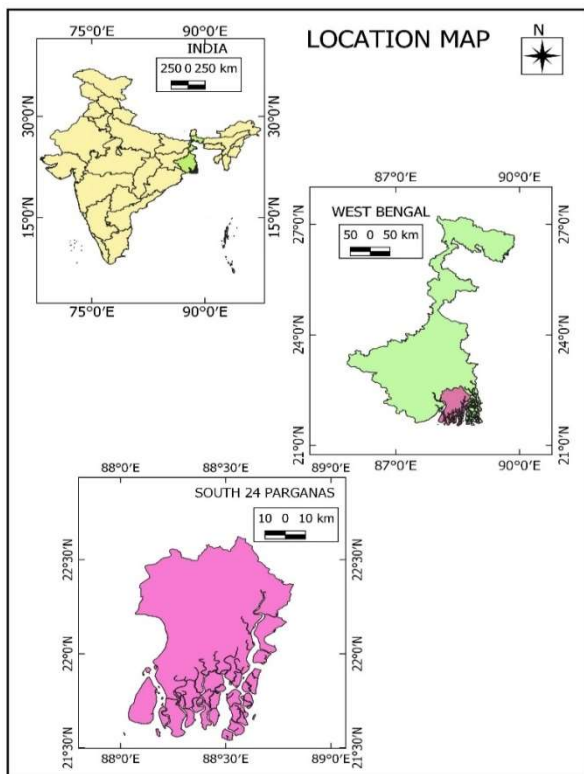
## I. INTRODUCTION

A long-term issue is climate change, incident and the responsibility for this incident is natural and human activity. Anthropogenic impact regulates the velocity of it to impact more on human life.

The study of this matter is called paleoclimatology. Till now there have many geological ages in the world's geological history where some parts of the earth were covered by ice caps in many periodic glacial periods for a long time and a gap period between two ice ages when the same region was ice-free or the ice replaced backward due to the melting of the gradually atmospheric warming (All About Climate).

\*Corresponding Author: Madhuchhanda Dhole

*Figure.1. Location Map, prepared by the author in QGIS*



The district Twenty-Four Parganas South [24 PGS(S)] is situated in the southmost part of West Bengal and it is situated on the Lower Gangetic Deltaic Plain and coastal region of the Bay of Bengal. The location of this district is  $21^{\circ}29'00''$  North (N)– $22^{\circ}33'45''$  N latitude and  $88^{\circ}03'45''$  East (E) – $89^{\circ}04'50''$  E longitude. The area is 9960 sq. km. A location map has been shown in figure.1 in this paper. According to the Census Report of India 2011, this district has been divided into 5 sub-division, 7 municipalities, 111 Census Towns (C.T.), 29 Community Districts (C.D.), 312 Gram Panchayats (G.P.) and a total of 2042 villages (Census of India, 2011 Part XII-B). According to the Census of India, 2011 Part XII-A, the forest area of this district is

around 44.94% of the total reporting area, 37.78% of the land is under cultivation and 15.11% of the land is non-agricultural use. Climate change is defined as a change in temperature that the United Nations Framework Convention on Climate Change links directly or indirectly to anthropogenic activity that alters the composition of the world atmosphere and that occurs on top of natural climate variability over comparable time periods (UNFCCC) (UN, 1992). The Intergovernmental Panel on Climate Change claims that (IPCC) in 2007, climate change is the term used to describe any alteration whether brought on by natural variability or as a result of human activity, changes in the climate throughout time. In 1998, the earth's temperature peaked. Additionally, eleven of the past twelve years (between 1995 and 2006) rank among the twelve warmest years on record for the global surface temperature since the invention of the sensor in 1850. This temperature rise has altered weather patterns, caused widespread snow and ice to melt, and raised the world's average sea level. (IPCC, 2007a).

Climatic change and global warming are a world's serious phenomena as well as West Bengal and many research works have been done on this topic by researchers. The impact of global warming is seen on the water use system, sources of irrigated water from the rivers which are nourished by

monsoon rainwater and melted glacial of the Himalayan. Climatic change is affected the agricultural system through the climatic hazards in this state like in other regions of the world. As a result, land use system changes and food insecurity (West Bengal Development Report, 2010).

