Asia-Pacific
Economic Cooperation

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Application of Internet of Things in Earthquakes and Waterfloods Monitoring System

APEC Telecommunications and Information Working Group

February 2019

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FOREWORD

Since APEC establishment, member economies have always put a premium on ICT implementation for reducing material and human losses in case of emergencies. APEC economies are taking active measures to predict and prevent emergencies and natural disasters in order to reduce human and material losses. It is hard to imagine how many lives were saved because of coherent and comprehensive measures taken within the Asia-Pacific region, as well as in a single economy, to predict and to be prepared to the emergency. However if an emergency or natural disaster occurs, it throws residents and administration of the economies off their guard and causes huge material and human losses.

APEC has been taking efforts to increase the predictive potential of the existing monitoring systems. As a part of its long-term activities in this area Russia held a workshop on Earthquakes and Waterfloods Monitoring System with the Application of the Internet of Things (IoT) on margins of the 58th meeting of the APEC Telecommunications and Information Working Group. The workshop aims to tackle the issue via inviting leading researchers from different sciences, including emergency preparedness, physics of Earth and the geomagnetic processes (such as earthquakes and waterfloods), biogeochemistry (behavior of living and inert subjects, influenced by the global processes) and engineering development of the radio technical means and software applications.

This report is an output and the result of the discussions on this workshop as well as the other relevant work done in 2018 under the project “TEL 01 2017A – Earthquakes and Waterfloods Monitoring System with the Application of IoT”.

CONTENTS

ABBREVIATIONS

LDCs	-	Least Developed Countries
SIDS	-	Small Island Developing States
UN	-	United Nations
HFA	-	Hyogo Framework for Action
SDGs	-	Sustainable Development Goals
MDGs	-	Millennium Development Goals
DRM	-	Disaster Risk Management
DRR	-	Disaster Risk Reduction
CREWS	-	Climate Risk Early Warning Systems
WMO	-	World Meteorological Organization
UNISDR	-	UN Office for Disaster Risk Reduction
GFDRR	-	World Bank's Global Facility for Disaster Reduction and Recovery
ACC	-	Adaptation to Climate Change
MHEWS	-	Multi-Hazard Early Warning System
GDPFS	-	Global Data Processing and Forecasting System
MHS	-	Meteorological and Hydrological Stations
GTS	-	Global Telecommunication System
CAP	-	Common Alerting Protocol
IASC	-	Inter-Agency Standing Committee
GFCS	-	Global Disaster Alert Coordination System

ICTs	-	Information and Telecommunication Technologies
GIS	-	Geographic Information Systems
RS	-	Remote Sensing
EWS	-	Early Warning Systems
ECMWF	-	European Center for Medium-Range Weather Forecasts
EFAS	-	European Flood Alerting System
WB	-	World Bank
Sava FFWS	-	Sava Floods Forecasting and Warning System

REPORT SUMMARY

- As evidenced from the data and information received from APEC member economies, the issue of exploring the possible improvement of Earthquakes and Waterfloods Monitoring Systems' predictive potential with the application of emerging technologies, including Internet of things, is a high-impact and relevant activity, which APEC should incorporate into its agenda of regional cooperation.
- The current predictive potential of such systems is built mainly on the basis of data from conventional sources collected during the previous emergencies, and the systems in place are used primarily for response and post-emergency recovery planning.
- Post-emergency statistical evidence suggests that many phenomena, or natural sensors such as groundwater changes, electromagnetic fluctuations, animal behavior, have a distinct and, compared to the sensory capabilities of humans, more articulated reaction to the upcoming waterfloods and earthquakes.
- At the same time, the physical link between these phenomena and occurrence of waterfloods and earthquakes is not well understood. Which sensors react earlier, more consistently and with what level of reliability remains an open question for further inquiries.
- There is a consensus among wide range of stakeholders that the use of new ICTs, such as IoT, presents a good opportunity to create an effective next-generation monitoring systems.
- It is plausible that some natural sensors are more suitable than the others in the ICT-based sensor network system.
- There is a general agreement that the need is there to further explore this issue within the dedicated Research centres in APEC region enabling the dialogue among the wide range of scientists from different disciplines and research backgrounds (such as

Telecommunications and ICT, Physics of Earth, Biogeochemistry, Economics, Ecology, Meteorology, Statistics etc.), while engaging other stakeholders, such as policy-makers, business circles and general public.

