Build a Bridge on Flood Risk Management

South-South and Regional Cooperation for Flood Risk Management in the Islamic Republic of Iran

Synthesis Report of Knowledge Sharing and Capacity Development Workshop

9-10 October, Tehran
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## Acronyms and abbreviations

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<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AIT</td>
<td>Asian Institute of Technology</td>
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<tr>
<td>APDIM</td>
<td>Asian and Pacific Centre for the Development of Disaster Information Management</td>
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<td>APDR</td>
<td>Asia-Pacific Disaster Report</td>
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<td>APDRN</td>
<td>Asia-Pacific Disaster Resilience Network</td>
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<tr>
<td>CDR</td>
<td>Coast Deltas Rivers</td>
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<tr>
<td>Eco-DRR</td>
<td>Ecosystem-Based Disaster Risk Reduction</td>
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<td>EPS</td>
<td>Ensemble Prediction System</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>HII</td>
<td>Hydro Informatics Institute</td>
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<tr>
<td>ICHARM</td>
<td>International Centre for Water Hazard and Risk Management</td>
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<tr>
<td>ICT</td>
<td>Information and communications technology</td>
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<tr>
<td>IFI</td>
<td>International Flood Initiative</td>
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<tr>
<td>IHA</td>
<td>International Humanitarian Assistance</td>
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<tr>
<td>INSF</td>
<td>Iranian National Science Foundation</td>
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<tr>
<td>IRIMO</td>
<td>Islamic Republic of Iran Meteorological Organization</td>
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<tr>
<td>IWMI</td>
<td>International Water Management Institute</td>
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<tr>
<td>KWPA</td>
<td>Khuzestan Water and Power Authority</td>
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<tr>
<td>NDMO</td>
<td>National Disaster Management Organization</td>
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<tr>
<td>NHRI</td>
<td>National Human Right Institutions</td>
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<tr>
<td>NMHS</td>
<td>National Meteorological and Hydrological Services</td>
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<tr>
<td>NSFC</td>
<td>Chinese National Science Foundation</td>
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<tr>
<td>PBO</td>
<td>Plan and Budget Organization</td>
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<tr>
<td>PDNA</td>
<td>Post Disaster Need Assessment</td>
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<tr>
<td>RIMES</td>
<td>Regional Integrated Multi-Hazard Early Warning Systems</td>
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<tr>
<td>SiDRR</td>
<td>Silk Road Disaster Risk Reduction</td>
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<tr>
<td>SRCIF</td>
<td>Special Reporting Committee on Iran Floods</td>
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<tr>
<td>WMO</td>
<td>World Meteorological Organization</td>
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Background

Changing contours of flood risks:
Flood is the most common, frequent and ubiquitous of all disasters. As per the global database of disasters, this analysis is based on the compilation of the EM-DAT data,\(^1\) which includes a total number of 11,414 natural disasters recorded since 1900, in which ten or more persons were killed, or 100 or more persons were injured and where floods accounted for as many as 5,072 in number (44.4 per cent).\(^2\) No region or country is immune to the risks of flood, which mainly consists of riverine floods in basins and flash floods in hilly settlements. Rising temperatures, melting glaciers and changing patterns in precipitation have caused desert floods and glacial lake outbursts, which are a relatively new phenomenon. Urban floods have become more common as large metropolises, in both developed and developing countries, become submerged with low frequency and high density floods. The hazards of flood (defined as ‘overflow of water submerging land that is usually dry’) is a natural phenomenon and nature has, at the same time, provided ecological cushions for protection in flood plains and forest covers. The disasters of flood (loss of lives, livelihood, assets, economy, environment) is a man-made phenomenon, as flood plains are encroached with human settlements, the carrying capacity of natural drainage and storage systems (rivers, reservoirs etc.) is reduced due to overload of silts, trees are felled, forests denuded, dams and reservoirs not maintained and managed unsustainably and city drainage systems are not designed and managed properly.

Floods in the context of the Asia-Pacific region:
Floods in Asia and the Pacific have been most frequent and quite devastating. Since 1970, natural disasters in Asia and the Pacific have killed two million people, which accounts for 59 per cent of the global death toll. The principal causes of deaths due to natural disaster were earthquakes and storms, followed by floods. Floods have taken a greater share of fatalities to the extent of 12 per cent over this period, with multiple incidences occurring in Afghanistan, China, the Democratic Republic of Korea, India, Japan, the Lao People’s Democratic Republic and other countries, in 2018.\(^3\) According to the World Resources Institute (WRI), 10 out of the top 15 countries in the world with the most people and economies exposed to annual river floods are in the Asia-Pacific region. They are, by order of population exposed to flood risk; India, Bangladesh, China, Viet Nam, Pakistan, Indonesia, Myanmar, Afghanistan, Thailand and Cambodia (Figure 1).

\(^1\) ESCAP, based on EM-DAT (Accessed on 30 May 2019).
\(^3\) Asia-Pacific Disaster Report (2019).
Background

The extent of the total risk is represented by the absolute average annual loss (AAL) in US dollars. For the region as a whole, the multi-hazard AAL of the extreme events is $148,866 million, which represents 54 per cent of global multi-hazard risk. Of this, 34 per cent is contributed by earthquakes, 33 per cent by riverine floods, 32 per cent by tropical cyclones, and 2 per cent by tsunamis. Of the total flood AAL, China represents 28 per cent and India 13 per cent, followed by the Russian Federation at 9 per cent and Australia at 7 per cent. Other countries with a significant proportion of the region’s flood AAL include Bangladesh, Indonesia, Japan, the Republic of Korea, Thailand and Viet Nam. The countries with the highest flood risk are Bangladesh, Cambodia, Lao People’s Democratic Republic and Myanmar.

**Flooded Future:**

Using tools from the World Resource Institute, ESCAP has developed flood risk projections for moderate (RCP4.5) and severe (RCP8.5) scenarios. Both indicate a substantial increase in flood losses, particularly in East, South, South-West and South-East Asia, with the problems becoming worse by 2030. Bangladesh, China, India and Pakistan will experience losses two to three times greater than in the reference year of 2010. Under the severe scenario, India will be the country worst affected, with nearly $50 billion in annual losses, followed by China, Bangladesh and Pakistan.\(^4\) While flooding can be considered by country, in fact much of the excess water spreads across the region’s major river basins and over national frontiers. Under the moderate and severe climate change scenarios, the transboundary flood losses will be 2 to 6 times greater in the Ganga-Brahmaputra and Meghna basin; 1.5 to 5 times in the Indus basin; 1.2 to 2 times in the Mekong basin; and 1.1 to 1.5 times in the Amur basin.

Further, a new research conducted by Climate Central, suggests that, by 2050, the sea level rise could push the high-tide line above the homes of 150 million people living on coastlines today. Rising sea levels could also push chronic floods higher than the land that is currently home to 300 million people, and this number could reach 480 million people by 2100. These totals are significantly larger than previous estimates and have wide-ranging and profound implications for economic and political stability. Importantly, the greatest impact will be felt in Asia, where six nations, notably Bangladesh, China, India, Indonesia, Thailand and Viet Nam are home to 75 per cent of the 300 million people who will be living in chronic flood zones. These findings are based on CoastalDEM, a new digital elevation model that uses machine learning methods to correct for systematic errors in the principal elevation dataset previously used for the international assessment of coastal flood risks, NASA’s Shuttle Radar Topography Mission.5

2019 Floods in Islamic Republic of Iran – a new climate reality:
Climate change is the greatest anthropogenic factor which is changing the pattern and dynamics of flood, destabilising the existing knowledge and practices of flood management as the past is no longer a definitive guide for the present and the future is uncertain. The flood of 2019 in the Islamic Republic of Iran is another unprecedented flood in the era of changing climate. Three spells of heavy rainfall inundated 26 out of 31 provinces of Iran (83.8 per cent) that has had no precedent in the past. Contrarily, lesser widespread flood in 1954, 1956, 1987 and 1993 had resulted in more fatalities in the country. Yet, 2019 was devastating as nearly 10 million people were affected, hundreds of thousands of houses collapsed, roads and bridges damaged and power, telecommunication and other networks of infrastructure were adversely affected. Scientists attributed this to the unusual and combined movement of rain bearing clouds from the Caspian Sea, the Red Sea and the Persian Gulf that occurred due to impacts of climate change. However, economic losses due to flood were enormous; a staggering $4.27 billion. According to ESCAP’s Asia-Pacific Disaster Report (APDR) 2019, in the context of the Islamic Republic of Iran, the annualised economic losses was pegged at US$ 16.47 billion, which is close to 3.7 per cent of its GDP. This called for the development of a comprehensive framework for flood risk management in the country, which has so far escaped the attention of policymakers as floods, unlike earthquakes, landslides and droughts, never figured prominently in the riskscape of the Islamic Republic of Iran.

ESCAP’s Asia-Pacific Disaster Resilience Network (APDRN) is geared toward implementation in high disaster risk areas. The Asia-Pacific Disaster Report 2019 identifies distinct disaster risk hotspots in the region, where disaster risk is much higher and critical. A complex sequence of climate and weather disasters such as drought, sand and dust storms, desertification and floods are on the rise in arid and semi-arid subregions of South-West and Central Asia, as indicated clearly in the recent IPCC ‘Global Warming of 1.5°C’ report, which refers to such phenomena as a new normal. The widespread 2019 floods in the Islamic Republic of Iran, which followed droughts and sand and dust storms in quick succession, exemplify this new climate reality.

Build a bridge for flood risk management in Islamic Republic of Iran:
A regional high-level expert’s workshop was organized jointly by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the Special Reporting Committee on Iran Flood 2019 (SRCIF), and the University of Tehran, and held in Tehran on 9 and 10 October, 2019. At the workshop the experts presented a set of policy recommendations and initiatives, including a scale-up of South-South and regional cooperation for flood risk management in order to complement national efforts in managing flood risk.

The event was attended by more than 100 experts drawn from China, India, Iran, Japan, the Netherlands, Pakistan and Thailand, as well as from key UN and international and regional institutions, namely the Asia and Pacific Centre for Development of Disaster Information Management (APDIM), the Bangkok-based Asian Institute of Technology (AIT) and Regional Integrated Multi-hazard Early Warning System.

the International Centre for Water Hazard and Risk Management (Tokyo), and the International Water Management Institute (Colombo). Recognizing that flood risk management is a multi-sectoral and multidisciplinary endeavour, the high-level workshop facilitated knowledge sharing on the good practices of the region, including science-based, risk-informed public policies and investments, grey and green infrastructure for flood protection, resilient agriculture, effective flood forecasting and early warning systems, ecosystem-based approaches, economic analysis, and socio-cultural and health-related challenges.

Following the unprecedented March/April 2019 floods, the President of the Islamic Republic of Iran, Hassan Rouhani, issued a decree to establish the “Special Reporting Committee on Iran Floods 2019” (SRCIF), headed by the President of University of Tehran and with the participation of distinguished academic scholars and technical experts from across the country. The high-level expert workshop helped in shaping the ‘build a bridge’ initiative of the SRCIF by bringing together national, regional and international institutions, experts and professionals to share common ideas and experiences on managing floods following the regional and South-South cooperation modalities. Lessons learned and experiences gained from the effective response of the Islamic Republic of Iran to the recent floods, and initiatives taken to enhance flood risk management in the country were shared with the participants at the workshop.