Climate change is anticipated to have a direct impact on world food production. Many crops' growing seasons can be cut short by an increase in the average seasonal temperature, which will reduce their final output. Warming will have a direct impact on harvests in locations where temperatures are already close to the physiological maximum for crops (IPCC, 2007).

It has been predicted that the world's agricultural production is going to decline by almost 3-16% by 2080 due to the declination of crops' tolerance level for the temperature increase. India within the developing countries will be declined production drop nearly 30-40% (Mahato, 2014).

Positive population growth, changes in economic development, and food habit changes force change in land use that regulates climate change. On the other hand, the reverse effect of climate change hit crop production which creates pressure on farmers to change their land use (Thapa, 2021).

**Objectives:** The researchers have selected some objectives to prove the relationship

between Land Use change with climate change. The objectives are-

- i. To find Land Use has been changing with time.
- ii. To show the climate is changing.
- iii. To identify the relationship between Land Use and Climate change.

#### Hypotheses:

- i. There has a relationship between Land Use and Climate change.

#### Methodology:

This research has been done based on secondary and quantitative data, which have been collected from authentic websites. The data analysis has been done to prepare the report for showing the interrelationship

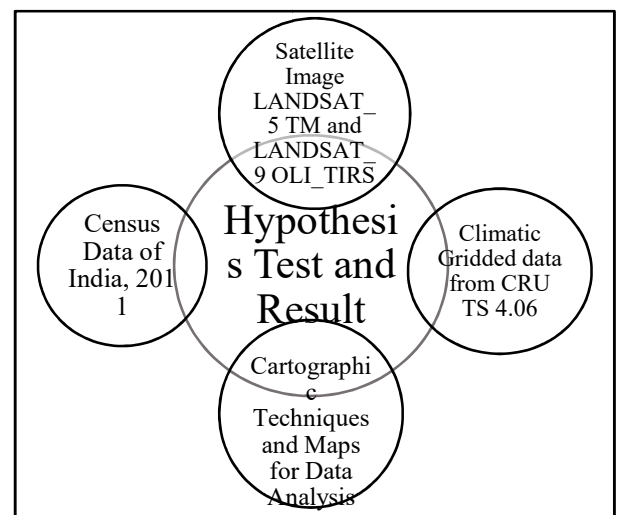


Figure.2. Technique of Methodology

between climatic change and land use. Some hypotheses have been structured and tested in this paper. The structure of the methodology has been shown in figure.2.

#### Causes of climate change:

Change in climate is a world-wise problematic issue for the last some decades and it has become more difficult for the world's creatures some little or and its effect has seemed like a climatic disaster now. There have been some reasons for this incident and the anthropogenic impact has been blamed for the rapid increase in temperature. Various types of Green House Gases (GHGs) have been emitted from different sectors of human activities like Carbon dioxide ( $\text{CO}_2$ ), Carbon monoxide (CO), Methane ( $\text{CH}_4$ ), Chlorofluorocarbon (CFC), Nitrous oxide ( $\text{N}_2\text{O}$ ) etc. Because of the nature of Green House Effect of GHGs, all these gases act to increase the world temperature or global warming and degrade the quality of air (Shindell et al. 2012).

A huge amount of GHG emits from the agricultural fields in the lower atmosphere. Carbon dioxide gas emits due to the burning of scrubs and after the decomposition of organic matter. Methane is produced from the wetlands, pasture and paddy fields. The application of fertilizer and pesticides is produced nitrous oxide (Kang and Banga, 2013). According to the Intergovernmental Panel on Climate Change (IPCC 2007), agriculture was responsible for 10%–12% of all worldwide anthropogenic GHG emissions.

Change in land-use occur due to the deforestation of the dense forest of the Sundarban for natural and man-made

reasons. Even the transformation of bare soil, and wetlands for the increasing human necessity and impact of pollution effect on land use and its change. The change in land use pattern impact and damage the species' biodiversity and this species disaster report has been published by the Zoological Survey of India with the title of "Biodiversity: Present Status and Past Exploitation". Also, a species declining report was published in West Bengal from 1985-2005.

