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CENTRE FOR DISASTER MANAGEMENT
Lal Bahadur Shastri National Academy of Administration, Mussoorie

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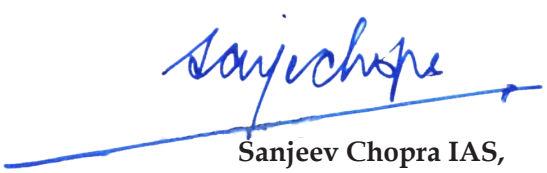
DIRECTOR'S MESSAGE

Due to its unique geographical and geological conditions, India is vulnerable to various natural disasters. In India, the incidents of flood, drought and other natural disasters are on the rise and pose a tremendous challenge to the society in general and administration in particular. Each disaster heightens the sense of urgency to equip ourselves better in coping and managing them. In this context, the training of civil servant in Disaster Management assumes critical significance.

There is a need to move from the paradigm of responding to disasters to one of building in resilience against disasters in all aspects of decision making. A key challenge to administrators would be raise the level of awareness in the society regarding the cost of allowing disasters to affect it and to build resilience in infrastructure and in the community.

It gives me immense pleasure to note that Centre for Disaster Management, LBSNAA is bringing out the edited journal "Disaster-Response and Management" Volume 7, Issue 1 for the year 2019-20 under the project "Capacity Building on Disaster Management for IAS/Central Civil Services Officers" sponsored by National Disaster Management Authority (NDMA). This is the compilation of research articles providing insights in the recent trends in disaster management. I hope this volume will add to the knowledge base for disaster management in the country and will be useful for both the trainees and the administrators in the field.



Sanjeev Chopra IAS,
Director,
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PREFACE

The Centre for Disaster Management (CDM), Lal Bahadur Shastri National Academy of Administration (LBSNAA), Mussoorie is a training and research centre under the aegis of LBSNAA, Mussoorie. The centre is involved in training IAS and other Group-A civil service officers at induction as well as at in-service level in various aspects of disaster management, besides undertaking, action research projects, documentation of best practices, development of case studies, etc.

The magnitude and frequency of disasters has increased drastically in terms of human, economic and environmental losses. Under the conventions on SDGs, Paris agreement, Sendai framework for Disaster Risk Reduction, there is a need to document the research carried by individuals in the field of Disaster management to achieve the committed goals of India as a signatory. Disaster Response and Management in recent times received increased attention, both within the country and abroad.

It is our pleasure to publish Volume 7, Issue 1 of the journal "Disaster-Response and Management" for the year 2019-2020. This publication will provide an insight to administrators about the recent trends in response, planning and scientific interventions towards Disaster Risk Reduction. I would like to place on record the contribution of the faculty and staff of CDM in various towards this publication.

C. Sridhar, IAS
Deputy Director (Sr.) & Director
CDM, LBSNAA

CONTENTS

Indian Defence Forces – From Humanitarian Assistance Disaster Relief (HADR) to Humanitarian Assistance Disaster Response & Relief (HADRR) Approach

Lt Col Rahul Devran[1] and Kunal Sharma[2]

Abstract

The role of the Army in disaster management is very essential. It continues to be amongst the early responders in a disaster situation even before the civilian resources have been deployed. The unique geo-climatic conditions of India make it highly vulnerable to natural hazards. Disaster management is an area of primary concern for governments around the world today. Part of the reason for such a state of affairs is the increasingly aware and informed public perception of disasters and calamities. Armed forces, which are ultimately responsible to the head of the state in a democratic form of government, are expected to carry out all directives that are assigned to them. Professional soldiers are trained to ignore their personal situation and state of mind and carry out their duties regardless of the distress caused or the difficulties faced. It is this dedication and their training that can prove to be a valuable asset for disaster planners. The major role of armed forces in disaster management till date has been to conduct the rescue operation and evacuate the people. There is a need for better cooperation between the armed forces and other government and civil organizations of that area. Although, the armed forces are supposed to be called upon to intervene and take on specific tasks only when the situation is beyond the capability of civil administration, in practice, they are the "core of the government response capacity" and tend to be the first responders of the Government of India in a major disaster. Both the government and the public repose tremendous faith in the armed forces and believe that all emergencies and crises can be handled by the armed forces effectively.

Keywords: *Disaster, Relief, Response, Armed Forces, Disaster Risk Reduction*

Introduction

The Indian armed forces have rendered disaster assistance internationally to a number of countries in the past, adding yet another dimension to the international disaster response. A number of neighbouring countries look up to India on many a front, especially when struck by a major calamity.

With growing regional and global cooperation in disaster reduction and response, the Indian armed forces can play a vital role befitting India's emerging status of a regional power.India participated in numerous military disaster management exercises within the framework of multilateral as well as bilateral cooperation. For example, an annual disaster management training exercise called the South Asian Annual Disaster Management Exercise (SAADMEx).

The purpose of the exercise is to provide participants with an opportunity to review and discuss disaster response plans and capabilities of an affected country by both national authorities and external organizations. The exercise focused on national on-site emergency command and control, coordination, critical decisions, notifications, and the coordination and integration of regional and international humanitarian supports. In 2017 it hosted a similar exercise for BIMSTEC countries, and in 2019 India is hosting one for the Central Asian regional organization.The exercise involved SAR in boat and collapsed building structure scenarios. Lately, India has also participated in SCO exercises. India has engaged government of Nepal for support on Disaster Management through NIBCGS.

Disaster Relief refers to the provision of essential, appropriate and timely humanitarian assistance to those affected by a disaster, based on an initial rapid assessment of needs and designed to contribute effectively and speedily to their early recovery. Disaster Response is the second phase of the disaster management cycle. It consists of a number of elements, for example; warning/evacuation, search and rescue, providing immediate assistance, assessing damage, continuing assistance and the immediate restoration of infrastructure.

Disaster and Armed Forces

Coppola 2011; Harper 2006 elaborates and reiterates five key elements of disaster management consist of:

1. Prevention—relates to activities that will either prevent an incident occurring or minimize the impact of a potential incident;
2. Mitigation—in a similar manner to prevention, seeks to reduce the likelihood and impact of a hazard or an event on a community;
3. Preparedness—relates to activities to ensure that communities are better placed to respond to and cope with the impact of an incident;
4. Response—relates to activities that allow a community to control, respond to and reduce the impact of an incident; and

5. Recovery—relates to returning the community to a state of preparedness and to recover from the impact of an incident and move toward rehabilitation.

The unambiguous and primary role of the Defence Forces is related to the defense of the country against external and internal threats. The secondary role of the Defence Forces is to support the civil authorities in the situations of natural calamities anddisasters. In addition to above, few other reasons for which the Defence Forces can be calledout to aid the civil authorities to meet various contingencies are as follows:

- To maintain law and order.
- To maintain essential services.
- To assist during natural calamities.
- To assist in execution of developmental projects.
- Any other type of assistance which may be sought by civil authorities.

Although there is no need to prioritize the various secondary roles of the armed forces, aid to civil authority in the case of disaster management needs no clarification or emphasis. However, an important issue is the interpretation of the term 'disaster' in the issue of aid to civil authorities. Disaster by definition is an event of natural or man-made causes that leads to sudden disruption of normalcy within society, causing damage to life and property to such an extent, that normal social and economic mechanisms available are inadequate to restore normalcy. Therefore, technically, the armed forces need to be requisitioned by the civil administration only if the situation is clearly beyond the control and capacity of the local administration. It does not necessarily mean that the armed forces will only be pressed into service after exhausting the resources and efforts of the civil administration in case of a disaster. Ideally, a quick and comprehensive assessment of the required response to a disaster or impending disaster is needed. This will facilitate deployment of the necessary resources, including the armed forces elements, without loss of time, to limit the damage and losses to a minimum.

Developing countries like India and other neighbouring countries in South Asia are highly vulnerable to climate change and with the ongoing rapid developmental activities; we may witness worse disasters in the times to come. Hence, it will not be inappropriate to assume that in spite of the raising of the National Disaster Response Force (NDRF) and State Disaster Response Forces (SDRF) which is very small considering the magnitude and nature of the disasters, the armed forces will continue to get embroiled. Eight NDRF units are presently deployed in nine locations across the country and another four are in

the offing. Hence, in a number of cases, the armed forces may have to respond to a disaster even before the NDRF units, on account of their being located closer to the site of disaster than the NDRF units. Crisis management and managing disasters in remote and inaccessible areas where the armed forces are either deployed in the vicinity or due to their intrinsic capacity to reach such areas in an early time-frame would necessitate an active role of the armed forces. The next important aspect is the public faith in troops and resultant pressure on the administration to call the armed forces to provide succour to affected disaster victims. The reason why the armed forces are called upon to aid civil administration in the very first instance is the public outcry, growing political sensitivities and ever increasing media glare. No government or political establishment is willing to take a chance; hence, deployment of the armed forces in such scenarios becomes a play-safe option. Therefore, there is a need for a mechanism to carry out an audit, post-disaster, to examine whether deployment of the armed forces in aid to civil authority was done as a last resort or otherwise. This will help put a check on unwarranted deployment of troops when other governmental entities could undertake relief operations. Another major reason necessitating deployment of the armed forces in disaster response could be in case of mass casualty events. The threat of nuclear, biological and chemical warfare is more pronounced today than ever before.

What are the main roles of Armed Forces

The main role of armed forces is to coordinate the employment of forces and conduct humanitarian assistance and disaster relief operations. Relief operations which are being carried out by Armed Forces till date comprise of:-

Humanitarian Assistance and Disaster Relief –

- Search and Rescue operation is the main work for every organization at the time of any disaster. In rescue operation the armed forces plays an important role as they are well trained and well equipped as compare to the other civil organizations.
- Evacuation of people as in disaster management one of the most important parts is to safely evacuate the people to a safer place. Clearance of debris using heavy earth moving equipment.
- Immediate restoration of essential services like electricity, water and telephone lines, lifeline and critical infrastructure etc.
- Distribution of food, water, WASH items, set up emergency hospitals, blood banks, mortuary etc.

In India the armed forces have played important role in disaster management as a force of the nation. If any disaster may be natural or manmade breaks out, the Government calls armed forces to help and rescue the people. But, when they are helping the people they also face many challenges, some of the main challenges are follows:

- Preparedness for disaster response as most of the disaster comes without any intimation especially manmade disasters.
- Conducting relief operations a huge challenge in case of disaster with grave magnitudes. This can be done in hostile or friendly environment.
- Increasingly uneven frequency of disasters in the recent years in both types; natural as well as manmade.
- Always first to respond in any disaster which is the main challenge for the armed forces as they have to face adverse situation
- Resource constraint is also huge challenge for armed forces and in situation of disaster they have to use their limited resources which are not tailor made for Disaster Response.

HADRR Operations

Armed forces are best suited for HADRR operations since they are :-

- A large disciplined, trained and professional force with strong motivation and commitment.
- Have exhaustive inventory of heavy earth moving equipment.
- Specialize in SAR, IRS, Relief operations, management of relief camps, short term recovery, can assist in rapid damage and needs assessment/PDNA by providing local guides, assist in establishing emergency communication networks, assist in restoring basic essential services, table top and mock exercises, assist in running medical establishments, running community kitchens, air evacuation of critical fatalities.
- Holding Disaster bricks for medicines, tentage / temporary accommodation, Power, Communication, Rations, Fuel, potable water as single source agency.
- Having a organized structure for effective response.
- Scenario Building, Joint Meetings, Early Information of Developing Situation, Identification and security of Very Important Areas
- Have a quick and fast outreach nationally and globally for achieving quick response to carry out emergency relief.

Figure- 1: Inter service organization for emergency response

HQ IDS Collabotaes with all the stakeholder sandiniti at esemergency response whenre quired in case of emergency as shown in above figure.

Approach of Organizations for Assistance

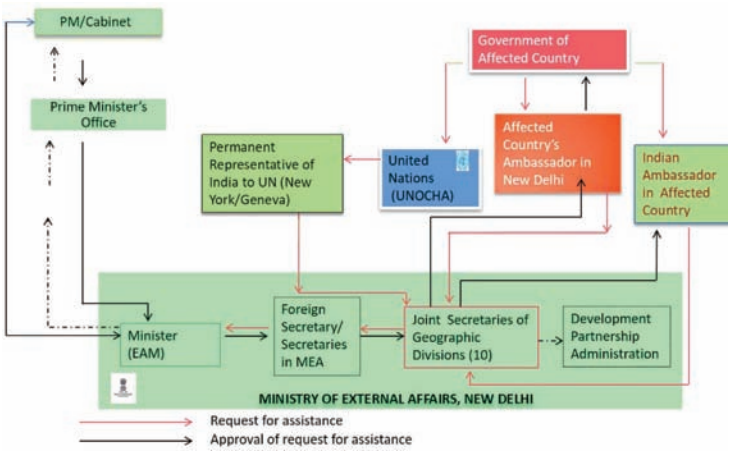

Figure-2: Methodology for providing assistance in disasters

The above figure elaborates the approach that shows inter agency coordination to come out for necessary framework for providing requisite relief and related assistance. The role of each stakeholder is very clear and this lead stocome on conclusion for approval of request for assistance.

Recommendation & Way Forward for Migration from HADR To HADRR

1. Defence forces have traditionally being involved in all Disasters in India and abroad and know the nuances of Response.
2. Since the duration is beyond the relief phase, the response phase also requires the same continuity and momentum to maintain the response.

3. The response phase also involves quick restoration of lifeline and critical infrastructure for continuity of Business and provide immediate succor to the victims of Disaster.

4. The Defence forces are equipment heavy and also have disaster bricks ready for deployment hence can be impressed in Response at the earliest.

5. They are ideally suited for Disaster management in a conflict zone as they have inherent security and war fighting capability.

6. They work in close coordination and cohesion so that the aim and objective is not lost sight of.

7. They are best suited to assist the local government to carry out its basic functions of coordinating and liaison with other stakeholders and agencies.

8. Heavy Airlift capability exists with the Defence forces which is a very important in disaster response.

9. Manpower is highly trained and needs no supervision and control. They can easily do transition from the traditional relief phase to the response phase smoothly.

10. They have Mobile hospitals, Air ambulance and Ship hospitals which have proved very useful in international Disasters and have been applauded for their role. These can be effectively employed in the response phase where the numbers of casualty are very high and it keeps increasing day by day.

11. Defence forces have the capability to maintain Disaster Warehouses are key strategic locations comprising of essential non expendable stores which can be purchases from NDRF/SDRF.

12. The expendable stores like rations(MRE),WASH items, clothing/disposable kits, medicines etc can be kept under respective ministries for regular turnover, which can be made available at a short notice to MoD .These would be utilized during the response phase.

13. Prepositioning of Disaster Management kits and essential equipment purchased out of NDRF and SDRF to state government agencies which can be further issued to local defence units as sector stores. These can be effectively used during response phase.

Way Forward

1. The Defence forces need to create dual task forces involving Territorial Army, Scouts, Defence Security Corps with Disaster Management included

in their role and training. They can be trained likewise with state govt forces like SDRF/local NDRF/Civil Defence/Home Guards etc.

2. A separate DM equipment inventory can be maintained at Field Army level so that their deployment and maintenance is better. The same is an issue presently with respective state line departments.

3. A Defence liaison officer needs to be attached with State Government for better civil-military coordination.

4. Regular meeting of civil and military officials for ensuring local level preparedness and response.

5. Regular Table top and mock exercises to be conducted involving Defence forces and all stakeholders. Exhaustive SOPs can be prepared for smooth conduct of such operations giving detailed instruction for inter / intra agency coordination and liaison.

6. The Defence forces need constant liaison meetings with state govt line departments which deal with quick and early restoration of lifeline and critical infrastructures.

7. Expenditure from NDRF/SDRF to be done for procurement of Response equipment by each state.

Conclusion

NDRF is a response force, similarly the Defence forces need to graduate from being relief centric to response and relief centric force being better poised and suited for such operations. The political and military will need stochange the approach and outlook in this regard. With the frequency of the natural and man-made disasters on the rise, the Defence forces need to be more proactive and abreast with the rapidly changing scenario. They cannot absolve themselves of their responsibility towards the nation. This will not only restore the diminishing confidence on Defence Forces but also drastically improve their image. The armed forces may be deployed on similar ground slike NDRF and in such situations which a rebeyond the coping capacity of the civilian administration and deployment should not for long period, more dependence on armed forces for disaster management is not in favour of a country and thus should be minimized. For efficient utilization of armed forces services in disaster management, a proper coordination among different stakeholders is prerequisite. To achieve this first all stakeholders should be included in the process of making disaster management plans at all levels and second all stakeholders should be included in the joint exercises for disaster management.

References

1. Alexander, David. 2006. Globalization of Disaster: Trends, Problems and Dilemmas. Journal of International Affairs, Spring/Summer, 59(2):1-22.
2. Anderson, E.W.1994. Disaster Management and the Military, Geo Journal, 34(2):201-205.
3. Brancati, Dawn. 2007. Political aftershocks: The Impact of Earthquakes on Intrastate Conflict. Journal of Conflict Resolution, 51(5):715-743.
4. Col. Deshbir Singh. 2013. Select Case Studies of Disaster Management in India and the Role of Indian Armed Forces, Department of Defence and Strategic Studies, Bhonsala Military College, Nasik, University of Pune, Pune.
5. Col. O S, Dagur. 2008. Armed Forces in Disaster Management A Perspective on Functional Aspects of Role, Training and Equipment. Manekshaw Paper, 4:1-38.
6. Garge Ramanand N, Huong Haand Susie, Khoo. 2015. Disaster Risk Management and the Role of the Armed Forces: Critical Analysis of Reactive Disaster Management in India.in StrategicDisaster Risk Management in Asia, Edited by Huong Ha, R. Lalitha S Fernando and Amir Mahmood, Springer, New Delhi, pp.49-68.
7. Gautam, P.K. 2013. Role of the Indian Military in Disasters, Institute for Defence Studies and Analyses, New Delhi.
8. Hall, Rosalie Arcala.2008. Civil-Military Cooperation in International Disaster Response: The Japanese Self Defense Forces' Deployment in Aceh, Indonesia. Korean Journal of Defence Analysis, 20(4):383-400.
9. John. Y. Schrader. 1993. The Army's Role in Domestic Disaster Support-An Assessment of Policy Choices, RAND, CA, United States.
10. Krishna, Amarand Parmod, Damle. 2017. Armed Forces in Disaster Management in India: Need for Improving Civil–Military Coordination. International Journal of Innovative Research in Science, Engineering and Technology, 6(7): 13238-13243.
11. Kumar, Ganesh. 2017.An Analysis of International Arms Transferin Contemporary World. JIMQUEST Journal of Management and Technology, 13(2) : 54-61.
12. UNISDR. 2016. Sendai Framework for Disaster Risk Reduction 2015- 2030.
13. United Nations International Strategy for Disaster Reduction. 2009. 2009-UNISDR Terminology on Disaster Risk Reduction, United Nations, Geneva, Switzerland.

14. Motomura, T.; Hirabayashi, A.; Matsumoto, H.;Yamauchi, N.; Nakamura, M.; Machida, H.; Fujizuka, K.; Otsuka, N.; Satoh, T.; Anan, H.; etal. Aeromedical Transport Operations Using Helicopters during the 2016 Kumamoto Earthquake in Japan. J. Nippon Med. School 2018, 85, 124–130. [Cross Ref] [Pub Med]

15. Alaska, Y. A.; Hirabayashi, A.; Matsumoto, H.; Yamauchi, N.; Nakamura, M.; Machida, H.; Fujizuka, K.; Otsuka, N.; Satoh, T.; Anan, H.; etal. The impact of crowd control measures on the occurrence of stampedes during Mass Gatherings: The Hajj experience. Travel. Med. Infect Dis. 2017, 15, 67–70. [Cross Ref] [Pub Med]

16. Bochicchio, D. Response capabilities of the National Guard: A focus on domestic disaster medical response. A m. J. Disaster Med. 2010, 5 , 49–55. [Cross Ref] [Pub Med]

17. Dunlap,C. Disasters and emergencies: Legal and the military's role. Law fire. Available online: https://sites.duke.edu/lawfire/2017/09/21/disasters-and-emergencies-legal-authorities-and-the militarys- role/(accesse don 27 December 2018).

18. Act on General Defense Obligation of the Republic of Poland. Available online: http://prawo.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU19670440220. (accessed on 19 March 2018).

19. Rzonca, P .; Galazkowski, R.; Podgorski, M. Role of Polish Medical Air Rescue in national medical rescue system. Disaster Emerg. Med. J. 2017, 2, 64–68.

20. Kahn, C.; Koenig, K.L.; Schultz, C.H. Emergency physician disaster deployment: Issues to consider and a model policy. Prehosp. Disaster Med. 2017, 32, 462–464. [Cross Ref] [Pub Med]

21. Barbera, J. A.; Macintyre, A. G. U S emergency and disaster response in the past, present, and future: The multi-faceted role of emergency health care. Emerg. Care Public's Health 2014, 113. [Cross Ref]

22. Fitzgerald, G.; Rego, J.; Ingham, V.; Brooks, B.; Cottrell, A.; Manock, I.; Surjan, A.; Mayner, L.; Webb, C.; Maguire, B.; etal. Teaching emergency and disaster management in Australia: Standards for higher education providers. Aust. J. Emerg. Manag. 2017, 32. Available online https://knowledge.aidr.org.au/media/6006/ajem_monograph_no1_240918.pdf (accessedon 27 December 2018).

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A Case Study on Two Severe Thunderstorm Events Over Tripura on the Same Day During 13th May 2019

Ranjan Phukan and Dilip Saha

Abstract

Thunderstorms cause a lot of damages in India every year and also lead to loss of life. Therefore, it is very important to forecast them with good lead time. Accurate forecasting of the events helps in preventing the loss of life. Tripura and adjoining areas experience a lot of such severe events accompanied with strong surface winds. Two severe thunderstorm events occurring in Tripura on the same day during 13th May 2019 have been considered for the present study. The prevailing weather systems over the region and an unstable atmosphere over Agartala and neighborhood were the precursors for the same. The tracking of the thunderstorms was done with help of Satellite and Doppler Weather Radar which helped to predict its expected intensity and direction of movement. The thunderstorms were observed starting from its generation to dissipation to know details of its structural development and movement.

Keywords: *Severe Thunderstorms, Atmospheric Instability, Doppler Weather Radar, Satellite, Nowcast.*

Introduction

In meteorology, thunderstorm is considered as a severe weather phenomenon, which causes a lot of casualties all over the world. Some of the other weather phenomena, such as, lightning, heavy downpour, high speed wind, hailstorm etc. are sometimes accompanied with thunderstorms which proves to be even more dangerous for the people. The distribution of thunderstorms varies from time to time and place to place. The pre-monsoon season (March – May) is the peak season for thunderstorm occurrence in India. The east and northeastern regions of the country are considered as one of the most prone areas for thunderstorms (Tyagi 2007: 196). The mean number of thunderstorm days is more than 30 in some places of northeast India during April and May (Singh et al., 2011: 164). In this region, severe thunderstorms generally start in the month of March and continue till May, with its peak during April and May. During June, the southwest monsoon advances into the region and severity of the thunderstorms decreases with that. These thunderstorm events in the east and northeast India are known

as 'Norwesters' or 'Kalbaisakhis'. The severe thunderstorms mostly originate over Jharkhand, Chattisgarh, Orissa, West Bengal and other areas (Tyagi et al., 2012:30). As per the data from Doppler Weather Radar Agartala, it has been observed that these thunderstorms travel at a speed of 60-80 kilometers per hour or more from northwest to southeast direction.

The type of the cloud associated with thunderstorms is known as cumulonimbus (CB) cloud. It is the only type of cloud out of ten different types, that can lead to thunderstorms. The essential criteria for occurrence of thunderstorm are, (i) feeding of moisture at the lower levels of the atmosphere, (ii) instability in the atmosphere and (iii) vertical lifting of air in the atmosphere (Khole and Biswas., 2007: 369).

For development of thunderstorms, the first requirement is the availability of moisture for development of Cumulonimbus clouds. Feeding of moisture at the lower levels of the atmosphere helps in that. This moisture feeding is generally done if the winds at lower levels are coming from large bodies of moisture source.

The second requirement is instability in the atmosphere. This concept can be visualized by considering a parcel of air, which is an imaginary mass of air that does not exchange properties with surrounding air masses. When an air parcel rises, it gets cooled at a near constant rate. If the air is unsaturated (i.e. if its relative humidity is less than 100%), this rate of change of temperature with height is called the Dry Adiabatic Lapse Rate (DALR). An adiabatic process is a process that does not allow exchange of heat with the environment. But after some time, its relative humidity becomes 100% and the air parcel is said be saturated. Further cooling of the air parcel will cause it to get condensed. The level at which the air parcel becomes saturated is known as Lifted Condensation Level (LCL). Condensation of the parcel will lead to release of latent heat and as per our assumption the parcel does not exchange any properties to the surrounding, this latent heat will not be mixed with the surrounding environment and will rise the temperature of the air parcel. Hence, a saturated air parcel will cool at a slower rate than an unsaturated air parcel. In such case, the rate of change of temperature with height is called Saturated Adiabatic Lapse Rate (SALR). The surrounding environment will also have its own lapse rate known as the Environmental Lapse Rate (ELR). If both DALR and SALR are greater than the ELR, the air parcel will be colder than its surrounding environment. Cold air is denser than warm air. Hence being colder, the air parcel will sink in such case. Such an atmosphere is known as stable atmosphere. If ELR is greater than both DALR and SALR, it means that the environment will cool rapidly than the air parcel. Therefore, the air parcel will be warmer than its surrounding environment at any height. Since warm air is less dense than cold air, the air

parcel in such case will tend to rise automatically. Such an atmosphere is known as absolute unstable atmosphere. In some cases, the ELR is smaller than the DALR, but greater than SALR. It means that, when the air parcel is unsaturated, it will cool faster than the environment, but slower than the environment when it is saturated. Such an atmosphere is called conditionally unstable atmosphere. In this situation, the air parcel needs to be lifted by some other mechanism until it gets saturated and once it reaches saturation and gets condensed, it will continue to rise by its own. The level above which a parcel will be rising freely without any other forcing is known as the Level of Free Convection (LFC). Once the air parcel gets condensed in an absolute or conditionally unstable atmosphere it will lead to formation of clouds and will continue to rise vertically. At one level above the LFC, the parcel temperature becomes equal to that of the surrounding temperature, known as the Equilibrium Level (EL). After reaching the EL, the parcel will rise for some distance due to the accumulated kinetic energy and after which, it will not continue to rise vertically. Along with it, the vertical development of the cloud also stops. Sometimes, this vertical development of clouds continues up to height of 18-20 kilometers.

The third requirement is, lifting of the air parcel. Solar heating is one such lifting mechanism, which heats up the air near the earth surface and triggers rising motion. Another lifting mechanism is, orographic lifting, where the air is forced to move after striking some hilly terrain or other topographic barrier. Also, sometimes the air at the lower level of the atmosphere converges at one place from all directions. In such case, air starts rising vertically upward in the converging point.

Clouds are formed when saturated water vapor condenses on tiny airborne particles to give rise to small water droplets. These tiny particles are known as cloud condensation nuclei. The small water droplets after colliding with other droplets, grow bigger in size and ultimately they become big enough that they are pulled down by earth's gravity. In such situation they fall down as precipitation. The falling droplets also create a strong downdraft of air which after colliding with the earth's surface, gets spread and causes strong surface winds. Sometimes the wind speed increases suddenly reaching more than 100 kilometers per hour. Ice crystals are formed when the temperature inside the cloud reaches below 0. These crystals also collide with each other to grow bigger in size and form ice balls. Sometimes the ice balls also fall down with them as hailstorm.

Tripura is one of the most prone states for thunderstorms. The annual mean number of thunderstorm related deaths in the state is 6 and that of injuries is 13 (Source: Revenue Department, Government of Tripura). The India Meteorological Department (IMD) has two observatories in the state, one at Agartala and the

other at Kailashahar. The annual mean number of thunderstorm days is 81 in Agartala and 85 in Kailashahar. The frequency is highest during April and May. In Agartala, monthly mean number of thundery days during these two months are 12 and 16 respectively, while in Kailashahar, these numbers are 13 and 15 respectively. Thunderstorms in these two months are comparatively more severe than other months of the year. During the years 2018 and 2019, the number of severe thunderstorm events was quite high in the state. Two such cases of severe thunderstorms over Tripura on 13th May 2019 have been considered for the present study. High speed gusty winds were accompanied with both the thunderstorm events, causing severe damage in some areas. The first event was reported in the evening, with maximum wind speed reaching up to 50 knots (approx. 93 kilometers per hour) at 1733 IST (Indian Standard Time) and the other was in the midnight of the same date, with maximum wind speed of 56 knots (approx. 104 kilometers per hour) at 2353 IST. In both the cases, wind speed of more than 50 kilometers per hour lasted for about 15-20 minutes. The events were analyzed based on large scale meteorological features, upper air atmospheric indices, Doppler Weather Radar (DWR) and Satellite data.

Material and methods

India Meteorological Department (IMD) has a Meteorological Centre at the capital Agartala of the state Tripura. The centre has an observatory for 24 hours monitoring of weather. It is equipped with instruments that can continuously record weather parameters like temperature, wind speed and direction, rainfall at every instant of time. The data recorded at this observatory have been utilized for the present study. Meteorological Centre Agartala issues daily weather forecast bulletins which contain district wise weather forecast and severe weather warning for Tripura. It also issues nowcast warning, which is the type of forecast with very short validity period, maximum of three hours. The nowcasts are issued only when there is a possibility of development of severe weather and are shared through WhatsApp, Email, SMS, Telephone etc. to various users.

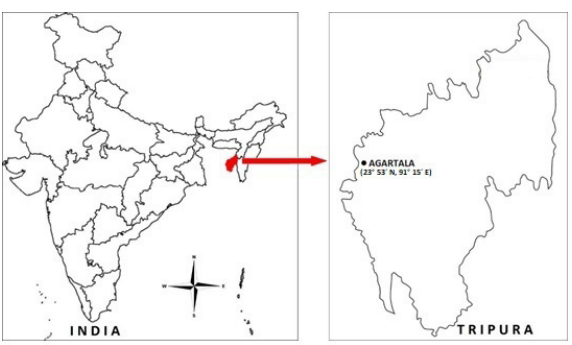


Figure 1 : Map of Tripura

For observing the condition of the upper atmosphere, India Meteorological Department releases balloons, filled with Hydrogen gas and sensors tied with the balloons that senses various parameters, such as temperature, humidity, wind at various heights of the atmosphere up a to height of more than 30 kilometers. Such observations are called as Radio Sonde/Radio Wind (RS/RW) observations. Some atmospheric indices are calculated on the basis of the meteorological data obtained from the RS/RW observations, which help in assessing the instability of the atmosphere. Since the air pressure decreases, as we move upwards in the atmosphere, therefore the pressure values expressed in unit of hectopascal (hPa) are mostly used to indicate the height above ground level. The atmospheric indices used for the present study uses the data recorded at 850, 700 and 500 hPa pressure levels, which corresponds to the heights of approximately 1.5, 3 and 5.5 kilometers respectively above sea level.

$$Showalter\ Index\ (SHOW) = T_{500} - T_{parcel}$$

where,

T_{500}= Temperature corresponding to the height of 500 hPa pressure level

T_{parcel} = Temperature corresponding to the height of 500 hPa pressure level of a parcel of air lifted from 850 hPa pressure level.

$$Lifted\ Index\ (LI) = T_{500} - T_{parcel}$$

where,

T_{500}= Temperature corresponding to the height of 500 hPa pressure level

T_{parcel} = Temperature corresponding to 500 hPa pressure level of a parcel of air lifted from near the surface.

$$Total\ Totals\ Index\ (TTI) = (T_{850} - T_{500}) + (TD_{850} - T_{500})$$

where,

T_{850} = Temperature corresponding to the height of 850 hPa pressure

TD_{850} = Dewpoint temperature corresponding to the height of 850 hPa pressure

T_{500} = Temperature corresponding to the height of 500 hPa pressure

$$K\text{-}Index\ (KINX) = (T_{850} - T_{500}) + TD_{850} - (T_{700} - TD_{700})$$

where,

T_{850} = Temperature corresponding to the height of 850 hPa pressure

T_{500} = Temperature corresponding to the height of 500 hPa pressure

TD_{850} = Dewpoint temperature corresponding to the height of 850 hPa pressure

T_{700} = Temperature corresponding to the height of 700 hPa pressure

TD_{700} = Dewpoint temperature corresponding to the height of 700 hPa pressure

$$\textit{Severe Weather Threat Index (SWEAT)} = 12 \times TD_{850} + 20 \times TERM2 + 2 \times SKT_{850} + SKT_{500} + SHEAR$$

where,

TD_{850}= Dewpoint temperature corresponding to the height 850 hPa pressure level

TERM2= MAX (TTI - 49, 0)

TTI = Total Totals Index as described in serial number (v)

SKT_{850} = wind speed in knots at height corresponding to pressure level 850 hPa

SKT_{500} = wind speed in knots at height corresponding to pressure level 500 hPa

SHEAR= 125 × [SIN (DIR500 - DIR850) + .2]

DIR_{500} = wind direction in knots at height corresponding to pressure level 500 hPa

DIR_{850} = wind direction in knots at height corresponding to pressure level 850 hPa

Both Showalter Index and Lifted Index indicates the instability in the atmosphere. A higher negative value of both the indices indicates more instability in the atmosphere. Showalter 1953: 250 found that thunderstorms have increasing probability as the value of his index falls from +1°C to -2°C and a value of -3°C or less is indicative of severe thunderstorms. Mukhopadhyay et al., 2003: 873 investigated the values of certain parameters for thundery/non-thundery days over three northeastern stations, namely, Agartala, Guwahati and Dibrugarh and the value of Lifted Index less than -0.2°C was found to have more potential for thunderstorm development. Singh et al., 2014: 549 considered the values of less than 2°C and less than 0°C respectively for the two indices, as threshold for occurrence thunderstorm over Agartala.

Higher values of both K-Index and Total Totals Index are more favorable for development of thunderstorms. Tyagi et al., 2011: 694 found the values of KINX and TTI to be greater than or equal to 24°C and 46°C respectively for higher possibility of thunderstorm development in Kolkata. Singh et al., 2014: 549 used

the thresholds of 24°C and 45.5°C respectively for favorability of thunderstorm over Agartala. Studies for other regions also show values close to these two numbers.

SWEAT index takes into account low-level moisture availability at 850 hPa pressure level, instability in terms of Total Totals Index, wind direction and speed at lower and middle-level (850 and 500 hPa pressure levels). Generally, values higher than 200 are considered to have potential for thunderstorms.

Convective Available Potential Energy (CAPE): It is another index, which physically means the measure of the amount of energy available for thunderstorm development. A value of 1000 Joules/Kg is considered as moderate instability in the atmosphere.

For the present study, RS/RW data of 0530 IST observations at Meteorological Centre, Agartala and Meteorological Centre, Patna have been considered.

For observation of development and movement of the two thunderstorm systems, Satellite data from INSAT – 3D satellite of IMD and radar data from the Doppler Weather Radar (DWR) at Meteorological Centre, Agartala have been used in this study. The INSAT – 3D satellite generates an image at an interval of every half an hour. The Infrared images of INSAT-3D have been used in the present study. The thunderstorm clouds are shown in bright tones in such imageries. The grey tones are generally clouds not associated with thunderstorm or rain. The Doppler Weather Radar can look into the internal structure of the thunderstorm clouds. It generates a wide range of products in pictorial form for near real-time monitoring of thunderstorm clouds up to a distance of 500 kilometers from it. But as the distance increases from the Radar station, the beam of the radar antenna goes vertically away from the ground since the earth's surface is curved. Hence, most of its products give better picture of the clouds up to a distance of 250 kilometers from the radar station. The intensity of the thunderstorms can be inferred from the distribution of water/ice particles inside the clouds and it is expressed in terms of dBZ (decibel relative to Z). Higher the dBZ values, more severe is the storm. Generally, a value of more than 45 dBZ is associated with moderate to severe thunderstorms. In a DWR image, the range of dBZ values of the clouds are indicated with the help of different colors. The color scale is also available along with the images for the ease of interpretation by the forecasters. The Doppler Weather Radar generates an image at an interval of every ten minutes. A DWR product named Max-Z has been used in this study. The Max-Z product gives the top view, north-south horizontal view (at the top of the image) and east-west horizontal view (at the right side of the image) of the cloud [fig. 4(a-g)]. With these three views a complete three dimensional

structure of the cloud can be obtained. While satellite gives the top view of the cloud systems, radars can give its complete internal structure and with a much better resolution. But there is a limitation on the distance covered by the radar, whereas satellites can cover almost half of the globe. Therefore, cloud systems are monitored by both radar and satellite, in conjunction with each other.

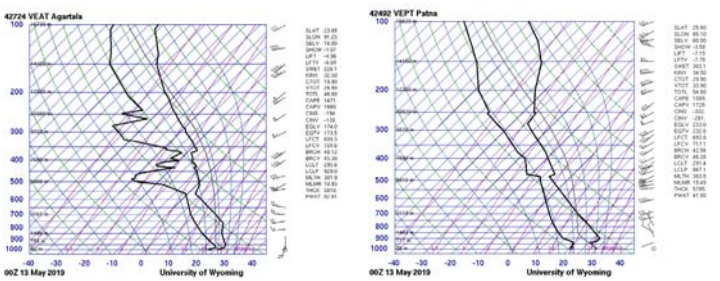
Results and Discussions

Large scale weather systems

On 11th May 2019, there was a cyclonic circulation lying over Bihar and neighborhood extending up to a height of 0.9 kilometers above mean sea level. Such circulations in this season are generally favorable for thunderstorm development over the region and they mostly travel towards Tripura, across Bangladesh. On the next day the system was lying over east Bihar and neighborhood extending up to 1.5 kilometers above mean sea level. In the morning of 13th May 2019, it was observed over East Bihar and adjoining Jharkhand extending up to 0.9 kilometers height of above mean sea level. Along with that, there was a north-south oriented trough of low pressure running along Longitude 86°E to the north of Latitude 24°N at 1.5 kilometers above mean sea level. Both these systems caused the winds over Agartala to be coming from south to south-westerly direction with speeds in the range 15-35 kilometers per hour at various levels up to a height of 1.5 kilometers above mean sea level, which worked as moisture feeding winds at lower levels from Bay of Bengal.

Upper Air Indices

The skew-T diagrams prepared from the 0530 IST upper air data from RS/RW observation at Agartala and Patna on 13th May 2019 are shown in Fig. 2(a) and (b). Since the second thunderstorm originated over Bihar, therefore upper air data of Patna is also considered for the study.



(a) (b)

Figure 2 (a & b) Skew-T diagrams prepared from the 0530 IST upper air data from RS/RW observation at Agartala and Patna on 13th May 2019.
(Source: Upper Air Sounding, University of Wyoming)

Based on the observations from both the RS/RW stations, the calculated values of atmospheric indices are shown in Table I.

Table I Upper air atmospheric indices based on 0000 UTC RS/RW observation of 13th May 2019

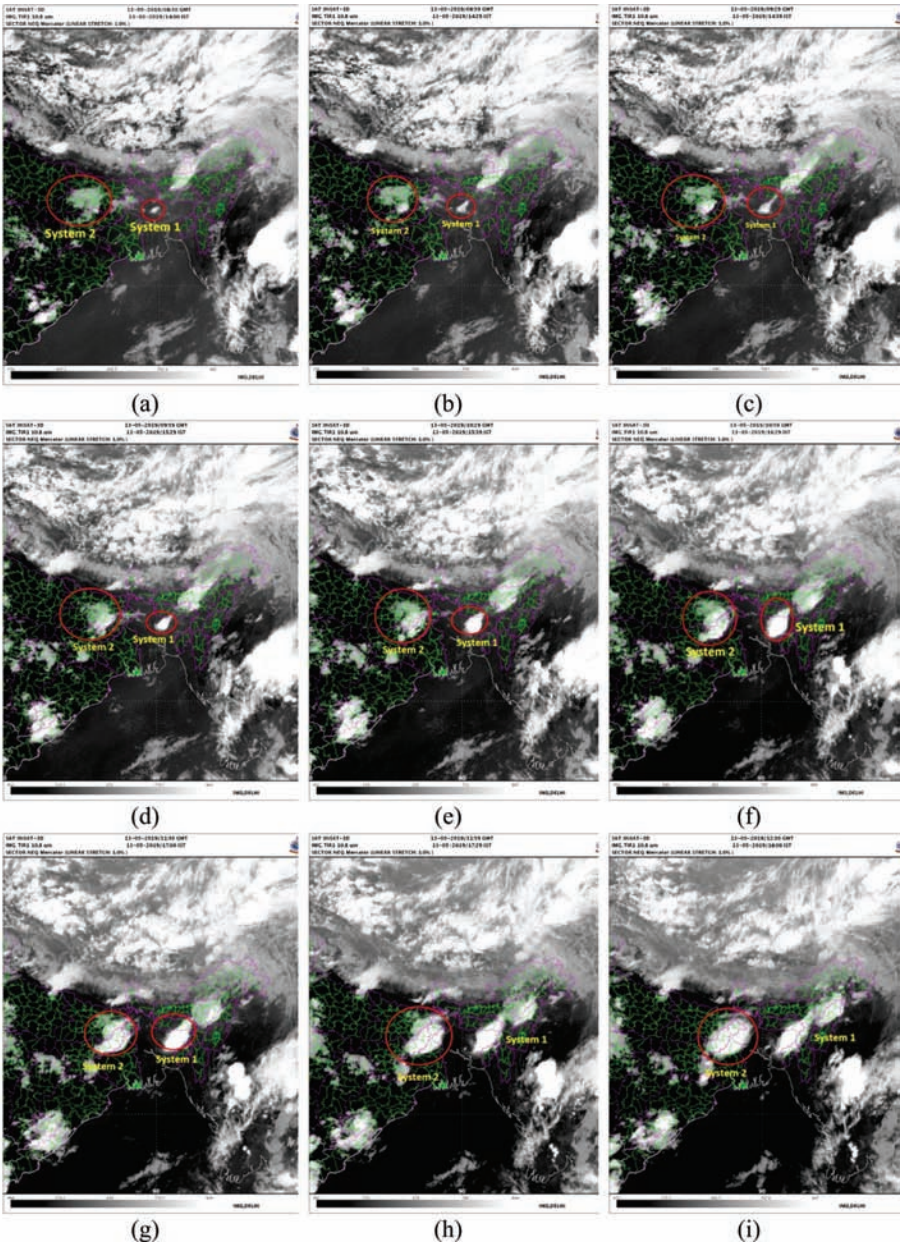
Indices	SHOW	LI	SWEAT	KINX	TTI	CAPE
Agartala	-1.07	-4.96	226.10	32.50	46.80	1471.00
Patna	-3.58	-7.15	303.10	34.50	54.80	1589.00

All the indices in Table I were within favorable range of values used for day to day forecasting of moderate to severe thunderstorm development. These values suggest that, the atmosphere was supporting thunderstorm activities over the region on that day.

Satellite Observations

The availability of lower level moisture feeding for the region and instability of atmosphere obtained from the upper air data in the morning of the same day made it very conducive for occurrence of severe thunderstorm in the region. All that needed was, close monitoring of development of thunderstorms in its vicinity.

Available pictures from INSAT-3D satellite shows development of some thunderstorm clouds over north-central parts of Bangladesh at 1400 hours IST [Fig. 3(a)]. It was the first thunderstorm system that affected Tripura on that day. Another system can be seen near the boundary of Bihar and Jharkhand on the same image. In the 1629 IST [Fig. 3(f)] satellite imagery, both the systems can be seen intensifying, with the first one very close to Tripura and the second one near Bihar, Jharkhand and West Bengal. Since the first system got generated within the range of the Doppler Weather Radar (DWR) at Agartala, its lifetime could well be monitored by the radar also. But the second system got generated and intensified much far from Agartala, its movement was initially tracked with the help of satellite imageries. From the 1900 and 1930 IST satellite imagery [Fig. 3(k) and 3(l)], the first system was seen already crossing western parts of Tripura and being present over northern Tripura and Mizoram and southern parts of Assam. By this time, the second system was over West Bengal and Bangladesh. In Fig. 3(n), the satellite imagery of 2030 IST is shown. It is seen that the bright bands indicating the thunderstorm clouds of the first system have cleared from Tripura but the second system was approaching towards the state with its spatial coverage increasing [Fig. 3(n-r)]. This system came under the range of DWR Agartala by then and its tracking was done using the DWR.


System 2
System 1
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)

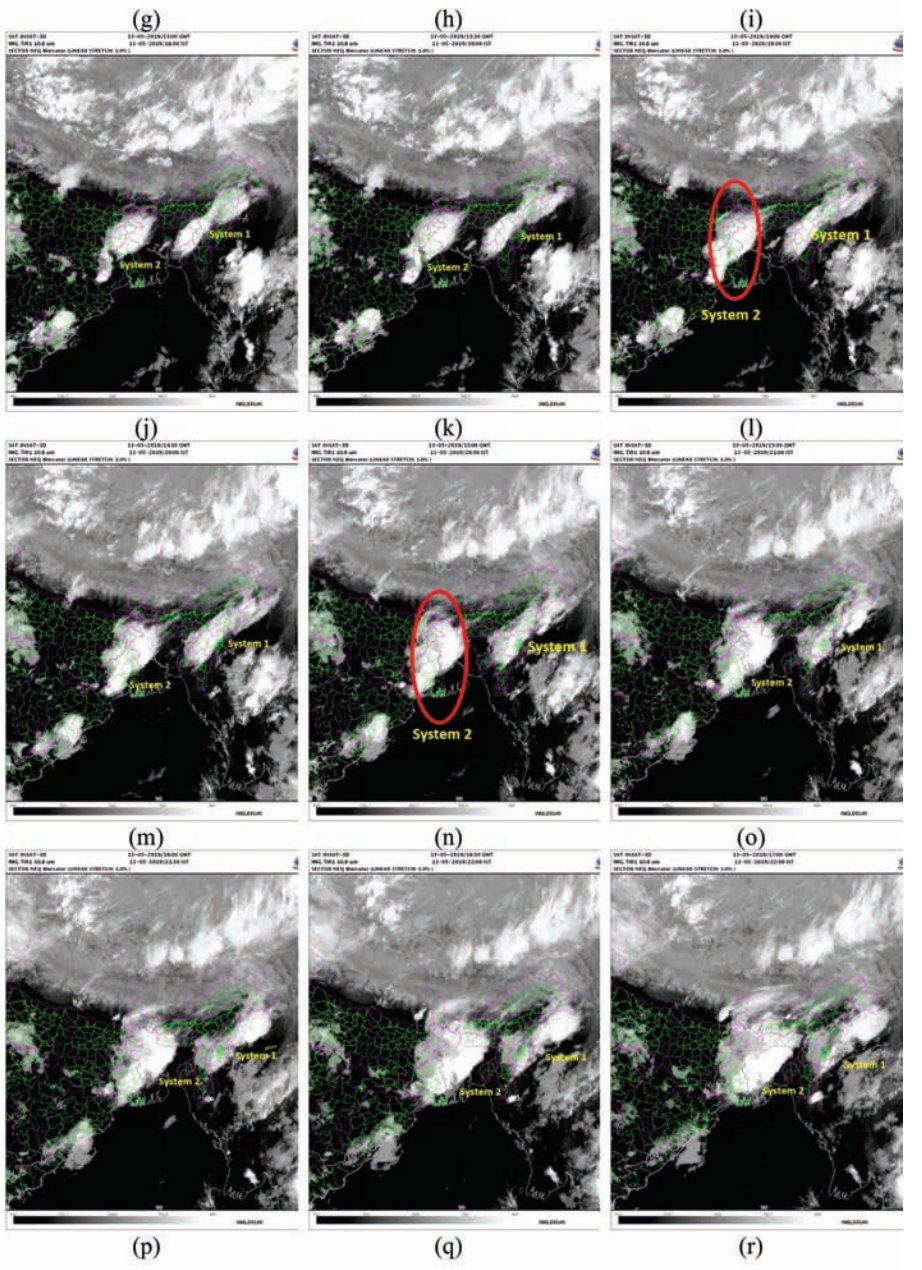
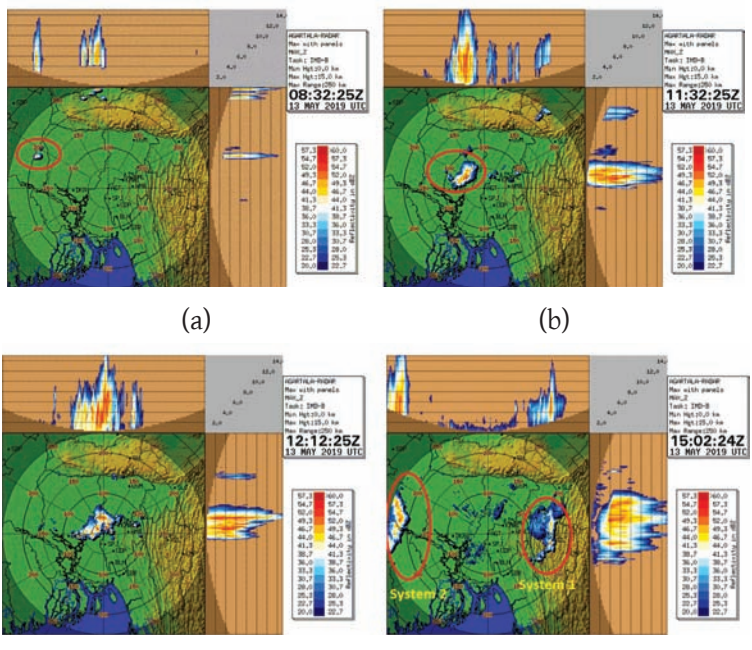


Figure 3 (a-r): Satellite imageries from INSAT-3D at half hourly interval from of 1400 IST to 2230 IST of 13th May 2019 respectively.(Source: Satmet Division, IMD, New Delhi)

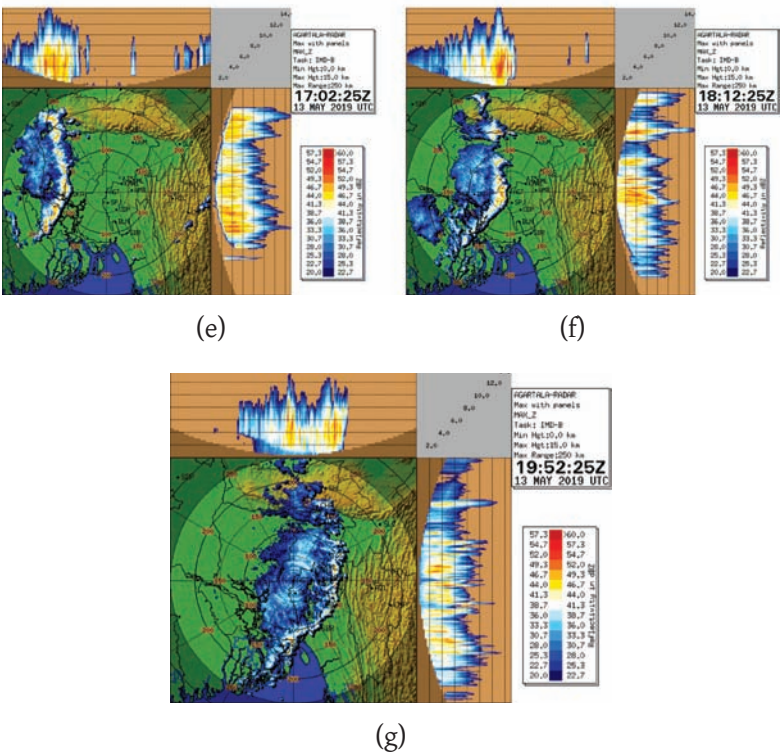
Doppler Weather Radar (DWR) Observations

Fig. 4(a) shows the generation of the first system at about 200 kilometers to the west-northwest from Agartala. Within next three hours, it came within 50 kilometers range of DWR Agartala [Fig. 4(b)], with maximum intensity of 53 dBZ and height of 15 kilometers, indicating severe thunderstorms. By 1742 IST [Fig. 4(c) of 1212 UTC], the system entered into the northwestern parts of Tripura, but along with that, its direction of movement slightly changed from southwestwards direction to completely westwards direction. At 2032 IST [Fig. 4(d)], the first system moved completely away from Tripura and entered into Mizoram, with its intensity decreasing. This system affected West, Sipahijala, Khowai, Gomati, Dhalai, Unakoti and North districts of Tripura, but did not have much effect in the South Tripura district. But the second system came into the range of the DWR by that time. This system looked even more severe than the previous one with a wider area of coverage. By 2232 IST, it entered into 100 kilometers range from Tripura [Fig 4(e)]. Its maximum intensity was 53.5 dBZ and height was about 12 kilometers. Such echoes which attain the shape of a bow are generally very severe in nature. It is seen touching Tripura in the 2342 IST image [Fig. 4(f)] of DWR Agartala and by this time, wind speed has exceeded 50 kmph at Agartala Airport. Within about one and half hours, the system covered the whole state [Fig. 4(g)] and all the eight districts of the state received thunderstorm accompanied with rainfall from this system.



(a) (b)

(c) (d)



(e) (f)

(g)

Figure 4 (a-g): Images from DWR Agartala at 0832 UTC, 1132 UTC, 1212 UTC, 1502 UTC, 1702 UTC, 1812 UTC and 1952 UTC of 13th May 2019 respectively.

Observed Weather

On 13th May 2019, the temperatures were very high in eastern and northeastern region of India. In Bihar, Gangetic West Bengal and neighborhood, the maximum temperatures were in the range of 37-39. These high temperatures provided a good amount of heating at the surface, which put trigger to development of thunderstorm clouds in the region. During the evening, in association to the first system, thunderstorm accompanied with rain started at Agartala Airport at 1732 IST and the highest wind speed recorded was 93 kilometers per hour. The high speed of wind of 35 kmph or more remained for about half an hour. By 1830 IST, speed of wind became light once again, but thunderstorm with light rain continued up to 1940 IST. Since the movement of this system was fast and its spatial coverage was narrow, it did not cause much rainfall. Only 2 millimeters of rainfall was recorded at Agartala due to this system. After a gap of about four hours, the other system approached towards Tripura and thunderstorm with gusty wind and rain started at the Agartala observatory at 2340 IST and continued till 0210 IST of next day. Since this system had a wider

spatial coverage, it caused more rainfall than the first one. 20 millimeters of rainfall was recorded at Agartala due to this system. The maximum wind speed recorded at Agartala due to this system was 104 kilometers per hour. Due to both the systems, light to moderate rainfall was observed over all districts of Tripura, with highest rainfall of 34.4 millimeters over Khowai, but the wind speed throughout the state was of more concern than the rainfall.

Forecast and Warnings issued by Meteorological Centre, Agartala

A low pressure area or a cyclonic circulation over Bihar, West Bengal and Bangladesh is a favorable condition for thunderstorm activity in this area (Srinivasan et al., 1973:24). The numerical weather prediction models were also suggesting formation of the north-south oriented trough and strong southerly winds from Bay of Bengal up to 1.5 kilometers height on 13th May. On the basis of these meteorological situations, Meteorological Centre Agartala had issued a warning for thunderstorm, lighting and gusty wind two days in advance for the 13th of May on its daily forecast bulletin dated 11th May. The same was consistently issued in the bulletin of 12th and 13th also. On 13th May, a nowcast warning was issued at 1646 IST for thunderstorm, lightning and squally wind. An updated nowcast for the same was issued at 1819 IST, for its direction getting diverted more towards North and Unakoti districts. For the second event, a nowcast was issued at 2244 IST about one hour before the thunderstorm started in Agartala.

Risk and Vulnerability

A large section of the population in Tripura is vulnerable to severe thunderstorm activities like these. People in the rural and forest areas are more vulnerable because of presence of more trees. Wind speed of this order is quite sufficient to uproot the trees or break their branches. Falling of trees takes lives of people, damages houses, causes road blockage. The strong winds also damage thatched houses, standing crops, power and communication lines, blows off roofs etc.

Conclusion

Thunderstorms are one of the most devastating weather events. During the pre-monsoon season, a good number of severe thunderstorms are observed in Tripura every year. Most of them occur in the months of April and May. Every single event lasts only for about an hour or two. But the high wind speed for that short duration is quite sufficient to cause serious damage to the state. Falling of branches of trees, or sometimes the whole tree, electric poles etc. causes threat to life, damages houses, blocks roads, disrupt electricity and communication. Lightning strikes are another disastrous phenomenon associated with the thunderstorms. Therefore, early prediction of such severe thunderstorms is very important. Based on prevailing meteorological conditions and lower to

upper air atmospheric parameters, favorable or unfavorable days for their occurrence can be predicted up to a great extent. Apart from that, available tools like satellite and radar makes the tracking of their generation and movement much easier up to high level of accuracy. Meteorological Centre, Agartala issues daily forecast and warning bulletins throughout the year. These bulletins contain severe weather warnings for five days at district level for Tripura. Along with those daily bulletins, in case of possibility of occurrence of any kind of severe weather, nowcasts are also issued as soon as such cases arise. Nowadays, WhatsApp has become one of the most popular social media platform to get connected with each other. So, nowcasts are shared with disaster managers, media, other publics with the help of WhatsApp messaging. Regular updates of the intensification, weakening, movement are also shared time to time. In the present study, one such severe thunderstorm day was considered, where two separate thunderstorm systems affected the state of Tripura. The high speed winds accompanied with the two thunderstorm events were very severe in nature. According to reports from daily news channels of Tripura, the strong winds caused destruction in the electric poles in some areas. Breaking of branches of trees was also witnessed in some places. All meteorological studies associated with the two events, along with the monitoring of its formation and movement with the help of satellite and radar, have been discussed. Various forecasts and nowcasts issued by Meteorological Centre, Agartala in association with the two events also have been discussed. This study is likely to provide guidance for monitoring of similar events and getting prepared for their possible impacts.

Acknowledgement

The authors are thankful to the Director General of Meteorology, India Meteorological Department and to the Deputy Director General of Meteorology, Regional Meteorological Centre, Guwahati for their constant motivation and guidance to the carry out the work. The authors are also thankful to all the staffs of Meteorological Centre, Agartala whose hard work for continuous observations made the data available for this study.

References

1. Khole M, Biswas HR (2007) Role of total-totals stability index in forecasting of thunderstorm/non-thunderstorm days over Kolkata during pre-monsoon season. Mausam, 58(3):369-374

2. Mukhopadhyay P, Sanjay J, Singh SS (2003) Objective forecast of thundery/ nonthundery days using conventional indices over three northeast Indian stations. Mausam, 54(4):867-880

3. Showalter A (1953) A stability index for thunderstorm forecasting. Bulletin American Meteorological Society, 34:250-252

4. Singh C, Mohapatra M, Bandopadhyay BK, Tyagi A (2011) Thunderstorm climatology over northeast and adjoining east India. Mausam. 62(2):163-170

5. Singh C, Yadav BP, Das S, Saha D (2014) Thunderstorm accompanied with squalls over Agartala for consecutive two days on 30 April and 1 May, 2012. Mausam, 65(4):539-552

6. Srinivasan V, Ramamurthy K, Nene YR (1973) Forecasting Manual, Part III, Summer-Nor'westers and Andhis and large scale convective activity over peninsula and central parts of the country. FMU Report No. III-2.2, India Meteorological Department, Delhi, India

7. Tyagi A (2007) Thunderstorm climatology over Indian region. Mausam. 58(2):189-212

8. Tyagi B, Krishna VN, Satyanarayana ANV (2011) Study of thermodynamic indices in forecasting pre-monsoon thunderstorms over Kolkata during STORM pilot phase 2006–2008.Natural Hazards, 56:681–698.

9. Tyagi A, Sikka DR, Goyal S, Bhowmick M (2012) A satellite based study of pre-monsoon thunderstorms (Nor'westers) over eastern India and their organization into mesoscale convective complexes. Mausam. 63(1):29-54

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Indigenous membrane technologies for clean water, and rescue of people during natural claminities: Experience of CSIR-CSMCRI

Bhaumik Sutariya, S. D. Patil, Ansul Yadav and Vinod K. Shahi*

Abstract

One of the significant challenges faced during and after natural disasters are ensuring access to safe drinking water. One common thread that ties these natural disasters together is their impact on potable water. It's essential to understand the dangerous effects contaminated water can have on your health and know-how to deal with it should you be put in an unfortunate situation where safe-drinking water becomes scarce. Membrane separation processes such as Reverse Osmosis (RO), Nanofiltration (NF) and Ultrafiltration (UF) have emerged as an effective solution to produce safe drinking water. Central Salt and Marine Chemicals Research Institute, a constituent laboratory of Council of Scientific and Industrial Research (CSIR-CSMCRI) has pioneered the membrane research and development in the country for desalination of brackish and seawater, and for water refinement, i.e., removal of harmful contaminants like pathogens, hardness, arsenic, fluoride, etc., present in water. CSIR-CSMCRI has designed and fabricated a mobile RO bus. The power to run the RO plant installed in the bus (22 kW) comes from the bus engine itself. To avail of the solar energy, the institute has installed solar panels on the roof of the bus. It will run all the accessories on the bus, e.g., lights, displays, fans, etc. Besides, there is a provision of consuming external electricity wherever it is available. Hence, in totality, three sources of energy have been considered in the fabricated unit. Since the inception of the mobile water-purification unit, the institute has successfully deployed it during many natural calamities, e.g., Cyclone Aila-West Bengal (2009), North India floods-Uttarakhand (2013), Cyclone Phailin-Odisha (2013), Draught of Latur-Maharashtra (2016), Kerala floods (2018) and Cyclone Fani-Odisha (2019).

Keywords: *Natural calamity; Membrane technology; Disaster management; Reverse osmosis.*

Introduction

In India, 34 types of disasters were identified by the High Powered Committee in 2002. Now Tsunami and Pandemic are added in the list. Most common natural disasters in India are earthquakes, cyclones, droughts, and floods, and their co-existence poses a potent threat, which cannot be eradicated but has

to be managed. Transfer of the surplus monsoon water to water deficit areas is a potential possibility. This process would also help in creating additional irrigational potential, the generation of hydropower, as well as overcoming regional water-imbalances.

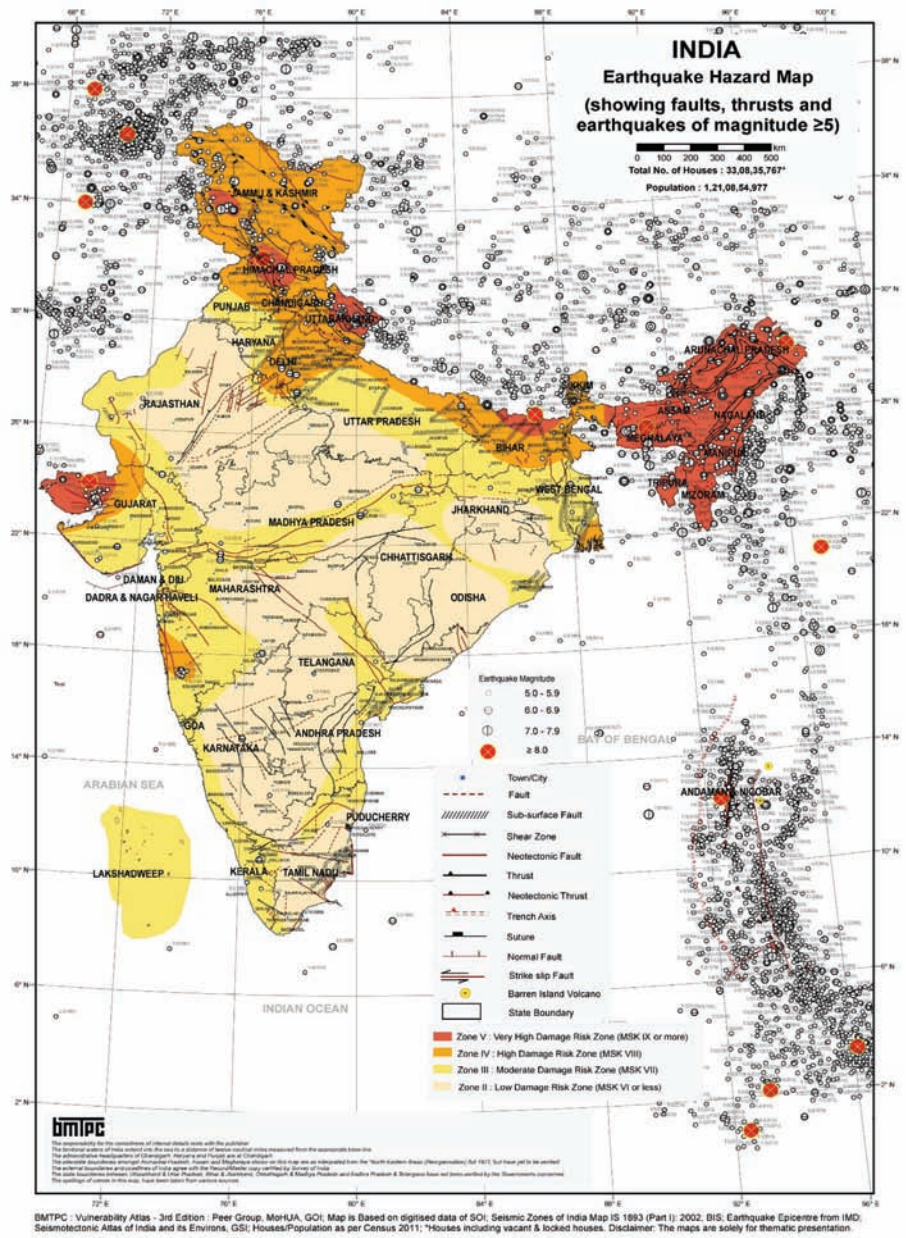

Figure 1: Earthquake hazard map of India [1]

According to the National Disaster Management Authority (NDMA), "An earthquake is a phenomenon that occurs without warning and involves violent shaking of the ground and everything over it. It results from the release of accumulated stress of the moving lithospheric or crustal plates." Figure 1 shows the earthquake hazard map of India. India's increasing population and extensive unscientific constructions mushrooming all over, including multi-storied luxury apartments, substantial factory buildings, gigantic malls, supermarkets, as well as warehouses and masonry buildings keep India at high risk. During the last few decades, India has experienced significant earthquakes that have resulted in over several thousand deaths. The increase in earthquake risk is due to a spurt in developmental activities driven by urbanization, economic development and the globalization of India's economy. The increase in the use of high-technology equipment and tools in manufacturing and service industries has also made them susceptible to disruption due to relatively moderate ground shaking. As a result, the loss of human life is not the only determinant of earthquake risk anymore. Severe economic losses leading to the collapse of the local or regional economy after an earthquake may have long-term adverse consequences for the entire country.

India is highly vulnerable to floods. Floods are a recurrent phenomenon, which causes massive loss of lives and damage to livelihood systems, property, infrastructure, and public utilities. It is a cause for concern that flood-related damages show an increasing trend. Floods are caused by various reasons, including a steep increase in population, rapid urbanization growing developmental and economic activities in flood plains coupled with global warming. Floods have also occurred in areas, which were earlier not considered flood-prone. Floods in these areas have been due to inadequate carrying capacity of rivers are responsible for causing floods, drainage congestion and erosion of river-banks. Cyclones, cyclonic circulations, and cloud bursts cause flash floods and lead to huge losses. Figure 2 shows the flood-prone areas of India.

Cyclones are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation. Violent storms and bad weather usually accompany cyclones. The Indian subcontinent is one of the worst affected regions in the world. In India, on an average, five to six tropical cyclones form every year, of which two or three could be severe. More cyclones occur in the Bay of Bengal than the Arabian Sea, and the ratio is approximately 4:1. Cyclones frequently occur on both the coasts (the West coast - Arabian Sea; and the East coast - Bay of Bengal). The tropical cyclones, characterized by destructive winds, torrential rainfall, and storm surges, disrupt healthy lives with the accompanying phenomena of floods due to the exceptional level of rainfall and storm surge inundation into inland areas. Their destructive potential to damage structures characterizes cyclones, viz. houses, lifeline infrastructure-

Figure 2 : Flood hazard map of India [1]

power and communication towers; hospitals; food storage facilities; roads, bridges and culverts; crops etc. The most fatalities come from storm surges and the torrential rain flooding the lowland areas of coastal territories. Figure 3 shows the cyclone-prone areas of India.

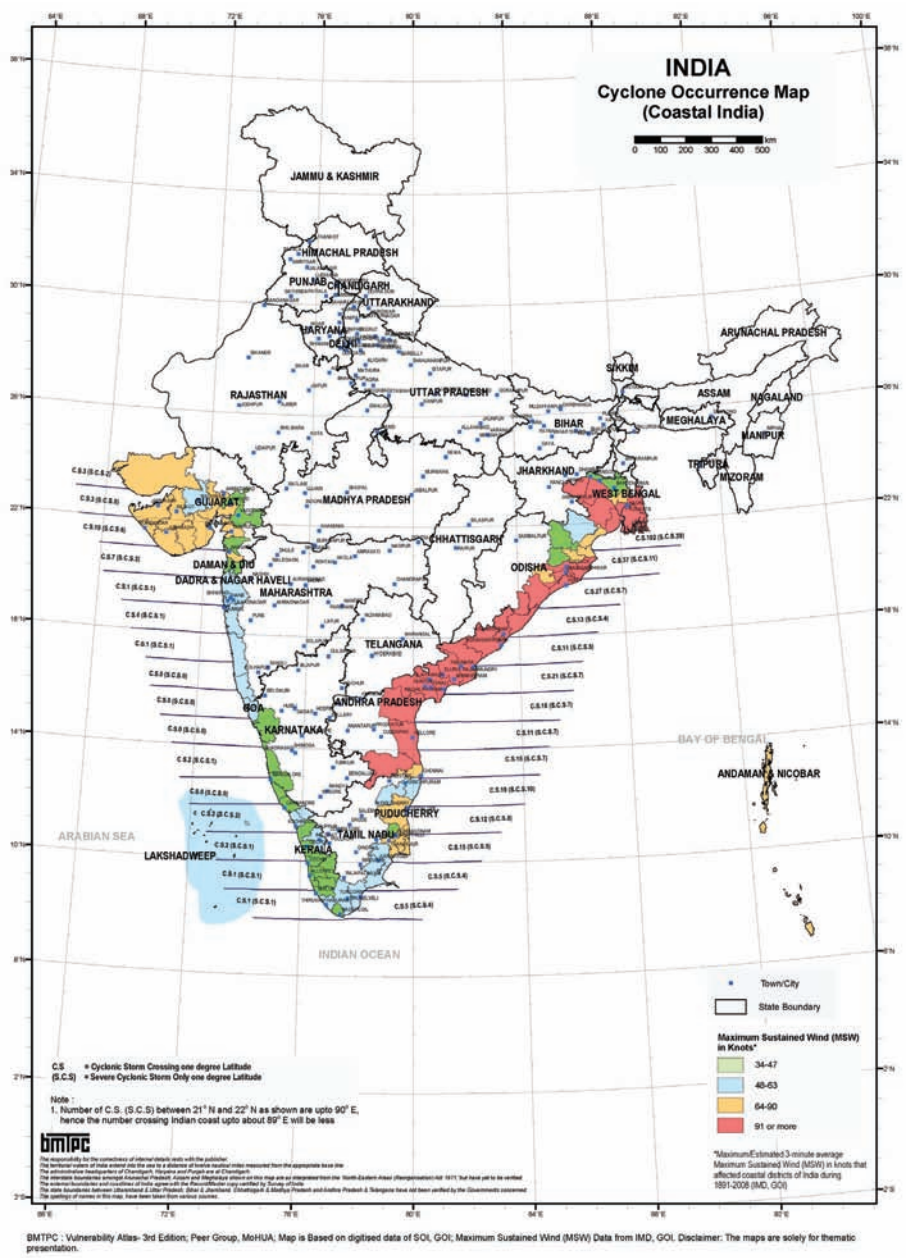

Figure 3: Cyclone hazard map of India [1]

One of the significant challenges faced during and after such natural disasters are ensuring access to safe drinking water. One common thread that ties these natural disasters together is their impact on potable water. From ruptured

water pipes and wells caused by earthquakes, and flooding beyond imagination from storms, water contamination has become inevitable when areas are hit. It's essential to understand the dangerous effects contaminated water can have on your health and know-how to deal with it should you be put in an unfortunate situation where safe-drinking water becomes scarce. Membrane separation processes such as Reverse Osmosis (RO), Nanofiltration (NF) and Ultrafiltration (UF) have emerged as an effective solution to produce safe drinking water. Central Salt and Marine Chemicals Research Institute, a constituent laboratory of Council of Scientific and Industrial Research (CSIR-CSMCRI) has pioneered the membrane research and development in the country for desalination of brackish and seawater, and for water refinement, i.e., removal of harmful contaminants like pathogens, hardness, arsenic, fluoride, etc., present in water.

Filteration techniques

Microfiltration (MF)

Microfiltration (MF) is the process of physically removing suspended solids from water through a membrane. MF is often used in conjunction with other separation processes such as UF, NF as well as RO. The MF- filters have a pore size of approximately 0.1 microns (small). Bacteria and suspended solids are the only elements that can be removed through MF.

A typical use for an MF system can be:

- A pre-treatment for another water treatment process
- Certain types of effluent treatment
- Certain oil and water separation applications
- Treat wastewater
- Sterilizing beverages and pharmaceuticals without sacrificing flavor
- Processing dairy products while allowing protein through

Ultrafiltration (UF)

An ultrafiltration (UF) filter has a pore size of around 0.01 micron. An MF filter has a pore size around 0.1 microns, so when water undergoes MF, many microorganisms are removed, but viruses remain in the water. UF would remove these larger particles, and may remove some viruses also.

UF can be used in the following processes:

- Treating wastewater
- Concentrating proteins
- Chemical process separation

- Separating oil/water emulsions
- Removing pathogens from milk
- Clarifying fruit juices

Nanofiltration (NF)

A nanofiltration (NF) filter has a pore size of around 0.001 microns. NF removes most organic molecules, nearly all viruses, most of the natural organic matter, and a range of salts. NF removes divalent ions, which make water hard, so NF is often used to soften hard water.

NF can be used in the following processes:

- Water treatment
- Pre-treatment for RO
- Pharmaceuticals
- Textiles
- Bakeries
- Dairy

Reverse Osmosis (RO)

Reverse osmosis (RO) filters have a pore size of around 0.0001 microns. After the water passes through an RO filter, it is essentially pure water. In addition to removing all organic molecules and viruses, RO also removes most minerals that are present in the water. RO removes monovalent ions. It means that it desalinates the water. To understand how RO works, it is helpful to understand osmosis. Osmosis is a process of flow of solvent from a low concentration side to a high concentration side through a semi-permeable membrane partition. RO is the process, reverse to osmosis. It demineralizes or deionizes water by pushing the water under high pressure through a semi-permeable RO membrane from a high concentration side to a low concentration side.

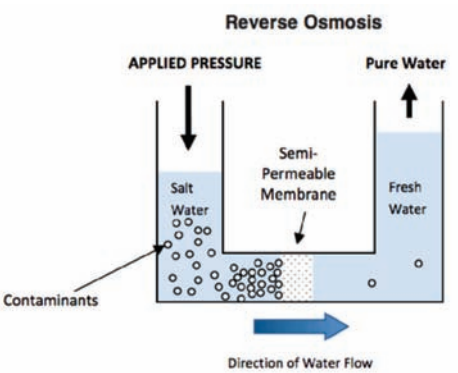

Figure 4 : Schematic diagram of the RO process [2]

RO works using a high-pressure pump to increase the pressure on the feed side and force the water across the semi-permeable RO membrane, leaving almost all (around 95% to 99%) of dissolved salts behind in the reject stream. The amount of pressure required depends on the salt concentration of the feed water. The more concentrated the feed water, the more pressure is required to overcome the osmotic pressure. As the feedwater enters the RO membrane under pressure (more than osmotic pressure), the water molecules pass through the semi-permeable membrane and the salts and other contaminants are not allowed to pass and are discharged through the concentrate stream, which goes to drain or can be fed back into the feed water supply in some circumstances to be recycled further through the RO system to save water. The water that makes it through the RO membrane is called permeate or product water and usually has around 95% to 99% of the dissolved salts removed from it.

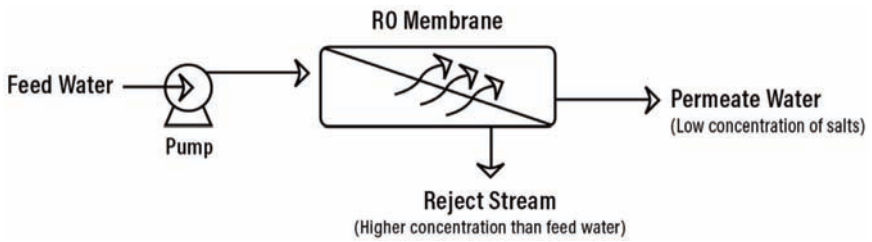

Figure 5 : Schematic diagram showing working-principle of the RO system [2]

RO is capable of removing more than 99% of the dissolved salts (ions), particles, colloids, organics, and bacteria from the feed water. An RO membrane rejects contaminants based on their size and charge. Any contaminant that has a molecular weight greater than 200 is likely to be rejected by a properly running RO system. Likewise, the greater the ionic charge of the contaminant, the more likely it will be unable to pass through the RO membrane. RO is very effective in treating brackish, surface, and groundwater. Some examples of industries that use RO water include pharmaceuticals, power plants, food and beverages, metal finishing and semiconductor manufacturing, etc.

To summarize, UF removes bacteria, protozoa, and some viruses from the water. NF removes these microbes, as well as most natural organic matter and some natural minerals, especially divalent ions, which turn the water hard. NF, however, does not remove dissolved compounds. RO removes turbidity, including microbes and virtually all dissolved substances. However, while RO removes many harmful minerals, such as salt and lead, it also removes some healthy minerals, such as calcium and magnesium.

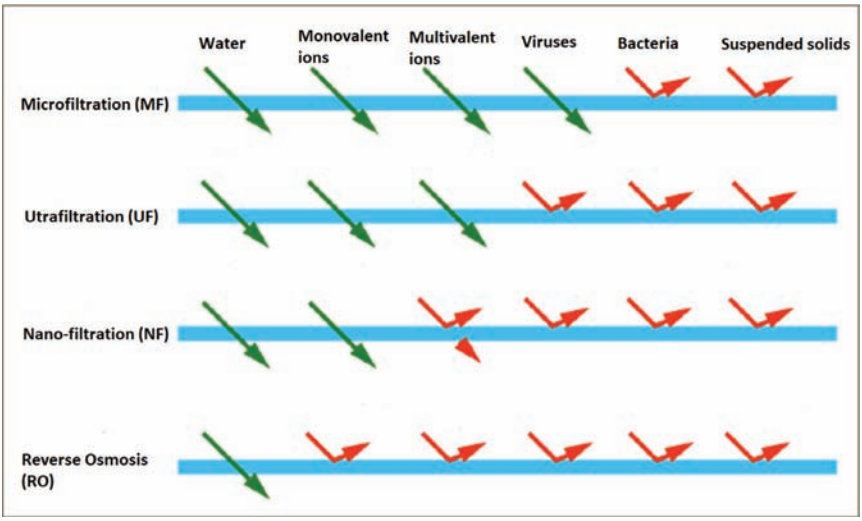

Figure 6 : Different membrane process characteristics

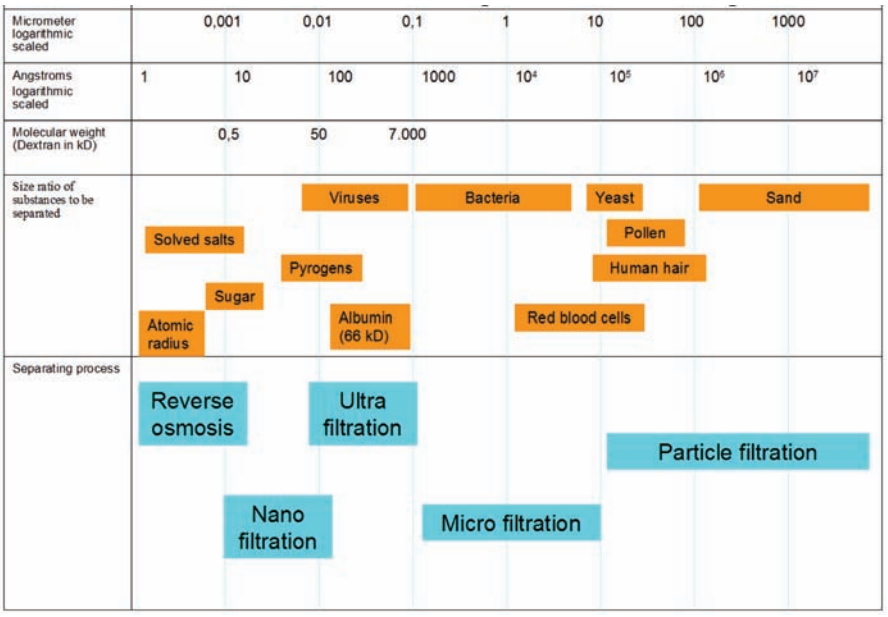

Figure 7 : Cut-offs of different filtration techniques [3]

CSIR-Central Salt and Marine Chemicals Research Institute (CSMCRI) excels in the areas of different membrane techniques such as RO, NF, UF and MF. CSIR-CSMCRI membrane gives more than 96±1% salt separation, and the product output is 350±50 LPH and 1350±150 LPH for 4" and 8" diameter membrane modules, in the normal operating pressure and brackish water salinity range.

The constant improvements in membrane technology have enabled the institute to fabricate plants at a lower and lower cost, day by day.

The technologies readily available with the institute are:

1. High flux hollow fiber ultrafiltration (UF) membranes and process for the preparation of the same (US patent no. US20130213875A1)

2. Thin-film composite (TFC) reverse osmosis (RO) membrane manufacturing technology: Polyamide composite membrane for RO and method of preparation of the same (Indian patent no. 244150)

These technologies have been licensed to three different commercial partners, namely Uniqflux Membranes LLP, Pune; Rinzai Hydratech, Ahmedabad; and Omtech, Rajkot.

Development of Indigenous Membrane-Technology

Water is necessary, both for sustainable human development and for the healthy functioning of the planet's ecosystem. CSIR-CSMCRI is at the forefront in the areas of water research and has continued to play a laudable role in providing potable water to the needy. In the area of membrane-based desalination and water-purification, the institute has worked since the early seventies. The institute has given more impetus on the water as a research priority and has developed indigenous brackish water RO membranes based on polyamide thin film composite (TFC) membrane technology. The inherent advantages of the TFC membrane are its low compaction rate, and ability to work under a wide pH range. These have resulted in a simpler operation and longer membrane life. The developed technology is robust and it can handle brackish water, seawater as well as industry effluents. The institute has made a foray into seawater desalination based on a two-pass RO design with the help of its indigenously developed brackish water membrane.

Since 1999, The institute has been able to alter mindsets and make an impact on the society with RO plants set up by us based on our indigenous TFC-RO membrane technology, focusing majorly on the rural population. It has set up more than 130 plants of various capacities in and out of the country. It has installed 25 nos. of RO Plants 1000 liters per hour (LPH) capacity in Afghanistan during 2009-12. In collaboration with Barefoot College, the institute had successfully installed its first solar-powered community scale (700 LPH) RO plant in Rajasthan. Recognizing that there are remote villages and situations where no electricity is available, the institute embarked on the development of animal-powered desalination technology (US patent no. US7387728B2). Sustainability of these projects after installation is ensured by training the local personnel for the basics of operation and maintenance aspects.

Mobile Water-purification Unit

In the majority of the calamity cases, the electricity is not available in the affected areas. Besides, the distribution of water-pipelines may also get damaged. Hence, the water-distribution system gets hampered, and people try to obtain water for domestic use from any source available. This water may not always be healthy for consumption. Hence, to cater to the affected population with safe and healthy potable water, CSIR-CSMCRI has designed and fabricated a mobile RO bus. The power to run the RO plant installed in the bus (22 kW) comes from the bus engine itself. To avail of the solar energy, the institute has installed solar panels on the roof of the bus. It will run all the accessories on the bus, e.g., lights, displays, fans, etc. Besides, there is a provision of consuming external electricity wherever it is available. Hence, in totality, three sources of energy have been considered.

The key motivations for the fabrication of such a unit include:

1. Creating awareness among the public on indigenous water-purification technologies
2. Providing on the spot demonstration of the capabilities of the various water-purification units
3. Being in a state of readiness to respond swiftly to emergencies
4. Creating a model to serve a cluster of villages

(a)

(b)

Figure 8 : Mobile water-purification unit in operation during cyclone Fani, Odisha in 2019 stationed at Badahat

The water-purification and desalination unit can purify any contaminated water, including silt-laden left by floods, and brackish water along coastal areas to make it potable by removing viruses and bacteria. The unit can cater to up to 4000 LPH of potable water from turbid water, water contaminated with pathogens and saline water in the brackish range, and up to 3000 LPH of potable water from highly saline water like seawater. It is being managed by the installation of a hollow fiber (UF) unit and a two-pass RO unit. The conventional pre-filtration system of disk filters, cartridge filters as well as carbon filters have been incorporated to reduce turbidity and foul smell. The water contaminated with colloids and/or pathogens, but free from excess salinity is passed through the UF unit to convert it into potable water. However, saline water (brackish or seawater) is passed through the RO unit in single or two passes based on the salinity. If the water is highly turbid along with being saline, the UF unit can be taken into pre-treatment along with the conventional pre-treatment system before passing the water through RO units. Hence, based upon the condition of water available at any location, various configurations can be used to get pure and healthy water as per World Health Organization (WHO) standards.

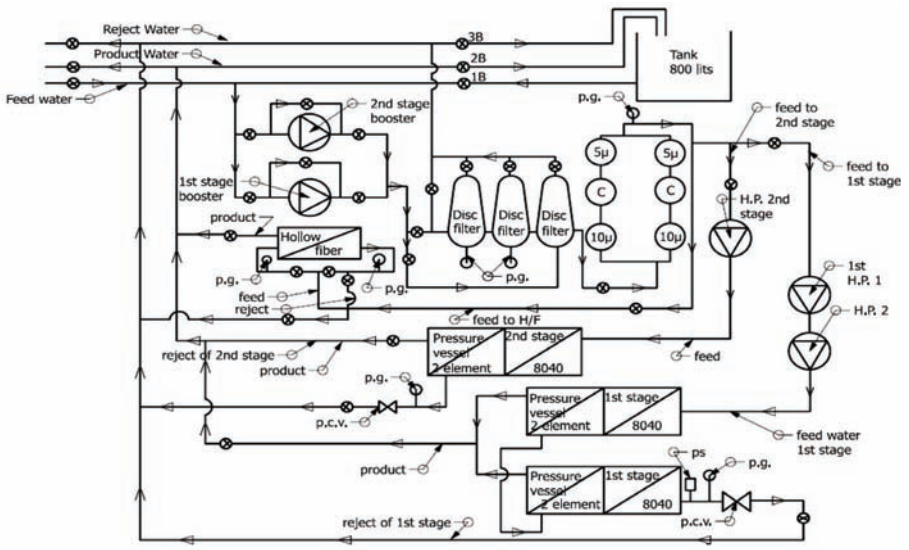

Figure 9 : Line diagram of RO-UF plant installed in existing mobile water-purification unit

Since the inception of the mobile water-purification unit, the institute has successfully deployed it during many natural calamities, e.g., Cyclone Aila-West Bengal (2009), North India floods-Uttarakhand (2013), Cyclone Phailin-Odisha (2013), Draught of Latur-Maharashtra (2016), Kerala floods (2018) and Cyclone Fani-Odisha (2019).

One of the first missions the mobile unit was deployed for was mitigation of acute drinking water problems in North 24 Parganas, West Bengal, in the aftermath of Cyclone Aila. India and Bangladesh were severely affected by the disaster. In India, 149 people are believed to be killed due to it. The state government along with the central counterpart, took up the rescue work. CSIR-CSMCRI shared the responsibility and mobilized the mobile water-purification unit. It was stationed in the BSF camp, where pond water of 5000 parts per million (ppm) salinity was available. The unit provided more than 30,000 liters per day of potable water through RO desalination technology.

In June-2013, the state of Uttarakhand received a heavy amount of rains, subsequently floods as well as landslides. The state government, along with the Army, Airforce, Navy, Indo-Tibetan border police, National Disaster Response Force (NDRF), initiated rescue operations. CSIR-CSMCRI also deployed the unit to Uttarakhand to cater to the drinking water needs of people in the regions affected by floods. The RO unit, along with the bus, was stationed at Hrishikesh, and one separate hollow fiber (UF) unit was set up at Srinagar (Garhwal). The units produced approx. 45000-50000 liters of potable water a

day and was distributed in the surrounding areas via tankers provided by local authorities.

In October 2013, the state of Odisha was hit by cyclone Phailin. This cyclone was considered to be an extremely severe cyclonic storm by India Meteorological Department (IMD). Andaman and Nicobar Islands, Andhra Pradesh, Jharkhand, and many more states were affected along with Odisha. There were flash floods in Bhanjanagar and Jagatsingpur Districts of Odisha. The quench of thousands of villagers in these districts was satisfied via the mobile water-purification unit (RO and a separate UF (hollow fiber) unit) of CSIR-CSMCRI, operating from two different stations. In totality, these units supplied more than 20,000 liters of potable water to the needy, and it was distributed via tankers with the help of RWSS authorities.

In May-June 2016, Latur faced severe drought in the region. Only a few locations had the availability of sweet water. People had to stand hours in the queue to have access to water for drinking purposes and domestic use. The mobile water-purification unit was deployed and demonstrated in the city. It was stationed at the open well of Gorakshan Sanstha—a place in the heart of the Latur city. The water available in the well was not used due to contamination. Potable water (approx. 40,000-50,000 liters per day) was made available from the well water by the mobile water purification unit and was distributed to the people in the city for ten days.

In August-Sept. 2018, the mobile water-purification unit was deployed and demonstrated in Pandanad village in the Chengannur district of Kerala that was facing severe scarcity of drinking water during floods. The flood was the worst in the state in nearly a century. The Indian Government declared it a "calamity of severe nature." The Governments, non-governmental organizations, as well as non-profit organizations, started relief work. The mobile unit was stationed at a pumping station in Pandanad, where the water was available in the bore well, which was reddish and not drinkable due to various contaminations. The water from the pumping station was purified and was made available for drinking. Approx. 20,000-25,000 liters of potable water per day were made available by the mobile water-purification unit and was distributed to the people in the flood-affected areas for 12 days.

In May 2019, the state of Odisha struck by cyclone Fani. It paralyzed drinking water Supply and contaminated many ponds and wells in the worst-affected Puri district. There was no electricity for many days to follow since lakhs of poles were uprooted across the state. It was difficult for people to get access to safe drinking water, or even the local authorities to help them with the issue. Hence, CSIR-CSMCRI deployed the mobile water-purification unit to the Puri district. It was initially made operational in Kakatpur. It supplied approx — 17000 liters of

potable water per day to the affected people. After serving the Kakatpur block for two days, the unit was stationed near a huge pond, having contaminated water at Badahat village in the Satyabadi block. Since the salinity of pond was within limits, the UF unit, along with conventional pre-treatment system was made operational to convert the pond water into potable water. Approx. 15000-17000 liters of potable water were produced per day for 15 days. It was distributed in surrounding villages via tankers provided by local authorities of Rural Water Supply and Sanitation (RWSS). A team of WHO visited the site and were satisfied with the quality of water produced by the unit.

New and compact mobile water purification unit

The existing mobile RO unit is huge (L = 11.5 m, W = 2.5 m, H = 3.3 m) and difficult to maneuver. Hence, a smaller and compact unit was required to be fabricated with the same capacity. CSIR-CSMCRI has taken up the challenge and started working on it, and currently, two such units are being fabricated. The purpose of the vehicle will be the same as the existing water-purification unit, i.e. to go to the calamity affected areas to cater to the drinking water needs of affected people. Also, it can be used in saline areas wherein it can operate as a mobile water distribution system in normal days.

The key motivations and advantages of the new vehicle are:

1. Vehicle of smaller turning radius up to 6.3 m instead of the existing bus with a turning radius of 10 m.
2. Compact unit with the same capacity of water-purifying plants
3. Less bulky and energy-efficient unit
4. A vehicle capable of reaching difficult terrains
5. Reduction of maintenance of the vehicle with better design and weight balance
6. Ease of maintenance through detachable panels on the vehicle body

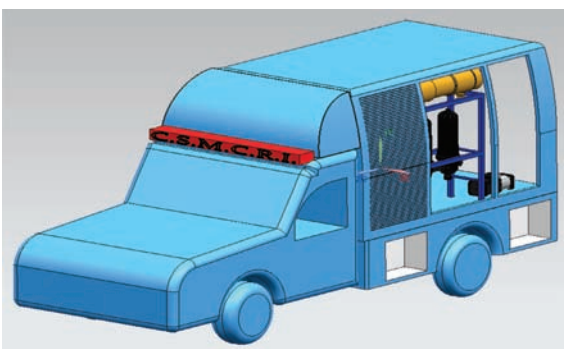

Figure 10 : A three-dimensional model of the new water-purification unit

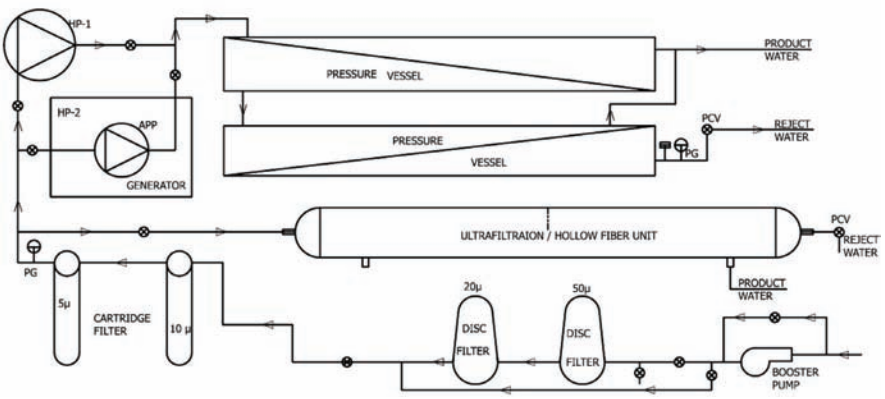

Figure 11 : Line diagram of RO-UF plant to be installed in new mobile water-purification units

The new units are expected to be available on the Government e-Market portal. Various agencies and various state governments can procure it for the betterment of people in the area susceptible to calamities or of the people living in areas where available water is saline.

References

1. http://bmtpc.org/
2. https://puretecwater.com/reverse-osmosis/what-is-reverse-osmosis
3. https://www.freepurity.com/blogs/resources/micro-ultra-nano-filtration-vs-reverse-osmosis-whats-the-difference

Figure no. Source of image

1 http://bmtpc.org/topics.aspx?mid=56&Mid1=178
2 http://bmtpc.org/topics.aspx?mid=56&Mid1=178
3 http://bmtpc.org/topics.aspx?mid=56&Mid1=178
4 https://puretecwater.com/reverse-osmosis/what-is-reverse-osmosis
5 https://puretecwater.com/reverse-osmosis/what-is-reverse-osmosis
7 https://www.freepurity.com/blogs/resources/micro-ultra-nano-filtration-vs-reverse-osmosis-whats-the-difference

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Geo-spatial technologies for effective management of Forest Fires in Mandakini Valley, India

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Abstract

Forests are essential for survival and sustenance of life on earth. They are source of many benefits and need to be managed very well. One of the most common hazard in forests is forest fire. They pose a threat not only to the forest wealth but also to the entire regime of fauna and flora. Eventually, it disrupts the bio-diversity of a region. Mandakini Valley in Rudraprayag District of Uttarakhand, India has rich flora and fauna, spread across the district. Every summers, different forest areas are experiencing forest fires on a regular basis leading to colossal loss of vegetation cover in that region. Total 198 Forest Incidents were reported in year 2018 and total 2000+ incidents were reported from 2002 onwards as reported by Forest Survey of India. As, Rudraprayag is well known for its religious importance because of Char Dham - Kedarnath Dham Temple, most of the people visit this place in the summer months, increasing risk of man-made forest fires. Geo-spatial technologies can effectively be utilized for developing fire behavior modeling and associated spatial-temporal problems of forest fires. Application of Remote Sensing & GIS has become an important tool in the Forest Fires Management. A number of studies are available to identify and demarcate Fire Risk Zonation and to develop measures to mitigate forest fires, but still, because of non-availability of integrated platform, timely action to minimise heavy losses to flora and fauna is limited. Hence, in this study, Forest areas in Mandakini Valley were considered for Fire Risk Zonation. An integrated GIS based platform is also proposed to leverage Remote Sensing & GIS technology for planning mitigation measures and efficiently manage forest fires.

Keywords: *GIS, Disaster Management, Fire Risk Reduction, Forest Fires*

1. Introduction

Forests are essential for survival and sustenance of life on earth. They are source of many benefits and need to be managed very well. Protecting these forest resources and managing them in today's ever changing world is becoming an increasingly complex and demanding challenge. The most common hazard in forests is forest fire. Nearly 55% of the total forest cover in India is prone to fires every year. An estimated annual economic loss of Rs.440 crores is reported on

account of forest fires over the country as per Global Forest Fire Assessment Report by FAO, United Nations. Forest fires has huge environment significance as biomass burning has implications. It produces large amounts of gases, aerosol and play a pivotal role in disturbing climate. They pose a threat not only to the forest wealth but also to fauna and flora by seriously disturbing the bio-diversity, the ecology and environment of the region. Frequency of these fires increases during summers as there is no rain for months and forests become littered with dry leaves, which gets ignited by the slightest spark.

Forest fires are caused by Natural as well as Man-made triggers (http://agritech.tnau.ac.in/)

- **Natural causes**- Many times, forests set on fires because of lightening. High temperatures and dryness (low humidity) also provide favourable circumstance for a fires to start.
- **Man-made causes**- Many a times, the key reason for fires is burning of agricultural wastes, cigarette, *bidies*, electric spark or any other source of ignition that comes into contact with inflammable material, in close proximity to forests.

Forest fire can broadly be classified into three categories(http://agritech.tnau.ac.in/);

- Natural forest fire.
- Forest fires caused by heat generated through carelessness of people (human neglect) and
- Forest fires purposely caused by local inhabitants

There are two types of forest fire i) Surface Fire and ii) Crown Fire(http://agritech.tnau.ac.in/)

- **Surface Fire**- A forest fire may burn primarily as a surface fire and spread along the ground through surface litter spread across.

- **Crown Fire**- In this type of Forest Fire, Crown catches fire first which spread across forest tree crowns and shrubs and often sustained by a surface fire. Coniferous forest are highly vulnerable to these type of fires as resinous material given off burning logs burn furiously. On hill slopes, it spreads up fast as heated air adjacent to a slope tends to flow up. Fire initiated uphill, has less likelihood of spreading.

Forest fires pose other environmental and health issues by producing smoke and noxious gases. The burning of vegetation gives carbon dioxide and host of gases like such as carbon monoxide, methane, hydrocarbons, nitric oxide

and nitrous oxide, that lead to global warming and ozone layer depletion. As a result, thousands of people suffered from serious respiratory problems due to these toxic gases.

Forest fires are normally seasonal in nature primarily seen in the summer season and can be prevented by adequate planning. At the time of British period, fire was prevented in the by removal of forest litter all along the forest boundary called "*Forest Fire Line*" which is also practiced in today's time as informed by different state forest officers. These lines prevent fire entering into the forest and spreading from one compartment to another. Normally, the fire spreads only if it gets continuous supply of fuel along its path. The most common way to manage and control forest fire therefore, is to prevent it from spreading, which can be done by various methods like creating firebreaks in the shape of small clearings of ditches in the forests.

Geographic information system (GIS) technology provides tools that integrate and analyze data from disparate sources, help in performing advanced geo-spatial analysis / modeling and assist forest fire managers in determining fire hazard and identifying forests at risk. It stores spatial information in a digital mapping environment that allows fire managers to quickly select and view data that can influence fire behavior. Various factors responsible for forest fires like slopes, aspects, vegetation types, proximity to agricultural fields, proximity to water bodies, natural or man-made barriers, and historical weather patterns can be overlaid for modeling potential fire behavior and can help in determining potential fire hazard zones (Sahana et al , 2017).

Up till now, a number of studies were undertaken globally to identify Fire Risk Zonation, identification of Fire-prone areas, Damage assessment etc. but still, because of non-availability of integrated platform, heavy losses to flora and fauna has been experienced.

The present study proposes a framework to use GIS Platform for Forest Fire Zonation by integrating Spatial / Non-Spatial parameters which have direct / indirect influence on the occurrence of fire and establishing a GIS based Platform for efficient fire management.

2. Study Area

Mandakini Valley in Rudraprayag District of Uttarakhand has rich flora and fauna, spread across the district (see Table I). Every summers, forest fires are experienced on a regular basis leading to colossal loss of vegetation cover in the region. As per Forest Survey of India, total 198 Forest Incidents (see Table II) were reported in year 2018 in the study area (http://fi-re.in/smsalerts/dashboard.php).

Administratively, Mandakini River Valley, lies in district of Rudraprayag, State of Uttarakhand, covering an area of about 1984 sq. km lies between lat. 30° 12" 58.132' – 30° 48" 27.642' N and long. 79° 2" 58.649' – 79° 2" 0.952' E falling in the Survey of India toposheet nos. 53J /14, 53J/15, 53N/1, 53N/2, 53N/3, 53N/4 and 53N/6. Rudraprayag is well known for its religious importance also because of Char Dham - Kedarnath Dham Temple where most of the people visit in the summer months, increasing risk to environment and pilgrims both.

Hence, for this study, Forest areas in Mandakini Valley (see Figure 1) is considered for Forest Fire Risk Zonation and proposing Remote Sensing & GIS technology based platform to control, mitigate and effective management of Forest Fires.

Rudraprayag District Mandakini Valley

Figure 1 : Study Area

Table: Area Statistics

Year	2017	2019
Total Geographical Area (sq.km)	1984	1984
Forest under Very Dense Forest (sq.km)	252	252
Area under Moderate Dense Forest (sq.km)	580	580
Area under Open Forest (sq.km)	309	310.17
Total Area under Forests (sq.km)	1141	1142.17
% of Geographic Area	57.51	57.57

Source: FSI Report

3. Approach & Methodology

GIS integrated with Indian Remote sensing Satellite (IRS) systems covering IRS-P6, IRS-1D, and data given by TERRA/AQUA Moderate resolution Imaging Spectro radiometer (MODIS), National Oceanic and Aeronautic Administration - Advanced Very High Resolution Radiometer (NOAA-AVHRR), Defense Meteorological Satellite Program-Operational Line scan System (DMSP-OLS),

Environment Satellite (ENVISAT) are extremely useful in forest fire detection, active fire progression monitoring, near real time damage assessment, and mitigation planning. GIS & Satellite remote sensing with its synoptic and temporal coverage can augment the ground operations in terms of fire detection, damage assessment and mitigation planning in a time and cost effective way.

Hence, it is proposed to perform Fire Risk Zonation and implement an **integrated GIS Platform** using ArcGIS technology for Rudraprayag Forest Department to meet requirements of Forest Fire Risk Zonation for planning and integrated framework for automated Fire Alerts & Early Warnings for efficient Mitigation / prevention of Forest Fires.

Following approach was used to implement this framework:

a. Forest Fire Risk Zonation

b. Framework for automated Early Warnings, support mitigation activities

To implement this, following software were used

a. ArcGIS Desktop and ArcGIS Spatial Analyst Extension

b. ArcGIS Enterprise Server technology

For Fire Risk Zonation, a number of other related layers were required. Framework was created using ArcGIS Platform to access and use these layers, already available in the form of services with national / international agencies like ISRO/ Bhuvan, NASA, USGS etc. Wherever information was not available in service, it was generated with the help of Primary layers like DEM, Satellite Imagery (Cartosat-2, Landsat 8, Digital Globe etc.). All Forest related layers like Forest Boundaries, Forest Cover, Forest Density, Forest Types, Forest Assets were taken from FSI, NRSC (Bhuvan) and Uttarakhand Forest Department (Srivastava et al, 2005).

Fire Risk Zonation was performed using following data:

a. Primary Data generated using ASTER DEM, Basemap layers and GIS tools

- Demarcation of Mandakini Valley Catchment using ASTER DEM
- Generation of Slope, Aspect, Drainage Network
- Proximity to Villages, Roads, Rivers, Agriculture Farms

b. Secondary Data Collection

- Survey of India - Administrative Boundaries
- Forest Survey of India - Forest Boundaries, Forest Types, Crown Density, Forest Assets etc.
- NRSC - Satellite Imagery, Landuse/Landcover, Roads, Infrastructure, PoI

- Esri ArcGIS Online – Live Feeds of Earth Observation data from Global / National sources like NASA, FEMA, MODIS, IMD, ISRO, High Resolution Imagery, Roads Network, Times Series services of Sentinel-2, LandSat, Digital Globe, MODIS Fire Feeds, Rainfall etc

An GIS Platform was implemented integrated with generated data layers and Fire Risk Zonation. Provision was created to access and use Live Feeds from NASA, IMD, ISRO, NRSC to identify Fire and generate Fire Alerts.

A series of Web and Mobile Apps were configured to share and access fire alerts with exact location of fires and access details of resources required to mitigate forest fires anf efficient response and management of fires.

4. Discussion & Results

4.1 Primary Data Preparation

4.1.1 Establishment of boundaries using ASTER DEM

ASTER GDEM is an easy-to-use, highly accurate DEM (15 m resolution) provided by NASA, covering all the land on earth, and available to all users regardless of size or location of their target areas. It can be used for building terrain and demarcation of catchment areas, placement of watch towers, view shed analysis and environmental monitoring etc. This data was used to demarcate Mandakini River Valley and generate rivers, and terrain map for the study area. (Garg et al, 2001)

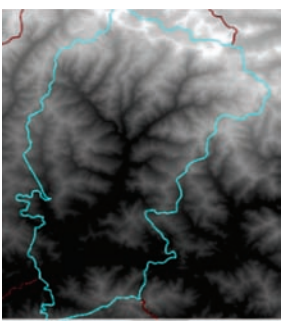


Figure 2: High Resolution DEM (ASTER Data Source: NASA, ESRI)

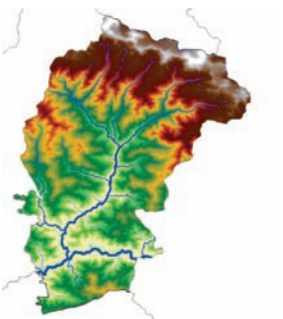


Figure 3: Generation of Drainage from ASTER DEM

4.1.2 Preparation of other Map layers required for preparation of Area Profile

For Fire Risk Zonation, a number of other related layers were required. Framework was created using ArcGIS Platform to access and use these layers, already available in the form of services with national / international agencies

like ISRO/ Bhuvan, NASA, USGS etc. Wherever information was not available in service, it was generated with the help of Primary layers like DEM, Satellite Imagery (Cartosat-2, Landsat 8, Digital Globe etc.). All Forest related layers like Forest Boundaries, Forest Cover, Forest Density, Forest Types, Forest Assets were taken from FSI, NRSC (Bhuvan) and Uttarakhand Forest Department (Srivastava et al, 2005).

4.1.3 Forest Boundaries & Forest Cover

For the Study area, Forest Boundaries and Forest Cover Map was integrated by accessing services from Forest Survey of India (FSI) and Uttarakhand Forest Department.

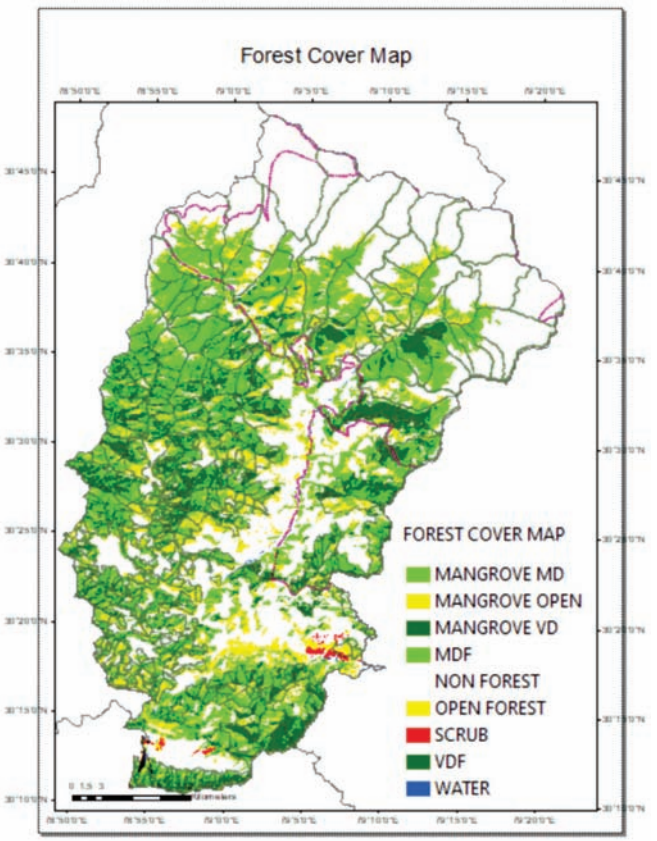


Figure 4: Forest Boundary and Forest Cover Map

4.1.4 Terrain Profile

Terrain plays a critical role in Forest Fires. Hence, following data layers were also generated using ASTER DEM with the help of ArcGIS Platform:

- Slope Map (in Degrees)
- Aspect Map (Surface Direction)
- Hill shade (Considering 315 Azimuth and 45 Degree Altitude Angle of light source)
- Contours (Interval 5 mtr.)

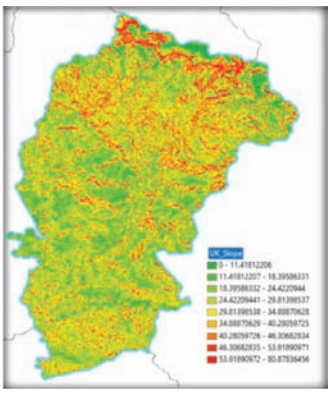


Figure 5: Slope Map (in Degrees)

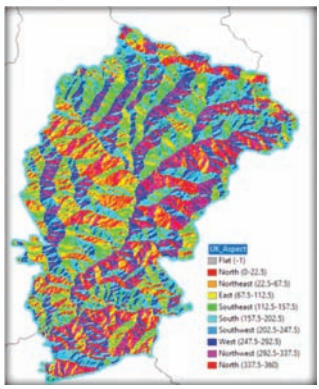


Figure 6: Aspect Map

Figure 7: Hill shade Map

Figure 8: Contour Map

4.1.5 Preparation of multi-temporal Land use / Land cover map

The nationwide land use/land cover (LULC) map is generated by ISRO / Bhuvan using AWiFS data. This **multi-temporal** data is provided through ISRO / Bhuvan Portal in the form of web services. Framework implemented for seamless access of these services and perform overlay analysis w.r.t other critical layers of the Study Area. Time-series data to be accessed for necessary comparison. Different Satellite Imagery were also accessed and used for preparation of Landuse / Landcover Map. (Garg et al, 2001)

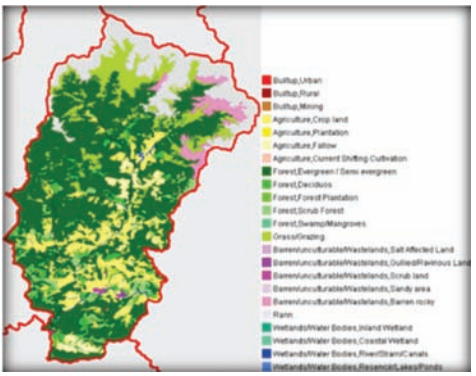


Figure 9: Landuse / Landcover Map (2011-12) accessed through ISRO / Bhuvan Portal

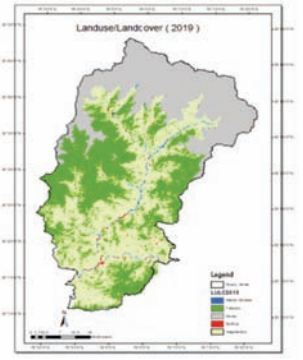
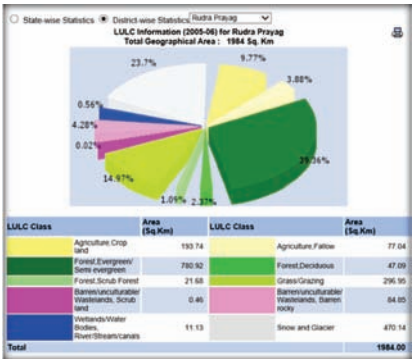
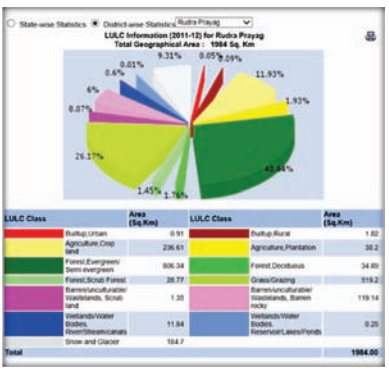


Figure 10: Landuse / Landcover Map (2019) generated using Sentinel data



LULC Class	Area (Sq.Km)	LULC Class	Area (Sq.Km)
Agriculture,Crop land	193.74	Agriculture,Fallow	77.04
Forest,Evergreen/ Semi evergreen	780.92	Forest,Deciduous	47.09
Forest,Scrub Forest	21.68	Grass/Grazing	296.95
Barren/unculturable/ Wastelands, Scrub land	0.46	Barren/unculturable/ Wastelands, Barren rocky	84.85
Wetlands/Water Bodies, River/Stream/canals	11.13	Snow and Glacier	470.14
Total			1984.00

Figure 11: *Landuse / Landcover Statistics (2005 -06)*



LULC Class	Area (Sq.Km)	LULC Class	Area (Sq.Km)
Builtup,Urban	0.91	Builtup,Rural	1.82
Agriculture,Crop land	236.61	Agriculture,Plantation	38.2
Forest,Evergreen/ Semi evergreen	806.34	Forest,Deciduous	34.89
Forest,Scrub Forest	28.77	Grass/Grazing	519.2
Barren/unculturable/ Wastelands, Scrub land	1.35	Barren/unculturable/ Wastelands, Barren rocky	119.14
Wetlands/Water Bodies, River/Stream/canals	11.84	Wetlands/Water Bodies, Reservoir/Lakes/Ponds	0.25
Snow and Glacier	184.7		
Total			1984.00

Figure 12: *Landuse / Landcover Statistics (2011 -12)*

Source : Bhuvan, NRSC

4.2 Secondary Data Collection and Integration

Data is backbone for performing various analysis and arriving at various conclusions.

Key challenge of any such study is availability of desired data in required format specifically as required for scientific calculations and integration with various models & algorithms for analysis and testing. Archived Data was collected from various sources under following categories (Garg et al, 2001)

- Administrative Boundaries covering Districts, Blocks, Villages, Settlements etc.
- Transportation Network – Highways, Roads, Streets and other connectivity
- Infrastructure like Schools, Hospitals, Banks, Facilities, etc.
- Historical Hazards

Figure 13: Village Map
Source : Bhuvan, NRSC

Figure 14: Road Network

Figure 15: Critical Infrastructure

1.3 Preparation of Standardized Forestry Data Model

A Standardized Forestry Data Model was designed in compliance with **National Design Code** for storing and managing Forestry Data. In this Standardized Data Model, it was ensured to have data Accuracy, Scalability, Integrity and scale / projection in order to minimize any data integration issues. As Forest Department needs to store secured data also, provision was created to ensure Data Security. In general, an integrated and Standardized Data Warehouse based on proposed National Design Code covering Spatial / Non Spatial information was implemented to store and share information for entire organization hierarchy.

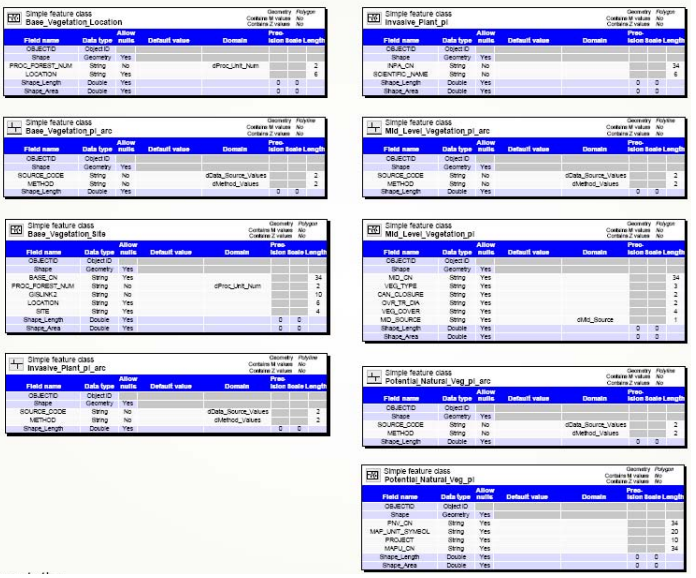


Figure 16: Forestry Data Model

4.4 Integration of Live Feeds from NASA and FSI on Fire Alerts

For seamless access of Forest Fire related information, provision was created for integration of Global Fire Feeds from MODIS by NASA in an automated way.

MODIS Global Fires is a product of NASA's Earth Observing System Data and Information System (EOSDIS). It is a part of NASA's Earth Science Data. EOSDIS integrates remote sensing and GIS technologies to disseminate global MODIS hotspot/fire locations to fire managers and other stakeholders around the World. Historical Data is also provided from MODIS Satellite & NASA FIRMS live feeds. Additional useful information like Burn Index available through NASA was also integrated. All inputs were integrated to demarcate vulnerable areas.

Live Feeds from MODIS were integrated and results were compared with historical Fires

Live Feeds were integrated from MODIS Satellite & NASA FIRMS live feeds.

Historical incidents were collected from respective Disaster Management & Forest Department.

All collected data from Primary & Secondary Sources was integrated with Historical Data of Hazards in past collected for different Hazards in the Area.

Hazard data collected during field visits using GPS was also integrated and geotagged with existing map layers. This data was analyzed w.r.t current observations from Field Study and Hot Spot Analysis was generated to identify Multi-Hazard Vulnerabilities.

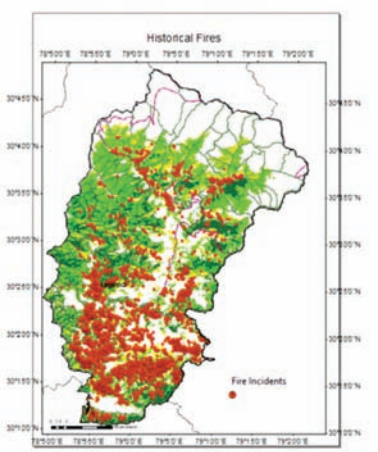


Figure 17: *Historical Fire Incidents*

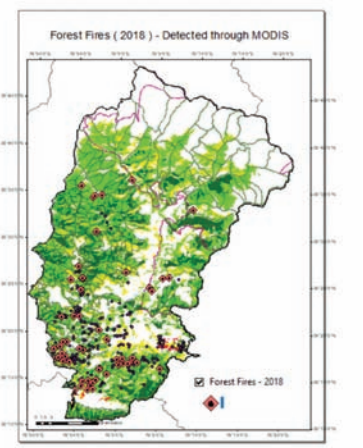


Figure 18: *MODIS Live Feeds*

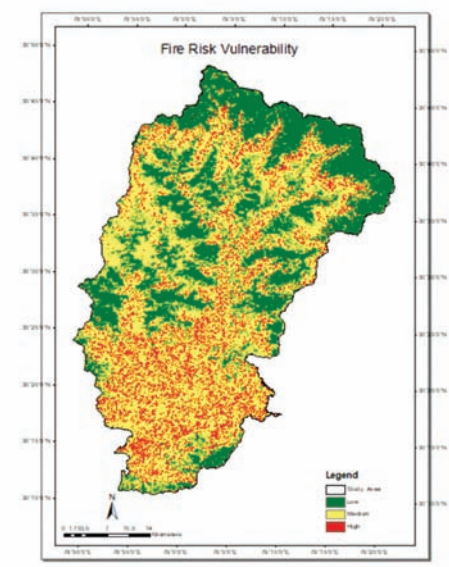


Figure 19: Forest Fire Risk Vulnerability Map

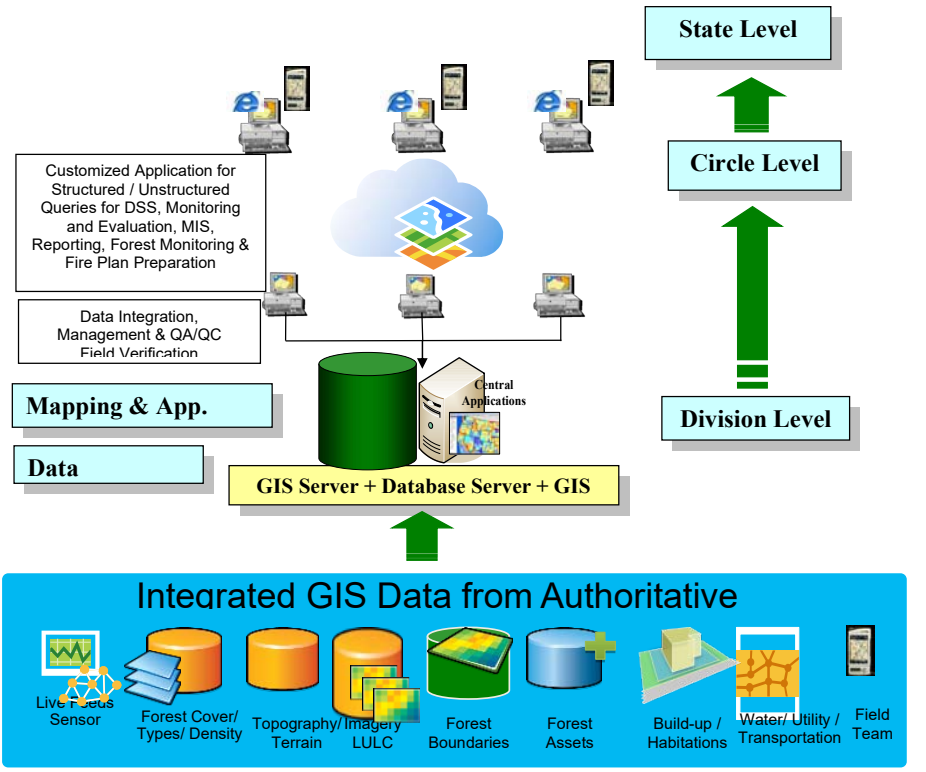
4.5 Establish GIS Platform for Forest integrated with Web Apps, Mobile Apps & Dashboards

All collected information was integrated and a Forestry Platform was configured integrated with Forestry Data, Gallery, Standard Web Services, Apps & Maps using available data to meet the requirements of Forest Department. This GIS Platform framework was configured so as all stake holders and members of Forest Department could Access and Update Forest data, web layers, create apps, and share the maps, layers, and apps with others. Secured Access & User Management was also provided along with required Privileges.

Following features were incorporated to ensure seamless access and sharing of information and take action in time:

- Configuration of Platform as single Gateway access
- Configuration of User Management and Access Control for Secured access of Maps & Apps by Authorized Users
- Implement Framework for Users to access, update and publish web maps, add layers, create apps, and share the maps, layers, and apps with others.
- Provision will be created to implement a Gallery of Apps, Basemaps, Imagery, Live Feeds and tools to develop Apps and extend them further.
- Configuration of Gallery of Forest Contents with Web Apps, Mobile Apps and Dashboard integrated with data from various sources.

Proposed GIS based Solution – Flow Diagram



5. Conclusion & Recommendation

The present study proposes an integrated GIS Platform for Forest Fire Zonation and efficient Management by integrating Spatial / Non-Spatial parameters which have direct / indirect influence on the occurrence of fire. It recommends to access real-time feeds to have real time alerts with exact location for efficient response in order to bring fires under control and minimize losses.

This GIS based Platform provide information in real-time to all stakeholders using Web & Mobile Apps from the field. This Platform generates automated alerts for the early warning and send triggers to forest officials and stakeholders in analyzing and mitigating fires efficiently.

Overall, **it proposes a GIS based framework for identification of fire-prone areas in forests, leverage seamless access to live feeds from national/global sources to generate automated alerts and early warnings and leverage GIS platform for its effective monitoring, response & management.**

6. Annexure

Table II : List of Historical Forest Fire Incident (2018)

Circle	Division	Range Name	Block	Beat	Forest Block	Compartment	Count of Incidents
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	AGASTMUNI RANGE	AGASTMUNI RANGE	AKHODI BEAT			1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	AGASTMUNI RANGE	AGASTMUNI RANGE	BADALPUR BEAT	MAIKHANDA_ FIRST	4a	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	AGASTMUNI RANGE	AGASTMUNI RANGE	NF		NF	7
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	CHAURAS BEAT	CHAURAS	4	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	CHHANTIKHAL BEAT	CHHANTIKHAL	2	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	CHHANTIKHAL BEAT	PHARASU	Pharasu	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	1	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	2	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	3	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	4	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	5	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	7	3
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	6a	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	6b	3
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	8a	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	MUJULI BEAT	SYANRI	8b	4

Circle	Division	Range Name	Block	Beat	Forest Block	Compartment	Count of Incidents
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	NARKOTA BEAT	NARKOTA	2	3
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	NARKOTA BEAT	NARKOTA	1a	3
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	NARKOTA BEAT	NARKOTA	1b	4
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	NF		NF	26
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	NF	SYANRI	NF	7
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	SYANRI BEAT	SYANRI	9	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	SYANRI BEAT	SYANRI	10	3
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	SYANRI BEAT	SYANRI	11	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	SYANRI BEAT	SYANRI	12	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	KHANKRA RANGE	KHANKRA RANGE	SYANRI BEAT	SYANRI	13	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	DAMARGAD BEAT	DAMARGAD	4	3
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	LANGAD BEAT	LANGAD	6a	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	LANGAD BEAT	LANGAD	6b	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	LANGAD BEAT	LANGAD	7a	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	LANGAD BEAT	LANGAD	7b	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	LASTERGAD BEAT	LASTERGAD	5	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	LASTERGAD BEAT	LASTERGAD	6	1

Circle	Division	Range Name	Block	Beat	Forest Block	Compartment	Count of Incidents
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	LASTERGAD BEAT	LASTERGAD	7	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	NF		NF	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	NF	PAJANA	NF	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PADAMKHAL-I BEAT	PADAMKHAL	7	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PADAMKHAL-II BEAT	PADAMKHAL	8	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PAJANA BEAT	PAJANA	5	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PAJANA BEAT	PAJANA	6	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PAJANA BEAT	PAJANA	7	3
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PAJANA BEAT	PAJANA	10	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PAJANA BEAT	PAJANA	11	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PAJANA BEAT	PAJANA	12	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PAJANA BEAT	PAJANA	13	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PAJANA BEAT	PAJANA	4a	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	NORTH_ JAKHOLI RANGE	NORTH_ JAKHOLI RANGE	PAJANA BEAT	PAJANA	4b	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	BHUNKA BEAT	DHANPUR_ SECOND	4	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	BHUNKA BEAT	DHANPUR_ SECOND	5	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	DOBHA BEAT	DHANPUR_ SECOND	9b	1

Circle	Division	Range Name	Block	Beat	Forest Block	Compartment	Count of Incidents
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	NAGRASHU BEAT	DHANPUR_ FIRST	1a	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	NAGRASHU BEAT	DHANPUR_ FIRST	1b	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	NF		NF	15
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	POKHARSARI BEAT	RUDRAPRAYAG	7	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	POKHARSARI BEAT	RUDRAPRAYAG	8	4
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	POKHARSARI BEAT	RUDRAPRAYAG	9	4
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	POKHARSARI BEAT	RUDRAPRAYAG	11	3
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	POKHARSARI BEAT	RUDRAPRAYAG	10a	3
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	RUDRAPRAYAG BEAT	RUDRAPRAYAG	1	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	RUDRAPRAYAG BEAT	RUDRAPRAYAG	2	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	RUDRAPRAYAG BEAT	RUDRAPRAYAG	3	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	RUDRAPRAYAG BEAT	RUDRAPRAYAG	5	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	RUDRAPRAYAG BEAT	RUDRAPRAYAG	6a	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	RUDRAPRAYAG RANGE	RUDRAPRAYAG RANGE	RUDRAPRAYAG BEAT	RUDRAPRAYAG	6b	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	BHARADARIGAD BEAT	BHARADARI	5	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	BHARADARIGAD BEAT	BHARADARI	16	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	BHARADARIGAD BEAT	BHARADARI	17	2

Circle	Division	Range Name	Block	Beat	Forest Block	Compartment	Count of Incidents
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	BHARADARIGAD BEAT	BHARADARI	18	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	BHARADARIGAD BEAT	BHARADARI	19	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	BHARADARIGAD BEAT	BHARADARI	6a	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	JAKHAL BEAT	JAKHAL	5	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	JAKHAL BEAT	JAKHAL	6	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	JAKHAL BEAT	JAKHAL	10	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	JAKHAL BEAT	JAKHAL	4b	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	JAKHAL BEAT	JAKHAL	7b	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	NARSING BEAT	NARSING	4	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	NARSING BEAT	NARSING	10	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	NARSING BEAT	NARSING	11	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	NF		NF	7
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	NF	JAKHAL	NF	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	NF	LESWALTA	NF	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	NF	NARSING	NF	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	RATANPUR BEAT	RATANPUR	8b	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	SARALVAN BEAT	JAKHNI	4	1

Circle	Division	Range Name	Block	Beat	Forest Block	Compartment	Count of Incidents
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	SARALVAN BEAT	LONGA	2	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	SARALVAN BEAT	LONGA	21	2
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	SARALVAN BEAT	LONGA	1a	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	SARALVAN BEAT	LONGA	1b	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	SARALVAN BEAT	LONGA	3a	1
GARHWAL CIRCLE	RUDRAPRAYAG FOREST DIVISION	SOUTH_ JAKHOLI RANGE	SOUTH_ JAKHOLI RANGE	SARALVAN BEAT	LONGA	3b	1
Grand Total							198

Source FSI / NASA : http://117.239.115.41/smsalerts/index.php

7. References

1. Agritech Portal -http://agritech.tnau.ac.in/agriculture/agri_majorareas_disastermgt_forestfire.html
2. Daily Fire alert by NASA: www.nrsa.gov.in/rsgisweb/forestfires/dailyforestfires.html
3. FSI Van Agni : http://117.239.115.44:90/fsi_fire/fire.html
4. Forest Survey of India: http://117.239.115.41/smsalerts/index.php
5. Forest Fires Monitoring Programme, FSI: http://fi-re.in/smsalerts/dashboard.php
6. Forest Survey of India - STATE OF FOREST REPORT 2019,
7. Vulnerability-of-Forest-Fire-February-2017, Forest Survey of India (Ministry of Environment Forest and Climate Change)
8. Anon, 1999. Aviation and forest fire management, Forest fire fundamentals, Ontario Ministry of Natural Resources, 1999. (www.mnr. gov.ca)
9. Garg, J.K; Murthy T. V. R; Kimothi, M. M Singh, T. S. (2001). Environmental Hazard Zonation and Optimal Resources Use in the Alaknanda Valley, Garhwal Himalaya using Remote Sensing and GIS Techniques
10. Rawat, G.S, November 2003, Fire risk assessment for forest fire control management in Chilla forest range of Rajaji national park, Uttaranchal, India International Institute for Information Science and Earth Observation (ITC) Enschede The Netherlands M.Sc Thesis 2003

11. Sahana M; Ganaie T A: GIS-based landscape vulnerability assessment to forest fires susceptibility of Rudraprayag district, Uttarakhand, India (2017)
12. Srivastava, K. Sanjay, December 2005, A Geo-Information System Approach for Strengthening Conservation Measures in Protected Area with Reference to Forest Fire.

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'SAMARTH'- An Annual Awareness Campaign for Building Resilience and Reducing Vulnerability

"There is no harm in hoping for the best as long as you are prepared for the worst" -Stephen King

Rana, D. C.[1], Yadav, N[2]., Sharma, V[3]. and Sharma, G[4].

1. Background- The Hazard, Vulnerability and Risk Profile of Himachal Pradesh

Himachal Pradesh is one of the most multi-hazard prone States of India. Situated in the lap of the Himalayas between latitude 30°22 to 33°12' N and 75°45'E to 79°4'E, the state is prone to frequent natural and human-made hazards of various intensities. Their impacts on the people, the land and its resources are the gravest concerns, which hamper the development of the state. The state is crisscrossed by tectonic and neo-tectonic faults, shear zones and thrusts, which make it extremely vulnerable to earthquakes and landslides particularly, of varying magnitudes.

Four major perennial rivers of the Himalayas– Chenab, Ravi, Beas and Satluj either originate or pass through the State. Numerous large and small tributaries feed these rivers as also three other major rivers of the region – Indus, Yamuna and Ganga. The entire State has a hilly terrain with varying altitudes, geomorphology, temperature and climatic conditions, making the State prone to various hydro-meteorological hazards like flood, flash flood, cloudbursts, droughts, forest fire, cold wave, avalanche and frosts. Climate change with rising temperature and uncertain rainfall is impacting the frequency and intensity of these hazards, creating new hazards like Glacial Lake Outburst Floods (GLOF) leaving indelible impacts on the rich flora and fauna, horticultural and agronomic practices and human and animal health (Himachal Pradesh State Disaster Management Authority [HPSDMA], 2017:10-12)[1].

The High Powered Committee on Disaster Management (National Centre For Disaster Management, 2002: 132[2]) has identified 33 hazards for our country, out

of which Himachal Pradesh is vulnerable to 25 different hazards. Vulnerability to natural hazards coupled with socio-economic vulnerability of people highlights the need for evolving a comprehensive plan for building the capacities of the Himalayan community for disaster management. To safeguard the people of Himachal Pradesh from the ever growing risk of disasters, it is crucial that capacity building initiatives are planned and promoted to make communities self-reliant to cope-up with disasters.

Keeping in view the hazard, vulnerability and risk profile of the State, the Himachal Pradesh State Disaster Management Authority (HPSDMA) launched a novel Mass Awareness Campaign titled as 'Samarth' in October 2011. As a symbol of camaraderie with the global efforts to observe the celebrations related to the International Day of Disaster Risk Reduction (IDDR), the HPSDMA conceptualized and launched an innovative 'Annual Mass Awareness Campaign on Disaster Risk Reduction', under the name 'Samarth'.

2. Evolution of 'Samarth'-The Annual Mass Awareness Campaign

Prior to 2010, there was no well-defined setup for disaster management in the State. Under UNDP's Disaster Risk Management Project, Sh. D.C. Rana was appointed as the State Project Officer who demonstrated commendable administrative will to spearhead the cause of capacity building for effective disaster risk reduction in the State. Sh. Navneet Yadav was appointed as the Training and Capacity Building Associate under the above mentioned project. He envisioned a mass-awareness campaign, which would create an enabling environment to support capacity building initiatives on disaster risk reduction for the State; and proposed the name 'Samarth' to organize multifarious activities involving multiple stakeholders. Financial approval was sought to organize this event, and this commitment came a long way and took considerable efforts to get institutionalized as an Annual event at the State level.

'Samarth' is a Hindi word which refers to the capability of someone to do something. The Samarth campaign commenced from 8th of October 2011, marking the 6th anniversary of the Kashmir Earthquake. Through Samarth, the people and the government of Himachal Pradesh extended solidarity with the global community and its initiatives observed on the occasion of the IDDR.

The IDDR initiated in the year 1989, after a call by the United Nations General Assembly for a day to promote a global culture of risk-awareness and disaster reduction. Held every year on 13 October, the day celebrates how people and communities around the world are reducing their exposure to disasters and raising awareness about the importance of reining in the risks that they face[3].

By launching this programme, the HPSDMA aims at making the people of the state more aware and prepared to reduce the underlying risks of disasters. Different awareness generation and capacity building programmes are organized at State, district and community level(s) with the involvement of stakeholders like District Disaster Management Authority(s) of respective districts, Department of Education, Department of Health & Family Welfare, Himachal Fire Services, Department of Civil Defence, Department of Information and Public Relations, Department of Panchayati Raj, the Municipal Corporation(s), Nehru Yuva Kendra Sangathan, Himachal Pradesh University, etc.

This state-wide campaign is marked by the organization of variety of events and activities in the month of October every year. A range of Information, Education and Communication (IEC) materials are developed and disseminated among different target groups to enhance their knowledge and understanding of disaster risk reduction.

During this period, the HPSDMA also launches an awareness drive using print and Electronic Media, Social Media, Radio, Television and alternative media like street plays. Different types of events like solidarity marches, inter-school quiz and photography competitions, thematic workshops, etc. are organized at various levels. In order to achieve the objectives of 'Samarth', it is very crucial for every citizen of Himachal Pradesh as well as all the District Disaster Management Authorities, Line Departments, Media Houses, Academic & Research Institutions, Corporate Houses, GOs, NGOs and CBOs participate pro-actively in the campaign and contribute effectively to the process of making Himachal Pradesh a disaster resilient State.

3. 'Samarth' – A Reflection of Global Themes on DDR

In March 2015, the Sendai Framework for Disaster Risk Reduction (SFDRR) was adopted in Sendai, Japan. On this occasion, the United Nations International Strategy for Disaster Reduction (UNISDR) launched the Sendai Seven Campaign to endorse the seven targets of the SFDRR. It marked an opportunity for all, including governments, local governments, community groups, civil society organizations, the private sector, international organizations and the UN family, to promote best practice at international, regional and national level across all sectors, to reduce disaster risk and disaster losses. Post 2015 every year, the 'Sendai Seven Campaign' of the UNISDR emphasizes global action on these targets by celebrating the IDDR with a theme based on one of the seven targets.

The Samarth campaign is organized every year keeping the global themes centre stage. Table 1 enlists the broad themes around which these awareness generations cum capacity building programmes have been organized, which run parallel to the themes of the IDDR.

Table 1. Organization of Samarth Campaign: Aligned with the Global Themes for IDDR

S. No	Year	Themes for IDDR and 'Samarth'
1.	2011	Children and Young People are Partners in Disaster Risk Reduction
2.	2012	Women and Girls-The Invisible Force of Resilience
3.	2013	Living with Disability and Disasters
4.	2014	Older Persons and Disasters
5.	2015	Knowledge for Life
6.	2016	Target A:Reducing Global Mortality (#Live to Tell)
7.	2017	Target-B:Reducing the Number of Affected People (#Home Safe Home)
8.	2018	Target-C:Reducing Disaster Economic Losses in Relation to Global GDP (#Resilience for All)
9.	2019	Target-D:Reducing Disaster Damage to Critical Infrastructure and Disruption of Basic Services (#Build To Last)

4. Planning, Preparation and Execution of 'Samarth'

The initial discussions regarding Samarth begin from the first week of August. A meeting is held under the Chairpersonship of Additional Chief Secretary/ Principal Secretary (Revenue) which is moderated by Director-cum-Special Secretary (Revenue-DM). The staff and DRR consultants working in the State are also invited for this meeting. The theme for the IDDR campaign (for the current year) is discussed and ideas to design an innovative and relevant campaign are tabled. The DDMAs are also requested to share their ideas for organizing various events.

A number of novel activities/events are planned under the umbrella of the Samarth campaign, such as:

i. Mock drills at various educational institutions and office spaces
ii. Hands on session of fire safety and medical first aid
iii. Gram Sabha Meetings
iv. Citizens' solidarity march
v. Exhibition on equipments and technologies related to disaster preparedness and response.
vi. Sensitization workshops for various stakeholders (such as media personnel, personnel of folk theatre groups and so on)
vii. Organization of film festivals

viii. Thematic competitions for schools (such as quiz, slogan writing, poster making and essay writing, photography)
ix. Broadcasting of radio jingles in various FM Stations
x. Broadcasting of awareness videos on local cable network
xi. Organization of theme based gamified activities
xii. Organization of theme based street plays
xiii. Earthquake simulation by shake table van for general public's awareness and sensitization
xiv. Contests for developing innovative prototypes for disaster preparedness and response
xv. Contests for Leadership Awards in DRR sector
xvi. Workshops and conferences

The rationale is to create awareness and build knowledge and capacities of citizens in the most creative and constructive ways. Each year, the attempt is to add value and novelty to the events. After finalizing the events and activities at the State level, the DDMAs are formally informed to commence preparations for the event. Various stakeholder departments, NGOs, Inter-Agency Groups and the private sector collaborate to prepare for this event. The event takes its final shape with the concerted efforts of the DDMAs and all other stakeholder departments. Glimpses of the events held under 'Samarth' campaign in October 2019 have been showcased in figures one to six.

DRR in Hill Towns of NW Himalayas

As depicted above, such events characterize the 'Samarth' campaign at district and sub-divisional levels. Over the years, the outreach of the event has significantly improved. The event is covered by both print and electronic media. After culmination of the event, a detailed report is compiled by all the DDMAs and a comprehensive report is developed at the State level by HPSDMA. All the reports prepared from 2011-2019 are available for reference at HPSDMA's website, under the 'Events' section[4].

5. The Success Stories Attributed to 'Samarth'

Case example 1: Bridging the Gaps

Conceptualized in the year 2011, an exhibition was organized to showcase state-of-the-art technologies to deal with emergency and risk management. A renowned company through its kiosk showcased how the use of bikes, can be an efficient and sustainable investment to deal with contingency situations. The Himachal Pradesh Fire Services Department witnessed this first hand, and within a year the Department procured bikes for fire-fighting in narrow lanes

Figure 1. Quiz Plays and Film Shows on DRR

Figure 2. Citizens' Solidarity March

Figure 3. Practical Demonstration Sessions

Figure 4. Posters Designed by Students

Figure 5. Regional Workshop on Challenges of Materials

Figure 6. Development of IEC

and congested roads to minimize the delay in response time.

Case example 2. Learning through Engagement

While planning various activities for generating awareness among masses, it was felt that learning is most impactful when the learner is actively involved in the learning process. Hence, instead of just showcasing equipments of fire safety and sharing principles of medical first response through graphs, charts, models etc., it was decided to provide active-hand on learning experience to citizens, where they learn how to use fire extinguishers and practice giving Cardio Pulmonary Resuscitation (CPR) and learn other basics of medical first response. To enhance general knowledge and awareness about disasters and DRR, multimedia quiz has been developed to create an interactive and enriching platform for learning.

Case example 3. Inclusion of Folk Media-Localizing the DRR Knowledge

To enhance the outreach of activities and the knowledge and awareness on various issues related to DRR; for the past two year (2018 and 2019), HPSDMA and DDMAs have been involving the folk theatre groups to organize street plays at sub-divisional level on the IDDR theme of the year. In the year 2019, the folk theatre groups from all the districts of the state were invited for a sensitization workshop, where they were mentored to develop scripts on 'Safe Construction Practices'. A set of key messages were emphasized, which they included in their scripts for the plays conducted at sub-divisional levels. Street plays on the subject were conducted in far-flung tribal areas of Kinnaur, Chamba and Lahaul Spiti, which witnessed participation of scores of local populace.

Case example 4. Reaching Out to the Grass Root Level

Over the years the involvement of districts in this event has significantly improved. Official communication regarding this event reaches up to the Panchayat level. The impact has been such that the gram Sabha meetings which are organized on the 2nd of October every year, takes into account discussion related to disasters and risk reduction measures.

6. The Way Forward

'Samarth' aims to create a disaster resilient state. The aim now is to reach the most inaccessible and the most vulnerable communities. The success of this event has enabled the State to plan and conceptualize more of such programmes/. The HPSDMA and DDMAs have also been organizing various activities for awareness generation on April 4 every year, marking the anniversary of the Kangra

iv SMC-School Management Committee

Earthquake of 1905, which accounts for the largest death toll ever recorded during a disaster in the Western Himalayas.

The HPSDMA has made an initiative to observe 4th of April ('4/4') every year as Disaster Awareness Generation Day. All departments and districts have been requested to conduct various activities, events and sensitization programmes to ensure better preparedness of the stakeholders and the community.

References

1 Himachal Pradesh State Disaster Management Authority (HPSDMA).2017.State Disaster Management Plan, available at https://hpsdma.nic.in//admnis/admin/showimg.aspx?ID=76

2 National Centre For Disaster Management. 2002. The High Powered Committee on Disaster Management-A Report. Government of India.

3 Information accessed from the website https://www.unisdr.org/we/campaign/iddr. On January 12, 2020

4 The State level reports of the 'Samarth' campaign(2011-19) are available at the following link: https://hpsdma.nic.in/Index1.aspx?lid=5087&lsid=5246&pid=5117&lev=3&langid=1

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Use of Natural Resources for Disaster Risk Reduction

A case study on use of special species of bamboo plants for reduction of soil erosion caused by flash floods in Tripura

Arabinda Chaudhury[1] and Dr. Sarat Kumar Das[2]

Abstract

River bank erosion is one of the major threats to floods in Tripura. The young alluvial soil along the flood plains massive erosion along the river banks particular to the inhabitants and small landholding farmers. The case study undertaken in Madhya Krishnapur Gram Panchayat under Khowai district of Tripura stating how bamboo plantations could converted the erosion threat to risk reduction measures and provide opportunities of livelihood options to poor affected farmers. Now, Madya Krishnapur Panchayat is safe from river/cherra bank erosion and an example of best DRR practice for other similar vulnerable areas.

Keywords: *floods, erosion, bamboo plantation, risk reduction*

PRACTICE: *Using bamboo plants to arrest soil erosion*

IMPACT: *Villagers and school community are stabilizing river/ cherra bank*

REPLICATION: *Can be replicated with similar plants in flood prone areas*

Objective of Case Study:

- To promote science driven traditional coping practice
- To build sense of ownership
- To mobilize community for maintaining ecological balance
- To promote behavior change communication for natural resource management
- To make a reference for research and development

The river bank erosion tend to be a continuous process almost all flood plains in Tripura. Without this process rivers will not and change course. Land management patterns can change the . Vegetation cover can act to increase or

decrease channel migration rates. In many places, whether or not the banks are unstable due to human activities, people try to keep a river in a single place. This can be done for environmental reclamation or to prevent a river from changing course into land that is being used by people. One way that this is done by placing riprap or along the bank. A common natural method to reduce bank erosion is the re-introduction of native plant species in the area. The expansive root systems of these plants provide support within the soil and prevents erosion due to rain runoff.

Madhya Krishnapur GP under Teliamura RD Block, Khowai District is a gift of nature. It is situated some 15-18 KM away from the Atharamura Hill range. It is enriched with natural resources. The geographic area of the panchayat is 858.16 ha, total population is 4673 Nos. Almost 89.64 percent people are involved in agricultural practice and rest are engaged in Government service and other livelihood practice. Out of 1139 families, 1021 families are associated with agriculture farming. Sonali Cherra and Ashirambari Cherra passes through the GP area. People of the area are mostly farmers. They cultivate Rabi crops in the month December-March, Boro Rice in the month December - April and Aman rice in the month June – September. In short around development of the families are dependent on agriculture.

Since 2000, it was observed that depth of Khowai river as well as Sonai Cherra & Ashirambari Cherra are being decreasing due to silt reserve which resulted flood along with erosion of river and cherra bank. The main source of livelihood i.e. agriculture were in threat in short education of their children, health care of family members etc basic needs of the cultivator families were in risk.

During 2005 flood, 30.27 ha crop field was damaged which directly affected 142 families. But the flood during 2006 was less damaging. Yet, it damaged 1.12 ha agricultural land. Next year flood (during 2007), also caused damage to 17 ha agricultural land affecting 124 cultivators. In 2008, paddy and winter vegetables of 16 ha land was damaged. As per report, 2009 massive flood caused huge damage to paddy and vegetable. 64 ha of crop field was damaged affecting 580 cultivators . As per report of Sri Tapan Kr. Sarkar, Agri Assistant, Madhya Krishnapur Circle, continuous heavy rain during 05/10/2010 to 09/10/2010 damaged 12.2 ha crop field (partly/ fully).

In every flood situation, flood water carries sand and deposit it in the crop fields. So clearing of deposited sand is also another challenge for the small farmers. In 2011 flood, sand was deposited in 3 ha of crop land. Beside of it, 30 ha crop field was damaged which directly affected 200 families. So, flood was a nightmare for the poor farmers.

Bhubaneshwar Majiumder (57 years) and Praneshwar Majiumder also expressed ,*....some 30 years back the flood water from Ashirambari Cherra used to break the cherra bank and frequently entered in our crop fields resulting complete damage of our crops. Regular flood also used to damage the Teliamura – Ghilatali road. Massive flood compelled us to go for daily wages work (as all of our crops destroyed) and compromise with the education of our children.*

Beside of flood, erosion was also a major problem. Report states that 2005, 2007, 2008, 2009, 2011, 2017, 2018 & 2919 flood caused damage to 6.5 ha crops due to erosion. Fulbasi Das Para High school is a leading educational institution in that area. At present it has 105 Students. Some 20 years back, total area of the school was of 0.62 ha (approx.). But continuous erosion on the east side of the school left 0.46 ha (approx..) for the school. School authority was compelled to shift Class room and village road to the safer place. Mr. Sachindra Das one of the School Management Committee Member of the school told,'*..... once we decided to shift the school to safer place..".* In last 30 years few families had been migrated to other place due to erosion. Sri Kanu Debnath is one of them. Sital Sarkar (from Ward-4) one of the victims of erosion who was compelled to migrate from Madhya Krishnapur to Office Tilla, Teliamura.

But the families who are still living nearby the Ashirambari Cherra bank changed their mindset and decided to fight back. They raised the cherra bank from where flood water entered in their crop fields and destroyed their crops, their hopes and badly affected the education of their children by reducing their income. They gathered the silt which was reserved during flood in their crop fields and placed them alongside the cherra bank to raise the bank. They had a hope that it would work. But in next flood, heavy current of flood water swept the soil of raised cherra bank and washed away and again destroyed crop fields. Again they stood up on their feet. They analyzed the reasons of failure and started thinking how to stabilize the raised bank. Then Late Ratneswar Majumder, elder brother of Bhubaneshwar Majumder motivated them to start plantation of bamboo alongside of raised cherra bank. Then they decided to start innovative practices such as plantation of bamboo trees alongside the raised bank. Bhubaneswar Majumder, Late Ratneswar Majumder, Abhiram Majumder, Sachindra Biswas, Indra Kumar Biswas, Late Dinabandhu Saraka, Late Jogendra Sarkar, Thakurchand Biswas of Madhya Krishnapur and Uttar Krishnapur GP started planting of bamboo plants alongside the raised cherra bank of their land. Within a year, planted tree rapidly spread their roots and covered the raised bank as nets. Strange enough!!! In next year floods, there was no erosion in the raised bank. Roots of the bamboo tightly hold the soil of the raised bank. So, in next year monsoon season, flood water could not wash away the soil from raised bank and thus the crop fields were saved. Every year, the bamboo bushes are increasing by reproducing baby plants. The families started to use the full

grown bamboos for fencing of crop field and selling for income generation and so on. Now the risk of livelihood of the families has been reduced and sustained income gearing up their all-round development including education of their kids.

In 2010, Debendra Biswas, a senior citizen (80 years old) of the area and Krishnadhan Sarakar also planted a good number of bamboos alongside the cherra bank. Now these bamboo plants created a natural fence by spreading its roots and tightly hold the soil. Result was tremendous. There was no erosion in last 7 years.

Once Mahatma Gandhi quoted, *"The forest is a peculiar organism of unlimited kindness and benevolence that makes no demands for its sustenance and extends generously the products of its life and activity; it affords protection to all beings."*

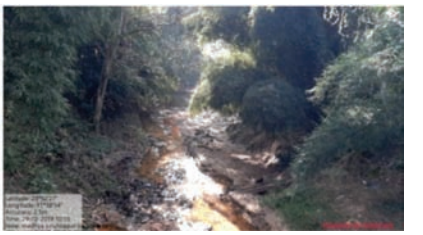
People sharing the success story

Pic.1: Bubaneswar Majumder sharing the story of success

Pic. 2: Debendra Biswas explaining his experience

Pic.3: SMC Members of Fulbasi Das High School owned the program

Success motivated to sustain the practice



Pic.5: Bothe cherra bank protected by bamboo bushes

Pic.6: Raised cherra bank with planted bamboos

Pic.7: Raised cherra bank with planted bamboos safeguarding crops

Pic.4:Future generation decided to take care of future silent friends (bamboo plants)

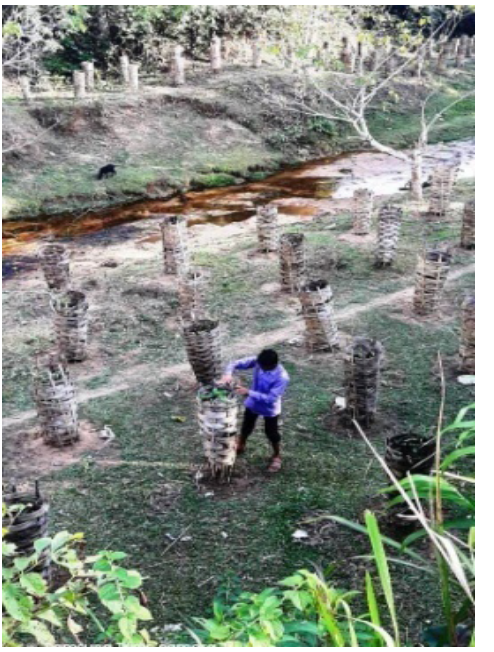
Pic.8: Ongoing plantation alongside of old plants

These practices clearly show that as nature has created the problem, nature has gifted the solution also. The community Madhya Krishnapur and North Krishnapur noticed that erosion in raised cherra bank of Sri Bhubaneswar Majumder, Late Ratneswar Majumder, Abhiram Majumder, had been reduced and erosion in the land of Krishnadhan Sarkar & Debendra Biswas had also been notably reduced and it was because of planted bamboo bushes. That fact motivated them enough.

New Drive: Endless effort of Forest Department to make the Earth green is really appreciable. On 19/07/2019, under MGNREGA, JALA SHAKTI ABHIYAN a massive plantation program was carried on by Forest Department in collaboration with local School and people in both side of river /cherrra bank to avoid erosion. Sri Tutan Debnath, Forester, BO, Teliamura informed that total 2500 Nos plants were planted alongside the Ashirambari Cherra. During the mega plantation drive, SMC Members, Students, teachers of Fulbasi Das Para High School and their guardians were also actively involved. Now, the school community is taking care of the baby bamboo plants. Even, beside of the school community, nearby families / guardians of students are also taking care of the baby plants. Madhya Krishnapur GP has also taken massive drive to ensure proper drainage of rain water to avoid water logging. Beside of it, to promote livelihood of the farmers, land development drive has been undertaken under MGNREGA.

Plantation drive by Forest Deptt.

All these practices (plantation of bamboo trees, excavation of katcha channel, land development for agricultural purpose) triggered a ray of hope among the students, guardians, teachers and small farmers who were at risk of erosion or flood. They are in hope that once the baby plants will grow enough it will protect their school, their livelihood by protecting flood water from entering in the crop fields, by protecting cherra bank from erosion and by draining rainwater. Selling of bamboo on other hand will enhance their income. Sustainable income will capable them to continue education of their kids.



Sign of ownership by the community

Panchayat is also motivating the community people to plant more trees. Mr. Prantosh Sarkar, one of the community leader of Madhya Krishnapur GP quoted ,'*....families realized the effectiveness of plantation. It is low cost and eco-friendly. So they themselves are practicing. Even they are also taking care of the planted bamboo plants as these plants stands as friend to protect their houses & crop fields and generating income....*"

SMC Members, students, teachers of Fulbasi Das Para High School and even guardians of the students are closely monitoring and nursling the baby plants. When asked, Sri Kartik Das, a student of class-IX of Fulbasi Das Para High School replied,' *.....we are taking care of these plants. We obstruct, if any one comes to tie the rope of cows, goats in the fences of baby plants. It is our resource. These plants are safeguarding our school from erosion."* Then he threw his concern," *...tell us, otherwise where our younger brothers and sisters will go for study if the school erodes?'* Community as a whole has owned the plantation drive for their own interest. On 04/01/2020, In the SMC meeting, all members have decided to protect and nursling of the baby plants. Ownership is the only way to sustain the practice. Smt. Sabitri Debnath, Teacher In charge of Fulbasi Das Para High School commented," *while teaching our students in classes, we are sensitizing them about importance of plants for our survival...*"

Success of plantation (carried out by particular families in the village) changed their mindset and accumulated strength to fight back and succeeded. Mr Amar

chand Biswas, Community leader of Madhya Krishnapur GP opined that *after proper hazard , risk analysis and capacity analysis if plantation drive is taken , it might reduce erosion. In short, we should adopt science based new practice keeping balance with the nature.*

Plantation under MGNREGA

Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. In order to mitigate the impact we need to take action now—before the next disaster—to reduce human and financial consequences later (analyzing risk, reducing risk, and insuring against risk). It is important to know that heavy rainfall may trigger flash flood in the Sonai Cherra and Ashirambari Cherra which could cause massive land erosion in the east side of Fulbasi Das Para High School. But the planted bamboos will reduce the velocity of flood water hitting to the cherra bank where the school is situated. Thus no erosion or less erosion may occur. Finally the school would be protected. Further that traditional coping practice may be promoted to minimize erosion which is low cost. It may generate livelihood also. In short local available resources should be utilized in the best way.

References

1. The Atharamura Range starts from Amarpur Sub-division of Gomati District and then enters the Khowai Sub-division of Khowai and runs along the border of West Tripura and North Tripura District. It is a southern extension of the Siwalik Hills.
2. Report of Agri Assistant, Madhya Krishnapur Circle, Teliamura Agri Sub Division, Khowai District, Dated: 29/04/2005.
3. Damage report of Agriculture Deptt, Krishnapur circle, Teliamura Agri Sub-division Vide No.F.11(ASO)/KSP/2005-06/88, Dated: 30/05/2006.

4. Report of Village Level Worker (VLW), Madhya Krishnapur GP, Teliamura Agri Sub Division, Dated: 18/06/2007.
5. Report of Village Level Worker (VLW), Madhya Krishnapur GP, Teliamura Agri Sub Division, Dated: 03/11/2008.
6. Damage report of Agriculture Deptt, Krishnapur circle, Teliamura Agri Sub-division Vide No.F.11/ASO/KSP/06-07-08, Date: 23/03/2009.
7. Report of crop damaged by flood in different years at Madhya Krishnapur GP Report of Agri Assistant, Madhya Krishnapur Circle, Dated: 11/10/2010
8. Crop Damage report of Agriculture Deptt, M Krishnapur circle, Date-11-10-10
9. Report on Natural Calamity submitted by Agri Asst. Madhya Krishnapur, Date-27-05-2011
10. Report of crop damaged by flood in different years at Madhya Krishnapur GP Report of Agri Assistant, Madhya Krishnapur Circle, Dated: 11/10/2010
11. Information regarding case study on Disaster Mitigation (Vide No.F.3-1/Dev/Gen/SDFO/TDS/2019-20, Dated:09/01/202020)
12. Work Sanction copy,VideNo.30(41)PO/BDO/TLM/MGNREGA/2018-19/13547-51, Date:13/09/2019
13. Work Sanction copy,Vide No.30(41)PO/BDO/TLM/MGNREGA/2018-19/12084-89, Date: 03/08 / 2019
14. Work Sanction copy, Vide No.30(41) BDO/TLM/MGNREGA/2018-19/11558-63, Date: 12/07/ 2019
15. Work Sanction copy, Vide No.30(41) BDO/TLM/MGNREGA/2018-19/3869-74, Date:24/06/2019
16. SMC Meeting Minute held on 04/01/2020
17. Science Text Books of Tripura Board of Secondary Education class-VI, VII, VIII

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Leveraging Geo-Spatial Technologies for Disaster Management and Emergency Response for Building Resilient Communities in Mandakini Valley

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Abstract

Mandakini River Valley in Uttarakhand State by virtue of its geographical setting, is one of the highly disaster-prone area. This area is vulnerable to various hazards like landslides, forest fires, cloudbursts, flash-floods etc. which are seasonal phenomena that strike at a certain period every year with high frequency, leading to various disasters.

As per Sendai Framework for Disaster Risk Reduction, while the hazard posing a disaster risk – a flood, earthquake, cloud burst etc. generally cannot be influenced, the impact and frequency of disasters can be significantly reduced by effective use of technology and through coordinated efforts of governments and experts in building resilient communities to mitigate against, prepare for, respond to and recover from such disasters. Hence, the first important step towards reducing disaster impact is to correctly analyze the potential risk and identify measures that can prevent, mitigate / prepare for emergencies and specifically generate Early Warnings before Disaster is experienced. Once Disaster is experienced, it is further required how efficiently we respond to Disasters and manage Recovery. Although damage to property cannot be avoided, loss of life can be prevented if disasters can be managed much more effectively by implementing efficient disaster warning systems, evacuation procedures and use of integrated information & communication technologies.

Geo-spatial technologies provide an integrated and collaborative platform for accessing and sharing data and applications, which supports all facets of Disaster Management and Emergency Response. In the present study, a detailed framework- integrated with standardized Data Model- is proposed, which leverages Geo-spatial technologies Platform, to support all phases of Disaster Management and Emergency Response efficiently.

Keywords: *GIS, Disaster Management, Risk Reduction, Space Technologies*

1. Introduction

The Himalayas, which are considered to be the youngest mountain system on Earth, are tectonically very active. The high tectonic activity, steep slopes, highly variable altitudes and uncertain climatic conditions make Himalayan region inherently vulnerable to numerous types of hazards. Mandakini River Valley in Himalayan region of Uttarakhand State, by virtue of its geographical setting, is a highly disaster-prone area. Year after year, the region is experiencing earthquakes, rock-falls, landslides, debris flows, snow/ice avalanches, flash floods, failure of high altitude natural and glacial lakes, extreme rainfall events causing widespread hazards that leads to great losses to lives and infrastructure every year.

As stated in UNISDR Global Assessment Report (2015), "There is no such thing as a natural disaster, but disasters often follow natural hazards".

It is well accepted that disasters can be managed much more effectively by implementing efficient disaster warning systems, evacuation procedures and use of integrated GIS, Space, IT technologies.

In order to prevent disasters from hazards, a critical need was felt for improved observation of the planet. Hence, many governments and organizations collaborated to implement an earth observation system. To support this, a voluntary partnership called the "Group on Earth Observations (GEO)" was also established (http://www.earthobservations.org/pr_gnl.shtml), to share earth observation data and science, which included 90 countries, the European Commission, and 77 inter-governmental, international, and regional organizations as stated by Anonymous in Meteoworld (2014). GEO initiated one of the most comprehensive efforts to monitor the entire face of the earth by building a Global Earth Observation System of Systems (GEOSS).

As availability of Real-time updated data is very critical for situational awareness and efficient handling of Disasters and building resilient communities, this Earth Observation datacan play a key role to address the challenges of disaster management cycle, including understanding disaster risks, responding to emergencies, assessing damage and loss and providing inputs to mitigate disasters. Sensors, satellites, radar, and other earth observation technologies are also very useful and are used to monitor various hazards. Although damage to property cannot be avoided, loss of life can be prevented if this data and information can be made available to various stakeholders to support planning, analysis, monitoring and taking action in advance. In fact, the overall Success of Disaster Management lies in how best Disaster impact is reduced and how fast authorities manage to bring life back to normal.

Several Research Studies were made in the past related to hazard Risk vulnerabilities and zonation, for different hazards individually like in Garg

JK, (2001). Most of these studies have focused on causative analysis of disaster and post disaster experiences. Many a times, it was observed that one Hazard triggers another Hazard also. In almost all cases, it was observed that in the past, there were no early warnings received by communities. Moreover, when disaster struck, there was no single place from where authorities could access information seamlessly for decisions in crisis. Primarily, there exist no such platform which can help authorities and communities to assess situations and respond to disasters efficiently, resulting in huge losses.

Several initiatives were taken by the Government in the past to use technology to mitigate and manage disasters effectively, but in most of the cases, challenges were encountered due to the non-availability of an integrated platform, which can be used for sharing & dissemination of right information in right time, as we have seen in Kedarnath Disaster (WIHG, 2013). Even after availability of technology & information, it is not accessible to all stakeholders. Hence, there is a key requirement to Study which measures to suggest, how to leverage Geo-spatial & Information Technologies and help building resilient communities to manage disasters much more efficiently in this region as discussed in Carrara A. (1991 and 1999).

In the present study, an integrated GIS based framework is conceptualized and proposed, which can seamlessly access and integrate all required information from different sources, sensors, live feeds etc., provide tools to analyze available data sources and share this information for efficient decision support, even in the middle of crisis.

2. The Study Area

Although, proposed framework is applicable for any location, in the current paper, a Geo-spatial framework is proposed for Mandakini River Valley in Himalayan region as shown in Figure 1. This region is highly vulnerable to a number of hazards like landslides, forest fires, cloudbursts, flash-floods etc. which are seasonal phenomena and strike at a certain period every year with high frequency leading to various disasters.

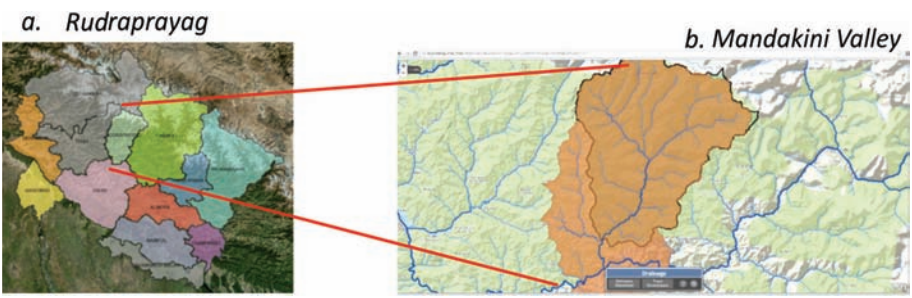


Figure 1 Study Area

3. Technology perspective

The key requirement for an efficient Disaster Management is *seamless availability of all required information to all stakeholders,* through a simple to use interface, for collaborative planning and efficient decision making. This framework should provide a service delivery mechanism for sharing of information to support all phases of disaster management i.e. preparedness, planning, mitigation, response, recovery and rehabilitation, for effective monitoring, forecasting, advance warnings, assessment, predictions and mitigation of various disasters.

The proposed framework, provides an easy to use interface for accessing and using Earth Observation data and other live feeds to support different phases of Disaster Management requirements. Studies on indigenous weather forecasting knowledge of the people of Higher Himalaya in Uttarakhand by Rautela P. et al. (2014), suggest effective use of technology for disaster risk reduction in remote and inaccessible areas can provide improved avenues to build community resilience as stated by Gupta P. et al (2014). Similarly, Venkatachary K.V. et al. (2001) has proposed a proto-type, to provide a holistic design and for development of an information system, mainly to support the information needs for preparedness, prediction, damage assessment, rehabilitation and research. The system enables networking, mainly to be able to speedily provide access to the information system at any point of time from any place. It paves the way for decision making to support speedy and efficient decisions being taken and for actions being implemented along with feedback mechanisms.

GIS technology-based platform, supports requirements of advance planning, modeling and simulations, by integration of information & live feeds available from disparate sources and help timely dissemination of necessary geospatial information to all the stakeholders associated with emergency and disaster management activities. In addition to integration of Earth Observation data, this device's independent Platform provides capabilities to organize, manage and deliver information to emergency management teams, based upon their specific missions and roles within the organization and across the State Agencies, using any mobile device. It also provides an analytical engine where advanced algorithms can be integrated for modelling and simulations, to quantify and understand the impact of Disasters. It also supports integrated Crowd Sourcing and Mobile GIS, for situational awareness and information capturing. Provision is also available to integrate live feeds, Social media feeds and tracking of Response Forces using integrated GPS in real-time / near real-time situations. It allows all stakeholders to manage their data, perform hazard analysis & risk assessment and deliver information in an effective manner.

Hence, in order to leverage geo-spatial technologies for disaster management, an enterprise geo-spatial framework needs to be defined for deployment using

web / cloud architecture so that all the agencies are able to access the desired information / resources in-time and with minimal efforts over the internet, providing a common operational picture.

4. Solution Approach

It is proposed to establish a GIS based Platform for Disasters and Emergency Management for integration, analysis and timely dissemination of necessary geospatial information to all the stakeholders associated with disaster management and emergency response, as shown in Figure 2.

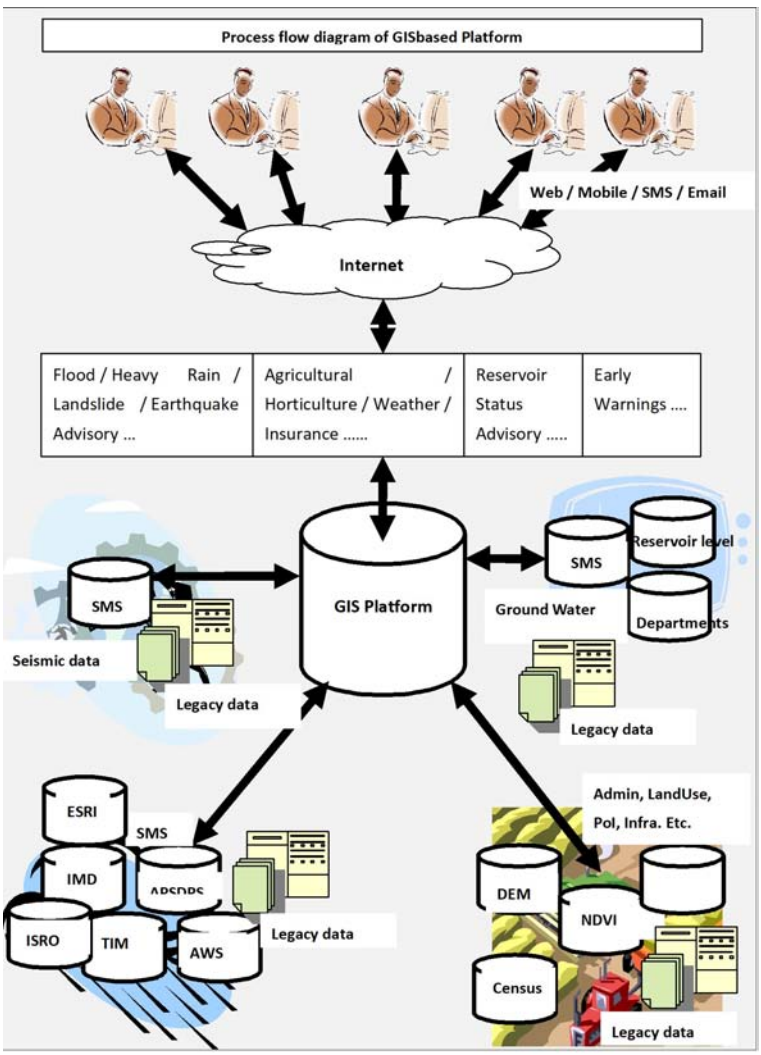


Figure 2: Conceptual Framework for DRR & building Community Resiliency

This Platform's aim is to provide a geo-spatial backbone, which will facilitate interaction among multiple agencies for data sharing and risk communication to field level functionaries, and act as a reliable and effective gateway for Decision Support and to meet disaster management requirements (see Figure 3).

Figure 3 GIS Platform

This GIS based Platform will enable common workflows across all aspects of the disaster management mission, from planning to response and recovery. It will also provide the analytical engine that supports the foundation for good preparedness by allowing organization to conduct comprehensive risk and hazard analysis, identify community vulnerability and highlight mitigation priorities with enhanced situational awareness.

It will support requirements of advance planning and analysis by integration of data & live feeds available from different sources like NRSC - Bhuvan, NDEM, IMD, NASA, NOVA, USGS, Asia Pacific Disaster Centre etc. (Figure 4) with timely dissemination of necessary geospatial information to all the stakeholders. It also integrates Global feeds (Figure 5).

Provision will also be made available to integrate location of Response Forces using integrated GPS based mobile devices to support and enable coordination with field teams and capture real-time / near real-time field situation. Overall, the Platform will provide framework to integrate all needed information and provide simple to use tools and interface for effective Decision Support. The components of the platform include:

(a) Integration of live feeds from ISRO, IMD, Bhuvan for Situational Awareness (Figure 4.)

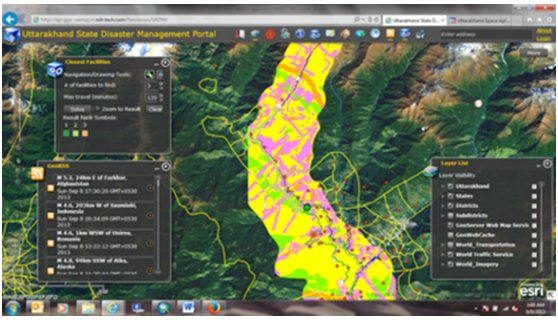


Figure 4 : Integration of National Feeds

(b) Integration of live feeds from Global Sources i.e. NOAA, NASA, USGS, FEMA, ECMWF (Figure 5).

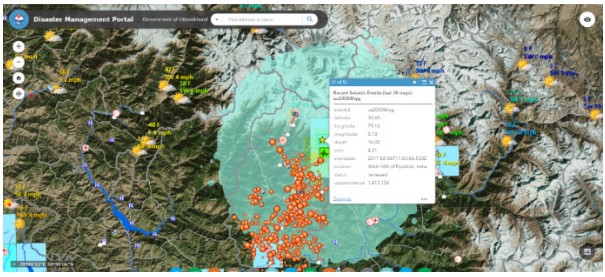


Figure 5 : Integration of Global Live Feeds

(c). Simulation& Advanced Modelling tools provided to support Early Warnings, Integrating Telemetry / live feeds and generating automated Hydrographs (Figure 6),

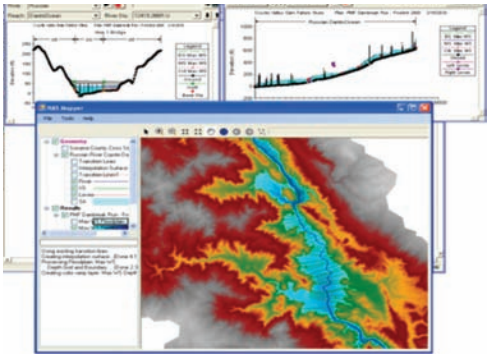


Figure 6 : Hydrographs

(d) Platform to support integration of Social Media (Figure 7) and implement Crowd Sourcing Apps for enhanced situational awareness and integrated Field / Mobile GIS.

Figure 7: Seamless Integration of Social Media

(e) In addition to Public and Departmental access, integrated Executive Dashboards (Figure 8) to be configured for decision makers in a secured way.

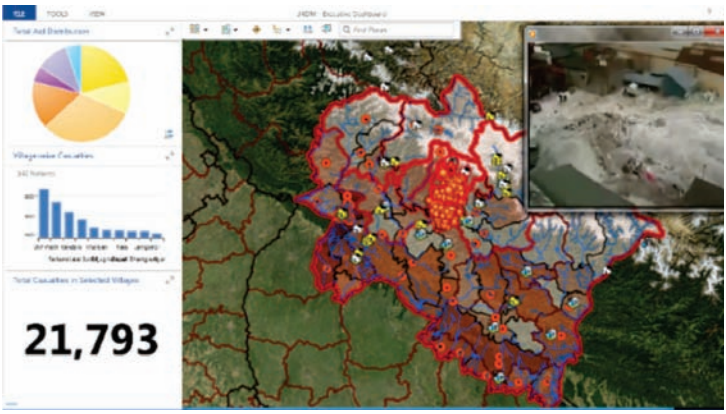


Figure 8: Executive Dashboards

This GIS based Platform is needed to promote access to data and tools via multiple mission specific easy to use apps, based on user's role and responsibilities. These apps can be accessed through any device and will provide meaningful support for DSS and mission specific requirements. Following chart (Figure 9) shows Sample Apps that will be made available with a location strategy through this platform, to support various activities.

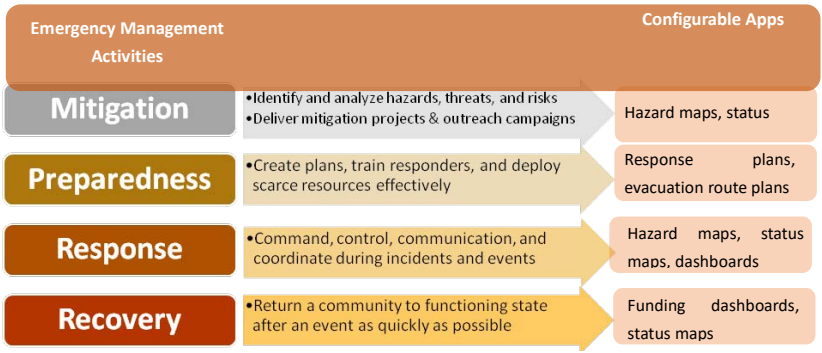


Figure 9. Key Disaster Management activities and supporting Apps

Overall, this Platform attempts to provide integrated capabilities to support:

- Data Management
- Planning & Analysis
- Situational Awareness and Response
- Integrated Field GIS

4.1 Data Management

Disaster Management relies on a multitude of data that drives analysis and helps in taking informed decisions. Creating, editing, managing and updating data on a regular basis is the foundation to provide a common operating platform. Using this Platform, data from different departments and sources (spreadsheets, web services, business systems, etc.) can be quickly integrated to provide location-based analysis. Using integrated data in real-time / near real-time mode, Platform will enable workflows and analytical models to generate intelligent maps that provide insight into how an event is unfolding, for decision support in crisis.

Data management is not just about consumption. Sharing relevant and authoritative data and information products with stakeholders is vital. This Platform will provide sound data management and sharing mechanism that will allow users to form common communities for collaboration.

4.2 Planning and Analysis

Raw data might not be useful, but analyzed information is. Analysis is critical to support the emergency management lifecycle. Proposed GIS Platform should provide the analytical engine and GIS tools to turn the raw data into actionable information. It is how an organization can analyze risk, understand vulnerability, identify mitigation priorities, develop comprehensive response plans (Figure10) and test the impact of different

event scenarios. Examples of common planning and analysis functions for disaster management include:

- Conducting a jurisdictional Vulnerability Analysis based on the occurrence or presence of:
  - Critical Infrastructure
  - Natural Hazards
  - Technological Hazards
  - Historical Risk
  - Vulnerable Populations

Figure 10. Planning & Analysis

- Resource Management and preplanning
- Modeling loss estimates and impact analysis for events
- Build Disaster Management Plans (DMP) / Incident Action Plan (IAP) maps
- Plan for Special Events and promote common incident command and control

4.3 Situational Awareness and Response

Proposed GIS Platform needs to allow information flow across the organization in a targeted and meaningful manner in the form of Simple to use Maps & Apps that will be tailored for situational awareness and to the role each decision maker or staff is responsible for.

This platform aims to provide multiple mission specific Apps, which align with Disaster Management requirements, and delivers data and tools based on the Incident Command System (ICS) framework. For example, a Logistics Chief has a very different requirement from an Incident Commander. This Platform will allow configuring & aligning Apps to the organization structure, where each person enters into a user-friendly experience that makes sense, based on his/her mission. These Apps can be further customized to even more specific requirements of the Local / National / State Disaster Response Framework (NDRF / SDRF) and other Emergency Support Functions (ESF) to provide a Common Operational Picture.

4.4 Integrated Field GIS

A final component of proposed Solution and perhaps the most critical is the mobile GIS. Building tools and applications that works in the field and empowers field workers to complete their workflow in a more streamlined and sustained manner is an important part of Disaster Management lifecycle.

These mobile applications connect field to the office using the same common operating platform and are largely deployed in support of command and control (incident management), response (search and rescue; situational awareness), and recovery (damage assessment; debris removal) workflow. The executive in the field accesses the application on their mobile device. As they begin their work, the application gets aligned to their mission by providing only the data and collection tools needed. Field GIS platform will also support Real-time Data updating from the field for integrated Decision making.

5. Methodology & Results

5.1 Standardizing Data Model & Workflows with regular Update Mechanism

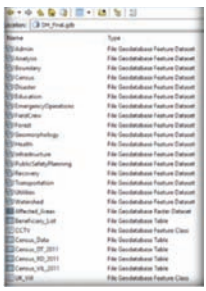
The first requirement is to collect Primary & Secondary Data layers of the Study Area and integrate all information from multiple sources in GIS. As a number of datasets are available with various National & State Agencies, they are available in different formats and types.

As required data will be available from different sources and formats which needs to be integrated (moreover, spatial data might be available in different projections, which may not overlay as desired). Hence, a standardized data model needs to be designed at par with Global Standards for being a systematic unit of storing and retrieving the spatial data.

Following steps will define the design of Geo-database:

a. Regional and National Coordinate System and Datum to be defined.

b. Existing Data Models & Global Product Libraries (data model) to be analyzed and after identification of gaps and rounds of discussion, Standardized Data Model (Figure 11) to be arrived at as illustrated in the below snapshot.



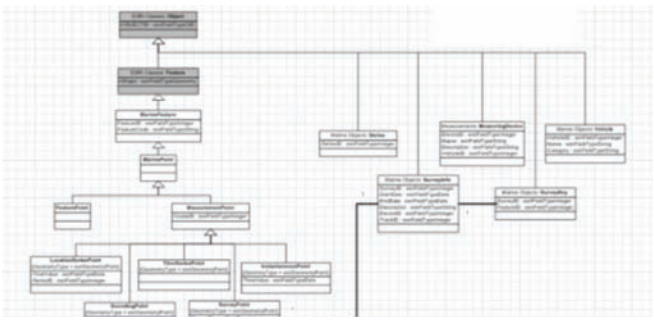


Figure 11. Data Model

c. All the Feature Datasets to be organized.

d. Various features and their attributes will be defined.

e. Symbols, Styles, Style Sets will be created / migrated.

f. Various templates to be developed

g. Mechanism for QA/QC will be implemented.

h. Workflow for Authorization, Integration and Updating of data along with user management to be implemented.

5.2 Preparation of Data and other Map layers required for preparation of Area Profile

For preparing detailed Physiographic and Geomorphologic Profile of the area, a number of other related layers are required. Framework is to be created in GIS Platform to access and use these layers (if already available in the form of services with national / international agencies like ISRO/ Bhuvan, NASA, USGS etc). Wherever information is not available, it needs to be generated with the help of Primary layers like DEM, Satellite Imagery (Cartosat-2, Landsat 8, Digital Globe etc.). For MIS like Demography and Socio-Economic Profile of the Area, data needs to be collected from Census and related sources. Following data layers were also required to be generated using ASTER DEM with the help of GIS Platform:

- Slope Map (in Degrees)
- Aspect Map (Surface Direction)
- Hill shade (Considering 315 Azimuth and 45 Degree Altitude Angle of light source)
- Contours (Interval 5 mtr.)

5.3 Preparation of multi-temporal Land use / Land cover map

The nationwide land use/land cover (LULC) map is generated by ISRO / Bhuvan using AWiFS data. This multi-temporal data is provided through ISRO / Bhuvan Portal in the form of web services. Framework was implemented for seamless access of these services and perform overlay analysis w.r.t other critical layers of the Study Area. Time-series data was accessed for necessary comparison. Different Satellite Imagery were also accessed for preparation of Land use Map.

5.4 Secondary Data Collection and Integration

Data is the backbone for performing various analysis and arriving at various conclusions. Key challenge of any such study is availability of desired data in

required format specifically as required for scientific calculations and integration with various models & algorithms for analysis and testing. Archived Data to be collected from various sources under following categories and integrated (Figure 11) include:

- Administrative Boundaries covering Districts, Blocks, Villages, Settlements etc.
- Transportation Network – Highways, Roads, Streets and other connectivity
- Infrastructure like Schools, Hospitals, Banks, Facilities, etc.
- Social Amenities
- Land use / Land cover
- Hydrological Features
- Soil & Geology
- Historical Hazards
- Disaster Management related layers – Control Rooms, Evacuation Centers etc.
- Demography and Socio-economic Profile of Study Area

Figure 11: Base data Layers collected and integrated

5.5 Developing GIS based scientific models for Early Warnings

In recent past, a number of disaster events were reported in the study area. As we cannot control nature, in order to develop disaster resiliency, Geo-spatial technologies can be leveraged to develop various Scientific Models for identification of hazard vulnerabilities and integrate Early Warning models to build community resilience.

GIS based Analytics tools can be provided to implement following Disaster Specific Scientific Models for multi-hazard vulnerability assessmentof the Study Area:

- Landslides – Probabilistic Certainty Factor, SINMAP
- Floods / Cloud Bursts - ArcHydro, HEC RAS, HEC HMS, Rainfall-Runoff etc.
- Earthquakes – USGS historical data and Live Feeds
- Forest Fires – NASA – MODIS, VIIRMS Feeds

5.6 Designing Geo-Spatial Solution framework for identification of risks, analyzing multi-hazard vulnerabilities, mitigation and response planning

A Single Gateway is to be configured to access and integrate all data required for Disaster Management which can be shared with all stakeholders through simple to use Web and Mobile Apps. (Figure 12). This will further support collaboration between various departments and agencies across the state and brings Geo-enabled services to citizens and various government organizations. Integrated Solution will further provide base for extended Analysis, needed for informed Decisions under Common Operating Platform.

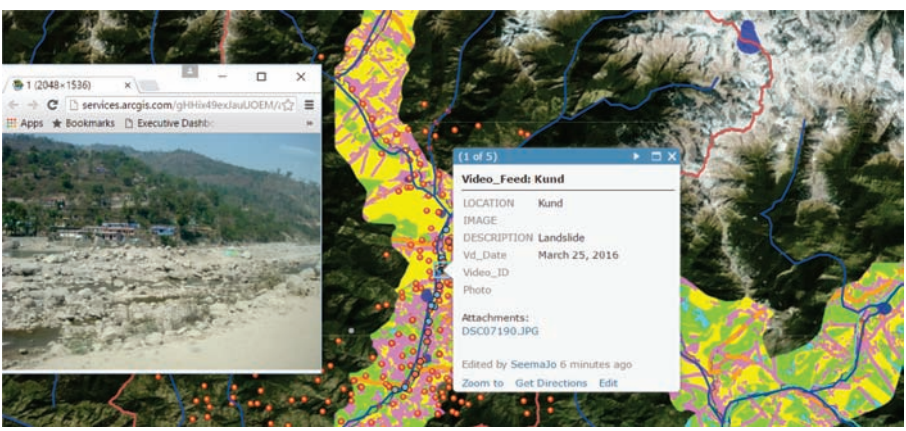


Figure 12 – Single Gateway to access all information enabling efficient Disaster Managemen

6. Conclusion & Recommendation

This paper presents how the proposed GIS Platform can provide a seamless interface to access available information, leverage Earth Observation Data along with other sources, in an integrated way for effective Management of Disasters and responding to emergency. It can effectively integrate all information and provide a Common Operational Platform for:

- Accessing & Sharing GIS based information from disparate sources.
- Perform advanced modeling and simulations for vulnerability analysis.
- Generate Early Warning Alerts
- Making information and knowledge available to all stakeholders for decisions.
- Improving delivery of services and empowerment of Departments & Stakeholders for regular updates and collaborative decision making
- Connecting Government, Citizen and other Stakeholders
- Adopting bottom up, enterprise solutions approach for effective implementation
- Enhancing overall efficiency and effectiveness of Disaster Management using this GIS

In a nutshell, the proposed Platform can help in effective Recovery, minimizing risks and building resilient communities.

7. References

1. Anonymous, UNISDR Global Assessment Report (2015): https://www.preventionweb.net/risk/disaster-risk

2. Anonymous (Meteoworld, February 2014) : https://public.wmo.int/en/resources/meteoworld/group-earth-observations-ministerial-summit

3. Carrara, A., M. Cardinali, R. Detti, and F. Guzzetti., (1991), GIS techniques and statistical models in evaluating landslide hazard: Earth surface process, Landform v. 16(5), pp 427-445.

4. Carrara, A., F. Guzzetti, M. Cardinali, and P. Reichenbach., (1999), Use of GIS technology in the prediction and monitoring of landslide hazard, Natural hazards, 20, pp 117- 135.

5. Garg, J.K; Murthy T. V. R; Kimothi, M. M Singh, T. S. (2001). Environmental Hazard Zonation and Optimal Resources Use in the Alaknanda Valley, Garhwal Himalaya using Remote Sensing and GIS Techniques.

6. Rautela, Piyoosh; Sajwan, Krishna Singh; Khanduri, Sushil; Ghildiyal, Suman; Chanderkala; Rawat, Ashish. 2014. Geological Investigations in Rudraprayag District with special reference to mass instability. DMMC Book, 1-117 pp.

7. Venkatachary K.V., BandyopadhyayV. ,Bhanumurthy V., Rao G. S., Sudhakar S., Pal D.K., Das R.K., Sarma U. , Manikiam K., Meena Rani H.C.,

Srivastava S.K. 2001. Defining a space-based disaster management system for floods: A case study for damage assessment due to 1998 Brahmaputra floods, CURRENT SCIENCE, VOL. 80, NO. 3, 10 FEBRUARY 2001

8. WIHG, 2013. A Report on Kedarnath Devastation. December 2013.

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Disaster and Institutionalising Rehabilitation: Survivors experience and institutional Contestations

S. Mohammed Irshad

Abstract

Tsunami rehabilitation was considered by the government as a successful project; however, a close examination of the rehabilitation process reveals violation of rights and legitimization of social exclusion. The survivors were given basic facilities, but their long term need to survive the recurring impact of disaster was not assessed. The survivors call it as re-plantation rather than rehabilitation. It is not a model for disaster rehabilitation as the community lost their access to non-fishing resources in the area.

Keywords: Tsunami, Rehabilitation, Relocation, Secondary Disasters

Introduction

The Indian Ocean Tsunami of 2004 is the critical focus of this paper. It was a trans-boundary disaster that affected India, Sri Lanka, Indonesia, Maldives, Myanmar, Bangladesh and Thailand. It was one of the major natural calamities in the country, claiming 12,405 lives and causing an approximate loss of Rs.11,544.91 Crores at the national level[1]. This paper has taken the impact of the 2004 Tsunami on Kerala as a case study and is specifically focused on two coastal villages Alappad and Azheekal situated in Kollam and Alappuzha districts. The community had to relocate to non-coastal 'created colonies' as part of rehabilitation. Administratively, it could be read as a project of disaster risk reduction and safe relocation. However, in principle, it is exclusion from the coastal ecosystem and gradual alienation of a large chunk of coastal community from local resource ownership. Post-disaster rehabilitation for Tsunami was one of the longest administrative intervention programmes in Kerala. Rehabilitation started one year after Tsnami and continued till 2012 as the State government's development programme. This study is being conducted 14 years after Tsunami and the survivors' life experience in these long years has been taken as its second

[1] TSUNAMI - A Report to the Nation, June 3, 2005

case. The community is yet to recover from the social, economic and individual impact of Tsunami. It took more than a decade for the community to realize that a natural disaster can impede the very personal and social life of a victim.

Tsunami rehabilitation was largely an effort to ensure the bare minimum facilities to survivors. Thereafter, rehabilitation efforts became a burden on the people. No government department involved in the Tsunami rehabilitation accepts that it led survivors into vulnerable conditions. Recurring coastal erosion and Tsunami taught many lessons to the community, such as dependency on State institutions for support, living with bare minimum support as maximum possible rehabilitation, and the new identity of 'disaster victims'. For the government, it was a successful project of maximum State intervention. What was missing in these articulation were the early warnings, risk forecasting and risk governance. Fourteen years after Tsunami, disaster management has become an institution in the country. Institutions for disaster managements are primarily helps the governments to control disaster rehabilitation. Community consider these institutions are for building coping capacities. For instance, Paton et al (2008) discuss, in their paper, the importance of having coping capacity to face and adapt to the losses and disruption that a disaster leaves behind. Cardona, Ordaz, Marulanda, Carreño and Barbat (2010) pointed out that if the risk is not presented and explained in a way that attracts the attention of stakeholders, it would not be possible to make progress in reducing the impacts. Thus, disaster governance needs large-scale institutional interventions and mechanisms. This paper argues that the success of institutional interventions in disaster rehabilitation should not be the only criteria to assess and evaluate disaster rehabilitation.

1. Conceptual framework and Method

The efficiency of disaster rehabilitation depends on how it ensures resilience and adaptation to the survivors. Castle (1978) argues that the global economy is directly involved in establishing the demand and supply relationships for many materials. Short-term shifts in the pattern of use and in demand or supply lead to severe adjustments in resource use within an economy. According to him, public policy has the capacity to influence the environment within which property rights are mentioned and need to be considered simultaneously with rule changes. Schlager and Ostram (1992) explain this critical issue with reference to common property resource management. This paper refers Schlager and Ostram in the context of the alienation from commons due to rehabilitation and protection of rights. Agrawal (2003) argues that failure of market-oriented policies to manage commons has initiated the enquiry of alternative governing mechanisms for forests, pastures, water and fisheries. The study states that institutions usually come into being as a result of human actions, and allow specific individuals and groups to reap advantages from

altered social circumstances rather than allowing societies as a whole to capture efficiency gains. The paper further elaborates that the processes of development and modernisation, and attempts to raise the efficiency of use and management of commons can end up increasing State capacities to control and intervene in local affairs. The 2006 paper by Kurian et al discussed the geomorphic changes in the coastal area due to Tsunami. The paper observed that the December 2004 Tsunami had made a devastating impact on some parts of the coast of Kerala. It brought about changes in the geomorphic settings of the coast. Sheth et al (2006) observed that the major reason for this impact was the narrow strip of land bound on the West by the Arabian Sea and on the East coast by a network of backwaters.

Hettiarachchia and Kushani De Silva (2014) tried to study the role of comprehensive disaster management programmes of Sri Lanka in reducing the direct and indirect risks and thereby, reducing the impact on community. The paper argues that such special projects and programmes would borrow best practices from across the world and proposes that disaster risk reduction measures should be linked with national development projects. Larson et al (2013) brought out some of the crucial factors in disaster rehabilitation and development in India. The paper is focused on the role of self-help groups in women empowerment after Tsunami. It explained that self-help programmes provide women with new income sources, training, access to micro-credit and savings. Such programmes have offered opportunities to women to take part in the decision making process and social action.

The study by Oxfam International (2005) came up with data showing that in Cuddalore, Tamil Nadu, almost three times as many women as men were killed by the Tsunami. Also in Pachaankuppam, another village in Tamil Nadu, only women lost their lives in Tsunami. The study by Irshad (2014) assessed the post-Tsunami rehabilitation in Alappad and Azheekal villages of Kerala. The paper observed that Tsunami rehabilitation was limited to ensuring the bare minimum support to the affected community and the ongoing sand mining from the coast further excluded the fishermen from the area. The displacement of the community from the land as part of disaster risk reduction eventually helped the mining companies to mine the evacuated area. The rights of the local community to resources were ignored and no benefit sharing practices were followed. The paper also discusses that unsustainable mining led to massive erosion and total submergence of two fishing villages in the area. Another study by Irshad in 2016 observed that the rehabilitation of Tsunami-affected people in multiple settlements had generated a sense of resilience towards the Tsunami risk. However, the long-term impact is critically negative in nature, since the post-Tsunami rehabilitation investments in the area did not bring about any substantial changes in the quality of life of survivors. The above-mentioned

studies have discussed Tsunami and risk governance contexts and not discuss on the secondary impact of disaster.

Disaster highlights the inherent weakness of the society. There could be multiple forms of this weakness, out of which, the critical one in this context appears in the crisis faced by the society while handling rehabilitation. It also manifests in the development and rehabilitation policies. Development and rehabilitation are, in principle, interrelated. There is ambiguity about the idea of development vis a vis disaster. Cowen and Shenton (1996:7) argue the developmental activities in disaster affected areas on the one hand, it is virtually synonymous with 'progress' and on the other hand, it also refers to intentional efforts to 'ameliorate the disordered faults of progress' Thomas (2000) also defines that idea of development exists because it help to identity poor, so development according to Thomas development exist if it intervene the capitalism to alleviate poverty. The concept and idea of rehabilitation has not been subjected to any substantial change from the perspective of war-torn societies. Green and Ahmed (1999) also argue that rehabilitation after disaster mainly involves reconstruction of physical infrastructure and providing interim basic needs to survivors. Rehabilitation is more about *how* to rebuild what was destroyed in the disaster rather than *what* to rebuild. Rehabilitation is a supply-driven process and hence, rehabilitation interventions by the government, external aid agencies and NGOs consist of individual programmes that are implemented mainly at the local level and have few links with other reconstruction interventions

Institutionally, rehabilitation and development are interrelated. The basic principle of rehabilitation is to ensure the self-reliance of the affected the community. In an attempt to link rehabilitation to relief and development, Harvey and Campbell (1997[2]) suggest that:

Rehabilitation...is part of a process of protecting and promoting the livelihoods of people enduring or recovering from emergencies. It aims to provide short-term income transfers, rebuild household and community assets, and rebuild institutions. Its key task is to help reinforce developmental objectives, notably livelihood security, participation, sustainability, gender equity, and local institutional capacity

Essentially, rehabilitation and development manifest in institutions; otherwise they would remain abstract ideas. The coming part of the paper discusses this in detail.

[2] Harvey, P., W. Campbell, et al. (1997). Rehabilitation in the Greater Horn: Towards a Strategy for CARE. Brighton, Institute of Development Studies.

1.1 Method followed

This paper attempts to trace the experience of Tsunami Survivors in Kerala. The paper is focuses on two coastal villages Alappad and Azheekal situated in Kollam and Alappuzha districts of Kerala. The affected community had to relocate to non-coastal 'created colonies' as part of rehabilitation. One could consider it as a project of disaster risk reduction and safe relocation, however for community it was project of exclusion. Fifty-six resettlement colonies were setup as part of rehabilitation projects and these colonies offer only bare minimum facilities and support to the Tsunami Survivors. Three focus group discussions with the community members were conducted and secondary data also used for this study.

2. Tsunami: Impact, Loss and Assessment

Government of India had appointed a team to assess the loss caused by the tsunami and the cost of recovery. The committee recommended a special package of Rs. 3,644.05 crore named as 'Rajiv Gandhi Rehabilitation Package for Tsunami-affected Areas'. The scheme was proposed for immediate relief and response, revival of fishery and agricultural sectors, immediate construction of temporary shelters, and repair/restoration of infrastructure. Out of this amount, Rs. 2,036.95 crore was approved for immediate relief and response, which included ex-gratia to the kin of the deceased, running relief camps and other essential relief services

In addition to the ex-gratia payment approved under the Rajiv Gandhi Special Package, additional ex-gratia payments of Rs. 1 lakh and Rs. 50,000 were approved from the Prime Minister's Relief Fund and the respective state's Chief Minister's Relief Funds, respectively. In case of A & N Islands, Rs. 2 lakh were additionally provided to each orphan.

2.1 Scenario in Kerala

In Kerala, Tsunami had affected Kollam, Alappuzha, Ernakualm , Kannur and Trissure. Of these districts, Kollam and Alappuzha were most heavily damaged in terms of life and material, Aratupuzha and Alappad coastal Panchayats in particular. There was a separate damage and loss assessment done for each State. Gulati Institute of Finance and Taxation (GIFT) conducted a monitoring of the Tsunami Rehabilitation in 2012 which carried a revised assessment of damage and loss. Table 1 shows the details.

Table 1: Damage and Loss in Kerala

Component	Initial Assessment	Revised after In-depth Assessment
Coastal length prone to sea erosion (Kms)	250	590
Penetration of water into the mainland (Kms)	2-Jan	5
Average height of the tidal wave (Ms)	3 to 5	5 to 10
No. of villages affected	187	226
Population affected (in Lakhs)	4.25	10
Human lives lost (Nos)	171	238
Persons moved to safer places (Nos)	24978	24978
Dwelling places destroyed	2919	2919
Livestock lost (Exc. Poultry)	883	883
Crop area affected, including riverbank near the seashore (Ha)	949	3989
Boats destroyed (Nos)	10882	3989

Source: Disaster Management Department, GoK quoted in GIFT report

The above said background information helps to understand the complexities in disaster rehabilitation in Kerala.

3. Post-disaster Rehabilitation

Post-disaster rehabilitation is a buzzword in the disaster management sector. Every agency involved in rehabilitation has a sense of controlling the whole life and livelihood of the affected people. It is true that the survivors have fewer choices in designing rehabilitation even though a participatory method is adopted. This research is being conducted 14 years after the incident, which has provided us enough ground to strongly argue that the rehabilitation of Tsunami survivors was not a big institutional challenge to the Government of Kerala. The government acted as both a facilitator and an agent. The major tasks were construction of houses, replacement of lost livelihoods, relocation of people within the 50 High Tide Line (HTL), replacing social overhead capitals, and timely completion of pending projects of infrastructure development Water supply and sanitation were pressing demands by the community even before Tsunami and the area-specific schemes were pending for a long period of time. All of these pending schemes were included in the TRP list and completed.

3.1 Rehabilitation, Basic Needs and Common Property Rights

Rehabilitation is, in general, a challenging project since the agency is accountable to the State as well as the society. One of the biggest challenges regarding

Tsunami rehabilitation was the relocation of survivors. It is still an incomplete project in the two most heavily affected coastal villages- Azheekal and Alapad. 1131 families were relocated away from the coastal area, clustered in 56 colonies and provided with 3 to 4 cents of land and houses[3]. The government also offered them debt relief, livelihood support and educational assistance (Tsunami Scholarship) to students. Individual and collective needs of the community did not receive priority in decision making. The researcher has consistently visited the area since 2010 and issues pertaining to rehabilitation still exist. In fact, new issues are emerging. The following part discuss it.

3.2 Life of Tsunami-affected Communities

All the houses constructed in Alapad and Azheekal Panchayats have an area of 340 Sq Ft only, including the common structures and facilities. The plinth area of the newly constructed houses is not more than that of previously owned houses. None of the agencies engaged in providing houses has made any attempt to increase the existing norms of the minimum habitation concept. Houses with an area of 340 Sq Ft are common to all subsidized or free housing schemes for the deprived sections in Kerala[4] and the cost of construction was Rs. 3,00,000, it was very minimum in local standard of Kerala.

Moving into indistinguishable houses creates a new cultural identity for the survivors. Agencies involved in the rehabilitation programme could not overcome the structural inequality and backwardness existing in the coastal areas. It seems that rehabilitation was a conscious effort to simply replace what kind of structure did exist such as small houses and limited access to public services. Upward economic and social mobility were not the focus of rehabilitation. It looks like a well- defined project aimed at ensuring bare minimum provisions as rehabilitation, while also imposing a new identity on the community. Government records recognize them as 'Victims of Tsunami'[5]. Tsunami *Veedu* (Tsunami House) is a common term used in Malayalam to refer to these houses. A new person entering the area can also easily recognize the houses and identify the agency that has constructed them. It contributes to an identity of the people living there and is often considered as landmarks of the locality. People having financial capacity have altered the structures of the house just to overcome the new identity. It needs an in-depth research to examine the complexity of this problem and would need a different theoretical framework as well. Rehabilitation results multiple social boundaries and identities within the

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3 Tsunami Rehabilitation Project Unit, Kollam district

4 The famous M N One lakh housing for Scheduled Caste population and the ongoing tribal housing schemes are following a norm of 325 to 410 sq ft

5 Panchayat documents, income certificates, water supply connections, electricity bills and land taxes to local self-governments etc possess a specific note about this

community. The cultural geography of these villages has been subjected to the 'interest and limitations' of the rehabilitation agencies and has therefore, created 'boundaries' as well. The public memories retain this question of identity for years to come. Government assessments often look into the structural aspects and ignore the social implications. Yet, even the government assessment report does not appreciate the housing rehabilitation projects.

The GIFT evaluation report explains that the initial project was to construct 11,000 houses and resettle the coastal households to a safer area away from vulnerable locations. It was later narrowed down to 9,124 houses. About 19.74 acres of government land and 120.74 acres of private land were acquired for the project across nine districts. Private land was purchased by the government. An amount of Rs. 331.66 crore was allocated for the project by the erstwhile Planning Commission of India. There were three categories of houses constructed: agency-implemented cluster housing, beneficiary-driven cluster housing, and *in situ* housing. Agency-driven houses were constructed by agencies from governmental and non-governmental sectors. The cost of houses was estimated on the basis of the prevailing rates and the release of funds was based on completion of construction. In beneficiary-driven houses, the families from the vulnerable coastal areas were allotted plots for constructing houses at the rate of Rs. 2.78 lakhs/house. *In Situ* houses were constructed on the land owned by the beneficiaries and an amount of Rs. 2.50 lakh was allotted for construction of each house, which was carried out by the beneficiaries themselves. GIFT also conducted a sample survey of 54 houses and found that these families have now settled down in 3 cents of land when they had owned more than that before Tsunami had owned more than 3 cents of land before Tsunami and they have now settled down in cents of land. The GIFT team rated the rehabilitation of housing as average. The report of the GIFT assessment is accurate and hence, has long-term impacts. The situation is more complex when it comes to colonies.

Displacement of disaster-affected communities is a global phenomenon. International Displacement Monitoring Centre, in its 2014 assessment, stated that disasters displaced an average of 270 lakh people every year between 2008 and 2013. This report is based on a global assessment which also found that 80.9 percent of these people belonged to Asia. This macro-level picture points to the severity of the issue and the absence of a comprehensive disaster risk management plan. Disaster-induced displacement has two phases: displacement due to disaster and displacement as part of rehabilitation. Tsunami has contributed to the creation of these two distinct types. Tsunami made life impossible for people living near the sea due to future risks. Thus, displacement of these survivors was an essential component of rehabilitation. They were provided with 4 cents of land and 410 Sq Ft houses. There are 56 rehabilitation colonies set up as part of the scheme. However, according

to a survey conducted in 2011, not all of the residents were landless before Tsunami.

4. The New Identity of Tsunami Colonies

Tsunami was the first experience of its kind for the survivors. Major material losses consisted of houses and livelihood equipments. The lost lives, however, are irreplaceable and continue to be painful after 14 years. The survivors moved into the rehabilitation colony after staying in a temporary shelter with poor support systems for one-and-a-half years. They were excluded from the public life and underwent a grave struggle in order to survive. Though, it was difficult and painful to recollect a disaster memory, still the respondent shares their lived experiences to this author. The life of the survivors changed after that and the mental stress and physiological disorders were regular in the area. Still, some were open to talks. For instance, Mr. Suman (52) who lost his daughter in Tsunami, the family got an ex-gratia payment of Rs. 1 lakh. Another survivor Mr. Ram (62) lost his son. Those who did not lose their loved ones have adapted to the new system, rather have been forced to adapt. However, families of the deceased are still struggling to accept the truth. Mothers who lost their children have not come out of the trauma. It was also discovered that some women had spent ex-gratia payment on treatment to get pregnant again[6]. One could read it as individual cases; however, the fact is that the method rehabilitation never gives them a sense of relief from the trauma and distress.

Every natural calamity leaves various imprints on its survivors. Rehabilitation alienate the survivors from coastal resource and access, also they subject to the authority of random agencies. Social, economic and political power exercise on the community and they must live with these imprints. It may take time for them to come to terms with the reality. Once settled down, the survivors revisit the manner in which they were treated at the time of the disaster. 14 years of living in rehabilitation colonies made Tsunami survivors contemplate the government's approach towards them when the disaster had struck. As Ms. Devika (58) narrates, *the government could make use of our panic situation and we had no choice except to move according to government's instructions.* According to her, government agencies took advantage of the situation and decided about relocation and compensation according to its own interests and convenience. The State exercises its power over the weak and interprets the lives of the people made vulnerable and disempowered by natural disasters. It could be read as lack of interface between government agencies and Tsunami victims. However, the Tsunami survivors believe that the government misused the situation as the government was aware, more than anyone else, that the people needed its

[6] The respondents were reluctant to share more details in spite of having a personal meeting with them

support to survive and hence, there would be total acceptance of government programmes and policies. Such a critical view on the government intervention happens after more than one decade, and it is because of their engagement with the general public. Government and rehabilitation agencies were delivering the 'maximum possible' support within their economic capacity. Interestingly, the community are more critical on government and not on the private agencies and NGOs. Only government could have given them better and socially and economically affordable and acceptable rehabilitation. It is a democratic right to aske the government why such bare minimum rehabilitation project was initiated.

One of the respondents narrated that the facilities provided have badly affected '*our work, food system and income sources also'*. This is true, since many of them have been displaced from practicing decentralized traditional fishing to become workers in fishing boats. They have lost their access and social power on the coast, which allowed them complete freedom in docking fishing boats, drying fish and even selling it. For them, Tsunami took away their community life and forced them to lead a highly regulated and controlled social and economic life. Mr. Sudhakaran (55) termed it '*re-plantation'*. Although the administrative language defines it as relocation that prevents them from further exposure to hazard, it was 'replanting' for the community in terms of psychological pressure and isolation. Sudhakaran put it in simple yet powerful words, '*We can't hear the sound of sea*'. The statement expressed every aspect of their pain. Isolation has disempowered them and stopped them from taking advantage of relocating to a safer area.

Moving to the settlement colony was not a direct passage. When Tsunami struck on 26th December, 2004, the local victims were moved to temporary relief camps constructed by government and NGOs. Many survivors eventually moved to their relatives' houses and later to the settlement colonies. The respondents stated that they had accepted this solution since they did not any option to bargain with the government. There are several issues with their residence. They were initially offered pipe water and electricity free of cost, but had to pay for them later. Another issue is space congestion, which is even more significant for the fishermen who were accustomed to open coastal areas and had to settle in a small settlement. In addition to the altered lifestyle, they also have to bear the demeaning public perception of them as people living under mercy. The new identity is unpleasant for the community.

People who survived or were injured in the disaster had to stay in temporary shelters and camps with inadequate facilities for an year. They opt poor sanitation facilities and other support facilities out of compulsion. Respondents shared many experiences of living with mental stress and the emotional pain of

losing their family members. Ms. Susheela (56) said, *'We lost everything, clothes, furniture and documents, so we had no choice left except to move to the camp and live with the support offered by others*'. Relocation change their working hours, they have to start their day at 1 AM to reach the shore on time. Sometimes if there is a possibility of a good catch, they start even earlier and many of the residents of the rehabilitation colony are unable to join.

One of the most sensitive and critical questions pertaining to relocation is social isolation. It also reflects how the society views the victims, especially in Kerala. The survivors' experiences with the settlement are far more worrying than what the disaster rehabilitation management envisages. They have acquired a new identity- The *Tsunami Colony*. Mr. Madhu (48) narrated it saying, '*Outsiders wanted us to be obedient to them as if we are under their mercy'.* School children complain that teachers often treat them differently because '*S/he is from Tsunami Colony'*. There exists an undeclared boycott for residents of *Tsunami Colony*. Such boycott gradually disempowers the survivors. Social boycott is demonstrated in keeping them away from public functions and private gatherings where they can interact with outsiders. It could be argued that rehabilitation efforts excluded such communities further while ensuring them security from coastal hazards. Government programmes or projects are not going to stop such social exclusion. It needs a larger transformation in the society to view it as a violation of rights.

Rehabilitation has actually become an impediment to the socio-economic mobility of the survivors. It is in violation of the 'International Covenant on Economic, Social and Cultural Rights[7]'. This convention talks about the inherent dignity of human beings. The government, with respect to Tsunami rehabilitation, ensured basic needs to the survivors, inevitably constituting to promotion of the 'excluded' method of rehabilitation. Large- scale changes are necessary in the approach towards rehabilitation.

Building a life after disaster is a complicated process in developing countries, more so due to the dependency on agencies supporting survivors during the crisis. The survivors unanimously agreed that the government often considered them as *beggars.* This opinion formed simply because of the dominating approach of the bureaucracy towards them. It is true to some extent that the bureaucracy treated them as people who constantly seek support and keep complaining. Also, social and cultural diversity were neglected while planning rehabilitation, which, according to the survivors, was because government and bureaucracy never wanted to discuss the matter and possible solutions with them

[7] General Assembly resolution 2200A (XXI) of 16th December, 1966

4.1 Livelihood Rehabilitation at the Local Level

A qualitative assessment of cases from the relocated colonies was conducted to examine the complex nature of livelihood rehabilitation after a disaster. Since it is a fishing community, every single coastal disaster first affects their livelihood by taking away livelihood equipments and displacing livelihood practices. Ms. Sheena, a fish worker, mentioned that her family lost all their livelihood assets. For her, '*We lost all our life and life support systems'.* She had to start from scratch and depend on support from agencies, both public and private. The survivors seldom had a chance to follow a selective approach to agencies. Instead, they had to seek support from whoever was willing to offer it.

The NGOs and other non-State agencies actively supported survivors immediately after the disaster. Government offered an immediate cash support , and NGOs and religious organizations offered clothes and essential utensils to the community. It is also true that government agencies were not able to differentially assess individual needs at the time of the calamity. They wanted to view them as a homogenous community and provide a common support system. This has some demerits. Primarily, individual resilience is never taken into consideration; instead, a collective mechanism is offered and community mobilization for resilience is expected. A critical feature of rehabilitation was that no non- governmental agency was effectively involved in the livelihood promotion projects. Some NGOs offered fishing equipments to those who lost it to Tsunami.

Loss assessment is considered a key component of disaster rehabilitation and economic recovery. Ms. Sheena (46) recollected that they stayed in camp for months and the officials and government agencies kept informing them that they would be compensated for their loss to Tsunami. She remembered that no one could assess their real loss. Later, they rented a house and the government paid them Rs. 7000 for vacating the house and Rs. 1000 for the rent. A proper assessment of needs was not done and the community was not consulted with for the same. According to her, *'Government and bureaucracy were busy demonstrating their ability and did not consider the community or protect the coast'.* This comment came 14 years after Tsunami, which is a reflection of how the institutions approach Tsunami survivors. It is also true that the bureaucracy holds undue power when a natural calamity strikes in an economically backward area. They can define the need of the society according to their institutional norms and power.

Creating new livelihood options and searching for new income sources consumes their time and energy. There is no surplus income generated; they have to struggle to sustain themselves. As Buck (1989) argues that property rights are either transferable or not transferable and individual rights are saleable for

goods or money, or are subject to bestowal and removal for services rendered. His study shows that non-transferable rights have often been removed from individual control and rest with the government or with the community of users. These rights may be assigned to individuals, but the individual may not transfer the right to another.

5. Concluding observations

Tsunami rehabilitation is not considered as a model to be emulated in other crises. Multiple institutions and organizations participated in the effort. It could be argued that all agencies acted according to their mandate. Survivors were not consulted with and the vulnerability of the community was taken for granted while providing support. The affected community was given no choice but to accept what was assigned to them as rehabilitation. Every agency enjoyed full autonomy in defining the others' life world. Tsunami was a disaster; however, the rehabilitation created secondary disasters in the form of deprivation, social isolation and poor socio-economic mobility. There are neither public discussions nor any active government involvement in addressing these critical complexities of Tsunami rehabilitation in the state. The agencies assigned for disaster management also not put any efforts to prevent the secondary impacts of disasters in among the survivors.

References

1. Agrawal, A. 2003. Sustainable Governance of Common-Pool Resources: Context, Methods, and Politics. Annual Review of Anthropology, Vol.32 (2003).
2. Buck, Susan J.1989. Cultural Theory and Management of Common Property Resources. Human Ecology, Vol.17, No 1 (Mar 1989).
3. Cowen, M.P. and Shenton, R.W. (1996) Doctrines of Development, Routledge, New York
4. Castle, Emery N.1978. Property Rights and Political Economy of Resource Scarcity.
5. American Journal of Agricultural Economics Vol 60 No 1 (Feb 1978)
6. Cardona, OD; Ordaz MG; Marulanda MC; Carre? ML and Barbat AH.2010. Disaster risk from a macroeconomic perspective: a metric for fiscal vulnerability evaluation. Disasters. 2010 Oct;34(4):1064-83
7. Green, R.H. and Ahmed, I.I. (1999) 'Rehabilitation, sustainable peace and development: towards reconceptualisation', Third World Quarterly, Complex Political Emergencies, Vol. 20, No. 1,February, pp.189–206.
8. Hettiarachchia, Samantha and Kushani De Silva.2014. Post tsunami rehabilitation in the context of national initiatives Case Study-Port City of Galle Sri Lanka. Procedia Economics and Finance 18 (2014) 865-872.
9. Irshad, S.M. 2014. Governing disaster risk and 'survivability': the case of two villages

in Kerala, India. Int. J. Emergency Management, Vol. 10, Nos. 3/4, pp.276–287

10. Kilby, Patrick.2007. The strength of networks: the local NGO response to the tsunami in India. Journal compilation. Overseas Development Institute, 2007.doi:10.1111/ j.0361- 3666.2007.01030.x
11. Kurian, N. P; T. N. Prakash; M. Baba and N. Nirupama. 2006. Observations of Tsunami Impact on the Coast of Kerala, India, Marine Geodesy, 29:2, 135-145, DOI: 10.1080/01490410600748301.
12. Larson, Grant; Julie Drolet and Miriam Samuel.2013. The role of self-help groups in post- tsunami rehabilitation. International Social Work 0(0) 1–16.
13. Oxfam International (2005) 'The Tsunami Impact on Women', available online at: https://oxfamilibrary.openrepository.com/bitstream/handle/10546/115038/bn-tsunami- impact-on-women-250305- en.pdf;jsessionid=C33640140E207A689850AAC2 E57A7876?sequence=1 (Accessed 19th July, 2018).
14. Paton, D; Gregg CE; Houghton BF; Lachman R; Lachman J; Johnston DM and Wongbusarakum S.2008. The impact of the 2004 tsunami on coastal Thai communities: assessing adaptive capacity.Disasters. 2008 Mar;32(1):106-19.
15. Schlager, Edella and Elinor Ostram.1992. Property Right Regime and Natural Rights: A conceptual analysis Land Economics Vol.68 No 3 (Aug 1992).
16. Sheth, Alpa; Snigdha Sanyal; Arvind Jaiswal and Prathibha Gandhid. 2006. Effects of the December 2004 Indian Ocean Tsunami on the Indian Mainland. Earthquake Spectra, Volume 22, No. S3, pages S435?473, June 2006; Earthquake Engineering Research Institute.
17. Thomas, Alan.2000. Development as practice in a liberal capitalist world. Journal of International Development J. Int. Dev. 12, 773±787 (2000)
18. W Campbell, 'ODA Strategy for Rehabilitation Assistance to Ethiopia' Falmer, UK: IDS, 1996; M Korner et al,Management of Social and Institutional Rehabilitation: Perspectives from Seven African Countries, proceedings ofan International Workshop, Debre Zeit, Ethiopia, 1995, p 5

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