The workshop presented the region’s knowledge and experiences and suggested pathways to build a bridge for flood risk management. This thematic report, while illustrating these pathways, is developed to support the initiatives of Member States towards building a resilient development paradigm and developing institutional capacities for flood risk management, in the context of new climate realities where risks are characterized by complexities and deep uncertainties.

Structure of the workshop

The workshop was held in the conference hall of the historic Negarestan Garden and Museum of the University of Tehran. The two-day workshop had six technical sessions, besides the opening and closing sessions. The technical sessions were: (a) Understanding the Climate Risk for managing Hydro-Meteorological Disasters in the Islamic Republic of Iran, (b) Understanding the institutional capacity of the Iranian National Meteorological and Hydrological Services (NMHSs) and related organizations, including academia and research institutions flood risk management, (c) Multi-sectoral approaches for flood risk management: sharing experiences, (d) Building the bridge with international organisations initiatives, (e) Innovations in flood forecasting and early warning systems, and (f) Partnership network for flood risk management in the Islamic Republic of Iran. Several academics and researchers of the University of Tehran including the President of SRCIF and Chairman, members of working groups, experts and professionals of UN agencies like ESCAP, UNDP and UN Environment, in international and regional organizations like ICHARM, IWMI and RIMES, and in scientific and academic institutions like AIT, NHRI and HII and experts from China, India, Netherlands, Pakistan and Thailand, attended the workshop.
Opening Session

Welcome Remarks. Dr. Mostafa Mohaghegh, Senior Coordinator, Asian and Pacific Centre for the Development of Disaster Information Management (APDIM), Tehran, welcomed the dignitaries on the dais, the national and international participants of the workshop and explained the purpose and objectives of the workshop. The purpose of the workshop was to share the experiences of flood risk management in the Islamic Republic of Iran and other developed and developing countries, and the objective was to develop a framework of regional and South-South cooperation for better management of extreme flood events in the country.

Welcome Remarks. Dr. Mahmoud Nili Ahmadabadi, Professor of Metallurgy, President of University of Tehran and President of SRCIF, expressed his great pleasure for hosting the workshop in the premises of the University. He explained the background and contexts of the workshop. On the aftermath of the devastating flood this year, His Excellency the President of the Islamic Republic had constituted a Special Reporting Committee on Iran Floods (SCRIF), which he had the honour to Chair. The President had further set up 16 working groups to investigate the causes and consequences of the Iran Flood 2019. Nearly 300 professors and academics from 54 universities have been involved in the study which is the first of its kind in the country. Fifteen working groups studied the separate aspects and dimensions of the flood, such as meteorology and climatology; environment; hydrology and water resources; river engineering and hydraulic structures; agriculture and natural resources; urban planning, architecture and cultural heritage; infrastructure; education and human resource management; economics and finance; business; legislative issues; crisis management; health, relief and rescue; risk transfer and insurance; and social, cultural and communication. The sixteenth working group has been tasked with the responsibility of collating the analysis and recommendations of other working groups and producing a synthesis report. The report of the Special Committee is expected to be finalized in the coming months. This workshop provided excellent opportunities to the academics and researchers of the university to present their studies on the floods and to learn from the regional and global experiences of flood risk management in order to find sustainable solutions to the problems of recurring flood in an era of changing climates.
Opening Remarks. Dr. Seyed Hamid Pourmohammadi, Deputy Vice President, Plan and Budget Organization (PBO) of the Islamic Republic of Iran and Chairman of APDIM Governing Council, highlighted the importance of reducing risks and building resilience to disasters for achieving the sustainable development goals. The Islamic Republic of Iran and its people have demonstrated their resilience in dealing with the devastating floods of 2019, despite the economic sanctions that blocked international humanitarian assistance for the victims of flood. However, the Islamic Republic of Iran suffered enormous losses of productive assets, housing and infrastructure which resulted in serious setbacks to development. In order to avoid such losses in the future, it is necessary to find innovative solutions through various structural and non-structural measures, the application of technology, and the timely dissemination of critical knowledge and information to the people, so they can be prepared to deal with floods and other disasters. Dr. Pourmohammadi informed that the Government of the Islamic Republic of Iran has enacted a new law on disaster management and is in the process of developing a national policy on disaster management. Disaster risk management has been identified as one of the key strategies of Seventeenth Plan for sustainable development of the Islamic Republic of Iran. He expressed hope that the outcomes of the knowledge sharing workshop would provide valuable inputs for enhancing regional cooperation for flood risk management in the Islamic Republic of Iran and the West Asia region.

Remarks. Ms. Ugochi Daniels, UN Resident Coordinator in the Islamic Republic of Iran gave an overview of the engagement of UNDP in the country, with a focus on disaster risk management, in general, and flood risk management, in particular. Building resilience to shocks and disasters is one of three key development strategies of the UNDP in the Islamic Republic of Iran. This has been pursued through various initiatives including technical assistance packages for community-based disaster risk management. After the devastating floods this year, the UNDP assisted the Government of the Islamic Republic of Iran to develop a comprehensive Post Disaster Need Assessment (PDNA) as well as a recovery strategy based on the principle of building back better. The UNDP will continue to support all future initiatives of North-South, South-South and Triangular Cooperation for disaster risk management.
Dr. Sanjay Srivastava, ESCAP shared the key findings of the Asia-Pacific Disaster Report (APDR) 2019, the flagship biennial research publication of ESCAP. The theme of the Asia-Pacific Disaster Report (APDR) 2019 is “Disaster Riskscape across Asia-Pacific: Pathways for Resilience, Inclusion and Empowerment”. He also highlighted the five key messages of the Asia-Pacific Disaster Report in the specific context of the Islamic Republic of Iran.

a) The Asia-Pacific region accounts for nearly 60 per cent of all disaster fatalities globally and 12 per cent of these fatalities are due to floods. Climate-related risks account for nearly 85 per cent of all disaster risks in the region. Total annualised economic losses due to disasters in the region are estimated to be a staggering US$ 675 billion, of which the share of drought was as high as 60 per cent. For the Islamic Republic of Iran, the annualised economic loss is pegged at US$ 16.47 billion, which is close to 3.7 per cent of its GDP. Therefore, reducing risks of disasters is critical for sustainable development in the Islamic Republic of Iran.

b) Environmental fragility, poverty and disaster risk are converging in four risk hotspots of the Asia-Pacific region. These are: Trans-boundary River Basins, the Pacific Ring of Fire, Pacific Small Island Developing Countries, and Sand and Dust Storm Risk Corridors. Almost the entire geographical area of the Islamic Republic of Iran falls in the Sand and Dust Storm Risk Corridor.

c) Risks of disaster threaten to slow down the impacts of poverty eradication measures and widen inequalities in opportunities, which further deepen poverty over generations. Based on computable general equilibrium (CGE) simulations, ESCAP has estimated that the rate of poverty reduction in the Islamic Republic of Iran would slow down by 19 per cent, by 2030, if disasters continue unmitigated. This would provide a serious setback to the achievement of the sustainable development goal of the ‘eradication of poverty in all its forms everywhere’. The ESCAP study further estimates that a 1 per cent increase in exposure to extreme climatic events may result in 0.24 per cent increase in Gini coefficient, 0.3 per cent increase in under-5 mortality and 0.26 per cent decrease in the rate of education.
Background

Investments in development can reduce the incidence of poverty, but there are differential impacts of the various types of investments on poverty reduction, with social protection having the maximum impact, followed by health, education, and infrastructure. Additional investments are necessary for disaster risk reduction, but the benefits of such investments far outweigh the costs. In the context of the Islamic Republic of Iran, it has been estimated that an annual additional investment of US$ 4 billion can substantially bring down average annual loss to US$ 16 billion.

Effective analysis and use of big data can mitigate the challenges of complex disaster risks, just as innovative application of technology can enable adaptation to emerging climatic risks, thereby empowering the communities at risk to deal with disasters. There are several examples of new and emerging technologies for disaster risk management. Predictive analytics of Internet of Things can provide affordable earthquake early warning to communities. Ensemble Prediction System (EPS) can generate flood forecasting with a longer lead-time. Artificial Intelligence and computerized simulations can integrate various parameters of flood such as topography, rainfall, river discharge, land-use land-cover etc., to create localized flood forecasting models through Google Public Alerts. These predictive analytics generate maps and accurately predict the location, time and severity of flood, which helps in planning and implementation of flood response, evacuation, relief and recovery initiatives.

ESCAP has established the Asia-Pacific Disaster Resilience Network (APDRN) that has created regional platforms for the early warning of extreme climatic events, slow-onset events and geophysical hazards, through partnerships between various global, regional and national level agencies. This has opened new opportunities for action at national and regional levels in each of the four disaster hotspots of the Asia-Pacific region. The newly created Asian and Pacific Centre for the Development of Disaster Information Management (APDIM) in the Islamic Republic of Iran will facilitate collection and dissemination of such knowledge-based action and action-based knowledge.

**Figure 2: Annualized Average Loss US dollars (Disaster Riskscape of the Islamic Republic of Iran)**

![Graph showing annualized average loss in US dollars for different disasters in the Islamic Republic of Iran.](source: APDR 2019 based data.)

d) Investments in development can reduce the incidence of poverty, but there are differential impacts of the various types of investments on poverty reduction, with social protection having the maximum impact, followed by health, education, and infrastructure. Additional investments are necessary for disaster risk reduction, but the benefits of such investments far outweigh the costs. In the context of the Islamic Republic of Iran, it has been estimated that an annual additional investment of US$ 4 billion can substantially bring down average annual loss to US$ 16 billion.

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1/
Understanding Climate risk for managing Hydro-Meteorological disasters
1.1 Climate Change and Flood Risks in South-West Asia: Challenges and Opportunities for Actions

The session started with a keynote presentation on ‘Climate Change and Flood Risks in South-West Asia: Challenges and Opportunities for Actions’, by Dr. Mukand S. Babel Professor, Water Engineering and Management and Chair, Climate Change Asia at the Asian Institute of Technology (AIT) Bangkok, Thailand. Professor Babel explained the difference between climate variability and climate change and analysed the changing climate with reference to rising temperatures, changing precipitation, rise in sea levels, and increasing frequency and intensity of extreme climatic events. Half of the world’s annual precipitation falls in just 12 days and this phenomenon of intense rain in a shorter duration is likely to be more uneven, exacerbating the risks of flood. Risks of flood are created when vulnerable people and assets are exposed to the hazards of flood as manifested in its extent, depth, duration, and velocities.

Professor Babel presented different models of flood risk assessment, such as community-based risk assessment in Bangladesh, and the cascading effects of flood on infrastructure in Thailand. He introduced the concepts of ‘water security’ as learning to live with an acceptable level of water risk, which includes both flood and drought; ‘climate risk informed decision analysis’, which factors climate risks into the decision-making process; and ‘ecosystem-based adaptation’, which uses natural resources of land, water and vegetation for adaptation to climate change. In this context he highlighted the opportunities of using flash floods as resources.

Concluding his presentation, Professor Babel identified several issues as a way forward for flood risk management. These are: (a) translating global/regional future climate at operational scale to analyse flood risk and its management at local levels; (b) developing more accurate and reliable forecasting and early warning systems; and (c) working on water security as an overarching concept for using floods as a resource and as part of the strategies for mitigation and adaptation to climate change.