Even there have some natural reasons for climate change. The climate is impacted by tectonic plate movement, volcanic eruptions, and the tilt of the Earth's axis (All About Climate). The responsible for climate change are categorized in three separate reasons- Extra-terrestrial sources (solar irradiance, sunspot cycles, interstellar nebulae, Extra-terrestrial bodies collision etc.), Terrestrial sources of climate change (Dust particulates, Pollens, Smoke and soot, Salt particles, Volcanic dust and Ashes, oceanic variation, continental drift- pole wandering and solar albedo etc.) and anthropogenic impacts (ias score, 2022).

One-quarter of the ice-free land surface has changed in land cover, primarily due to deforestation for agricultural expansion, while the remaining half has maintained its vegetation cover but is managed, as is the case, for example, in forestry. The remaining one-half of the ice-free land

surface has not undergone any changes in land use. The management of the land and the changing of the land cover all have an impact on the climate. Politicians mostly focus on land use change as a factor in the human-caused increase in atmospheric CO<sub>2</sub> and subsequent global warming (Pongratz, 2015).

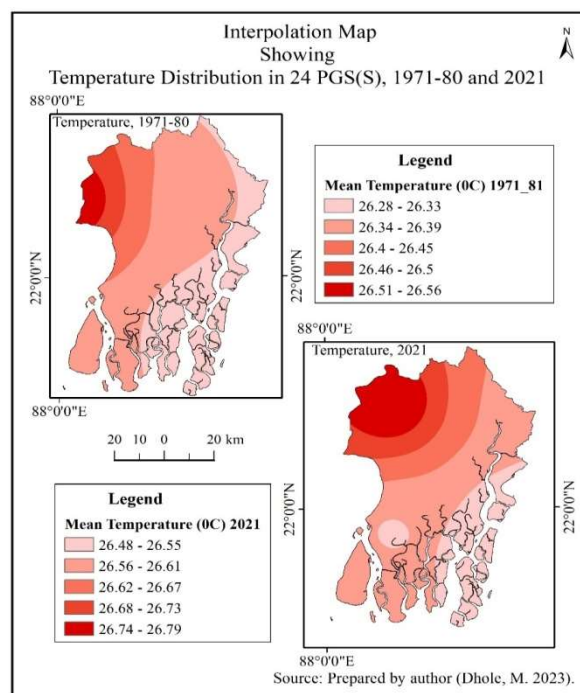
A climatic change has been seen in India that is annually 0.68<sup>0</sup>C mean temperature increase rate seen per century and the temperature has increased during the post-monsoon period and the amount of rainfall has increased to the north-eastern part of India where the no. of rainy days has decreased along the east coastal region (Sivakumar and Stefanski, 2011).

As it is proved that the emission of GHG is responsible for the temperature increase and agricultural fields along with the change of land use and forestry are responsible for emitting and mixing of GHG in the atmosphere and take an important part in climate change (Maharjan and Joshi, 2012).

### Result and Discussion:

Monthly temperature data for 1971-80 and 2021 of the study district 24 PGS(S) have been downloaded from the CRU site in tiff format and yearly mean temperature interpolation maps of two separate years have been prepared in ArcGIS software and the maps have been shown in figure.3. The maximum and minimum temperature of the district in 1971-80 were varied 26.51<sup>0</sup>C –

26.56<sup>0</sup>C and 26.28<sup>0</sup>C – 26.33<sup>0</sup>C, i.e., the range was 0.23<sup>0</sup> C. But the maximum and minimum temperatures of the district in 2021 varied from 26.68<sup>0</sup>C – 26.73<sup>0</sup>C and 26.48<sup>0</sup>C – 26.55<sup>0</sup>C, i.e., the range was 0.20<sup>0</sup> C. *Figure.3. Temporal Temperature Change of the District 24 PGS(S).*



Source of data: Climatic Research Unit: Data: High-Resolution Datasets: CRU TS 4.06: CRU TS 4.06 Data Variables. [https://crudata.uea.ac.uk/cru/data/hrg/cru\\_ts\\_4.06/cruts.2205201912.v4.06](https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_4.06/cruts.2205201912.v4.06)

There has a noticeable change in temperature increase for both the maximum and minimum sectors. The increase for maximum temperature is 0.23<sup>0</sup>C and 0.2<sup>0</sup>C for minimum temperature in the last 40 years in this area. The temperature variation has been categorized into 5 classes and the temperature variation has been seen from maximum to a minimum from the western

part to the eastern part for both years but the observed change has been noticed that the maximum temperature zones have spread more their areas from the west to east portion and the minimum temperature zone has decreased in 2021 than the 1971-80 year. Though both temperatures have increased, still, the changing temperature may not be taken as a very big matter but the temperature increase area is very vulnerable for local species or the ecology and environment. The causes of temperature increase have been discussed before in this paper and the land use pattern is acted an important role in the temperature change also has been discussed. Land and climate change impact each other and that has been tried to test in this paper for the study district.

