Role of Space Technology in Averting and Mitigating Climate Change

Mr. Mononjit Baruah[1] and Prof. (Dr) Arvind P. Bhanu[2]
[1]*Ph.D. Research Scholar, Amity Law School, Noida, Amity University Uttar Pradesh*
[2]*Addl. Director & Jt. Head, Amity Law School, Noida, Amity University Uttar Pradesh*

Abstract: **Space technology can play an important role in monitoring, averting and mitigating the disaster owing to climatic change. The 21st century has witnessed a tremendous change in climatic conditions all over the world. Climate change is a major cause of various natural calamity disasters which has resulted in loss of both mankind and property. It has become a concern for the world community to take steps to avert and mitigate climate change. The inputs provided by remote sensing satellites based on space technology are vital regarding early warning and monitoring regarding information on essential climate variables (ECVs). This paper highlights as to how space-based technology can contribute by providing necessary information through remotely sensed data. Space technology can facilitate the transmission of warnings through satellite communication and therefore play a crucial role in identifying the location where disaster may take place due to climatic change. The paper focuses the manner in which space based remote sensing data has help to identify the indicators and agents of climate change. The source of the paper is mainly based on secondary data based on related articles published in journals, documents related to space and climate change published by United Nations Office for Outer Space Affairs and reports of the Committee on the Peaceful Use of Outer Space. The outcome of the paper is to assess the role of space-based technologies as tool to minimize economic losses and damages due to dynamic impact of climate change.**

Keywords: **Climate Change, Data, Information, Mitigate, Role, Space Technology.**

INTRODUCTION

Space technology is very important for long term monitoring and observation of Earth's environment and climate for aiding the possible patterns of climate change its effects on the environment and human health. The Convention on Climate Change, 1992 has justified the use of satellites as a major tool for "systematic observation and development of data archives" for monitoring the various aspects of climate change. Climate change is a major cause of various natural calamity disasters which has resulted in loss of both mankind and property. Lack of early warning and monitoring hinders one to take necessary precautions in order to mitigate the risk of disaster due to climate change. The consequences of climate change have adverse effects in terms of weather, environment, agriculture, animals and human health. It also poses as a challenge to global sustainable development.

The impact of climate change can be assessed through information which reflects the substantial changes on essential climate variables (ECVs). Satellite remote sensing (SRS) technology has led to a new aspect of observations by providing multiscale information on essential climate variables (ECVs). Space technology through satellite communications facilitates transmission of data regarding warnings of climate change among various States and helps to identify the location of critical infrastructure. Spaced based technologies such as Earth observation satellites, communication satellites, metrological satellites and global navigation satellite systems (GNSS) have played an important role in averting and mitigating climate change.

The use of space technology through satellites for climate change related issues has been voiced by national space organizations such as the European Space Agency (ESA) and Indian Space Research Organization (ISRO). The United Nations 2030 Agenda has emphasized the importance of using space technology for climate change action by recognising the useful cooperation that subsist between space technology and earth-based goals. The Committee on Earth Observation Satellites, the Coordination Group for Meteorological Satellites and the Global Climate Observing System have been playing an important role to nurture for systematic observations the application of space-based satellite technologies to deal with climate change. The Special Report on the Inter-Agency Meeting on Outer Space

Activities on the use of space technology to address issues of climate change within the United Nations system highlighted the use of satellites at international level for monitoring the processes and trends of climate change (UN A/AC.105/991). The emerging use of integrated space-based technology in the field of mitigation and adaptation to climate change has drawn attention in the conference of the United Nations/Austria Symposium on Integrated Space Technology Applications for Climate Change (Graz, Austria, 12th -14th September, 2016). The Special Report of the Inter-Agency Meeting on Outer Space Activities on coordination of space-related activities within the United Nations system for climate action has focus regarding the use of space technologies to support climate action having regard to Sustainable Development Goal 13 (UN A/AC.105/1264).

Domains of Space Technology:

Space technology plays an important role by providing vital information and data to avert and mitigate climate change in the following domains:

- Communication: To forecast transmission of weather data and linking remote areas. Example – GSAT Satellites.
- Remote Sensing: To forecast mapping, resource management and environmental monitoring. Example – HYSIS Satellites.
- Weather Forecasting: To forecast real time weather data and climate. Example – Meteosat Generation Satellites.
- Disaster Management: To forecast real time information and support for various stages of response and recovery of natural disasters. Example – Earth Observation Satellite.