1.2 Managing the 2019 floods in the Islamic Republic of Iran: Key operational challenges and lessons learnt

Mr Esmaeil Najjar, Head of National Disaster Management Organization (NDMO) who led the flood response and relief operations spoke at length on the ‘Key Operational Challenges and Lessons Learnt in Managing 2019 Floods in the Islamic Republic of Iran’. The floods were unprecedented in its scale, spread and magnitude. Responding to the floods became challenging as there was no early warning of floods matching such magnitude. This made it difficult to plan a response and evacuate people in time to safe places. The nature of the floods in the three main affected provinces of Golestan, Khuzestan and Lorestan were different, requiring different strategies of response for which there were no warnings in advance. Unplanned release of water from dams further compounded the problem. Sanctions against the Islamic Republic of Iran blocked international humanitarian assistance. Adverse weather conditions did not permit the deployment of helicopters for search, rescue and relief operations. However, despite these constraints the NDMO and the provincial governments used all available information and resources to respond to the flood as best as they could. The primary objective of the response was to save lives and reduce damage and losses. The fact that mortalities were restricted to 90 persons and a major outbreak of epidemics was prevented, especially for such large scale floods were a testament to the success of the flood response and relief operations despite the constraints and challenges.

The major lessons learnt were that early warning of floods and dissemination of warnings must be improved considerably in order to provide the lead time for people to move to safe places in time, to save lives. Further, it was suggested that the houses and infrastructure must be constructed with proper designs and specifications to withstand the hazards of flood and other disasters. Development projects must be planned and implemented in a manner that does not create any new risks of disasters. Often,
faulty development practices have created risks of disasters. For example, conversion of dry drainage channels into road, in Shiraj, have resulted in flood in the city which could be easily avoided had the natural course of the channel been allowed to exist. Finally, it was highlighted that effective disaster risk management would require active participation of communities and people in assessing risks and reducing risks of disasters

1.3 Post-disaster Needs Assessment (PDNA) of the 2019 floods in the Islamic Republic of Iran - Key highlights and strategies for reducing flood risk in the future

Mr. Seyed Vahid Aldin Rezavani of Plan and Budget Organization (PBO) of the Islamic Republic of Iran and Dr. Mohsen Roozbahani of UNDP in the Islamic Republic of Iran, presented an overview of the ‘Post-Disaster Needs Assessment (PDNA) of the 2019 floods in the Islamic Republic of Iran’. The PDNA is a mechanism for jointly assessing the damages, losses, effects and impacts of disaster and for identifying recovery needs across sectors. This enables the analysis of macro-economic and human development impacts of disasters and facilitates development of a comprehensive recovery strategy and mobilization of resources for implementation of a recovery plan.

The PDNA team in the Islamic Republic of Iran had a three tier structure: (a) High Level Management Team comprising of senior representatives of the Government, the UN Resident Coordinator, the World Bank Country Director and other key national and international partners to provide strategic guidance and take key policy decisions; (b) Coordinating Team under key functionaries of the Government and the UNDP to manage the day-to-day planning and implementation of the assessment, as well as the development of the recovery framework; and (c) Sector Teams consisting of subject-matter experts from the appropriate line-ministries for collecting and integrating data on damages, losses, human development impacts and recovery needs from national and local sources.

3 sectors and 13 sub-sectors were included in PDNA. These were: (a) Productive Sectors (agriculture, commerce, industry and tourism); (b) Social Sectors (housing, education, health and culture); and (c) Infrastructure Sector (water and sanitation, community infrastructure, energy, transport and telecommunication). Additionally, gender, governance, environment, disaster risk reduction and employment and livelihood, which cut through all the sectors and sub-sectors were also included in the assessment.

The PDNA estimated that the Islamic Republic of Iran suffered a total damage and loss of US$ 1.470 billion due to the floods of 2019 in selected areas. The Housing sector suffered the maximum with estimated loss of US$ 413.32 million, followed by Agriculture, Fisheries and Livestock (US$ 379.20 million), Transportation (US$ 209.75 million), Water, Sanitation and Hygiene (US$ 168.95 million), and Employment and Livelihoods (US$ 135.91 million).

Total recovery needs were estimated at US$ 1.513 billion which was slightly higher than the total estimated damage and loss. Housing topped the list (US$ 709.53 million), followed by Employment and Livelihood (US$ 197.88 million), Water, Sanitation and Hygiene (US$ 173.14 million), and Transportation (US$ 165.66 million).

While the presentation did not note how resources could be mobilized for the implementation of sectoral plans as per the assessed needs of sectors and the time frame of implementation of the plans, it was clarified that the sectoral departments would find resources within the budgetary allocations in their respective sectors. It was further clarified that the assessed damage and losses included only the direct losses, which takes into account both the direct damage and losses, and also the indirect opportunity costs of the damages.
Understanding institutional capacity related to Meteorological and Hydrological Services
2.1 Atmospheric Science and Meteorological Research Centre’s (ASMERC) Flood Early Warning System

Technical Session 2 started with a presentation by Dr. Majid Azadi of Atmospheric Science and Meteorological Research Centre (ASMERC) on ‘Flood Early Warning System’ in the Islamic Republic of Iran. The country experiences four different types of flood and all these had their share in the 2019 floods: (a) Flash flooding, which is the most common, occurred in the provinces of Golabdareh, Masouleh, Golestan; (b) Mainstream or riverine flooding affected the provinces of Neka, Karoon and Karkhe; (c) Snow melt flooding was experienced in parts of Hirmand; and (d) Manmade flooding occurred due to malfunction of spillway gates and other control works, such as discharge from the Pishin dam.

The flood early warning system of the Islamic Republic of Iran, like in other countries, has two main components: (a) numeric weather model, and (b) hydrological model. The numeric weather model follows the process of observations through satellite, radar radio-sounds, synoptic stations and GPS systems. Data assimilation provides the initial condition for spherical models, global weather condition analysis provides initial and boundary condition for the regional models, and development of regional model drives the weather prediction.

The hydrological model is more complex, which factors rainfall, storage, evaporation, ground water recharge, river flow and discharge and river basin analysis etc. The two models are integrated to generate early warnings for flood. WMO guidelines are followed in forecasting lead time; starting with overall outlook, daily and sub-daily general forecast, heavy rainfall warning, flood watch and flood warning.

Dr. Majid Ajadi presented flood early warnings issued for Karun-Dez-Karkheh-Zohreh basins during 26 and 27 March and 1 and 2 April, 2019, on the basis of numerical weather simulation results and forecast maps from 24 March onwards. He admitted that forecasts did not match the ground realities due largely to the poor observation network of weather stations and shortcomings in hydrological models. The model does not fully account for factors such as carrying capacity of rivers, siltation load, topography, run off, land-use land-cover, settlement pattern and vegetation cover and therefore the model could not predict accurately the extent and depth of inundation due to flood.
2.2 Understanding 2019 floods in the Islamic Republic of Iran: Science perspectives

Mr. Bohloul Alijani, President of the SRCIF Working Group on Climate and Weather was the next speaker in the session and presented the ‘Understanding 2019 floods in Islamic Republic of Iran: Science perspectives’. The Islamic Republic of Iran has very diverse climatic regimes through time and space. There are wide ranges of variation in annual precipitation; from 50 mm in Bam to 2000 mm in Anzali. Most of the daily rainfall (>40 per cent) is concentrated in less than 10 per cent of rainy days. Therefore, climate-related hazards of floods and droughts are common in the country. However, the flood, in 2019, in the Islamic Republic of Iran was unprecedented. Accumulated rainfall in four days during 26 and 27 March and 1 and 2 April, 2019, was the highest recorded in history. Floods of such magnitude have a return period of 150 to 200 years, which defied all design calculations of river engineering and infrastructure.

Mr. Bohloul Alijani was of the opinion that climate change contributed to the floods of such magnitude. Moisture from the Caspian Sea, the Red Sea and the Persian Gulf moved into the mainland and the westerlies moved southward in the Middle East. The anomaly map of 500 hpa (Pressure Altitude in feet) and air moisture indicated an exceptional situation. The cooperation of the jetstream is again an exception like the 2010 flood in Pakistan. The dominant position of the westerlies was the higher zonal index and blowing directly from west to east, which indicate that these kinds of torrential rains will occur only sporadically in time. Mr. Bohloul Alijani suggested that the country prepare for more widespread and intensive hazards of such kinds in the future.
3 / Multi-Sectoral approaches for flood risk management
Technical Sessions 1 and 2 set the context for the Technical Sessions 3 and 4 which were more directly related to the theme of the workshop on regional and South-South cooperation on flood risk management.

3.1 Managing flood risks through grey and green infrastructure – Emerging trends and perspectives

The third technical session started with a presentation on ‘Managing flood risks through grey and green infrastructure – emerging trends and perspectives’, by Dr. Mukand S. Babel, Professor, Water Engineering and Management and Chair, Climate Change Asia at the Asian Institute of Technology, Bangkok. Professor Babel defined grey infrastructure as ‘the human-engineered solutions that often involve concrete and steel’. These include dams, storm water drains, sea walls, water treatment plants etc. Green infrastructures are the ‘interconnected networks of natural areas and other open spaces that conserve natural ecosystem values and functions, sustain clear air and water, provide wide variety of benefits to people and wildlife’. Examples of such structures include water harvesting structures, rainwater harvesting, bio-retention and infiltration systems, flood bypass, green roofs, permeable pavements, protection and restoration of wetlands, mangroves, coastal marshes, reefs and sand dunes, reforestation and afforestation etc.

Apart from the primary benefits of utilizing scarce water resources, green infrastructures have secondary co-benefits like the provision of food and recreation space and erosion control through the use of a more holistic approach. These provide low cost and sustainable solutions and help reduce the pressure on existing water infrastructures. These can play an important role in the wider strategies for adaptation and mitigation of climate change, and conservation of biodiversity through the creation of new habitats. Green infrastructures have their challenges as well. These are largely untested concepts and there is a considerable lack of capacities in designing and maintaining such infrastructure. Therefore, such infrastructures are yet to find acceptance as alternatives to grey infrastructure in scientific, socio-political and decision-making circles.

The hybrid infrastructures, as a mix of grey and green infrastructures, have been advocated as a sustainable solution, which can combine the benefits of structural and ecosystem-based approaches and which is resilient, adaptive, environment friendly and futuristic. The models of hybrid infrastructures have been followed in the redevelopment of Ho Chi Minh city, in Viet Nam and in Ayuthaya, in Thailand. Professor Babel concluded his presentation with specific examples on how grey and green infrastructure can be combined in designing river flood, urban flood and coastal flood management systems.

3.2 Performance of built infrastructures during the 2019 floods in the Islamic Republic of Iran

The next speaker in the session was Dr. Ali Akbar Aghakouchak, Professor of Structural Engineering, at the Tarbiat Modares University, in the Islamic Republic of Iran. His presentation was on the ‘Performance of built infrastructures during the 2019 Floods in the Islamic Republic of Iran’. According to the SRCIF Working Group on Iran Flood 2019, almost every type of built infrastructure, such as buildings, schools, roads, culverts, bridges, railway, healthcare facilities, water and wastewater structures, electricity network, gas distribution network, telecommunications, agricultural infrastructure and industrial complexes, suffered extensive damages, amounting to a total of US$ 1.52 billion. Although most of these damages occurred in the six most hard-hit provinces of Golestan, Lorestan, Khuzestan, Mazandaran, Ilam and Kermanshah, about 30 per cent of the losses were reported from other provinces that were not affected by severe floods. This was a matter of concern as built-up infrastructures were found to be vulnerable even in areas that were not affected by major flooding.
Dr. Aghakouchak presented a comprehensive analysis of the types of damages of built infrastructures, which can be summed up as follows:

a) Although a number of large dams were located in the rivers of the affected provinces, such as Karun, Karkhe and Gorganrud etc., no damage to these dams was reported.

b) Many retaining walls of rivers and roads were damaged mostly due to scouring in their foundations and water penetration behind the walls, indicating poor quality of construction and maintenance. A number of pumping and hydrometrics stations were damaged since these were not designed and constructed to withstand large volumes of flood.

c) More than 10,000 km of roads and railway tracks were damaged, mainly due to inadequate hydrologic and drainage systems, inadequate number of culverts and their flood flow capacity, non-observation of construction standards, improper maintenance of culverts, non-resilience of sub-base, base and pavements of roads to long time flooding and poor performance of retaining walls.

