

Building Resilience Navigating Nuclear and Radiological Exigencies

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Abstract—In the contemporary world, the advancements in science and technology have made countries prone to not only natural but also man-made disasters. Man-made disasters have primarily occurred as a result of novel inventions to resolve various crisis. One such field where countries are investing now are in renewable energy resources. Apart from solar and wind energies, the development of nuclear power has garnered attention due to its capacity to produce nuclear energy. Electrification can be now undertaken at a massive scale through the use of nuclear power. However, the accidents pertaining to nuclear reactors have strongly influenced public perceptions and have been viewed negatively. Although the scale of such radiological or nuclear emergencies may be very rare, it is crucial to take precautionary measures to avoid nuclear accidents. It is necessary to view these accounts in terms of the increasing urban infrastructure as the magnitude of such events may be greater today due to a higher density. India's atomic program encompasses the production of nuclear energy for electrification. The Atomic Energy Regulatory Board has framed guidelines and adopted safety measures for effective regulations in the industry. Despite this, there remains a possibility of nuclear disasters as a result of factors beyond the control of operational agencies. The paper aims to examine India's preparedness to deal with nuclear emergencies in various realms. It aims to suggest certain policy recommendations in order to improve the nuclear security architecture. The paper relies on secondary data particularly the NDMA guidelines as well as various reports. The limitation of the paper is that it restricts itself to nuclear disasters and does not take into account other man-made disasters.

Index Terms—Nuclear disasters, Disaster management, Radiological emergencies, Disaster guidelines.

I. INTRODUCTION

Developments in science and technology have profoundly affected human lives. Innovations in various fields have been instrumental in creating a positive impact and alleviating various concerns. As the world population rises exponentially, it becomes difficult to fulfil the needs, as the energy resources continue to dwindle (United Nations, 2021). The non-renewable energy resources across the world have been harnessed, and the world now falls short of them. Scientists and technologists across the globe have been trying to find solutions to alleviate the energy concerns. This has led to novel inventions based on renewable means such as solar, wind and hydro energy. (Holechek , Geli, & Raul, 2022) The events of the 20th century left a remarkable impact on global politics. The two World Wars were significant not only for altering the power patterns, but also for the technological developments. One of the biggest achievements was the invention of nuclear power. Across the world, the scientific community tried to harness nuclear energy through the development of nuclear power (Deutsch, 1989). Nuclearization soon became the agenda of many nations, leading to various international laws to restrict its uses. However, the peaceful use of nuclear energy continued to spiral, especially with the accentuating needs of the people. Electrification has been a major concern for countries across as the need to produce electricity magnifies due to the rise in human activities (Olabi & Elsaid , 2023). Moreover, nuclear energy remains clean and sustainable, which has proved to be a major boon for producing electricity on a mass scale. This facilitated the rise of nuclear power plants for civilian purposes. India,

immediately after its independence, established the Atomic Energy Commission in 1948 for the development of nuclear energy for civilian as well as military purposes (Ramana, 2009). Since then, India has been progressing well on both the civilian and military nuclear programs. Since nuclear power remains volatile, it has the potential to cause huge damage if disasters take place. The world has witnessed the devastating nuclear reactor accidents at Three Mile Island in the USA and Chornobyl in the former USSR. These accidents have strongly influenced the public perception of any nuclear emergency or disaster (IAEA, 2008). Although the number of such accidents has been minimal, it is crucial that India remains prepared for any such kind of exigencies, since the number of people affected today would be greater due to a higher population density and urban infrastructure.

Since its independence, India has embarked on a nuclear program for the generation of electricity to enhance the quality of life of the people. India has recently achieved the second stage of its nuclear program and will in the future also develop energy through thorium. Moreover, radioisotopes are exploited in many ways for applications in non-power sectors. India does maintain an inherent safety culture and follows safety practices which have been regulated by the Atomic Energy Regulatory Board, thus minimizing threats, accidents and impact on human lives. Despite this, nuclear emergencies can still arise due to factors such as human error, sabotage, natural disasters, etc. To combat these emergencies, it is vital that emergency preparedness be in place to avoid the loss of lives and property.