To prove the inter-relationship between both land use and climate change, the researchers have selected some specific locations and downloaded gridded temperature data from the CRU website and converted tiff data to excel data by the use of ArcGIS software. The location of selected places are Near Madanganj, Namkhana (21.75°N, 88.25°E), Near Diamond Harbour (22.25°N, 88.25°E) and Near Manaskhali, Gosaba (22.25°N, 88.75°E) respectively and downloaded the temperature data for 40 years (1971-2021). The data have been tabulated in table.1 and the temperature data have been represented

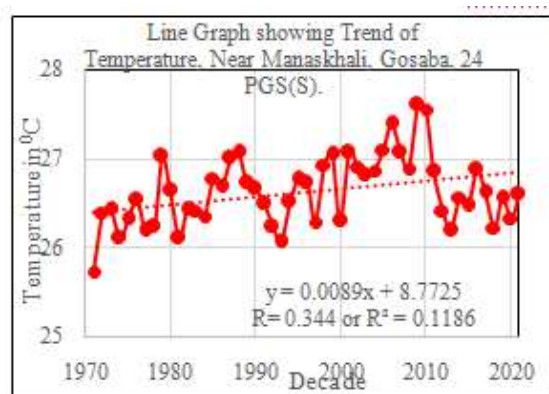
by a curve and tentative straight line to show the actual and regression trend temperature data with equation and correlation coefficient value ( $R$  or  $R^2$ ) in figures. 4(a), 4(b) and 4(c).

Table.1. Average Temperature ( $^{\circ}$ C) of some places of 24 PGS(S)

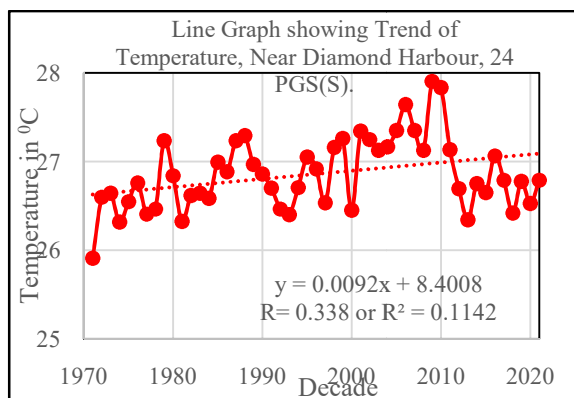
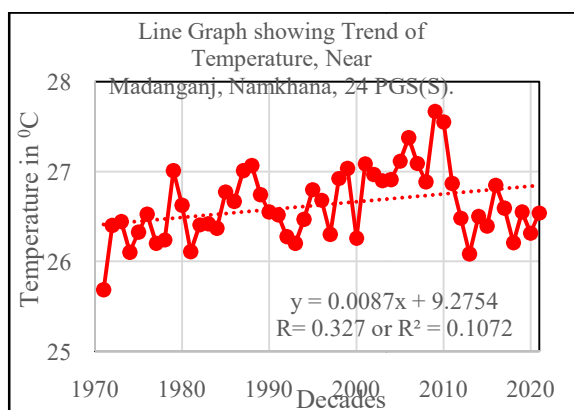
Year	Near Madanganj, Namkhana (21.75°N, 88.25°E)	Near Diamond Harbour (22.25°N, 88.25°E)	Near Manaskhali, Gosaba (22.25°N, 88.75°E)
1971	25.68	25.91	25.73
1972	26.40	26.60	26.40
1973	26.44	26.64	26.43
1974	26.10	26.32	26.11
1975	26.33	26.55	26.33
1976	26.53	26.76	26.53
1977	26.20	26.41	26.19
1978	26.24	26.47	26.23
1979	27.01	27.23	27.03
1980	26.63	26.84	26.64
1981	26.11	26.33	26.11
1982	26.41	26.62	26.43
1983	26.42	26.64	26.42
1984	26.37	26.58	26.36
1985	26.78	26.99	26.78
1986	26.67	26.88	26.68
1987	27.01	27.23	27.01
1988	27.07	27.29	27.07
1989	26.74	26.97	26.73
1990	26.55	26.86	26.67
1991	26.52	26.70	26.50
1992	26.28	26.47	26.24
1993	26.20	26.40	26.07
1994	26.47	26.71	26.51
1995	26.80	27.05	26.78
1996	26.68	26.92	26.73
1997	26.30	26.53	26.29
1998	26.93	27.16	26.93
1999	27.03	27.26	27.05
2000	26.26	26.45	26.30
2001	27.08	27.34	27.08
2002	26.97	27.25	26.91
2003	26.90	27.13	26.82
2004	26.91	27.17	26.87
2005	27.12	27.35	27.10
2006	27.38	27.64	27.39