About 100 bridges in the western and northern provinces were significantly damaged due to scouring at piers and abutments foundations, inadequate depth of deep or shallow foundation, improper design or construction of guide walls, overtopping of bridge decks, impacts of floating objects on piers and decks and improper design and construction of support and connection of decks to piers and abutments. These were mainly due to the fact that the national bridge design standards and guidelines do not have adequate provisions with regard to flood resistance. About 170,000 buildings were partially or totally damaged during the floods, accounting for about 30 per cent of the damages to infrastructure. The main causes of damage to buildings were; landslides, in provinces such as Golestan, Mazandaran and Lorestan; effects of flood flow loading on the buildings and their foundations located in flood way fringes, in provinces such as Lorestan; and effects of long lasting flooding, in provinces such as Golestan and Khuzestan. River-based water and waste water facilities, in areas such as Khuzestan province, were heavily disrupted and damaged. The rural areas of provinces, such as Lorestan, where water supply pipelines run alongside rivers were damaged significantly.

d) Power generation facilities were not damaged anywhere, and no major disruption of electricity supply occurred during the floods. However, in Khuzestan province, flooding of vast areas threatened the normal operation of distribution networks. In Lorestan province, where transmission and distribution lines were in floodway fringes, significant damages occurred and electricity supply to quite a number of villages was disrupted. Also, in Golestan province, landslides caused considerable damages to distribution lines.

For the main gas transmission lines, although in some places there were wash out of line covers or damage to supports, no major disruption to the gas supply occurred during floods. However, in Lorestan province, distribution lines crossing the rivers or located in floodway fringes were damaged. Landslides also caused considerable damages to distribution lines in addition to long lasting flooding in some cities.

e) Agricultural infrastructures, such as pump stations, irrigation channels, qanats and roads within the farms, were also damaged mainly in Khuzestan, Lorestan and Golestan provinces. Some of the damages were due to flood management operations, for example, in the Khuzestan province, where the authorities in charge decided to open some river dikes in order to prevent flooding of urban cities. However, in most cases the damages were due to technical reasons, such as wrong site selection, inadequate flow capacity of floodways due to deposition of sediments, and inadequate flood protection measures.

f) Landslides caused damages to almost all types of infrastructures, especially in rural and mountainous areas of provinces such as Lorestan and Golestan. The main technical reasons for such damages were: the non-existence of landslide hazard maps in most areas, non-consideration...
of landslide hazard in site selection of infrastructures, destruction of natural vegetation and forests, and inadequate slope stabilization measures or retaining walls.

Large scale damages of built-up infrastructure raised several technical issues which were presented very succinctly by Dr. Aghakouchak in his presentation.

a) Definitions of river bed, floodways and floodway fringes are not clear in Iranian technical guidelines and standards and allowable land uses. Flood resistant parameters for designing cross river structures are not clearly specified.

b) Flood and landslide hazard maps are not available for many parts of the country and these have not generally been considered in the preparation of comprehensive development plans of cities and villages, and in site selection of infrastructures.

c) River and floodways have not been managed properly. Floodways are partly occupied by farmers and structures. Vegetation and sedimentation has also reduced the flow capacity and dredging has not been carried out, on a regular basis, due to reasons such as lack of budget. Sand and gravel extraction from river beds has intensified river bed degradation and caused extra scouring at cross-river structures.

d) River morphology has not been considered during site selection of some cross-river structures. Hydrology studies have not been adequately conducted for road routing and site selection of related structures in many cases. In a lot of cases, culverts and bridges have not been properly maintained and dredged to allow designed flood discharge.

e) A comprehensive design standard for bridges, including flood resistance measures, does not exist. As such, hydraulic studies regarding selection of span length and deck elevation are deficient. Return period of design flood for many bridges is too short. Measures related to overtopping of decks are not addressed in existing standards. Geotechnical studies and foundation design are not often adequate. Design and construction of abutments and guide walls are also problematic in a number of cases.

f) Buildings located in floodway fringes that are fairly steep and are exposed to flows of high velocity and density cannot resist the loads on the structure and the corresponding effects on foundations. Hence, the construction of buildings in these regions must be prohibited. Buildings located in fairly flat floodplains must be designed and constructed for flood resistance as per measures specified in Chapter 6 of the National Building Regulations.

g) Water and wastewater facilities, power distribution and gas distribution networks in flood plains and rural areas are susceptible to flood damage. Flood and landslide hazards must be factored in during the site selection of such infrastructures and special measures should be observed for the eventual flooding of the sites. Alternative supply routes should be considered in order to increase the resiliency of such systems during disasters.

Dr. Aghakouchak concluded his presentation with the following seven recommendations for building resilience of the existing and new infrastructures in the Islamic Republic of Iran:

a) Revise the existing design standards and guidelines to avoid repetitions, clarify ambiguities, eliminate deficiencies and add missing criteria;

b) Monitor and manage rivers and floodways to prevent floodplain encroachment;
c) Ensure that flood and landslide hazards are taken into consideration during site selection and design of new infrastructures;

d) Ensure that essential facilities such as health-care centres, schools and emergency management centres are not located in the high-risk zones;

e) Set systems for monitoring the health and condition of essential infrastructures and lifelines, such as bridges;

f) Allocate necessary budgets for repair and maintenance of existing infrastructures and to execute this task; and

g) Take necessary measures to enhance resilience of existing vulnerable infrastructures in light of recent experiences.

3.3 Disaster resilience in the flood-impacted urban and rural settlements: Experiences from the Islamic Republic of Iran

Dr. Mohammad Mehdi Azizi, Professor University of Tehran who headed the SRCIF Working Group on Urban Planning, Architecture and Cultural Heritage gave a presentation on ‘Disaster resilience in the flood-impacted urban and rural settlements: Experiences from the Islamic Republic of Iran’. The terms of reference for the working group were the following:

1. How did the development of urban and rural areas, without consideration to the standards of urban resilience, impact the occurrence of damages?

2. How did the negligence of the principles of urban and rural planning and the available urban laws and regulation impact the occurrence of damages?

3. What were the most significant violations in urban developments that intensified the damages?

4. How did the performance of local urban and rural governments increase the amount of damages?

5. What are the main lessons learnt from the flooding incidents for the country’s urban and rural planning discipline and future urban and rural developments?

6. What are the necessary alterations needed in the laws, regulations, administrations, administrative procedures, and in crime prevention, in order to increase urban resilience?

The working group addressed these issues with a theoretical framework on urban resilience to floods. The framework has three interrelated components: (a) Integrated flood management through spatial planning, which includes land zoning, land use, evacuation planning, building regulations, and transferable development rights; (b) Integrated urban water management based on the concepts of sponge city, low-impact development, urban sewerage, separating sewerage and storm water systems, and sustainable storm water management; and (c) Integrated watershed management, which provides room for river and ecological restoration, conservation of reservoirs, afforestation, and land use management.

The working group collected data from all available sources including literature reviews, field visits and interviews, analysed the data, and undertook sample case studies of the most affected provinces, cities and villages. The case studies included samples of destructed neighbourhoods, damaged infrastructure, urban transportation and trends in future urban growth and development. Based on these comprehensive surveys and studies, the working group articulated five main lessons learnt from the floods of 2019.
These are:

a) Considerations of flood risks should be integrated with land use planning. This can be done in the future development of existing cities, locating new cities, implementing specific architectural codes in flood-prone areas, and mixing structural implementations with spatial land-use planning.

b) Consideration of flood risks should be included in the planning and building of urban transportation networks. This should be made mandatory in locating, designing and building future bridges, planning main highways and roads, locating and building underground passages, and planning and building ring roads and railroads.

c) Consideration of flood risks should be incorporated in integrated urban water resource management. This would include planning, restoring and constructing sewer systems, planning and building storm water networks, separating sewer systems and storm water networks, and preserving the natural condition of streams and canals.

d) Consideration of flood risks should be made part of integrated watershed management. This would involve preserving forest lands and wetlands, limiting urban development on upstream lands, preparing flood management plans at a watershed scale, and the ecological restoration of waterways and wetlands.

e) Legal and institutional mechanisms for flood risk management should be well-defined at national, provincial and local levels.

The working group suggested four-fold strategies for urban and rural flood risk management at national, provincial and local levels:

**Figure 3**: The transition of land use planning regarding storm water, seen as an opportunity rather than a threat

- a) Reviewing the general approaches towards policymaking for development planning and flood management

This would require a shift from the structural approach to a combination of structural and non-structural measures for flood management. Flood risk management should be considered as an integral part of any sustainable development policy. The linear definition of river should be changed to include flood plains which would vary according to topography and land use. The criminal discourse regarding the unofficial settlements in river basins should be changed in favour of in situ flood protection of the settlements, or if need be, resettlement through a consultative process.
b) Reviewing the current laws and regulation in order to meet the gaps in development planning and flood management

The preparation of flood risk zone maps should be made mandatory in urban and regional master plans. Zoning and building regulations should be revised to ensure that all future development activities are safe from risks of flood and these do not further create any new risks of flood. On the contrary, all future urban and rural developments should reduce the risks of flood. For this purpose, appropriate design guidelines should be developed for integrated water management in settlements.

c) Reorganize the organizational systems for development planning and flood management

The responsibilities of various organizations with regard to integrated water management in settlements should be defined in laws and regulations. Responsible organizations should be designated for surveying and supervising the flood risk zones. Similarly, legal supervisors should be appointed for inspecting flood control structures in urban and rural settlements. Inter-organization coordination arrangements should also be clearly laid down in the rules and regulations.

d) Develop and disseminate urban resilience knowledge

The syllabuses of university courses dealing with urban resilience, construction and design permits should be reviewed. Employees in governmental organizations, dealing with urban and rural planning and management, and flood risk management, should be trained. A research centre on flood management, integrated water management, and urban and rural settlements should be established to add value to existing knowledge and understandings on the subject in the specific contexts of the Islamic Republic of Iran.

3.4 Building resilience to water and energy infrastructure – Dams, reservoirs and power stations – China’s experience

Dr. Hua Zong, Senior Engineer of Nanjing Hydraulic Research Institute, spoke on ‘Flood Risk Management and Experiences and Practice in China’. China faces river basin wide floods, flash floods, typhoon floods and urban floods and water logging. Institutional mechanisms for flood risk management are well-defined in China. The China Meteorological Administration controls the national meteorological network comprising of space, airborne- and ground-based observations, weather forecasts and climate prediction systems. The Ministry of Water Resources oversees the functioning of the national hydrological network, the implementation of flood prevention and management plans, standards, flood monitoring and early warning systems, and flood control operations including dams, reservoirs, flood detention basins etc. The Ministry of Emergency Management, established in 2018, organizes rescue and relief for disasters and workplace accidents, and the State Flood Control and Drought Relief Headquarters performs coordinating roles on a real time basis.