II. RESEARCH QUESTIONS:

1. What are the emergency preparedness plans adopted by India to manage nuclear and radiological accidents?
2. What policy measures could be adopted to deal with nuclear and radiological exigencies?

III. RESEARCH METHODOLOGY

As the research focuses on the nuclear and radiological emergencies in India, it is vital to undertake a qualitative analysis. Primary resources such as the Ministry of Defence, the National

Disaster Management Guidelines, Official documents, Reports of the Government of India, and legal texts will be studied in detail. Analyzing various Government reports and legal texts published by various government agencies will provide insight into the implementation of various measures to deal in times of emergencies and minimize the impact on human lives.

Secondary Sources form a major component of this research. Online references, Journals, Articles, Magazines, Books, etc. have been extensively used to delve deep into the topic and gather data for the research. Books dealing with disaster management, nuclear emergencies, and radiological exigencies have been referred to. Journals such as International Journal of Disaster Risk Reduction, Disaster Prevention and Management etc., are some of the journals that have been referred to for researching the topic. Websites, Web Pages, and blogs like those of IDSA, ORF, CENJOWS, etc. have been referenced to highlight the opinions of various scholars. Along with the above-mentioned research institutes, the report released by various think tanks that work in the areas of disaster risk reduction has been examined.

IV. LIMITATIONS OF THE STUDY

The research delves into nuclear and radiological disasters and aims to understand disaster mitigation concerning the above in the paper. The paper does not aim to study other types of disasters, thereby restricting itself. Moreover, the study is constrained to India and discovers India's approach towards disaster management and hence does not undertake an analysis of other nations and their efforts towards mitigation of nuclear and radiological emergencies.

Nuclear and Radiological Exigencies: Management in India

India is a country of varied geographical landscapes, and thus has been traditionally vulnerable to natural disasters. With the development in science and technology, the country has experienced man-made disasters as well. These disasters have the potential to create havoc and destroy lives and property (Parasuraman & Unnikrishnan). Although nuclear technology has been a boon for humankind, the consequences of nuclear failure will lead to devastation on a scale which cannot be imagined. The

approach towards disaster management in India has undergone a drastic change since Independence, as the country realized that development cannot be sustained unless the disaster management activities are streamlined and policy measures are put in place to deal with emergencies (World Nuclear Association, 2024). Various organizational, operational and policy decisions are streamlined to create a robust network to deal with any emergencies. The enactment of the Disaster Management Act in December 2005, along with the formation of the National Disaster Management Authority as the apex body, with the Prime Minister as its Chairperson, has been the key step towards organizational structuring of the Disaster management plans (Second Administrative Reforms Commission, 2006). Similar authorities in the states, with the Chief Ministers as the Chairpersons, have ushered in better Disaster Management practices, making development work sustainable. The creation of the District Disaster Management Authorities with the District Collectors as the Chairpersons, along with the elected representatives of the local bodies as the Co-chairpersons, has been the major step to manage disasters effectively at the local levels (SANSAD, 2024). India thus has an effective mandate in place now where the NDMA assumes the responsibility of managing and strengthening the existing nuclear/radiological emergencies (AERB, 2022). To achieve a robust framework, a National Workshop on Nuclear Disaster Management was organized in 2006 by the NDMA (National Disaster Management Authority, 2016). Pursuant to that, the maximum emphasis has been laid on the prevention of such accidents. The guidelines provide recommendations to various to mitigate the accident at source, prevent health hazards, minimize the psychological impact and protect the environment.