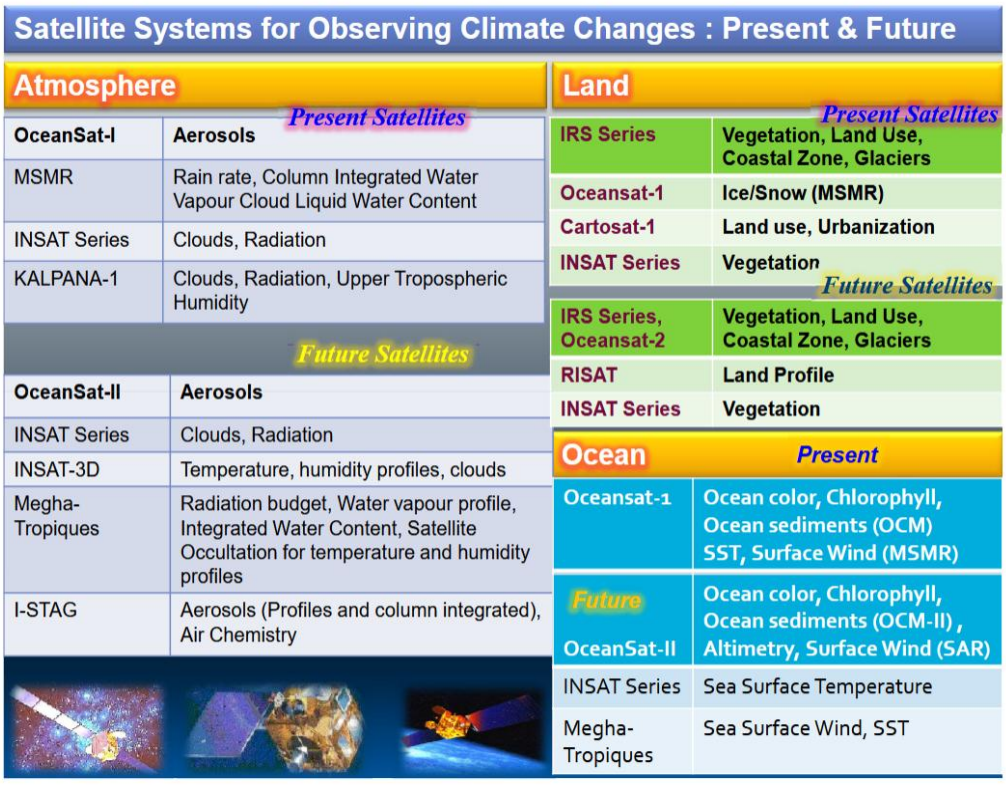

Figure 1: Satellites Observing Essential Climate Variables (ECVs)

Applications of Space Technology in Climate Change:

Space based satellite technologies can address the impact of climate change by providing three important information's – identifying the indicators of climate change, assessing the agents of climate change through sources and distribution patterns and modelling the impact of climate change.

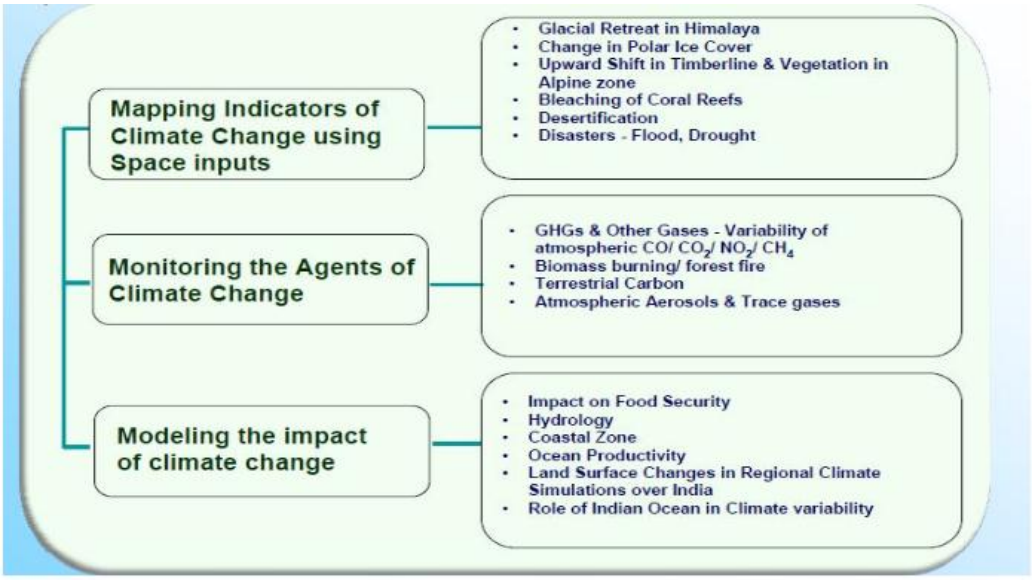

Figure 2: Research Themes and Activities of Climate Change in ISRO

Integrated space technology to address issues of climate change has been applied in the following arenas –