China has developed laws, regulations and guidelines on flood prevention and management. These include the National Flood Control Law, the National Standards for Flood Control (GB 50201-2014), the National Flood Control and Regulation (2011), Guidelines for Assessment of Flood Control Risk (SL 602-2013), the Guidelines for flood risk mapping (SL 483-2017), the Guidelines on compilation of flood impact assessment reports (SL 520-2014), the Guidelines for formulation of reservoir regulation (SL 706-2015), the Guidelines for the formulation of urban flood emergency plan (SL 754-2017), and the Guidelines on dam safety evaluation (SL 258-2017). Flood control and management plans have been formulated at different levels, such as the Basin-wide Flood Control Plan, Flood Control and Drought Relief Emergency Response Plans, and Flood Control Plans for mega cities, small towns, and villages. China has constructed several multi-purpose mega projects, which simultaneously perform the functions of flood control, navigation, transportation, power generation, irrigation, water supply etc. Cost-benefit analyses
of projects are undertaken combining structural and non-structural measures, using ICT, IoT, 5G, AI, etc., involving people through education and awareness generation. Research plays a very important role in flood risk management, in China for enhancing flood warning, forecasting, simulation, risk analysis, climate change adaptation and other aspects, focusing on harmony between man, nature, ecology and environmental safety.

3.5 Building resilient infrastructure for seamless connectivity

**Dr. Javed Iqbal of the Chinese Academy of Sciences** made a detailed presentation on ‘Silk Road Disaster Risk Reduction along the Belt and Road Region’. The presentation covered not only flood but other hazards like earthquakes, landslides, droughts, tsunamis etc., across Asia, Europe and Africa, which comprises of more than 150 countries and about 4.4 billion people. The common challenges faced by the Silk Road region includes inadequate data on natural hazards, insufficient assessment of disaster risks, uncertainties regarding the impacts of climate change, huge gaps in affordable hazards mitigation technologies, and a lack of information sharing and coordination among countries.

The four main components of Silk Road Disaster Risk Reduction (SiDRR) programme are: international cooperation, scientific innovation, inter-disciplinary research and information sharing. The programmes are supervised by an Advisory Committee drawn from various countries across continents. Twenty eight partner institutions from 10 countries are involved in collaborative research. Hazard-based working groups, on earthquakes, oceanic and meteorological hazards, geo-hazards, droughts and floods and disaster risk assessments, are responsible for the implementation of projects in their respective fields. Nine overseas science and education centres have already been set up and the tenth centre is planned to be operational by 2021. A Sino-Italian Laboratory on Geological and Hydrological Hazards has also been set up in Italy.

The SiDRR programme has taken up various innovative research projects. These include the analysis of Hazard Dynamic Process, Multiphase Flows and Numerical Modelling; Velocity Flow Monitoring, Debris Flow Monitoring System, Fluid Structure Interaction Studies, Large Scale Simulation Platform, Multi-Level Disaster Risk Assessment of Human Settlements, and Public Participation Monitoring and Warning System etc. DRR projects have been implemented in several countries, such as the Sri Lankan offshore Monitoring System, Potential Hazard Monitoring in Sarez Lake of Tajikistan, and Mitigation of Attabad landslide-induced dammed lake, in Pakistan. SiDRR has brought out its flagship publication on ‘Atlas of Silk Road Disaster Risks’, which is the first inter-continental map of its kind in the world. SiDRR has enrolled more than 50 international students from about 20 countries in the Silk Road area and provided them with scholarships to pursue doctoral and other studies in disaster risk reduction.

3.6 Challenges towards catastrophe risk transfer in the Islamic Republic of Iran; importance, feasibility and requirement for development of a Natural Catastrophe Insurance pool

Technical Session 3 concluded with the presentation of **Dr. Mohammad Reza Zolfaghari, Associate Professor of Khaje Nasir Toosi University, Tehran** on the ‘Challenges for development of a National Catastrophe Insurance pool in the Islamic Republic of Iran’. The presentation was based on the deliberations of SRCIF Working Group on Risk Management and Insurance, which Dr. Zolfaghari heads. Despite the high incidence of natural disasters, huge economic losses of individual houses and assets, and moderate-to-high per capita income of people in the Islamic Republic of Iran (GDP of US$ 450 billion with a population of 80 million people), risk pooling, risk transfer and risk insurance have not developed in the country. The factors that hinder the growth of risk insurance include the small size of the insurance industry, low capitalization and low retention capacity; lack of proper frameworks and regulations for risk-based pricing; low property insurance penetration / lack of awareness; a limited range of insurance products;
A lack of regulatory frameworks for risk pricing; a lack of affordability to pay risk-based premium; high costs of reinsurance due to political sanction; insufficient expertise and capital to adequately protect policyholders and high potential for insolvency or failure to pay claims in case of large events.

A National Catastrophic Insurance Pool can overcome some of these difficulties by providing a specialized single-source insurance for earthquake and flood for Iranian homeowners. This could include pooling risks in a diversified portfolio across a wide area; building up funds to retain some of the risk through reserves; minimizing the cost of reinsurance and better use of capital; and creating risk-based pricing and incentives for risk reduction. A National Catastrophe (Cat) Insurance would enhance and encourage risk awareness and mitigation, increase the penetration for residential risk insurance, and reduce fiscal exposure and pressure on the government budget. A national pool has obvious advantages over individual catastrophe insurance. High operational and administrative costs discourages the private insurance industry to provide nationwide catastrophe risk cover. A national pool would result in significant savings by pooling diversified catastrophe risks nationally, besides reducing the reinsurance premiums required to maintain solvency. Thus, making insurance more affordable for those who are in most need of insurance cover.

There are several formidable challenges hindering the development of a national pool. These include the provision of low cost insurance to high-risk properties; the inadequacy of data on hazards, vulnerabilities and risks for working out affordable and sustainable rates of insurance premium; the need to address social equity issues, high costs of reinsurance in early years due to thin capital, difficulties in selling policies; and the development of technical instruments, capacities and human resources for management of pool etc. The success of the National Risk Pools would depend on legal changes to make such schemes compulsory for all dwellings, and on government support in the form of regulatory initiatives, public information campaigns, capital support, appropriate operational design, the ability to pool risks nationwide, and last but not least, the political commitment toward and financial support for the initiative.
Innovations in flood forecasting and early warning systems
4.1 Challenges of decision-making during extreme floods in South-West Iran

Technical Session-5 on ‘Innovations in flood forecasting and early warning systems’ had three presentations. The session started with a presentation by Dr. Ali Shahbazi of Khuzestan Water and Power Authority (KWPA) on ‘Challenges of decision making in extreme floods in South-West of Iran’. Khuzestan province in the South-West of the Islamic Republic of Iran was one of the worst affected provinces of the 2019 flood. The province is located downstream of 5 main river basins. Almost all water generated at the upstream of the basins is regulated by more than 11 large dams with total capacity of 23,000 mcm (million cubic metres). Unprecedented rainfall in the catchment in two spells caused the dams to be completely filled up, necessitating the releases of excess water that inundated the downstream locations. KWPA has highly experienced engineers who collect real time information on rainfall and run off from the ground and from remote sensing-based observations and use advanced techniques for hydrological forecasts models, 2D hydrodynamic models, water resources system models etc., for decision-making. But, it failed to anticipate the extreme rainfall and take advance measures for emptying the dams in advance to prevent sudden releases to avoid a kind of manmade disastrous flood in Khuzestan.

This has raised many questions. How much of the reservoir volume should become empty to manage a probable, upcoming flood? How much lead time was available to do this? Where should the downstream overflow be diverted, in order to minimize the flood loss? First and foremost, there were uncertainties in meteorological forecasts (rainfall temporal pattern, rainfall intensity and inconsistency of forecasts). Second, there were uncertainties in the hydrological simulation and runoff forecasts (analysis of initial conditions, change in rainfall spatial-temporal distribution and differences between observed precipitation data and gridded meteorological forecast data). There was also a cascade of errors in the integration of meteorological forecasts with hydrological models. Furthermore, there were gaps between the meteorological forecasts horizon and the decision horizon, specifically in highly regulated water resources system of the dams.

4.2 Capitalizing on advances in weather and climate prediction for improved flood forecasting and early warning services

Dr. Kanoksri Sarinnapakorn of the Hydro-Informatics Institute, Bangkok, which is under the Ministry of Higher Education, Science, Research and Innovation, Thailand, was the next speaker of the session. She spoke on ‘Capitalizing on advances in weather and climate prediction for improved flood forecasting and early warning services’. Dr. Kanoksri gave an overview of the vision, mission and activities of the Hydro-Informatics Institute (HII) and presented the advances made in weather and climatic predictions in different time scales, and the dynamic, coupled, hybrid and urban canopy models adopted for such predictions. HII has developed Flood Warning Systems, Flash Flood Potential Index, Weekly Water Balance Forecasts and Cloud and Hailstorm Forecasts. HII has been collaborating with developed and developing countries in East and South-East Asia, Europe and America and would be happy extend similar collaboration with the Islamic Republic of Iran on the development of flood early warning and other related systems.
4.3 Flood forecasting in the frameworks of Integrated Water Management

Technical Session-5 ended with a presentation on ‘Flood forecasting in the frameworks of Integrated Water Management’, by Mr. Jean Henry Laboyrie, Director and Partner of Coast Deltas Rivers (CDR) International, a consulting firm based in the Netherlands. Mr. Laboyrie presented the framework of the integrated water management that is followed in the Netherlands, in which flood safety, urban expansion, and beautification of the landscape are integrated into one solution. River widening programme with secondary channels to provide room for the river has lowered the risks of flood much more than raising the embankments of a river. An institutional arrangement with the central Government setting the safety target, the regional water board making the plans, and the local governments taking the lead in the design and construction process in urban spaces, worked satisfactorily in Netherlands, which also involved all stakeholders in the flood risk management programme. CDR International has been involved with development of strategic delta plans for Bangladesh, Myanmar, the Netherlands, Viet Nam and flash flood management plan in Bhutan.

For effective flood risk management in the Islamic Republic of Iran, Mr. Laboyrie feels that the Flood Committee 2019 has made an excellent beginning. This should be followed with development of a national vision and national policies for flood management involving all the stakeholders. An integrated action plan needs to be prepared for phased implementation. Cost-benefit analysis and probabilistic approach should be followed for the preparation of programmes and projects for the implementation of plans. Adaptive governance along with a legal framework, budget and finance, and training and capacity building should be key components of the plan.
Building a bridge through South-South and Regional cooperation
Session 5 on ‘Building bridges with South-South and Regional Cooperation’ was divided in two parts. The first part had six presentations of which four were presented remotely through Skype.

5.1 Platforms on water resilience and disasters under the International Flood Initiative (IFI) of ICHARM

Dr. Ikeda Tetsuya, Chief Researcher, International Centre for Water Hazard and Risk Management (ICARM) spoke via Skype on, ‘Platforms on water resilience and disasters under the International Flood Initiative (IFI) of ICHARM’. The activities of ICHARM are based on three pillars; innovative research with advanced technology, efficient information networking, and effective capacity building. Under the IFI scheme, ICHARM supports the establishment of ‘Platforms on Water Resilience and Disasters’ in participating countries. The platforms bring together policymakers, researchers, practitioners, communities, NGOs and donors for the integrated management of water hazards, which include weather prediction and early warning, development of standards and regulations, structural and non-structural measures, and capacity building etc. ICHARM has established such platforms in Indonesia, Myanmar, the Philippines and Sri Lanka to provide country specific solutions for water-related hazards. Such solutions are typically developed and implemented in three phases.

