



Review Paper

Role of ICT in Climate Change Monitoring: A review Study of ICT based Climate Change Monitoring Services

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Abstract

The word 'Climate Change' is not as simple and small in meaning as it seen. It exhibits dangerous and alarming consequences. Climate changes is continuous process from East to West, North to South, Soil to Sky, Water to Air, Forest to Desert, Ocean to Mountains, in fact everywhere. Climate change Monitoring (CCM) is the phenomena to observe and record climate changes and put forward them for decision makers or domain experts to prevent environment, avoid or at least prepare for different kinds of natural disasters, to prevent contamination of various precious natural resources including water, air and soil etc. Rapid advancement of Information and Communication Technology (ICT) is blessing for mankind and incorporation of this revolutionary technology in serving mankind in diverse domain is remarkable. Use of ICT in climate change mitigation, adoption and monitoring not only replacing the conventional techniques and systems also adding great accuracy, reliability and flexibility also provide diverse choices in related domain. ICT Technology is contributing in variety of domain, similarly these fruitful technologies using in Climates changes observation, Climate changes monitoring and climates changes adaptation as well as in Disaster Management. ICT based application can help in reducing climate changes impacts on environment. By using ICT in climate monitoring specially, provide real time observation, reduce cost, decrease power consumption, lively tracking, real time data processing and analysis etc. This review study evaluates how widely ICT and ICT based applications can be used in mitigation, adoption and monitoring of climate changes in developed and developing countries.

Keywords: Climate Change, ICT, Role of ICT in Climate Change Mitigation, Adaptation and Monitoring.

Introduction

Climate Changes around the globe can not be leave out and ignored. It is a big reality and we will be ready to face the serious impacts of significant climate changes because these climate changes are the causes of increasing frequency of natural disaster occurrence. Climate changes includes global warming, changing weather pattern, heavy monsoon, unexpected rain fall, rapid urbanization, pollution and industrialization, losses of crop due to drought, glacier melting resulting rises water level in rivers and this phenomenon is the consequences of flash flood. Climate changes impose impacts on environment as well as human activities¹. Climate change is defined by the IPCC (2007) changing in climate; naturally or by human beings, climate changes impose negative impacts on environment and human life. According to the "United Nations Framework Convention on Climate Change (2007)" major climate changes are, Global Warming (increases in average global temperature) resulting in heat waves, bush fire, extreme temperature, droughts, Melting glaciers is resulting in increasing water level in rivers and floods intensity and frequency. Sea water is continuously absorbing carbon dioxide (CO₂) and heat from the atmosphere which is one of the major causes of rising ocean temperature and ocean acidity. Air pollution as a climate change is dangerous and harmful for inhabitants. Mostly bigger

cities of developing countries like Karachi, Mumbai, Tehran etc. facing environmental and social issues including rapid population growth, huge traffic, burning of fuel and energy which are the major causes of air pollutions, noise pollution. Air pollution can decrease the human life around five years¹.

What is Climate Change Monitoring?: Climate Changes monitoring is the process through which observation and surveillance of atmosphere, ocean, river, glaciers and other components of earth system take place and data regarding temperature changes, humidity, water level in sea, ocean and river measurement, wind speed, average rainfall etc observed and recorded²

Importance of Climate Changing Monitoring: Climate changes monitoring having importance in human life because climate changes effects human life activities and decision making. If we planning for journey we must know what is the weather and how we deal with the bad weather conditions if occurs. If we construct a building we usually want to know the changes in temperature in that region so that we can incorporate some appropriate designing in building structure. Fisher man wants to go for fishing in open sea they must know the weather updates for the upcoming week at least for better preparation of their journey. If there is extreme temperature there may be a

chance of bush fire in forest in this regard we must monitor the temperature changes and take appropriate decision regarding minimize losses due to expected bush fire. If there is heavy rainfall there will be a chance of flash flood so we prepare and take necessary steps to avoid the destruction or at least minimize the losses and save more and more lives. If temperature of sea surface is increasingly gradually there is chance for hurricane and we must ready for the consequences. All the above mentioned examples shows the importance of Climate change Monitoring.

Issues related to Climate Changes: Developed and developing countries both are facing different kind of issues due to severe climate changes. According to the empirical analysis³ study for developing countries heavy rainfall may be consequences of climate change and this unexpected heavy rainfall resulting in flood which damages crops and impose unbearable losses to agricultural sector while Drought is another outcome of climate change it produce water related problems, food prices, disease and health expenditures. Green House Gases (GHG) emission is the serious threat for the developing countries due to rapid expansion of industrialization. Developing countries facing two major challenges in account of climate changes, one is less opportunity for financing projects focused on a low carbon footprint and the second is lacking in adapting technologies that can help in mitigation in climate changes. ICT has the potential to help toward reduce the impacts of climate changes like emission of GHG⁴.