2007	27.09	27.35	27.07
2008	26.88	27.13	26.89
2009	27.67	27.91	27.61
2010	27.55	27.83	27.55
2011	26.87	27.13	26.85
2012	26.48	26.69	26.42
2013	26.08	26.34	26.20
2014	26.50	26.75	26.57
2015	26.39	26.65	26.48
2016	26.85	27.07	26.88
2017	26.59	26.79	26.62
2018	26.21	26.42	26.23
2019	26.55	26.78	26.56
2020	26.32	26.53	26.33
2021	26.54	26.79	26.60

Source: Climatic Research Unit; Data: High-Resolution Datasets: CRU TS 4.06; CRU TS 4.06 Data Variables. [https://crudata.uea.ac.uk/cru/data/hrg/cru\\_ts\\_4.06/cruts.2205201912.v4.06/](https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_4.06/cruts.2205201912.v4.06/)



The data in table.1 of some places of the study area are indicated that the temperature has been enhancing rapidly in the last decades (WMO, 2021) and the temperature increase rate is positive in all selected places but the increase rate is higher near Gosaba region than other two areas. The positive trend of the changing *Figure.4(c). Temperature Change near Gosaba*. scenario is indicating that as global warming is an active temporal and contemporary incident, the land use and temperature change will be continued in the future and people are going to suffer more and more from its bad effects if sustainable development and necessary steps are not taken by all of the world's people immediately.



*Figure.4(a). Temperature Change near Namkhana. Figure.4(b). Temperature Change near Diamond Harbour*

The climatic data table.1 and figure.2 are indicating that the temperature has increased rapidly as well as global warming has been happening for more than a century in the whole world. These incidents and evidence are proved that the climate has changed with time.



*Table.2. Land Utilization Statistics in District South Twenty-Four Parganas, (area in thousand hectares)*

Year	Total reported Area	Forest Covered	Non-agricultural Area	Current fallow	Net Sown Area
2006-07	948.71	426.36	136.15	10.08	372.79
2007-08	948.71	426.36	138.3	8.16	372.3
2008-09	948.71	426.36	140.06	4.63	373.66
2009-10	948.71	426.36	141.3	18.91	357.54
2010-11	948.71	426.36	143.32	16.69	358.4

*Source: District Statistical Hand Book, South Twenty-Four Parganas, 2010-11.*

The land use of district, 24 PGS(S) has changed and the changing scenario has been highlighted in table.2. Here in the table.2 yearly land use data in different categories have been distributed from 2006-07 to 2010-11. The total reported area and forest area were constant in the figure but the areas used under the purpose non-agricultural sector, current fallow and net sown area have changed with the year. There have positive changes in the non-agricultural and current fallow sectors and negative changes in the net sown area. That means the agricultural field was converted into non-agricultural or commercial purposes or fallow land or bare soil. It is indicating that the land use pattern has changed, according to government data.

A land use and land cover map (LULC Map) have been prepared for 1989 and 2022 on 24PGS(S) district map for a comparative analysis to show the land use change by figure.5 and tables.3(a) for 2022 and 3(b) for 1989. The maps have been prepared on LANDSAT 5 and LANDSAT 9 images which have been downloaded from the USGS website and an unsupervised classification has been done in QGIS and

the land use categories data or area have been got from the classification report in this software. There are 6 and 4 different types of land use categories in 1989 and 2022 in this district. Except for the land use under bare soil, all other categories of the land area increased in 2022 than 1989 which are clear from the maps of both years, shown in figure.5 and tables value 3(a) and 3(b).