The first phase is the consultative phase when discussions are held with stakeholders to assess the problems and needs according to the felt requirements of the country as per availability of funds. Systems are then developed for testing with support from ICHARM. In the second phase, prototypes are created with some concrete products, based on the experience of Phase 1, with the expectation of funding support from external sources. In the third phase, the systems are operated with ownership and support from the national Government. ICHARM organises the Regional Cooperative Implementation Meeting with IFI countries for sharing knowledge and experience for mutual benefits. ICHARM further contributes to regional cooperation through the WMO-ESCAP Typhoon Committee and the WMO-ESCAP Panel on Tropical Cyclone and offers to support the Islamic Republic of Iran by way of piloting IFI with the concerned organisation.

Figure 5: Ensemble prediction system: nested modelling for food forecasting with longer lead-time

Recent innovation in climate modelling is the use of an ensemble prediction system (EPS). Instead of offering a single forecast, an EPS offers a group or ensemble of forecasts indicating a range of possible outcomes (Figure 7). EPS is particularly useful in floods driven by extreme rainfall and in the context where it is difficult to get hydrologic data. It is also possible to incorporate rainfall predictions from multiple weather centres, as well as rainfall and river observations from many platforms and institutions. Some stations offer forecasts for up to 16 days in advance.6

5.2 Ecosystem-based flood risk management

Dr. Lisa Guppy of UN Environment submitted a PowerPoint presentation in absentia on ‘Ecosystem-based flood risk management’, which was made part of the proceedings of the workshop. Ecosystem-based DRR (Eco-DRR) refers to ‘sustainable management, conservation and restoration of ecosystems to reduce disaster risk and achieve sustainable and resilient development’. Eco-DRR provides low cost solutions with comparably low initial capital expenses and low on-going operational expenses. The benefits increase over time, compared to engineered solutions which tend to deteriorate over time. It typically uses low-technology solutions and provides multiple benefits.

Eco-DRR based flood risk management has been practiced successfully in different geo-climatic regions. These have been documented and principles and guidelines developed for nature-based flood protection measures for replication according to local conditions.

5.3 Initiatives for linking global, regional, products for local application

Dr. Anshul Agarwal, Hydrologist at Regional Integrated Multi-Hazard Early Warning Systems (RIMES) based in the Asian Institute of Technology in Bangkok, Thailand, made a presentation titled, ‘Initiatives for linking global, regional, products for local application’. RIMES was established in April 2009, and is registered with the UN under Article 102 of the UN Charter as an intergovernmental organization, owned and managed by its Member States. Currently, 21 countries in Asia and Africa; Afghanistan, Bangladesh, Cambodia, Comoros, Djibouti, India, Kenya, the Lao People’s Democratic Republic, Madagascar, Maldives, Myanmar, Mongolia, Mozambique, Nepal, Papua New Guinea, Philippines, Seychelles, Sri Lanka, Timor-Leste, Tonga and Yemen are members of RIMES. RIMES connects science, institutions and society to provide an integrated solution for a multi-hazard early warning system at the local level. The solutions are based on latest available information, data, models and technology globally, but are tailored to the requirements of local communities, using regional and national level institutions and capacities. The facilities of RIMES can be made available to the Islamic Republic of Iran.

5.4 Water-related disasters with a focus on droughts and floods in Asia and Africa

Dr. Giriraj Amarnath, Team Leader of Water Risks and Disasters in International Water Management Institute (IWMI) Colombo, Sri Lanka made a presentation via skype on the activities of IWMI on water-related disasters with focus on droughts and floods in Asia and Africa. IWMI has developed flood risk maps for the regions, showing the areas and depth of inundation in different time scales. Using remote sensing, GIS and in-house data inventory, IWMI generates high resolution flood maps showing agricultural land and types of standing crops affected by flood on a real time basis. Based on such information, and making use of digital identification and communication technology, IWMI has designed index-based flood insurance products for small and marginal farmers of flood affected areas in Bihar, India and in parts of Bangladesh, linking them with government programmes on agricultural insurance and flood

risk management. The insurance products are coupled with propagation of flood resisting seeds as a package solution for the farmers affected by flood. The products have been endorsed by the Government as well as insurance companies, creating cost-effective win-win solutions for all stakeholders. IWMI can extend its support for designing similar index-based insurance products for the Islamic Republic of Iran.

5.5 ‘Build a Bridge on Flood Risk Reduction’ outlined the prospects for future regional and South-South collaboration for flood risk management in the Islamic Republic of Iran

Dr. Sanjay Srivastava, Chief of Disaster Risk Reduction Section, ESCAP, Bangkok, in his presentation on ‘Build a Bridge on Flood Risk Reduction’ outlined the prospects for future regional and South-South collaboration for flood risk management in the Islamic Republic of Iran. Such collaboration can take place in two main areas:

a) Flood risk assessment and spatial land use planning:

ESCAP has developed a cloud-based regional data repository, which includes data on hazards, vulnerabilities and exposures. These can be used to assess risks of flood at a regional scale. Based on this data repository, ESCAP has developed the Asia-Pacific Disaster Risk Atlas on a digital platform. This can be used to generate regional and countrywide risk maps on identified hazards, vulnerabilities and exposures. The digital risk atlas has in-built decision support tools, which can be used for effective response, relief and other flood management operations. The Asia-Pacific Disaster Report 2019 has provided significant insights on the flood riskscape of the Islamic Republic of Iran: 11.1 per cent of population and 13 per cent of economy of the country is exposed to annualized risks of flood, which in monetary terms works out to US$ 2.141 billion.

**Figure 6: Exposed population to hydro-meteorological hazards**

![Exposed population to hydro-meteorological hazard](image_url)
b) Flood early warning system:

ESCAP has, in collaboration with various international and regional organizations, developed multi-hazard early warning systems for extreme weather hazards, geo-hazards and slow-onset hazards. ESCAP/WMO have developed flash flood early warning guidelines, which would be useful for improving systems in the Islamic Republic of Iran. ESCAP can support capacity development of the functionaries of the Meteorological Organization of Islamic Republic of Iran (IRIMO). Other international and regional organizations like ICHRAM, RIMES and IWMI can also support the improvement of flood early warning systems in the country, which can be coordinated by ESCAP. Bi-lateral assistance from China, India, Japan and other countries are also feasible. The Islamic Republic of Iran is already hosting the Asia-Pacific Centre for Development of Disaster Information Management (APDIM), which can play a significant role in coordinating regional and South-South cooperation for sharing knowledge, information, good practices and capacity development for efficient and effective flood warning system, in order to save lives and reduce losses incurred during floods in the country.

5.6 Lessons learnt and challenges faced for health system resilience for flood in the Islamic Republic of Iran

The Technical Session Part-1 ended with a presentation on the ‘Lessons learnt and challenges faced for health system resilience for flood in Iran’, by Dr Abbas Ostadtaghizadeh, of the School of Public Health in the Tehran University of Medical Sciences on behalf of SRCF Working Group on Heath, Relief and Rescue. Considering the sudden onset and magnitude of flood without adequate meteorological forecasting and early warning, the health system had moderate preparedness for the current flood. Casualties were restricted, but as many as 65 hospitals and 516 rural health centres were damaged. Preparedness should be further enhanced with preparation of plans for all hazards, as well as specific hazards like floods, earthquakes, droughts, landslides etc.

Despite concerns, no post-flood outbreak of epidemics was reported from any part of the country. This demonstrated the sensitivity of the health surveillance system, which needs to be further strengthened. Cooperation with other disciplines, both internally and externally, and with agencies such as the Ministry of Energy should be enhanced for better emergency response to floods.

Public participation in flood response was excellent. NGOs, CBOs, charities and individuals participated in flood relief operations spontaneously. Such participation should be organized more systematically. The Emergency Operation Centre in the Ministry of Health and other major hospitals functioned satisfactorily. Such centres should be set up at the local level, for a better and coordinated response. Coordination with other stakeholders, such as military forces, should be improved. Providing field security for health and relief systems remains a challenge and needs considerable improvement.

Despite economic sanctions, the International Humanitarian Assistance (IHA) was significant. The Ministry of Foreign Affairs was effective in coordinating such assistance. There should be quick preliminary post disaster needs assessment for issuing flash appeals to IHAs. The absence of a sustainable, multilayer communication system affected the health system, especially in the early response phase. Economic sanctions impacted the health communication system. More staff education for disaster communication is needed. Access to valid, accurate, and uniform information and sharing of available information still remained a challenge. Providing after action reports in different styles was a challenge for health-care workers and the health and relief services were overloaded. These should be strengthened through the engagement of professional, sensitive, culturally-adjusted, and need-based services. Investments on the education of local health workers needs to be enhanced.
The Technical Session Part-2 on ‘Building Bridges with International and other Cooperations’ had two presentations; one from China and the other from Thailand.

5.7 Building the bridge in the field of Flood Risk Management between the Islamic Republic of Iran and China

Dr. Hua Zong, Senior Engineer of Nanjing Hydraulic Research Institute spoke on ‘Building the bridge in the field of Flood Risk Management between the Islamic Republic of Iran and China’. He outlined three areas of possible collaboration between the two countries: Scientific Research, Education and Scholarship and Consultancy and Construction works, in the context of the One Belt One Road Initiative.

The Ministry of Science and Technology of China signed, in 2016, a MoU with Iran’s Vice-President in charge of Science and Technology, to fund joint research projects. This was followed by another MoU signed between the Chinese National Science Foundation (NSFC) and the Iranian National Science Foundation (INSF), in 2017. Funding opportunities are also available under the Research Fund for International Young Scientists and the Silk Road Research Fund. Furthermore, the Chinese Academy Science, the Administration of Water Resource, the Administration of Transportation, the China Meteorological Administration all offer several International Science Cooperation projects.

Hohai University established the Belt and Road Fund on Water and Sustainability. The Nanjing Hydraulic Research Institute, established in 1935, offers research opportunities on hydrology and water resources, hydraulic structures and hydraulics, inland navigation and harbours, dam safety, geo-engineering, and ecology and environment related to water. The Chinese Academy Science and several other universities offer Bachelors to Masters degrees and PhD programmes on hydrology, meteorology and other such related disciplines. Opportunities for scholarships are available from the universities and from the Chinese Scholarship Council and Silk Road Scholarship Program. The Silk Road Economic Belt programme includes construction of highways and railways from China to the Persian Gulf via Central and West Asia, besides other infrastructure facilities of seaports, airports and oil-gas pipeline. Funding opportunities for infrastructure are available under four major windows: BRICS Development Bank, SCO Development Bank, Silk Road Fund, and Asian Infrastructure Investment Bank.

5.8 Case study on Managing Flood Risks in Thailand

Mr. Thada Sukhapunnaphan, Executive Adviser for Hydrology in the Royal Irrigation Department, Thailand was the next speaker. He presented a comprehensive case study on ‘Managing Flood Risks in Thailand’. Based largely on the experiences of the devastating flood in Thailand, during October 2011, the presentation articulated the key lessons learnt in flood risk management which are relevant for the Islamic Republic of Iran as well. The floods in Thailand are of two types - overbank flow inundation and flash flood. The causative factors of both types of flood include both meteorological factors like monsoon troughs, low pressures trough and tropical storm trough, and non-meteorological factors like topography, river channel characteristics, reservoir management, vegetation cover, settlement patterns etc. Dr. Thada made a graphic presentation on all these factors leading to the floods of October 2011.
Risks of flood can be reduced through a combination of both structural and non-structural measures. The structural measures include dams, reservoirs and retarding areas, flood bypass, floodway, dredging or enlarging of channels, river embankment, levee etc. These are designed to move water and not people. Non-structural measures include rain gauge stations, telemetry networks, flood monitoring systems, early warning, and evacuation. These are oriented towards protecting the at risk community, to save lives and reduce losses.