Technology is everywhere: This is a technology revolution era. Technology is contributing in almost all fields of human life. Technologies enhance the capability and functionality of our daily routine life activities and serving mankind in its best. Technology is everywhere; we are using latest technology trends in our daily life activities like shopping, education, healthcare, sports, banking, stock market, public services, transportation and logistics as well as crisis or emergency management. We have same computational power⁵ in our pockets as was to get Neil Armstrong to the moon. Varieties of technologies are available and serving mankind but Computing and telecommunication are two main, most popular and adopting technologies now a days. The technologies covered the computer system, Internet, e-mail, mobile devices, and fax machine. ICT is a revolutionary technology and becoming most popular, fastest growing and vastly adopting technology⁶ in almost all the concerns of human life activities. Rapid development and advancement of Information and Communication Technology (ICT) and Mobile Technology (MT) cannot be underestimated. Accelerating adoption of MT is creating opportunities in providing variety of useful services through mobile devices⁷.

Material and Methods

The role of ICT in adaptation, mitigation and monitoring climate change discussed and emphasis using ICT⁸ by developed and developing countries to reduce the impacts of

climate or at least observe the current changes in environment and take appropriate decision according to situation. Information and Communication Technology can play a pivotal role in monitoring, mitigation and adaptation of Climate changes challenges. These ICT technologies includes Geographical Information System (GIS), Wireless Sensor Networks (WSN), Mobile Technology (MT), Web based applications⁹, Satellite Technology, Remote Sensing (RS)¹⁰. Weather patterns are changing intensively due to change in temperature globally. ICTs are enabling tools if integrated strategically can improve efficiency and effectiveness of efforts doing in climate change mitigation and adaptation; it includes knowledge centers, community radio, mobile phones and interactive media. ICT can help vulnerable community to reduce the risk related to climate changes by education and awareness at lowest level of community, sharing practical and theoretical knowledge, empowering community to access the knowledge and relevant information applicable locally to save lives¹⁰. Developing countries has seriously concerns regarding climate changes and looking for perspective technologies for monitoring, mitigating and adapting climate changes to reduce the vulnerability of the region. Developing countries are facing GHG emission problem due to rapid industrialization and transportation. ICT can be used in designing smart buildings, using ICT smart grids can be implemented in energy generation and power consumption, ICT can control transmission and distribution of energy⁴. Micro-sensor Wireless Network is one of the most popular technologies among the technologies gained popularity and appreciated in 21st century¹¹. Wireless sensor network applications are using in commercial or human centric applications, environmental monitoring, military applications and robotics¹². Wireless sensors are tiny devices and wireless sensor networking is one of the most exciting technologies to emerge in recent years¹³. Wetland ecosystem is looks like a kidney of the earth. A real time monitoring system¹⁴ based on Wireless Sensor Network (WSN) using digital video is presenting in this paper for monitoring wetland ecosystem. Presented Wetland monitoring ecosystem is an application of wireless Sensor Network (WSN) which can be defined as a self-organized system with calculating and communication ability composed of nodes with sensing and perform monitoring task independently according to different conditions. Main function of wetland monitoring system is to collect data with the help of deployed sensors, process these data and video signals to monitoring system, real time monitoring through internet and alarm for the effected and unexpected environment conditions. Xueye reservoir is located in town of Xueye, Laiwu city, Shandong province, method adopted in this region for measuring water quality is manual, based on sampling technique, water samples taken manually and then analyzed in laboratory. This method is not efficient and doing their best. A water quality monitoring system¹⁵ based on GPRS is presented by Wu (2010), this system uses GPRS technology for measurement and transmitting data of different parameter required for monitoring water quality. Water contamination is a root cause of environment degradation. Impure water is harmful for soil, habitat, birds, trees as well as human beings. A water

environment monitoring system¹⁶ is presented; this system is a combination of solar energy technology, the wireless GPRS technology, sensor technology, VPN agent technology and information security technology. Traditional environment monitoring system may be greedy for the power consumption which increase the cost of the whole system, by using solar energy based system can save cost on power generation and power consumption. A remote sensing information system¹⁷ for monitoring ecological environment is presented, this presented Remote Sensing (RS) information system help in capturing more accurate, real time, and wide-ranging data with the help of remote sensors also provide great assistance to relevant departments, helpful in decision making on the basis of current and accurate picture. An urban EM system¹⁸ is presented; a web based EM system with combination of variety of sensors is presented in this paper. This presented system collecting and archiving data from the deployed sensors for urban environment monitoring like temperature, air, pollution, humidity and different types of gases emission monitoring like carbon dioxide, carbon monoxide and oxygen. Ground and water Fresh water are the most important resource for human being, an application¹⁹ combination of remote sensing and GIS is presented for analysis of groundwater behavior and its potential zone.