As the land use area has changed with time which has been collected from different two sources [District Statistical Hand Book, South Twenty Four Parganas, 2010-11 and LULC Map, prepared from the Satellite images (LANDSAT 5 and 9)] with the area change data, so it can be said and proved that the land use has changed with time and can be predicted that it will be changed more in future with time along with the peoples changing demand of a dynamic economy that is related to the land use pattern.

If the LULC map of 1989 and 2022 can be observed the gradual change in lands in the map of 2022 can be understood mainly in the settlement, bare soil and natural vegetation. Surrounding the river Hooghly to the north portion of the map a dense settlement or urbanization has developed in 2022 and vegetation in the agricultural sector has reduced to 1989. So the high-temperature belt covered this area in 2022 which included the medium temperature



zone that is seen in figure.3. In this same way, the eastern and south-eastern part (Island area) of the map was under natural vegetation cover in 1989 but that area has converted into a mixed culture (natural vegetation with agriculture) land use pattern. Due to the land use change the sunlight absorption and reflection rate has changed, and lacking vegetation the temperature is increased gradually. Even, with the emission of GHG and increased settlement area the temperature change is affected in this portion. So, this mentioned portion of the map was a low temperature-covered zone in a large sector in 1989 but the area has decreased in 2022. It has proved that temperature change is affected by land use change and vice versa. So, it can be said that there is a relationship between temperature and land use change.

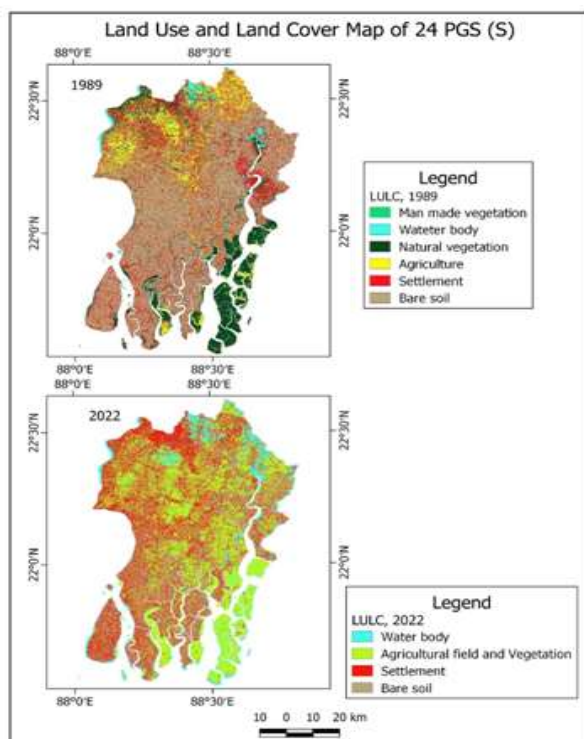


Figure.5. Temporal Change of Land Use and Land Cover of 24 PGS(S)

Source: Prepared by the author (Dhole, 2023).USGS

Earth Explorer. <https://earthexplorer.usgs.gov/>

Table.3(a). Land-Use and Land-Cover Area of 24 PGS(S), 2022.	
Land Class	Area (sq.km.)
Waterbody	614.24
Agriculture and vegetation	2107.38
Settlement	1815.33
Bare Soil	988.73
Source: Prepared by the author (Dhole, 2023).	

Table.3(b). Land-Use and Land-Cover Area of 24 PGS(S), 1989.	
Land Class	Area (sq.km.)
Waterbody	158.58
Natural vegetation	1062.15
Agriculture	765.64
Settlement	1162.82
Bare soil	2376.53
Source: Prepared by the author (Dhole, 2023).	