Timely dissemination of reliable, accurate and regular warnings regarding magnitude, location and duration of floods before the onset, during the occurrence and on the aftermath of floods, in a language easily understandable to people can save lives and property. Dissemination of the range of flood information such as flood risk maps, possible depth of inundation, and flood mark levels, in various local areas including buildings and houses, helps people to move things and persons to safe places and thereby reduce losses of lives and property.
Developing framework for flood risk management in the Islamic Republic of Iran
Based on the presentations made at various technical sessions of the workshop, Dr. P. G. Dhar Chakrabarti, former Secretary National Disaster Management Authority, Executive Director National Institute of Disaster Management of India and a leading international expert on disaster risk management suggested a draft framework for flood risk management in the Islamic Republic of Iran. Flood is the most common, frequent and ubiquitous of all disasters. As per the global database of disasters, out of a total number of 11,414 natural disasters recorded since 1900, in which 10 or more persons were killed or 100 or more persons were injured, floods accounted for as many as 5,072 in number (44.4 per cent).

No region or country is immune to the risks of flood which mainly consists of riverine floods in basins and flash floods in hilly settlements. Rising temperatures, melting glaciers and changing patterns in precipitation have caused desert floods and glacial lake outbursts, which are a relatively new phenomenon. Urban floods have become more common, as large metropolis, in both developed and developing countries, become submerged with low frequency high density floods.

**Figure 8: Suggested framework of flood risk management**

The flood of 2019, in the Islamic Republic of Iran, is an unprecedented flood in the era of changing climate. Three spells of heavy rainfall inundated 26 out of 31 provinces in the country (83.8 per cent) that has had no precedent in the past, yet total casualties were restricted to less than 90 persons and major post-flood epidemics were prevented, which bear testimony to a relatively robust system of disaster response in the country. Contrarily, lesser wide-spread floods in 1954, 1956, 1987 and 1993 had resulted more fatalities in the Islamic Republic of Iran. Yet, 2019 was devastative as nearly 10 million people were affected, hundreds of thousands of houses collapsed, roads and bridges were damaged and power, telecommunication and other networks of infrastructure affected, which by any standard was huge and unsustainable. This calls for the development of a comprehensive framework for flood risk management in the country, which has so far escaped the attention of policymakers as floods, unlike earthquakes, landslides and droughts, never figured prominently in the riskscape of the Islamic Republic of Iran.
Based on the presentations made in various technical sessions of the workshop, Dr. Chakrabarti suggested a framework of flood risk management in the Islamic Republic of Iran. The framework has eight main components — five ex-ante (flood risk assessment, flood prevention, flood mitigation, flood risk transfer and flood preparedness) and three ex-post (flood response, flood relief and flood reconstruction). General and specific actions to be taken under each of these components are highlighted as under:

**a) Flood risk assessment:** Flood risk assessment, like any other risks of disaster, is the function of assessing the interplay of hazards, vulnerabilities, exposures and capacities. Hazards of flood are mainly driven by the nature of rainfall, topography, run off, land use and land cover, vegetation cover and settlement pattern. Vulnerabilities are always manmade (unsafe settlements, houses and infrastructure; at risk production systems; vulnerable social and economic conditions and fragile environment). It is the exposure of the population and economy to these hazards and vulnerable conditions that create risks of flood, while the capacities of communities and institutions can reduce the risks. Flood risks in the Islamic Republic of Iran and its constituent provinces, cities and villages can be assessed by systematically analysing hazards, vulnerabilities, exposures and capacities. Total risks of flood in the country and its provinces, cities and villages can be measured by the equation \((h \times v \times e) \div c\) if datasets on hazards (h), vulnerabilities (v), exposures (e), and capacities (c) are available. Even if complete datasets on all these parameters are not available, approximate measurements of risks can be done on the basis of available data, and these can be revised as and when new sets of data are available.

The datasets can be geo-referenced, enabling the development of GIS-based hazard, vulnerability and risk maps for the country, as a whole, and separately for each province, city and village. The Government of Islamic Republic of Iran may consider setting up a disaster risk portal where a repository of meta-data on every hazard, like earthquakes, landslides, floods, cyclones, droughts, tsunamis and all related vulnerabilities and exposures, can be maintained and updated regularly as and when these are available. The portal shall have built in software for the calculation of risks and generation of maps as required. The portal may also be integrated with real time weather predictions and early warning systems to provide a decision support system to authorities, at each level, for planning response, evacuation, relief and other operations. The portal may be made accessible to all stakeholders and even people in general. This would serve as a potent instrument for communicating risks on a real time basis at a very low cost.

**b) Flood prevention:** Total risks of flood can be reduced through various measures of prevention and mitigation. Preventive measures can be mainstreamed into development programmes, activities and projects to prevent the creation of new risks and the exacerbation of existing risks of flood. Risks of flood can be prevented by avoiding human settlements in the flood plains, and hilly slopes, and developing and enforcing standards and specifications of flood resistant buildings, roads, bridges and infrastructures. Similarly, floods can be prevented by protecting forests, reviving degraded forests and afforesting new areas, thereby preventing soil erosion which would help to reduce silt loads on rivers and reservoirs and increase the carrying capacity of rivers and other drainage channels.

SRCIF working groups on infrastructure and urban and rural settlements have suggested a number of recommendations for preventing the creation of new risks and exacerbating existing risks of flood risks in the Islamic Republic of Iran which should be considered for implementation by the Government, at all levels. Every existing and new development project, across all sectors, should be audited through the lens of disaster risks to ensure that development does not create new risks. Disaster risk reduction should be mainstreamed in sustainable development as per the stated objectives of Seventeenth National Plan of the Islamic Republic of Iran. ESCAP has developed regional guidelines for mainstreaming disaster risk reduction in sustainable development, which contains inter alia principles, strategies and tools for mainstreaming. This can be used for guidance with suitable modifications as per local conditions.
c) **Flood mitigation:** Flood risk mitigation measures can be both structural and non-structural. Structural measures consist of dams, reservoirs, flood protection bunds, levees etc. These are capital intensive and can be effective in impounding excess rain and river water, which can be used for the generation of power and for irrigation in agriculture. China developed massive structural measures, such as Three Georges Dam, to reduce the recurrence of flood. Similar engineering solutions have been made for flood prevention in many countries, including the Islamic Republic of Iran. All existing structures of flood mitigation should be reviewed and new structures developed, taking into account the dynamics of flood in this changing climate and as experienced in the recent 2019 flood.

Non-structural measures of flood mitigation are less expensive but require sustained efforts for implementation. These consist of developing legal and institutional frameworks, regulations, standards, codes etc., for flood risk management; improving risk governance at all levels, especially at local levels; and building capacities of institutions, communities, families and individuals through education, training, awareness generation for dealing with and living with floods. There is enormous scope for strengthening non-structural measures for flood risk mitigation in the Islamic Republic of Iran. Several of the workshop presentations, particularly the case study on the Thailand flood of 2011, have outlined the range of structural and non-structural measures that can be implemented for mitigating the risks of flood. These may be considered for adoption with suitable modifications as per local conditions.

d) **Flood Risk Transfer Insurance:** The substantial part of flood risks, that can neither be prevented nor mitigated, can be pooled and transferred through market-based flood risk insurance and sovereign catastrophic insurance that would reduce fiscal burden for flood relief and reconstruction. Risk insurance is almost non-existent in the Islamic Republic of Iran. Considering the multi-hazard scenarios of the country, the size of its economy, and its economic conditions, there are good opportunities for the development of an insurance industry. Private sector insurance companies may not come forward in the near future and therefore, the Government should seriously consider designing an appropriate National Catastrophic Insurance Pool, in consultation with all stakeholders, and reinsurance companies, who would be interested to work in the country. The SRCIF working group on risk insurance has made several concrete recommendations for setting up such a pool in the Islamic Republic of Iran. These may be good staring points for a discussion with stakeholders, including foreign insurance companies.

e) **Flood Preparedness:** Flood risks that are neither prevented nor mitigated nor transferred are the residual risks that have to be accepted. The country and the communities in cities and villages must be prepared for disasters that may occur due to these unprotected, residual or accepted risks. Flood preparedness measures typically include early warning systems; contingency planning; mock drills for evacuation, search and rescue, medical response planning etc. Each of these preparedness measures have huge scopes for improvement in the Islamic Republic of Iran. Most of these are low hanging fruits that can be easily targeted in the immediate short-term period with moderate investments for quick and substantial improvements that would far exceed the costs of such investments.

Early warning of floods is a area of major concern in the Islamic Republic of Iran that has been highlighted in several of the presentations in the workshop. Various solutions for early warning have also been proposed with offers for support from RIMES, IWMI, ICHARM, HII and other agencies. SRCIF did not have a separate working group on Early Warning Systems for flood. A separate Task Force could be set up urgently comprising of representatives of IRIMO, WMO Regional Centre for West Asia, KWPA, ESCAP, RIMES and other agencies for suggesting measures for modernising flood early warning system in the Islamic Republic of Iran, covering both numeric weather prediction models of rainfall and hydrological models for inundation in local areas. Efficient and effective flood preparedness also involve development of flood management plans, flood contingency plans, epidemic management plan, standard operating procedures for evacuation, search and rescue, mock drills, training and capacity building etc. NDMO can initiate the development of such plans and procedures in a time bound manner.
f) **Flood response, relief, reconstruction:** The remaining three components of flood risk mitigation are response (saving lives), relief (providing humanitarian assistance), and reconstruction (‘building back better’ houses, infrastructure, livelihoods etc.). The Islamic Republic of Iran is relatively strong in post-disaster response and relief, as has been demonstrated in the flood response and relief operations, which were by and large well-managed despite international sanctions. The country also has considerable expertise in post-disaster reconstruction after the 2003 devastating earthquake of Bam. The PDNA of the flood of 2019 has already been developed and this would open new opportunities of reconstruction that would follow. The lessons learnt during the forthcoming reconstruction operations should be documented for future guidance. The Islamic Republic of Iran, like most of the countries in the Asia-Pacific region, has developed significant capacity for post-disaster response, relief and reconstruction, but it is relatively weak in pre-disaster risk assessment, risk prevention and mitigation, risk transfer and disaster preparedness. These components need to be strengthened through systematic planning and sustained investments in a time bound manner. Based on the suggested framework, an action plan can be prepared and a road map drawn up for implementation in the short, medium and long term with a strong mechanism for monitoring, review and evaluation.
Flood risk response and relief
• Disaster response and relief mechanisms are strong and effective
• These needs to be further strengthened

Understanding risks of flood
• Flood risks are focused primarily on hazards of heavy precipitation
• Analysis of vulnerabilities, exposures and capacities not integrated

Early warning of floods
• Flood EWS is strong on meteorological weather forecasting
• Weak on hydrological modelling
• Weaker on other parameters, such as land use–land cover, encroachment on flood basins, siltation load analysis, settlement pattern etc

Flood risk prevention
• Disaster Impact Analysis of projects not in place
• Mainstreaming DRR in development need to be strengthened and followed

Flood risk mitigation
• Structural mitigation measures inadequate
• Non-structural measures needs strengthening

Flood risk Investment
• Both direct and embedded investments on DRR low

Flood risk governance
• Enforcement of standards and regulations weak
• Reservoir management system needs improvement
• Risk communication needs further strengthening with focus on last mile connectivity

Lessons learnt from the 2019 flood in the Islamic Republic of Iran

Lessons that can be learnt from the regional flood risk management policies and practices

Specific areas of good practices
1. Integrated Flood Risk Assessment
2. Economic impact analysis of disasters
3. Multi-Hazard Early Warning Systems
4. Structural mitigation flood
5. Eco-system based flood risk management
6. Updating of Standards, Codes, Regulation
7. Index Based Flood Insurance
8. Capacity Building for Multi-Stakeholders
9. National and Provincial Platforms for DRR
10. Community Based Flood Risk Management
Closing Session

The workshop ended with the adoption of a set of the recommendations for action for improving flood risk management in the Islamic Republic of Iran, based on its own experiences as well as regional and international experiences. These will be further developed in the days ahead.