Result and Discussion

Role of ICT in Climate Change is important and use of ICT and ICT based application getting more and more attention across the world. Developing and developed countries seeking more opportunities in deploying ICT and ICT based application in climate change monitoring, mitigation and adaptation. Some

case studies are included in this study that shows the importance of role of ICT and the opportunities in climate change domain.

Case Study1: This case study²⁰ deals with the implementation of ICT or the use of ICT based services in agricultural sector at Adi tribal community (North East India) located at foothills of eastern Himalaya. Framers of the Adi tribal are very poor, poverty level is very high. Climate of the region is very hard, frequent climate changes directly impacts on agricultural sector. Farmers were facing the climate related problems along with accessing agricultural information and information regarding pest and diseases management. Resources like radio, TV, landline phone, cell phone and internet are not affordable as well as available. To help the poor farmers and to support the agricultural sector in tribal area ICT based project eArik (e-agriculture) was initiated in 2007. The purpose of this project is to sharing the climate smart agricultural practices among the farmers plus food security. A knowledge center equipped with digital devices like Computer, printer, scanner, internet, TV and phone, is established in the community. Agricultural Professionals, computer instructor and farmer facilitator are also contributing in this knowledge center each of above facilitate farmers according to his/her expertise. . A web portal www.earik.in contains information regarding *crop cultivation, agricultural practice, farmer welfare program, day to day market information and weather forecast*. Mobile phone and laptops are using in the fields for recording and updating information. Emails and web cams are used to communicate to each other. E-Arik staff regularly visits the fields and observes crop conditions, pests and disease possibilities then update this information using ICT.



Figure-1
www.earik.in



Figure-2
 Overview of e-Arik, source²⁰

Case Study 2: This case study²¹ emphasizes the importance of the role of ICT in monitoring climate changes. Increasing levels of Green House Gases (GHG) are one of the main sources of climate change on the planet. Most of the GHG emissions are due to electricity generation and industrial production. Deforestation is one of the major causes of increasing GHG emissions along with the above-mentioned causes. In Brazil, deforestation is one of the most important factors of environmental degradation and GHG emissions. For monitoring deforestation in Brazil, two satellite-based monitoring systems (PRODES and DETER) are deployed by the Federal Government of Brazil. In 1988, the Institute for Space Research (INPE) initiated a satellite-based deforestation monitoring system PRODES (Program for Calculating Deforestation in the Amazon) which identifies

deforestation by satellite imaging using US Landsat and the Chinese Brazilian CBERS satellites. A yearly report on deforestation in square kilometers is generated by PRODES along with a detailed online map also published for transparency purposes. DETER (Deforestation Detection in Real Time) is another satellite-based monitoring system that detects deforestation every 15 days and provides monthly estimates. ICT is playing an important role in monitoring and tracking climate changes. By using these ICT-based monitoring systems, climate monitoring is automated, live, and transparent, helping in policy making, law, and legislation enforcement. Not only the government but also different groups inside and outside the government, forest rangers, the enforcement agency of the federal Ministry of Environment, and the users of these systems

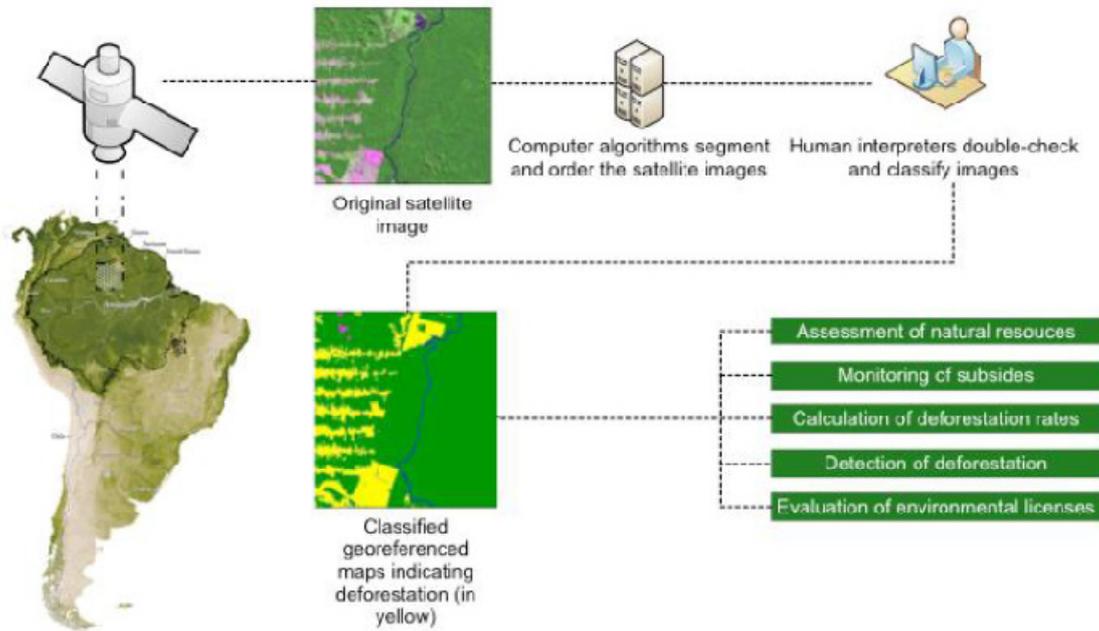


Figure-3
Schematic Representation of the Functioning of PRODES and DETER²¹



Figure-4
Forest Ranger using DETER and a GPS Device in order to Prosecute Illegal Deforestation in the Amazon²¹

Case Study 3: In this case study²² relationship between ICT and Climate change demonstrated. This case study exhibits the potential use of ICT in developing strategies, development of laws and legislation regarding climate change, spreading and sharing valuable information related to climate change impacts among the local community awareness and capacity building against climate change vulnerability. Like other developing countries India is seeking opportunities in integration and adoption latest technologies like ICT in the domain of climate change. In this regard India makes his first move towards Environmental Information System (ENVIS) in 1982 and gradually this system grown up till 2002 in association with World Bank Environmental Management Capacity Building Technical Assistance Project (EMCBTAP). ENVIS is distributed application. It is the central repository for collecting, storing, retrieving and disseminating climate related information to decision makers, researchers, engineers, policy makers and

scientist etc. ENVIS consisting 76 network partners which are working and contributing on: i. Environment Law and Trade, ii. Ecology and Ecosystems, iii. Environment Education and Sustainable Development, iv. Environment and Energy Management, v. Flora, Fauna and Conservation, vi. Media, vii. Chemicals, viii. Wastes and Toxicology.

India's National Informatics Centre (NIC), NIC is connected with different organizations through virtual private network (VPN). Other partners are collecting, storing, and updating, retrieving, sharing and dissemination environmental information via VPN. Geographical Information System (GIS) and Remote Sensing Technologies are used by different partners to monitor different climate changes parameters. Some Centre sites also attempt outreach and engagement through interactive discussion forums, "kids' corners" and the like. Following is the ENVIC outline figure.



Figure-5
ENVIC outline²²

Conclusion

Climate changes are impressive, impacts of climate changes are not negligible, in long terms these impacts can be consequences for various types of destructive events like natural disasters. Technology adoption and integration in Climate Changes Monitoring, Mitigation and adaptation can help to save environment from destruction and degradation. ICT and MT can play a pivotal role in monitoring, mitigation and adaptation of Climate changes challenges. By using these technologies which are very common, easily accessible and inexpensive we can replace the conventional CCM system with more sophisticated and advance systems and get more accurate, fast, live and multidimensional data in lesser cost and efforts as compare to older one. Rapid development and advancement of ICT and MT cannot be underestimated. Penetration and vast adoption of MT in human life is creating opportunities in providing variety of useful services through mobile devices. Developed and developing countries both tolerating against climate changes impacts and to get ride off these challenges by emphasizing use of ICT. Developed countries are enrich in using technology in observing climate changes or disaster management while developing countries still looking for deploying these technologies in CCM and DM. Insufficient budget, short term planning, lack of awareness, uneducated community, inadequate training and many social, economical and political factors are the main obstacle in deploying and adoption of ICT in developing countries. As to conclude developing countries still have vacuum and opportunities in technology integration in climate change monitoring, adaptation and mitigation as well.

References

1. Bana, M., Givechi, S., and Rezaee, A. A. The Observation on the Basis of Critical Management to Reduce the Air Pollution in Tehran, Iran. *Res. J. Recent Sci.*, **2(9)**, 63-68, (2013)
2. Climate monitoring MetOffice UK, Available at <http://www.metoffice.gov.uk/climate-change/guide/science/monitoring> accessed on 28-9-2013., (2013)
3. Drabo A., and Mbaye L.M., Climate change, Natural disasters and migration : An empirical analysis in developing countries (No. 5927), Discussion paperseries//Forschungsinstitut zurZukunft der Arbeit, (2011)
4. Niyibizi A. and Komakech A, Climate Change Mitigation in Developing Countries Using ICT as an Enabling Tool, In *Climate-Smart Technologies* (pp. 19-32), Springer Berlin Heidelberg, (2013)
5. Annika Small. "Could digital technology transform public services?". Available at http://www.theguardian.com/society/2013/jul/16/digital-room-tea-tyze-public-services?CMP=tw_t_gu accessed on 15-8-2013, (2013)
6. Ogbomo M.O. and Ogbomo E.F., Importance of Information and Communication Technologies (ICTs) in Making a Healthy Information Society : A Case Study of Ethiopie East Local Government Area of Delta State, *Nigeria*, (2008)
7. Sheng H., Nah F.F.H. and Siau K., Strategic implications of mobile technology : A case study using value-focused thinking, *The Journal of Strategic Information Systems*, **14(3)**, 269-290 (2005)
8. Zanamwe N. and Okunoye A., Role of information and communication technologies (ICTs) in mitigating, adapting to and monitoring climate change in developing countries. *Int. Conf. on ICT for Africa*, February 20 -23, Harare, Zimbabwe, (2013)
9. Karanasios S.T.A.N., New and emergent ICTs and climate change in developing countries. Center for Development Informatics, Institute for Development Policy and Management, *SED. University of Manchester*, (2011)
10. Ptrick P. Kalas, Planting the Knowledge Seed Adapting to climate change using ICTs Concepts, current knowledge and innovative examples, *Building Communication Opportunities (BCO) Alliance*, (2009)
11. Chong C.Y. and Kumar S.P., Sensor networks : Evolution, opportunities, and challenges. *Proceedings of the IEEE*, **91(8)**, 1247-1256 (2003)
12. Arampatzis T., Lygeros J. and Manesis S.A, survey of applications of wireless sensors and wireless sensor networks. In *Intelligent Control, 2005. Proceedings of the 2005 IEEE International Symposium on, Mediterrean Conference on Control and Automation*, 719-724 *IEEE* (2005)
13. Matijevics I. and Simon J., Control of the greenhouse's microclimatic condition using wireless sensor network, *IPSI J TIR*, **6(2)**, 35-38 (2010)
14. Peng J., The Design of Wetland Water Environmental Monitoring System Using Digital Video Based on Wireless Sensor Networks. In *Communications and Mobile Computing, CMC'09, WRI Int. Conf. on*, **2**, 391-395, *IEEE*, (2009)
15. Wu Q., Liang Y., Sun Y., Zhang C. and Liu P, Application of gprs technology in water quality monitoring system, In *World Automation Congress (WAC)*, 7-11, *IEEE* (2010)
16. Jianhua S., Xu Y., and Yu W, Solar Wireless Intelligent Online Hydrological Monitoring System, In *Info. Tech. and App. (IFITA), International Forum on*, **2**, 280-282, *IEEE* (2010)
17. Xue X., Wang A., Wang H. and Xiang F., The Use of Remote Sensing Technology in Environmental Protection. In *Wireless Communications Networking and*

- Mobile Computing (WiCOM), 6th Int. Conf. on 1-4 IEEE, (2010)
18. Song X., Wang C., Kagawa M. and Raghavan V., Real-time monitoring portal for urban environment using sensor web technology, In Geoinformatics, 18th Int. Conf. on, 1-5 IEEE (2010)
19. Arkoprovo B., Adarsa J. and Animesh M., Application of Remote Sensing, GIS and MIF technique for Elucidation of Groundwater Potential Zones from a part of Orissa coastal tract, Eastern India., Res. J. Recent Sci., 2(11), 42-49(2013)
20. Saravanan R. and Change C., e-Arik : Using ICTs to Facilitate 'Climate-Smart Agriculture' among Tribal Farmers of North-East India, Climate Change, Innovation and ICTs Project Case Studies, Centre for Development Informatics, University of Manchester, UK <http://www.niccd.org>, (2011)
21. Rajão R., ICT Based Monitoring of Climate Change Related Deforestation: The Case of INPE in the Brazilian Amazon, Climate Change, Innovation and ICTs Project Case Studies, Centre for Development Informatics, University of Manchester, UK <http://www.niccd.org>, (2012)
22. Madari U., Supporting Strategic Decision Making on Climate Change Through Environmental Information Systems : The Case of ENVIS, Innovation and ICTs Project Centre for Development Informatics (CDI), University of Manchester, UK With the support of the International Development Research Centre (IDRC), (2012)