The NDMA guidelines draw a detailed action plan to ensure inbuilt capabilities to avert a crisis. The guidelines chalk out the possible scenarios during nuclear or radiological emergencies, consisting of accidents at nuclear facilities, accidents during the transport of radioactive materials, malevolent use of radioactive materials by terrorist or illegitimate groups and a large-scale nuclear disaster arising out of a nuclear attack. Analyzing these scenarios is crucial as today radioactive materials are used on a widespread scale, leading to their misuse. Alongside

the legal mechanisms, the guidelines aim to create a holistic structure ranging from prevention, preparedness, response, rehabilitation, reconstruction and recovery. The effective management and response to nuclear disasters will be based on a multi-pronged approach which involves the role of organizational bodies as well as on-ground management of disasters. The following are some of the crucial recommendations that should become a part of the operational guidelines for disaster management in the nation.

V. RECOMMENDATIONS

The primary organization which is involved in the nuclear and radiological activities of India is the Atomic Energy Regulatory Board, established by the Atomic Energy Act, 1962 (Atomic Energy Regulatory Board, 2000). The AERB remains the apex organization having the mandate to issue licenses to nuclear and radiological facilities. It determines the compliance mechanisms, standards, and codes to be followed. The functioning of the AERB remains crucial to ensure the management of nuclear and radiological facilities. It has the power to command a partial or full shutdown of any facility which violates the guidelines. The AERB has to ensure that all beneficial aspects of a nuclear facility and use of ionising radiation do not cause undue risk to public health and the environment. Moreover, the AERB, its officials, and operating systems have to not only be well secured, but security has to be provided to its top personnel to avoid any mismanagement and leaks. Furthermore, AERB should see to it that preparedness plans are in place for the postulated emergency events. The on-site and off-site emergency exercises should be conducted on a timely basis whose reports have to be submitted. India has worked in this direction as a spectrum of Emergency Response Centres have been established by the BARC to deal with accidents. The work of these centres is to monitor and detect radiation sources, provide training to stakeholders, monitor instruments and ensure the availability of protective gear.

One major facet of nuclear and radiological activities is the fear instilled in the minds of the general populace. The secrecy, coupled with a lack of information about radiation and radiation standards,

has created a psychosis that any small mishap in the facilities can have the potential to create a situation like Hiroshima, Nagasaki or Chornobyl. To address these concerns, the disaster management policies should also include generating intense public awareness programmes in the country. Sensitization drives remain crucial so that people are not insecure about nuclear facilities. This is vital as, along with prevention, the peaceful production of nuclear energy should continue on a mass scale to provide a decent standard of living to the people.

The conventional disaster management policies in India necessitate the prevalence of a bottom-up approach, in which the community, in collaboration with individuals, NGOs, community-based organizations and the private sector, are equipped to implement the emergency management programme tailored to the prevailing situation. Although there remain strict surveillance and mitigation measures, during an off-site emergency, the preparedness plan should encompass evacuation of the local people from the immediate and peripheral areas. In order to ensure this, the region in and around nuclear facilities should be developed to the fullest. Infrastructure availability in terms of adequate roads, emergency transport vehicles and evacuation routes should be in place. The paramilitary forces, along with the district personnel, should ensure coordination, which is possible when drills take place on a continuous basis. It should also be noted that, if the situation escalates and evacuation of a large population is not possible, then bunkers or similar facilities should already be in place to provide shelter. The policy should also take into consideration that when radiological isotopes spread in the atmosphere, not only the air gets polluted but the water source and food produced also perish, becoming unsuitable for consumption. The emergency response plan should inculcate identifying alternate sources of water as well as food storage facilities have to be built. Situations like these would necessitate not only the central personnel involvement, but local politicians should also be briefed about the necessary steps that should be taken. The role of civil defence personnel and home guards as the first responders, along with the police force, remains crucial. The policies should also envisage the training and appointment of doctors and supporting medical staff who should be accorded training to handle patients who have been affected by

radioactivity. This necessitates not only the employment of specialized medical experts but also mandates the availability of necessary medical equipment.

With the private sphere now playing a major role in the development of peaceful energy through nuclear sources, it is vital that the regulatory authorities ensure that the knowledge base prevails along with the expertise needed. For this, the licensing of nuclear facilities has to be monitored and regulated on a strict basis. Alongside, the private industry should be mandated to have emergency protocols in place in sync with the NDMA guidelines. Thorough checks and inspections, along with drills, have to be a continuous component of license renewal. In addition, the facility and the places surrounding it should make provisions and store the necessary gear and equipment needed. The local population, during such times, may panic and not cooperate with the authorities. To prevent this, it is necessary, time and again, that people should be acquainted with the emergency response measures and the actions they should take to ensure their survival. Training of the local administrative and political authorities and the people at large should be at the top of the guidelines. To make this fruitful, the nearby schools and colleges, especially teachers, could play a crucial role in generating awareness. To successfully carry out awareness campaigns and programs in regions having nuclear and radiological facilities, trained human resources will be required. The corporate sector supports activities aimed towards disaster relief and infrastructure building. Civic authorities can take the aid of the corporate sector as a part of their social responsibility for volunteering and social campaigning.

To prevent a nuclear disaster from escalating, the paramilitary forces, especially the NDRF and CISF, have to be actively involved with the personnel from nuclear facilities to operate as a single unit during accidents. Despite all necessary precautions, it is possible that the accident escalates on a large scale. It is then that armed forces have to be inducted, for which the military forces should mandatorily train their personnel in managing the disaster. Alongside, effective Civil-military coordination should be undertaken by the NDRF. To manage a disaster of this level, it is thus crucial that agencies like the police, fire, medical and paramedical personnel be

equipped with the protocols and be integrated into the nuclear emergency programs at all levels of administration.

Most importantly, the coordination between various ministries of the government remains crucial to avert and mitigate the crisis. Thus, the various ministries such as Home Affairs, Defence, Railways, Civil Aviation, Health and Family Welfare, Urban Development, Earth Sciences, Petroleum and Natural Gas, Transport, and Departments of Space, Metrology and Atomic Energy coordinate with the scientific and technical institutes and the community. The implementation of emergency preparedness plans has to be undertaken phase-wise. In the initial years, it is crucial that capacity development by means of education and awareness generation, involving all stakeholders, consisting of training and community participation, is undertaken. It is necessary that critical infrastructure such as Emergency Response Centres, communication networks, and Quick Reaction Medical Teams are stationed to deal with unforeseen circumstances. In the next stage, upgradation of all relevant infrastructure, enhancement of regulation and extension of the risk reduction framework have to be undertaken. In the long run, capacity development with preparedness and response mechanisms should be completely integrated in terms of establishment of secondary and tertiary care units for treatment of radiation exposure. Additionally, critical technologies should be inducted so as to minimise the impact of the accidents.

These measures listed above have been an inherent part of the NDMA guidelines. However, it is crucial to understand that they have to be implemented at all levels to ensure the prevention and mitigation of nuclear and radiological exigencies.

VI. CONCLUSION

Although radiological and nuclear disasters have not taken place time and again, humanity has witnessed their destructive consequences at all times and places it has occurred. The potential of nuclear energy is manifold, and it has the ability to wreak havoc on a large scale. It is therefore critical that the nations across the world come together and form global guidelines aimed towards prevention and mitigation of nuclear and radiological disasters. This is vital as a

nuclear accident in one nation has the potential to spread distress in the neighboring countries. Moreover, if the radiation takes place on a large scale, the contamination of air can have an impact on a mass scale and lead to devastation. The social, political, economic and environmental repercussions of such an event will be so huge that it will destroy humanity. India is one of the fastest-growing nations with the highest population today. Over the years, the production of nuclear energy will increase to generate electricity. The private sector will have to scale up its production and increase its ties with the state to ensure that the energy demands of the nation are met. This has to, however, happen with the state implementing safety standards and policies which have to be adhered in the strongest form to avoid any losses to humanity.

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