### Consequences:

The temperature change effect mixed in the world. Several climatic hazards and disasters (cyclones, wildfires, floods and droughts etc.) attack frequently the earth's surface and attack badly in the coastal area. As the rapid temperature increase is mainly responsible for the GHG emission and their concentration in the atmosphere and the ocean water, the melting of glacial and rising of mean sea level has become an average of 3.29 (+ - 0.3) mm per year and that is happening due to the concentration of CO<sub>2</sub> mostly (23% approximately). As a

result, the ocean water has become more acidified with time and the sea level is rising which is more disastrous for the island countries or part of the lower portion of coastal areas of countries (WMO, 2021). Climate change impacts the terrestrial ecosystem, the environment and agricultural production inversely, especially if it applies to the developing countries of the tropical region. As the rising temperature and non-consistency in precipitation are badly impacted crop production and the declining crop production is causing losses to farmers in these countries and food insecurity is created another problem here. The monsoon system is affected by this situation of global warming. So, economically agricultural dominating countries like India which country are mostly dependent on monsoon rainwater for agriculture are being damaged in their crop production and as a result, their economic situation has crashed and affected the peoples' daily life. An increase in temperature enhances the water temperature and disbalances the aquatic environment for the living species of this ecosystem. Glacial melting activities is rapidly increasing and flood and drought happen in a different part of the whole country of India mainly it is affecting the river basin areas along with coastal areas. Extreme weather is a frequent incident on this day and forms more devastating with time (ias score, 2022).

Some specific crop production has

decreased and some are increased here in this district 24 PGS(S). Moreover, it has been observed that a specialty has developed in crop production in this district like a regional agricultural belt in the whole world. The production of rice, potato and sugarcane, sorghum etc. is increasing, reverse production is seen in the production of tea, maize, coffee and wheat in the tropical (Agricultural Census West Bengal, 1995-96, 2008-'09, 2011-'12, 2015-'16, 2018-'19), (Kubabigamba, 2015) and (Raza et al., 2019).

#### **Suggestion:**

Urbanization and industrialization are not be stopped in the twenty-first century, but the issue of climatic change and global warming should be taken very sensitively. So, some mitigated management should be adopted for land use and climatic change and its effect-related issues.

Both side area of river Hooghly near Kolkata and Howrah is a vital industrial region of east India and was declared vulnerable zone to climatic change due to the pollution in IPCC report, 2007. But the development is not stopped for the prosperous. So, some adaptation measures related to thinking should be taken by the government of West Bengal. The world Bank has launched a case study on 'Kolkata and Climatic Change' under the project on 'Climatic change and variability impact assessment and adaptation to coastal cities

of Asia' (West Bengal Development Report, (2010).

For reducing the emission of GHG in the atmosphere India as well as all countries should follow the rules-regulations and targets of GHG emission which are applied by many national and international committees like the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (Preston et al., 2010). Some crop production adaptation techniques should be followed in this climatic change period like plant breeding, genetic divergence analysis, genetics and genomics strategies etc. (Razz et al., 2015).

The National Bank for Agriculture and Rural Development (NABARD) is a controlling body, which was established by the government of India and the states of India can get support through this authority for taking new agricultural strategies to fight against climate change (Rao, 2016).

#### Reference:

- Agricultural Census West Bengal, 1995-96. Volume-1, Evaluation Wing Directorate of Agriculture & Land and Land Reforms Department Government of West Bengal. & 2008-'09, 2011-'12, 2015-'16, 2018-'19.
- All About Climate. Resource Library Article.
- <https://education.nationalgeographic.org/resource/all-about-climate>
- Census of India (2011). District Census Handbook South Twenty-Four Parganas. Part XII-A and XII-B. Village and Town wise Primary Census Abstract (PCA). <http://www.censusindia.gov.in>
- Climatic Research Unit: Data: High-Resolution Datasets: CRU TS 4.06: CRU TS 4.06 Data Variables. [https://crudata.uea.ac.uk/cru/data/hrg/cru\\_ts\\_4.06/cruts.2205201912.v4.06/](https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_4.06/cruts.2205201912.v4.06/)
- Ias score, (2022). Climate Change. GS Score Target PT IAS UPSC in 100 Days: Day 39 Environment of Climate Change, Day 39: Environment - Climate Change - IAS SCORE. <https://iasscore.in/target-pt/climate-change>
- Intergovernmental Panel on Climate Change (IPCC) (2007). *Climate Change 2007: The Scientific Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by S. Solomon et al., Cambridge Univ. Press, New York.
- IPCC. (2007a). Climate change 2007: Synthesis report. Working group contribution to the Fourth assessment report of Intergovernmental Panel on Climate Change. Geneva Switzerland: Intergovernmental Panel on Climate Change (IPCC).
- Kang, M. and Banga, S. S. (2013). Global Agriculture and Climate Change. *Journal*