- SPOT imagery used for tracking snow cover changes which causes floods and landslides In Lebanon by the National Centre for Remote Sensing of Lebanon.
- Satellite imagery used to elaborate cloud masks and cloud classifications, to track cyclones and to fill in gaps in observational data used to generate flood maps by the Philippine Atmospheric, Geophysics and Astronomical Services Administration.
- Satellite imagery used by LAPAN, an Indonesian Government's Space Agency to assess climate change related hydrometeorological phenomena and coastal vulnerability in Indonesia.
- Space-based data used by Mauritius to accumulate information on land suitability, to create flood risk maps, to carry out agricultural planning and for early warning purposes.
- Space technologies used for environmental monitoring, land use management and disaster management, to assess coastal erosion and sea level rise and to map risks and vulnerabilities in coastal ecosystems including mangroves, coral reefs and sea grasses by the Ministry of Water, Land, Environment and Climate Change, Jamaica.
- Space technology applications have been applied for mapping up changes in land cover and land use on various spatial and temporal scales and for early warning to assess drought by the Royal Centre for Remote Sensing of Morocco.
- The Department of Meteorology of Sri Lanka uses space applications to study seasonal rainfall patterns and rainfall anomalies, to detect trends in surface temperature and to understand the interaction between the ocean and the atmosphere.

Space Technology in India:

Space technology in India is primarily based on remote sensing (RS) technology and geographic information system (GIS). Remote sensing technology has been very well developed before the advent of geographic information system technology. Remote sensing data however can be digitized and analysed by geographic information system GIS tools to provide precise outputs in different formats. Remote sensing implies acquiring information by detecting and monitoring through a satellite or aircraft the reflected and emitted radiation of the physical attributes of Earth's surface through a distance. An electromagnetic radiation based remote sensing system generally works using has four components - a source, interactions with the earth's surface, interaction with the atmosphere and a sensor. Remote sensing technology through its application plays an important role to access data from dangerous or inaccessible areas. The Indian Remote Sensing Satellite (IIRS) programme was first launched in 1988 of which IRS-IA and IRS-1B are regarded as millstones in the Indian Remote Sensing programme for using space technology. Indian Space Research Organisation (ISRO) along with Department of Space (DoS) have launch various remote sensing satellites as shown in the Table No.1:

Name	Launch Year	Application
EOS-07	2023	Earth Observation
EOS-06	2022	Earth Observation
EOS-04	2022	Earth Observation
EOS-02	2021	Earth Observation
EOS-01	2020	Disaster Management System, Earth Observation
RISAT-2BR1	2019	Disaster Management System, Earth Observation
CARTOSAT-3	2019	Earth Observation
HYSIS	2018	Earth Observation

Table No. I: List of India's Remote Sensing Satellites.

A geographic information system (GIS) works on an integrated computer-based hardware and software system to captures, stores, analyses, manages and presents geographic data. Geographic information system (GIS) is fundamental tool in providing information relating to spatial analysis, mapping and visualisation, data management and communication. "Key index variable" is the means through which geographic information system (GIS) has the ability to relate previously unrelated information with the current data. Geographic information system (GIS) operations involve the systematic processes for managing, analysing, and visualizing spatial data which begin by capturing data from sources like GPS, remote sensing satellites and surveys. The most commonly used GIS Tools to analyse remote sensing data in space technology is shown below in Table No. 2:

Name of the GIS Tools	Description
GRASS GIS	It is a major tool available for geospatial data management and analysis, image processing, graphics and maps production, spatial modelling and visualization.
QGIS	It is one of the most popular users friendly and open-source GIS software which provides extensive tools for vector data handling. It can be easily integrated with GRASS and RGeostats.
gvSIG	It is a free GIS software which aims to represent, edit, analyse and manage information from the point of view of spatial relations.
RGeostats	It offers most of the famous geostatistical techniques and designed to tackle problems with several variables defined in a space of any dimensions. It is particularly adapted for students or researchers who want to test geostatistical procedures using R scripts.
AVHYAS	An in-house developed tool for processing, analysing and visualizing hyperspectral data integrated with the QGIS platform.
ILWIS	It is a popular GIS and image processing platform which provides various tools for raster and vector data analysis with special emphasis on water resource applications.
ArcGIS	It is a popular commercial desktop GIS software which provides vector and raster-based GIS data creation, processing and analysis tools with various extensions especially in windows operating system platform. Vector data handling is major strength of ArcGIS.
ERDAS Imagine	ERDAS is a popular commercial image processing software which provides various spatial data analysis tools for raster data formats.
ENVI	It is a popular image processing software which provides tools for LiDAR, SAR, multispectral or hyperspectral data sets.

Table No. II: Names of Popular GIS Tools.

Space Technology Based Climate Observation in India:

Indian Space Research Organisation (ISRO) in coordination with various institutions has applied space-based technology to map and monitor the indicators of climate change including domains pertaining to glacier retreat (Kulkarni et al. 2005, 2006, 2007), changes in polar ice cover (Vyas et al. 2003, 2004), wetlands (Garg et al. 2005) and coral bleaching (Bahuguna (2008), Bahuguna et al. 2008). Seasonal pattern of CO2 (Singh et al. 2008), CO, CH4 and NO2 have also been analysed. It has resulted in providing vital information regarding parameters of land surface which is crucial for information regarding the accuracy of regional climate models and their projections in India.

Programme on Climate Change Research in Terrestrial Environment (PRACRITI) Programme has been carrying out intensive studies to calibrate and validate these simulation models for Indian conditions (Pracriti, 2008). The Himalayan glaciers are being constantly subject to mapping and monitoring through satellite remote sensing data. Infact, IRS-1A LISS-II data was used for scaling the glacier inventory of Indian Himalaya was at 1:250,000 scale. A total numbers of 1702 glaciers have mapped through space-based technology covering an area 23,300 sq. km. Space based application were utilized to determine glacier inventory on the basins of Satluj, Tista, Dhauli Ganga and Chenab at 1:50,000 scale. Samudra Tapu (Kulkarni et al. 2006) and Parbati glaciers (Kulkarni et al. 2005) in Himachal Pradesh are on the verge of retreating as revealed by satellite images and data. National Meteorological and Hydrological Services (NMHSs) using the El Niño, the weather satellite has been monitoring the daily effects of weather thereby providing inputs regarding weather and climate information.

Benefits of Space Technology:

- Space technology through remote sensing activities helps in monitoring greenhouse effects, changes in ozone layer, rise in sea level, melting of ice in polar caps and glaciers.
- Space technologies are supporting climate research, as over 99% of accurate weather forecasts come from space.
- Satellites facilitate informed decision-making and raise awareness of climate changes and evolution as satellite data, communications and applications offer high resolution, real-time and global- scale monitoring.
- Currently, more than 160 satellites are monitoring the different climate change indicators thereby providing access to information regarding impacts of climate change at regional, territorial and national scales.
- Over half of essential climate variables can only be measured from space and as such space technology can evaluate and interpret data to support decision makers for a balanced implementation of protective measures.
- Impacts and threats of climate change for better understanding can be visualize through space technology and thereby assist to formulate the implementation of mitigation and adaptation actions.

CONCLUSION

The use of space technologies to face the global challenge of climate change and disasters is one that cannot be ignore. It has the potential to generate inputs through remote sensing (RS) technology and geographic information system (GIS) over areas which are inaccessible for ground-based observations. The use of satellites as a means of space technology has advantage to cover wider areas and thereby generating data inputs at difficult terrains. A static satellite can monitor on continuous basis which is very important for assessing the parameters of climate change. Space based technology can play an important role to gauge the threats of climate change thereby supporting the process of decision making regarding its prediction, adaptation and mitigation. The remotely sensed data provides valuable inputs to ground data for assessing and monitoring factors influencing climate change and its adverse effects. The timely reliable data provided through space-based technology can also help to minimize economic losses and damages as a result of impact of climate change. The world community under the aegis of the United Nations and the Committee on the Peaceful Uses of Outer Space have highlighted the use of space-based technology for monitoring the various aspects of climate change and its impacts from time to time. The New Delhi Declaration which came into effect on 16th May, 2016 implemented amongst space agencies from over 60 Nations along with Indian Space Research Organisation (ISRO) and the French Space Agency (CNES) mandated for an independent centralized international system to receive data from satellites pertaining to the Paris Agreement at the UN Climate Change Conference (COP21). It is evident that space-based applications have the provided valuable inputs and has the potential to advert and mitigate the effects of climate change.

At the conclusion the very statement of former Chairman of Indian Space Research Organisation (ISRO), A.S. Kiran Kumar is worthwhile to state "It is overwhelming to see the unilateral support of all space agencies to use space inputs for monitoring climate change. Earth observation satellites provide a vital means of obtaining measurements of the climate system from a global perspective."

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