Iranian Experiences

- To improve the knowledge and capacity of the country for understanding flood risk,
- To upgrade ground and satellite-based observation and early warning systems including meteorological, hydrologic and hydraulic aspects,
- To review and strengthen the laws and regulations in the field of urban/rural and regional planning considering flood risk and resiliency,
- To enhance ecosystem, society and infrastructure resiliency and develop regulations which consider natural and man-made risks,
- To establish integrated watershed and river management system, including flood risk management and governance,
- To improve national water governance system based on flood risk management approaches, and
- To initiate natural catastrophe insurance pool.

Regional/International Experiences

- Partnership with regional/international organizations including ICHARM, IWMI, RIMES, AIT, ESCAP/APDIM for flood risk assessment and early warning systems development,
- ESCAP/APDIM to organize specialized capacity development training and workshops such as spatial land use planning, resilient infrastructure etc., on flood risk management,
- To enhance South-South cooperation with China, India, Pakistan and Thailand for flood risk management,
- To improve partnerships with other developed countries such as Japan and the Netherlands, and
- To deepen flood-related research collaboration with China, Japan, the Netherlands and AIT through researcher and academic exchange programs.
Annex:
List of participants

National Participants

Alameh Tabatabee University
Mr. Arman Rashidi Nasab, Member of Legal Analysis of Flood Report and Student
Mr. Hadi Khaniki, Professor

Amirkabir University of Technology
Mr. Amir Reza Zarrati, Professor Hydraulic Engineering
Ms. Nazanin Zare, Professor
Mr. Reza Maknoon, Professor

Forest, Rangeland and Watershed Management Organization of the Islamic Republic of Iran
Mr. Khosro Shahbazi, Deputy of Forests, Rangelands and Watershed Management Organization

Golestan University of Medical sciences
Mr. Mohammad Reza Honarvar, Vice Chancellor of Research

International Institute of Earthquake Engineering and Seismology
Mr. Hooman Motamed, Assistant Professor

Iran Chamber of Commerce
Mr. Abolfazl Mirghasemi, Secretary of Environment Committee
Mr. Mahboubeh Zarezade Mehrizi, Secretary of the Water, Environment and Green Economy Commission

Iran University of Science and Industry
Mr. Mostafa Behzadfar, Professor

Iran Meteorological Organization
Mr. Abbas Ranjbar, Head
Mr. Ebrahim Fattahi, Vice-Chancellor for Research, Institute of Meteorology
Mr. Azadi Majid

Iran University of Medical Sciences
Mr. Hessam Seyedin, Professor

Iran Water and Power Development Company
Mr. Saeed Jamali, Department Head of Environment and Quality Control of Water Resources
Mr. Hessa Fouladfar, Head of River Engineering Department

Iran Water Resources Management Company
Mr. Ghazal Jafari, Director General of Rivers and Coasts Engineering Office

Iranian Association of Official Experts of Justice
Mr. Sadegh Jamali, Researcher of Legal Teamwork in Special Reporting Committee on Iran Floods

Iranian Culture and Sustainable Development Institute
Ms. Leyla Khademibami
Ms. Nastaran Deghan
Mr. Pejman Pazouki

Isfahan University of Technology
Mr. Hamid Reza Safavi, Professor

Islamic Azad University
Ms. Roya Kolachian Langroodi, Professor
Ms. Sina Nabaee, Ph.D. Candidate / Research Assistant
Mr. Bahram Saghaefian, Professor

Jahad Daneshgahi Development Studies Centre
Ms. Mahsa Jahandideh, Researcher

Judicial Advisory Centre
Mr. Hormoz Yazdani Zenozi, Attorney at Law
K. N. Toosi University of Technology
Ms. Najmeh Mahjouri, Associate Professor
Mr. Ali Khansefid, Associate Professor

Khajenasir University of Technology
Mr. Mohammad Reza Zolfaghari, Associate Professor

Kharazmi University
Mr. Hossein Serajzadeh, Professor
Mr. Bohloul Alijani, Professor of Climatology

Khuzestan Water and Power Authority
Mr. Ali Shahbazi, Director of the Office of Water and Environment Models
Lorestan University of Medical Sciences
Mr. Mohammad Hasan Kayedi, Professor of Medical Entomology

Mazandaran University
Mr. Mahmoud Reza Pourtabari, Professor
Annex: List of participants

Ministry of Energy
Mr. Jabbar Vatanfada, Expert
Mr. Mohammad Arshadi, Deputy of Social Affairs of Water Resources

Ministry of Health and Medical Education
Mr. Farhad Khanmirzaei, Adviser to Deputy of Management Development and Resources

Plan and Budget Organization
Mr. Seyed Vahid Aldin Rezvani

Qazvin Governorate
Ms. Tahereh Parhizkari, Environmental Advisor

Shahid Beheshti University of Medical Sciences
Mr. Katayoun Jahangiri, Associate Professor of health in Disaster Department

Shahid Chamran University of Ahvaz
Mr. Mohammad Azizipour, Professor
Mr. Mahmoud Shafaei Bajestan, Professor

Sharif University of Technology
Ms. Maryam Saghafti, Professor

Shiraz University
Mr. Naser Taleb Bidokhti, Professor

Supreme National Defense University
Mr. Rasoul Zargarpour, Professor

Tarbiat Modares University
Mr. Ali Bagheri, Professor
Mr. Aliakbar Aghakouchak, Professor
Mr. Amin Mirzaborojerdian, Professor
Mr. Majid Delavar, Professor
Mr. Manouchehr Farajzadeh, Professor
Mr. Mohammad Amin Amini, Professor
Mr. Saeid Morid, Professor
Mr. Vahid Shokri Kochak, M. Sc. Of Water Resources Engineer

Tehran University of Medical Sciences
Ms. Zahra Abbasi, Professor

University of Tehran
Mr. Abbas Ghanbari Baghestan, Professor
Mr. Abbas Ostadtaghizadeh, Head of department of Disaster and Health Emergency
Mr. Ali Salajegheh, Professor
Mr. Arash Malekian, Professor
Mr. Behnaz Aminzadeh, Director of Urban Planning, Architecture and Cultural Heritage Group
Mr. Ebrahim Moghimi, Professor
Mr. Gholamreza Zehayebian, Professor, Faculty of Natural Resources
Mr. Hasan Ahmadi, Professor
Mr. Hossein Arzani, Professor

Mr. Mahmoud Nili Ahmadabadi, President
Mr. Masoumeh Nikfar, Professor
Mr. Mehdi Yasi, Associate Professor
Mr. Mohammad Hossein Arabiyeh, Professor
Mr. Mohammad Hossein Sadeghi, Professor
Mr. Mohammad Pour Masoud, Professor
Mr. Mohammad Mehdi Azizi, Professor
Mr. Mohammad Rahimian, Vice President of Research
Mr. Mohsen Naseri, Professor
Mr. Mostafa Karimi, Professor
Mr. Omid Bozorg Haddad, Professor
Mr. Reza Ghiassi, Professor
Mr. Reza Kerachian, Professor
Ms. Sara Nazif, Assistant Professor
Mr. Seyed Mohammad Ali Baniashehmi, Professor
Mr. Taghi Shamekhi, Professor
Mr. Vahid Majed, Professor
Ms. Zahraie Banafshen, Professor

Intergovernmental Organizations, and Other Entities

Asian Institute of Technology (AIT)
Mr. Mukand Singh Babel, Professor, Asian Institute of Technology, Bangkok, Thailand

CDR International B.V
Mr. Jean Henry Laboyrie, Director and partner, CDR International B.V, Netherlands

Hydro-Informatics Institute (HII)
Ms. Kanoksri Sarinnapakorn, Head of Climate and Weather Section, Hydro-Informatics Institute, Thailand

Institute of Mountain Hazards and Environment, Chinese Academy of Sciences (IMHE)
Mr. Javed Iqbal, Assistant Professor, Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China

International Centre for Water Hazard and Risk Management (ICHARM)
Mr. Ikeda Tetsuya, Chief Researcher, International Centre for Water Hazard and Risk Management, Japan (via skype)

International Water Management Institute (IWMI)/CGIAR
Mr. Giriraj Amarnath, Research Group Leader – Water Risks and Disasters (WRD), International Water Management Institute (IWMI)/CGIAR, Sri Lanka (via skype)

Nanjing Hydraulic Research Institute (NHRI)
Mr. Hua Zhong, Senior Engineer, Nanjing Hydraulic Research Institute, China
Regional Integrated Multi-Hazard Early Warning System for Asia and Africa (RIMES)
Mr. Anshul Aggarwal, Team leader Hydrology, Regional Integrated Multi-Hazard Early Warning System for Asia and Africa, Thailand (via skype)

Royal Irrigation Department (RID)
Mr. Thada Sukhapunnaphan, Executive Advisor, Office of Hydrology and Water Management

United Nations Bodies

Food and Agriculture Organization (FAO)
Ms. Marjan Ghanbari, National Programme Consultant

United Nations Children’s Fund (UNICEF)
Ms. Mahdis Daniali, Health and Nutrition Officer and WASH focal point

United Nations Development Program (UNDP)
Ms. Daniels Ugochi, UNDP Resident Representative and UN Resident Coordinator

United Nations Educational, Scientific and Cultural Organization (UNESCO)
Ms. Maryam Soltanzadeh, Officer in Charge

United Nation Habitat
Mr. Mehmet Emin Akdogan, Officer in Charge

United Nations High Commissioner for Refugees (UNHCR)
Ms. Iryna Korenyak, Deputy Representative
Mr. Arya Shoaiie, Associate Programme Officer

United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA)
Mr. Amir Hossein Barmaki, Head

World Food Programme (WEP)
Ms. Bahareh Safaei, Emergency Preparedness and Response focal point, World Food Programme, Tehran office

Organizers

Asian and Pacific Centre for the Development of Disaster Information Management (APDIM)
Mr. Amin Shamseddini, Associate Programme Management Officer
Mr. Mostafa, Senior, Senior Programme Management Coordinator
Ms. Tara Sheshangosht, Staff Assistant
Ms. Niloofar Dehghan, Administrative Associate

ESCAP ICT and Disaster Risk Reduction Division (IDD)
Mr. Sanjay Srivastava, Chief of Disaster Risk Reduction Section
Mr. P. G. Dhar Chakrabarti, Expert Consultant