- of Crop Improvement*, 27(6):667–692.  
DOI: 10.1080/15427528.2013.845051
- Kubabigamba, J. (2015). Impacts of climate change on coffee production: a case of Karagwe district. The University of Dodoma.  
<http://hdl.handle.net/20.500.12661/763>
  - Maharjan, K. L. and Joshi, N. P. (2012). Climate Change, Agriculture and Rural Livelihoods in Developing Countries with Reference to Nepal. *Advances in Asian Human-Environmental Research*. (In M. Nusser ed.). Springer Tokyo Heidelberg New York Dordrecht London. DOI 10.1007/978-4-431-54343-5
  - Mahato, A. (2014). Climate Change and its Impact on Agriculture. *IJSRP*. 4(4): 1-6.  
<https://www.ijsrp.org/research-paper-0414.php?rp=P282518>
  - Pongratz, J. (2015). Climate Change and Land Systems: Impacts and Feedbacks. International Scientific Conference. Paris, France.  
[https://www.researchgate.net/profile/K-C-Gouda/publication/291356370\\_CFCC\\_abstractBook/links/56a28a0a08ae232fb201c552/CFCC-abstractBook.pdf](https://www.researchgate.net/profile/K-C-Gouda/publication/291356370_CFCC_abstractBook/links/56a28a0a08ae232fb201c552/CFCC-abstractBook.pdf)
  - Preston, B. L., Westaway, R. M., Yuen, E. J. (2010). Climate adaptation planning in practice: an evaluation of adaptation plans from three developed nations. *Mitig Adapt Strateg Glob Change*. Springer. 16:407–438. DOI 10.1007/s11027-010-9270-x
  - [Rao, G. B. \(2016\).](#) Strategies to Convert the Climate Change Challenges into Opportunities.  
[https://www.academia.edu/35835011/Strategies\\_to\\_Convert\\_the\\_Climate\\_Change\\_Challenges\\_into\\_Opportunities](https://www.academia.edu/35835011/Strategies_to_Convert_the_Climate_Change_Challenges_into_Opportunities)
  - Raza, A., Razzaq, A., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., and Xu, J. (2019). Impact of Climate Change on Crops Adaptation and Strategies to Tackle Its Outcome: A Review. *Plants* MDPI. 8(2):2-29. doi: 10.3390/plants8020034
  - Shindell, D., Kuylenstierna, J. C. I., Vignati, E., Dingenen, R. V., Amann, M., Klimont, Z., Anenberg, S. C., Klimont, Z., Anenberg, S.C., Muller, N., Maenhout, G. J., Raes, F., Schwartz, J., Faluvegi, G., Pozzoli, L., Kupiainen, K., Isaksson, L. H., Emberson, L., Streets, D., Ramanathan, V., Hicks, K., Oanh, N.T.K., Milly, G., Willials, M., Demkine, V., Fowler, D. (2012). Simultaneously mitigating near-term climate change and improving human health and food security. *Science* 335(6065): 183–189.  
DOI: 10.1126/science.1210026
  - Sivakumar, M. V. K. and Stefanski, R. (2011). Climate Change in South Asia. Climate Change and Food Security in South Asia. R. Lal et al. (eds.). Geneva. DOI 10.1007/978-90-481-9516-9\_2
  - Thapa, P. (2021). The Relationship between Land Use and Climate Change: A

Case Study of Nepal. In A. Harris (Ed.),  
The Nature, Causes, Effects and Mitigation  
of Climate Change on the Environment.  
(pp. 1-11). Alberta. University of Calgary.

DOI: 10.5772/intechopen.98282

DOI:

<http://dx.doi.org/10.5772/intechopen.98282>

USGS Earth Explorer.

<https://earthexplorer.usgs.gov/>

- UN. (1992). United Nations Framework Convention on Climate Change. FCCC/INFORMAL/84. New York, USA: United Nations (UN). Retrieved November 12, 2011
- West Bengal Development Report, (2010). Planning Commission Government of India. Academic Foundation. New Delhi.  
<http://14.139.60.153/handle/123456789/1591>
- World Meteorological Organization (WMO) (2021). Provisional State of the Global Climate in 2022. WMO- No. 1264.  
<https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate>