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Role of information and communication technology (ICT) in disaster management: A study in India

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Abstract
This study evaluates how ICT can help human beings be better prepared for disasters, resulting in fewer losses. Depending on their physical, social, political, and economic environments, many countries around the world endure various and varying repercussions of disasters. These disasters have detrimental repercussions, such as the loss of human and animal life, destruction of property, and disruption of livelihood systems; therefore, it is important to develop strategies to reduce these effects through prompt reaction and effective disaster management. Different technology, both new and ancient can help to mitigate the impacts of disasters. ICT may play an important role in disaster response by serving as a communication and informational channel. Disaster management systems based on GIS web services are specifically created to handle disasters like tsunamis, floods, earthquakes, and cyclones, among others. The method is necessary since the failure to provide prompt assistance to the affected victims and the slow reaction of relief efforts have put the lives of many individuals in danger. Disaster management systems integrate with GIS online services to determine the affected areas and potential routes to the place. The system makes information about providing the deceased victim with medical care and relief supplies available to the general public. Despite strong disaster management procedures in disaster-prone nations like India, recent disasters have highlighted the inescapable loss of life and property. This study discusses how ICT, such as the Internet, GIS, remote sensing, and satellite communication, play a crucial role in disaster risk reduction planning and implementation. This research highlights the potential of GIS and remote sensing as disaster management tools. ICT can help in various stages of the disaster management cycle, including early warning, readiness, and reaction. The study also covered the numerous ICT tools for disaster management in India. It is difficult to determine which media will be most effective in a given location based on the type and size of the disaster. Although disaster management appears to be easier in theory than in practice, there is a significant gap that must be addressed by focusing on developing human capacities to use these tools and technologies.

Keywords: Disaster Management, Information and Communication Technology, Geographical Information System, Disaster Risk Reduction, India

Introduction
Disasters are typically geo-climatic occurrences that affect people and often come on suddenly with little or no warning. Disasters occur all over the world, wreaking havoc on the infrastructure and economies of both industrialised and developing countries. Nearly 80% of all disaster-affected persons worldwide are a result of natural disasters. The scenario is identical in places such as South Asia. Natural disasters routinely cause human suffering in this region's countries. Natural disasters cannot be avoided, but their harmful impacts can be mitigated by using certain techniques. Planning and preparation are the most critical steps in mitigating the effects of a disaster. With the advancement of information and communication technologies, it is now possible to predict the location and breadth of a prospective disaster. ICT currently plays an important role in disaster management, providing tools and software to meet the diverse health needs of the affected population.

The term "information and communication technology" (ICT) refers to all technological systems that produce, store, exchange and use information in all of its forms, such as business data, voice conversations, still images, motion pictures, multimedia presentations, and other forms, including those yet to be imagined. It is a convenient name for merging computer and telephone technology.

Information and communication technology uses a wide range of modern electronic devices such as satellites, radars, computers, sensors, cameras, and so on to collect, process, and transmit data. It is a dependable, cost-effective, and time-saving technique of information management. Information technology is made up of several components that work either independently or collaboratively to manage the information that is accessible.

Review of literature

A review of the available literature on the role of information and communication technology (ICT) in disaster management in India yields some noteworthy results and insights. ICT has emerged as a vital instrument for solving the complex difficulties faced by natural and man-made disasters in India. The following are some of the important points mentioned in the literature:

"Disaster Risk Governance in India and Cross-Cutting Issues" Literature point out the role of government bodies such as the National Disaster Management Authority (NDMA) and state disaster management agencies in promoting the use of ICT. Various policies, guidelines, and initiatives have been launched to enhance ICT's role in disaster management.

"Technologies for Disaster Management: Proceedings of International Conference on ICTDM 2015" India's space capabilities, such as the Indian Remote Sensing (IRS) and Indian National Satellite System (INSAT), are lauded for their contribution to disaster management. These technologies provide valuable data for disaster monitoring and response.

"Information and Communication Technologies for Humanitarian Services" The literature also highlights the challenges of ICT in disaster management in India. These concerns include issues with infrastructure, connectivity, access, and the digital divide. Cybersecurity concerns and data privacy risks are also raised. Several studies have highlighted the importance of ICT in communicating disaster preparedness and response information to the general public. This includes the development of educational websites, mobile apps, and SMS-based notification systems.

"Disaster Risk Reduction in South Asia" ICT aids in the efficient management of resources, ensuring that relief materials and personnel are deployed to the right places at the right time. The literature explores the use of databases and logistics software for this purpose.

"Environmental Management and Disaster Risk Reduction: Role of ICT" ICT is recognized as a key tool for capacity building and training of disaster management professionals in India. E-learning platforms, webinars, and simulation exercises are discussed as effective methods for training.

"Disaster Management and ICT: Global Case Studies" Numerous case studies in the literature highlight specific disaster events in India and the role of ICT in managing them. Examples include the 2004 Indian Ocean tsunami, the 2013 Uttarakhand floods, and the 2018 Kerala floods. These case studies provide insights into how ICT was deployed in response and recovery efforts.

"Information Technology in Disaster Risk Reduction" Studies emphasize the importance of ICT-enabled early warning systems in India. These systems, often based on satellite and meteorological data, help in forecasting and disseminating timely alerts to vulnerable populations, enabling them to take necessary precautions.

"Disaster Management and Information Technology: A Holistic Approach" ICT has revolutionized data collection and analysis for disaster management. Geographic Information Systems (GIS) and remote sensing technologies play a crucial role in mapping risk-prone areas, monitoring hazards, and assessing vulnerability.

"Disaster Management: Future Challenges and Opportunities" Efficient communication and coordination are critical during disaster response. ICT tools enable various stakeholders, including government agencies, NGOs, and volunteers, to collaborate effectively and share real-time information. The use of social media and mobile apps for disaster communication is also explored in the literature.

Overall, the literature indicates India's substantial progress in using ICT for disaster management. It also emphasizes the importance of ongoing research, innovation, and investment in addressing the obstacles and realizing the full potential of ICT in lessening disaster effect and enhancing disaster resilience across the country.

Research objectives

- To assess the current state of ICT infrastructure for disaster management in India.
- To analyse the utilization of various tools of ICT.
- To evaluate the role of channels used for disaster alerts.
- To investigate policy and governance frameworks.

Disaster management

Disaster management is concerned with the planning, notifying, aiding, and reconstruction of society following natural or man-made disasters. Prevent or mitigate the effects of disasters caused by hazards; it is an ongoing process in which all individuals, groups, and communities manage risks. Comprehensive emergency plan integration at all levels of government and non-government involvement is required for efficient disaster management. Each level's (individual, group, and community) activities affect the others. The different stages of the disaster management cycle are not defined by any standardised rules. Depending on their objectives, several agencies use different cycles. Although approaches vary, it is widely agreed that disaster management operations should be carried out in cycles. The stages of the disaster management cycle are explained below:

- **Prevention:** Avoiding a disaster even at the eleventh hour.
- **Preparedness:** Plans or measures taken to aid in the response and rescue service activities while also saving lives or property.
- **Response:** Covers steps performed during catastrophes or disasters to conserve the environment, save lives, and avoid property destruction. The execution of action plans is the response phase.
- **Mitigation:** Any activity that reduces either the chance of a hazard taking place or a hazard turning into a disaster.
- **Risk reduction:** Anticipatory measures and actions that seek to avoid future risks as a result of a Disaster.
- **Recovery:** Includes actions that assist a community to return to a sense of normalcy after a disaster.

Typically, these six phases overlap. ICT is employed throughout all phases, but in certain phases, the use is more obvious than in others.

Fig 1: Disaster management cycle

Tools of ICT

These are the four tools of ICT, namely

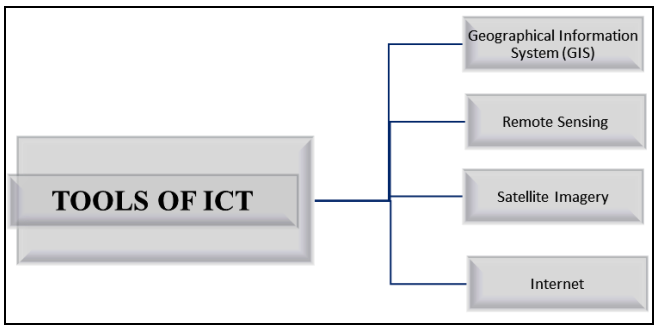

Fig 2: These are the four tools of ICT

1. Geographical Information System (GIS)

The Department of Environment defines GIS as a system that collects, stores, verifies, integrates, modifies, analyzes, and displays geographically related data. GIS consists of three main components: a computer system, software, and spatial data, as well as techniques for data administration and analysis. Spatial data, also known as geographical data, includes both positional information and details of non-spatial properties, along with connections to other features. For instance, spatial data for a specific area might include:

- Latitude and longitude as geographical references.
- Connection details such as service roads and rail heads.
- Non-spatial data like the amount of snow or rainfall, wind speed, and direction.

GIS uses geographical position or location as a central concept to combine and evaluate data from various sources. It can assess the risks to people and property from natural disasters like earthquakes, cyclones, tsunamis, and floods.

2. Remote Sensing (RS)

Remote sensing is a technology that uses electromagnetic radiation sampling to gather and analyze non-immediate geospatial data. This data provides information about features, objects, and classes on Earth's surface, oceans, and atmosphere by observing and measuring radiation, particles, and fields related to distant objects. Aerial remote sensing involves capturing images and data from the air, using sensors mounted on satellites, low-flying objects, or ground-based radars. The data can be recorded as photographic or digital (numeric) formats. For computer processing, data must be in digital form, so visually captured information like aerial photography is converted to digital form before use. Airborne scanner imagery and most satellite image data are initially stored digitally. Remote sensors detect energy emitted from or reflected by objects, with radar being an example of active remote sensing.

Applications of remote sensing data include:

- Land-cover mapping
- Environmental assessment
- Traffic management (navigation information)
- Air pollution modeling
- Disaster management (pre, during, post).

3. Satellite Imagery

Satellites, defined as bodies or masses revolving around larger bodies, are particularly useful in weather observation. Weather satellites, which orbit high above the atmosphere in elliptical paths, are ideally positioned to observe weather patterns from a clear vantage point, far from clouds and storms. This high altitude allows satellites to capture large areas of the atmosphere and, depending on the orbit, possibly view the entire earth within hours. Weather satellites are equipped with various instruments for creating multiple images and measurements, and they can provide timed photos and repeated coverage of specific areas. Satellite imaging is now crucial for meteorological research and has significantly improved weather forecasting accuracy, aiding in disaster preparedness for vulnerable populations.

4. Internet

The Internet is a network that connects thousands of local area networks, forming a global platform for resource sharing among millions of computers. It allows access to worldwide data banks, retrieving information quickly and automatically. The Internet can store large amounts of data digitally, enabling rapid and spontaneous disaster information dissemination globally. This capability can be used to develop an effective disaster mitigation system. Historical disaster data can be meticulously archived for future reference. A dedicated website with disaster information can notify the public about impending calamities. The Internet can also facilitate requests for external assistance from targeted organizations for affected areas, making it the most efficient and economical method. Additionally, various individuals and groups, including national meteorological services, experiment with providing real-time weather observations and forecasts via the Internet for experts and the public. The Internet supports two highly effective health response systems in both regular and emergency situations: telemedicine and medical transcription.

Indian scenarios

The India Disaster Resource Network (IDRN; www.idrn.gov.in) is a national computerised database of crucial and specialised resources for disaster response, including critical supplies, specialised equipment, and specialised labour. The Ministry of Home Affairs (MHA) and United Nations Development Programme (UNDP) have launched IDRN to systematically develop the disaster resource inventory as an organised information system for collection and transmission of information about specific equipment, human expertise, and critical supplies database from District level to State level to provide availability of resources for disaster response, so that disaster managers can mobilise the required resources.

The equipment and resources are included in the IDRN according to their type and the functions they carry out, along with the contact information (phone number and address) for the controlling officers in charge of those resources, allowing for quick mobilisation of the equipment. The IDRN is a real-time system that enables inventory updates every three months. Two levels—District and State level—are where entries into the inventory are made.

Policy and governance frameworks

The Ministry of Home Affairs, in collaboration with the United Nations Development Programme, has launched various ICT-based initiatives, and numerous tools and software have been developed to assist disaster managers in doing their duties more effectively. The Ministry of Home Affairs, as the Nodal Ministry for Disaster Management, is leading India's disaster management and mitigation efforts to reduce risk and vulnerability. The Ministry has designed a National Disaster Management Framework for the nation. This national framework focuses on institutional mechanisms at all administrative levels, disaster mitigation and prevention that should be integrated into the development process, envisioned legal and policy frameworks, early warning systems, preparedness and emergency response measures, and human resource development. The Ministry has started a number of national projects to improve the country's disaster management systems. Which is described below:

1. Online database of resources for emergencies

The ability to quickly mobilise specialised equipment and qualified human resources during a disaster depends heavily on a broad database of disaster management-related inventories and an organised information dissemination system on the availability of specialised resources. The India Disaster Resource Network (IDRN), located at www.idrn.gov.in, is a national electronic database that compiles basic and specialised materials for disaster response. Information on specialised tools, specialised labour resources, and essential supplies are covered. Authorised government representatives, This online information system is accessible to individuals at the district level, corporate entities and public sector units. The District Nodal Authority will be in charge of gathering, collating, and updating their inventory data to the central server with the assistance of pertinent District agencies.

2. Decision support systems based on GIS

The most flexible platform for decision support, GIS provides multilayer geo-referenced information such as hazard zoning, incident mapping, natural resources and essential infrastructure at risk, resources available for response, real-time satellite imagery, etc. Disaster managers may swiftly assess the impacts of a disaster or emergency on a geographic platform and plan the most effective resource mobilisation with the aid of GIS-based information tools. The Ministry of Home Affairs has begun creating a National Database for Emergency Management (NDEM) based on GIS and developing GIS-based technologies for emergency management on a trial basis.

3. National Emergency Communication Plan

The ability of decision-makers at different levels to communicate with operational response teams and site people is crucial for disaster response and management. The Ministry of Home Affairs intends to carry out its communication strategy in two stages. The VSAT network will only employ POLNET resources during the first phase, and it will provide the necessary communication channels between the National Emergency Operations Centre (NEOC), remote disaster locations, and the corresponding State Emergency Operations Centre (SEOC). The integration of the EOC and the deployment of portable terminals at disaster and emergency locations using satellite and terrestrial communication networks are both planned for the second phase.

4. National Disaster Management Authority Guidelines for ICT in Disaster Management

In 2012, the National Disaster Management Authority (NDMA) issued guidelines for a National Disaster Management Information and Communication System (NDMICS). This digital infrastructure includes a National Disaster Communication Network, GIS-based vulnerability analysis and risk assessment applications. It aims to provide a reliable IT solution for disaster management, enhancing communication and decision-making during emergencies.

Channels used for disaster alerts

There are different types of media both new as well as traditional way which can be utilized efficiently for disaster warning purposes. A few strategies may be more effective than others depending on the type, nature, and geography of the disaster being affected. All serve the same purpose: to distribute disaster alerts fast and correctly. Any one or a combination of several methods can be utilized for this aim.

1. Radio and television

This is the most common method of using electronic media for disaster warning since it is reasonably inexpensive, provides a dependable one-to-many communication medium, and, most crucially, does not require literacy. Radio, in particular, is the most accessible medium for the poor, particularly women at home, fishermen at sea, and agricultural workers. The sole potential disadvantage of these two media is that their impact is greatly diminished at night, when they are typically turned off.

2. Telephone (Mobile)

Telephones may be an extremely useful tool for alerting people to potential disasters. Making an immediate call can prevent losses and save lives by acting before the crisis occurs. The telephone can be helpful for informing friends, family, and neighbours about a tragedy that is likely to

happen soon. However, there are limitations to using telephones for catastrophe warnings. In many sections of developed and developing countries, there is still a lack of phone coverage, especially in the most vulnerable rural and coastal communities.

3. Short message service

Most digital mobile phones have access to short messaging service (SMS), which allows users to send quick text messages to other mobile phones, portable devices, and even landlines. When the network was operational, they were able to communicate more easily using SMS. Because SMS runs on a distinct spectrum, it can be transmitted or received even when phone lines are congested. SMS allows you to send a single message to a group or multiple places at once, providing it an advantage over phone calls.

4. Cell broadcasting

One-to-many text messaging service with a specific geographic focus is called cell broadcasting. The majority of current network infrastructure already has it incorporated, so installing connections, buying new software, or getting new phones won't add to the cost. Due to its geo-scalability, one message can quickly reach millions of people. Text messages can be delivered to all mobile devices to alert the public during an impending calamity. Due to its geo-specificity, the broadcast can be focused only on certain high-risk areas, preventing generalised panic. Users of the Maximum Phone cannot read and comprehend an English-language message. Therefore, it is essential to broadcast warning messages in regional languages.

5. Social Media

Social media has become essential in disaster management, especially during the response phase, as it enables community communication about crises. Traditional media sources like TV, radio, and newspapers are no longer the primary means of information dissemination due to technological advancements. Information now flows not just from authorities to the public but also among individuals horizontally and vertically. Citizens use smartphones and tablets to upload photos and news about incidents, marking the rise of 'citizen journalism,' which has revolutionized disaster communication. Social media plays an important role in raising disaster awareness, detecting early warnings, responding to and recovering from disasters, fundraising for relief, and coordinating with other humanitarian organizations. During the 2008 Mumbai terrorist attack, victims used YouTube, Twitter, and Flickr to share information, making them primary information sources ahead of mainstream media. Platforms like Twitter, with its 'hashtags,' group information effectively during disasters, creating searchable repositories for specific events, as seen during the 2015 Nepal earthquake with the #NepalEarthquake hashtag. Despite the benefits, challenges like misinformation require disaster managers to monitor and filter social media content carefully to ensure accurate and reliable information.

6. Big Data Analysis

Technological improvements have permitted the collecting of data from a variety of sources, including seismographs, satellite photos, and social media, for use in disaster management. This data, while frequently unstructured and variable, can be examined utilizing big data technology to yield significant information for successful emergency management. Big data analysis reveals insights into what individuals are thinking, saying, and doing during an emergency, allowing disaster managers to make swift, informed decisions. Big data analysis is useful in a variety of disaster management scenarios. Floods can be predicted and their impacts assessed by combining and evaluating data from many sources. During a disaster, big data can identify critical areas, analyze real-time situations, and optimize responses based on past experiences. It aids in identifying where help is needed, planning evacuation routes, and allocating resources efficiently using GPS data. However, challenges such as the lack of trained personnel, language barriers, inaccurate data, and irrelevant social media content need to be addressed.

7. Artificial Intelligence (AI)

Artificial intelligence (AI) involves using computer science to simulate intelligent behavior in machines. AI analyzes vast amounts of data using sophisticated algorithms to provide valuable insights in disaster management. It helps in mapping vulnerabilities, assessing risks, planning resource allocation, and conducting rescue operations. For instance, during an earthquake, AI can provide detailed damage assessments based on building designs, ages, soil structures, and other risk factors, aiding in escape route planning and relief supply distribution. AI plays a crucial role in disaster response by continuously analyzing data from field reports, media and social media posts, allowing disaster managers to update and improve resource deployments. Tools like MicroMappers, combining crowd sourcing and AI, analyze social media content to generate maps and provide real-time information for relief agencies.

Disaster risk reduction methods may now be planned and implemented considerably more readily thanks to advances in information and communication technologies such as the Internet, GIS, remote sensing, and satellite-based communication links. These technical improvements have been critical to the creation of early warning systems, hastening the process of readiness, response, and mitigation. ICT tools are commonly used to establish knowledge warehouses using the internet and data warehousing methodologies.

Suggestions

- Investing in robust ICT infrastructure across the country.
- Promoting digital literacy and training programs for communities and disaster management professionals.
- Enhancing data integration and sharing protocols among agencies.
- Formulating clear policies and frameworks for the use of ICT in disaster management.

Conclusion

The Internet, GIS, remote sensing and satellite communication are essential for disaster risk reduction projects. However, to fully utilize these technologies, early warning, readiness and response systems must focus on developing human capabilities. Information and Communication Technologies (ICT) address disaster preparedness, emergency relief, and recovery by making timely information more accessible and widely

disseminated. ICT is operationally useful at both macro and micro levels, increasing community understanding of disaster preparedness and mitigation. At national and international levels, it facilitates health network connectivity. It has significantly contributed to disaster medicine by enabling telemedicine and teleconsultation in remote locations, establishing technological connectivity between hospitals and disaster areas and ensuring high-quality medical care in real time during disasters.

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