- Member economies also expressed their support for the idea of having the research centres to explore choices in the natural sensors suitable for the use in the system of sensors built upon Internet of things technology.

- The proposed Research centres can facilitate knowledge sharing, management and monitoring of ongoing efforts, while also providing expert support in formulating strategic planning for future research and development activities.

- The economies might also want to consider expanding the cooperation via formal setting of use cases and guidelines to achieve a common approach, and serve as directory of standards and best practices for reference.

- It is further advised to explore ways to strengthen the partnership within the region, including internal cooperation between APEC foras on the issue of using ICTs in disaster preparedness, namely Telecommunications and Information Working Group (TELWG) and Emergency preparedness working group (EPWG).

- Feedback from member economies suggests that TELWG and EPWG should also look into information and education tracks for ICT in Disaster Risk Reduction.

INTRODUCTION

Since APEC establishment, member economies have always put a premium on information and communication technologies' (ICTs) applications for reducing material and human losses in result of emergencies. Today these questions are still as important as they were then. As it is stated in the APEC Leaders' Declaration 2015: "We recognize that our region, located in the Pacific Ring of Fire, is particularly vulnerable and exposed to disasters. We face typhoons, earthquakes, volcanic eruptions, rising sea levels, and pandemics, the impacts of which are magnified by our densely populated cities. It has become a "new normal" for us to face natural disasters of increasing frequency, magnitude and scope, and their resulting disruption of the increasingly integrated and interlinked production and supply chains". The same issue was considered during the 2nd Global Forum on Emergency Telecommunications (GET-2016) that was held in Kuwait City, 26-28 January 2016. In 2015, APEC adopted APEC Disaster Risk Reduction (DRR) Framework to support the global DRR agenda, guided by the Sendai Framework for Disaster Risk Reduction 2015-2030, adopted by the United Nations (UN).

However, significant gaps in capacities to address the emergencies, triggered by global natural processes, for example earthquakes or waterfloods still exist. Every emergency, for instance the earthquake, confounds residents and administration of the region and causes significant material and human losses. This happens because of low predictive potential of the existing monitoring systems, which are currently very costly in terms of capital expenses and human resources to be maintained properly.

ICTs can play a decisive role in improvement of measurement tools for data collection, analysis and dissemination. Increasing predictive potential of the existing monitoring systems via the application of new ICTs, particularly the Internet of Things (IoT), is vitally important for all APEC economies. These IoT-based system can contribute both before an earthquake or a waterflood occurs for monitoring, mitigation and prediction purposes, and can continue to serve in the response phase, e.g. in emergency alerting. The developed methodology of the IoT implementation for the earthquakes and waterfloods monitoring system can considerably increase the predictive potential of the existing monitoring systems and therefore reduce damage to the supply chains and businesses. Modified systems will provide early information, required for prediction results, preventive measures and post-disaster lessons learned. Results of the research and recommendations can be further extended to cover not only earthquakes and waterfloods but also other types of emergencies, such as typhoons, volcanic eruptions, rising sea levels and technogenic catastrophes.

This report acknowledges the recent trends in the APEC region, such as the observed increase in the activity of global processes, lack of improved and resilient construction, rapid urbanization, growing interconnectivity between supply chains. In October 2018 APEC held Telecommunication and Information Working Group (TELWG) workshop on Earthquakes and Waterfloods Monitoring Systems with the application of the Internet of Things. This workshop is a continuation of 2012 TELWG collaboration on the individualized alerting and rescue using the ICTs. It is believed that this continuation can allow building upon an existing groundwork, and to look further and dive deeper into the problem. This report also highlights the need for stronger commitment to cross fora collaboration within APEC, and recognizes the leading role of the Emergency Preparedness Working Group (EPWG) on the DRR activities in APEC. As such, this report is specifically aimed at advancing the work under TELWG Strategic Action Plan, line 5.1.D: Collaboration with Emergency Preparedness Working Group to promote the benefits of and share policy options for using ICTs for emergency preparedness and disaster prevention/ mitigation). It also covers the work under the line 3.4.C: Promote the Internet of Things (IoT) and application-to-application connectivity.

This report consists of three chapters. Chapter 1 discusses the global and regional initiatives in the field, explores the current status of the DRR approaches, and explores the issue of using ICTs for the relevant purposes. Chapter 2 deals with the case studies from the selected economies both in and outside of APEC region, and identifies the existing gaps. Chapter 3 brings recommendations to further the hybrid IoT-based systems with a focus on the scaling up the capacities of existing monitoring systems.

CHAPTER 1. CURRENT STATUS

"Risk is real. Although we cannot readily see risk, we can measure it by understanding how the probability of damaging winds, floods, or shaking compounds with the exposure of settlements and livelihoods and lives. Using vulnerability functions that link the hazard to the damage, we can calculate and map risk."

Robert Muir-Wood

Today there is no doubt that the rapidly developing and slow-onset weather phenomena entail devastating consequences around the world, resulting in deaths and injuries, displacement of people and destruction of livelihoods and property. Hydro-meteorological phenomena such as tropical cyclones, earthquakes, floods, tsunami, etc., continue to cause disasters. The personal and social costs, losses and financial impacts of such emergencies on the economy are significant.

Disasters affect a person's life and have a profound effect on the economy, sometimes discarding the development of these economies for many years ago. In this regard, meteorological, climate and hydrological monitoring is important for financial protection mechanisms to reduce residual risks.

The acceleration of urbanization as a global phenomenon leads to a rapid increase in population density in an increasing number of megalopolises and large urban agglomerations, many of which include coastal areas that are subject to flooding or water stress and have outdated infrastructure. These social and economic vulnerabilities will continue to exist and are likely to worsen, and along with prevailing weather events with significant impacts, such as tropical storms, create increased risks to the safety of life and property, especially in developing and least developed countries (LDCs) and in small island developing states (SIDS). The devastating Typhoon

Haiyan that hit the Philippines in 2013 can be an example.

Source: http://time.com/3554112/tacloban-yolanda-supertyphoon-typhoon-haiyan-anniversary/

Due to the cascade effect, which is exacerbated by the interconnectedness of economies, the impact of such natural disasters expands and leads to indirect and continuing effects. In addition, extreme weather events and climate variability, as well as their effects on the environment and other global risks, such as threats to health, pose new challenges in terms of building resilience to disasters, as well as rapid and effective economic recovery after disasters.

2015 was a turning point for the global development agenda, which addresses the above mentioned challenges. During the Third UN World Conference in Sendai, Japan, on March 18, 2015, the Sendai Framework for Disaster Risk Reduction 2015-2030 was adopted, lead from the Hyogo Framework for Action (HFA). The Third International Conference on Financing for Development, Addis Ababa, Ethiopia, July 13, 2015 led to the appearance of the Addis Ababa Action Agenda, the final document on financing sustainable development agreed during the intergovernmental negotiations. In October 2015, the final document “Transforming our world: the Sustainable Development Agenda until 2030” was endorsed at the UN Sustainable Development Summit. The purpose of this document is to adopt a post-2015 development agenda. The set of Sustainable Development Goals (SDGs) replaced the Millennium Development Goals (MDGs), in which disaster risk management (DRM) is an integral part for disaster risk reduction (DRR). Also The Climate Risk Early Warning Systems (CREWS) initiative was launched at the Oceanographic Institute in Paris as part of a raft of climate change solutions in the spotlight at the COP21 International Climate Summit in the French capital. The CREWS initiative is supported by three international organizations: the World Meteorological Organization (WMO), the

UN Office for Disaster Risk Reduction (UNISDR) and the World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR) which are actively involved in reducing the vulnerability and exposure of economies and communities to weather-related disasters.

One key thematic area that UNISDR emphasized across its activities in the biennium under review was enhanced understanding of the gender dimensions of disaster risk – the importance of gender-responsive disaster risk reduction strategies, and the need for systematic collection of sex-disaggregated data to identify the specific needs and vulnerabilities of women and girls. In order to support this work, UNISDR, UN Women and the International Federation of Red Cross and Red Crescent Societies launched a joint program entitled "Addressing the gender inequality of risk and promoting community resilience to natural hazards in a changing climate" at the 2017 Global Platform to support gender responsive implementation of the Sendai Framework.

Source: https://www.unisdr.org/archive/53431

The provisions of the abovementioned documents cover disaster risk reduction and transfer measures and ways to deal with loss and damage, in conditions where climate change mitigation and adaptation is not enough. This rare coherence between global political processes, the private sector and the interests of civil society provides an opportunity to position DRR and adaptation to climate change (ACC) and sustainability as fundamental components of sustainable development. In addition to these commitments, an increasing number of subjects require access to timely warning and forecasting methods, as well as information on hazards, both in weather and climate scales, in order to form a better information base for monitoring and making tactical and strategic decisions.

Economies main tasks to reduce the emergency risk are the following:

- deaths and livelihoods losses reduction;
- economic losses reduction;
- sectoral planning improvement, including wider use of weather, climate and hydrological monitoring for long-term strategic planning and the design and implementation of preventive measures;
- coordination of inter-organizational activities in the area of DRR improvement.

The Sendai Framework for Disaster Risk Reduction 2015-2030

The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) applies to the risk of small-scale and large-scale, frequent and infrequent, sudden and slowonset disasters, caused by natural or man-made hazards as well as related environmental, technological and biological hazards and risks. It aims to guide the multi-hazard management of disaster risk in development at all levels as well as within and across all sectors.

The Sendai Framework focuses on the following tasks:

- monitoring, assessing and understanding disaster risk, as well as sharing information about it and how it occurs;
- improving management and coordination of disaster risk reduction efforts by relevant institutions and sectors, and the full and full participation of relevant stakeholders at appropriate levels;
- investing in strengthening the resilience of people, communities and economies in socio-economic, health, cultural and educational terms and environmental protection, including through technology and research;
- strengthening early warning systems, improving preparedness and ensuring the effectiveness of response, recovery, rehabilitation and reconstruction in the face of various types of threats.

The priorities of the Sendai Framework are:

Priority 1. Understanding disaster risk

Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and response.

Priority 2. Strengthening disaster risk governance to manage disaster risk

Disaster risk governance at the economy-wide, regional and global levels is very important for prevention, mitigation, preparedness, response, recovery, and rehabilitation. It fosters collaboration and partnership.

Priority 3. Investing in disaster risk reduction for resilience

Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.

Priority 4. Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

The growth of disaster risk means there is a need to strengthen disaster preparedness for response, take action in anticipation of events, and ensure capacities are in place for effective response and recovery at all levels. The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating disaster risk reduction into development measures.

The implementation of these priority areas is consistent with the following UN Sustainable Development Goals:

- *SDG 1*: No poverty;
- *SDG 11*: Sustainable cities and communities;
- *SDG 13*: Climate action.

Source:https://www.primo-europe.eu/acceleration-on-disaster-reduction-sendai-framework/

To implement the abovementioned priorities, 7 global goals were agreed to achieve progress in disaster risk reduction. Thus, among the global targets, the use of early warning systems covering various types of threats is indicated – «substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030».

Multi-hazard early warning systems reduce the loss of life caused by hydro-meteorological hazards such as tropical cyclones, floods, severe storms, forest fires, heat waves and tsunamis, and proved to be a good investment to reduce economic losses.

To implement the Sendai Framework, the UNISDR has developed a Work Program that will contribute to disaster risk reduction. This Work Program will also be consistent with the goals and objectives of other international agreements, including the 2030 Agreement on climate change.

As it states in the UNISDR Work Program its overarching objective is the prevention of new and reduction of existing disaster risk and strengthening resilience through successful multi-hazard disaster risk management.

Also for the implementation of the Sendai Framework, the World Meteorological Organization has developed an A Disaster Risk Reduction Roadmap.

In 2003, the WMO DRR Program was established to provide an enterprise-wide framework for DRR coordination. The strategic vision of the Program is to strengthen the role of protecting the lives of people, their livelihoods and property by expanding their capabilities and cooperation in the area of DRR at the domestic and international levels. The scope and objectives of the Program are based on the HFA, in which the traditional focus has shifted from responding to disasters to a more comprehensive approach, including preventive measures and preparedness measures. This Roadmap brings the Program into line with the Sendai Framework, in particular with its four priorities. As already noted, the Sendai Framework pays particular attention to disaster risk management as opposed to managing disaster-related actions.

Strengthening disaster risk governance to reduce disaster risks

By contributing to this priority area of action, WMO encourages MHSs to actively participate in DRM and risk management in a broader sense, for example, in local, subregional, regional and global DRR platforms.

Investing in disaster risk reduction for resilience

Investing in disaster risk reduction and prevention through structural and non-structural measures is essential to increase the resilience of people, communities, economies and their assets, and the environment from an economic, social, medical, and cultural perspective.

Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

The focus is on supporting the four components of the Multi-Hazard Early Warning System (MHEWS): 1) analysis and assessment of relevant risks; 2) identification, monitoring, analysis and forecasting of hazardous phenomena; 3) distribution and transmission of timely, accurate, effective, comprehensive and authoritative warnings; 4) readiness and response capabilities. While the first component of the MHEWS is considered under the first priority area of action, the second component is supported by the WMO Global Data Processing and Forecasting System (GDPFS). It includes three world meteorological centers and 40 regional centers, including regional specialized meteorological centers, regional climate centers and regional drought control centers. These centers process data and regularly provide economies with test results and meteorological forecasts, as well as provide support in terms of early warning capabilities of MHSs. The third component of MHEWS is supported by the Global Telecommunication System (GTS), which connects all MHSs to collect and disseminate meteorological and related data, forecasts and alerts, including information and warnings related to tsunamis and earthquakes. This system is transformed into a comprehensive WMO Information System, which provides systematic access to data and information of all WMO and relevant international programs, as well as the retrieval of such data and information, their distribution and exchange. In addition, the Common Alerting Protocol (CAP) provides an international standard for emergency warning and warning the public about all hazards, including those associated with weather, earthquakes, tsunamis, volcanic eruptions, public health, power outages and many other emergency situations. This Protocol also applies to all media, including communications from sirens to mobile phones, fax machines, radio, television and various web communication networks. For the fourth component, emergency response is supported by WMO, especially at the global level. Through its work with the Inter-Agency Standing Committee (IASC), the Global Disaster Alert Coordination System (GFCS) and Copernicus Emergency Management Service, WMO links weather and climate services with international humanitarian agencies to improve emergency planning, response and preparedness.

Disaster Risk Reduction and Disaster Risk Management Concepts

DRR requires multidisciplinary expertise that, once applied, will contribute to the assessment, prevention, reduction and transfer of risks and negative effects of disasters, along with increased resilience. A prerequisite for the DRR process is a risk assessment, which determines the nature and extent of past, present and potential future risks. This process includes identification, analysis and evaluation:

- danger in terms of its location, intensity, frequency, duration and probability of occurrence;
- vulnerability in terms of its physical, social, economic and environmental aspects;
- exposure of people and property to exposure;
- effectiveness of prevailing or alternative opposing and adaptive capabilities.

Post-disaster data as well as loss and damage serve as baseline data for assessing future impacts. Such data should be correlated in time and geographically with a dangerous phenomenon, undergo quality control, be consistently cataloged and properly archived. The risk assessment is applied differently during the recovery / prevention phase (or the “cold” stage) of DRM, when it is necessary to conduct a long-term hazard, vulnerability and exposure analysis, and at the preparedness / response stage (or the “hot” stage), when the analysis is necessary in real time. Owning such risk information, economies can develop strategies and measures to mitigate and adapt to risks.

DRR are aimed at reducing the negative consequences of hazardous phenomena by adopting monitoring, prevention, mitigation, preparedness, response and recovery measures to reduce vulnerability and exposure to threat and increase resilience in the long term. DRR covers all hazards, including those related to climate, and covers all time scales, including sudden hazards, such as earthquakes and slowly developing hazards, such as drought and gradual environmental changes. An effective and efficient MHS is a key component of DRR, as it provides extremely important and high-quality hydrometeorological information.

MHS can play a key role in the management of DRR, and the regular provision of services and activities with a narrower focus on DRR. MHS plays a definite role on all time scales, from early warnings related to weather conditions and floods to information related to more slowly developing seasonal events or climate services. The second key point is that MHS also plays a certain role in prevention, which helps to reduce public exposure to risks and increase resilience.

Hydrometeorological observations, monitoring, forecasts and related aspects of data management and data processing in the MHS represent a major contribution to ensuring effective DRM.

The role of MHS at all stages of DRM is as follows:

- providing information on hydro-meteorological hazards for prevention, mitigation, preparedness (including early warning), response and recovery, and for risk and loss / damage assessment and financial security;
- providing recommendations and proposing approaches that could be taken to reduce exposure, reduce vulnerability and increase the resilience of society through taking measures of both structural and non-structural nature, such as providing advice on climate issues with particular attention to potential areas of vulnerability;
- information and mobilization of scientific institutions and other experts who could contribute to the preparation of such information and the provision of such consultations, as well as the establishment of partnerships with them;

• instructing governmental and non-governmental institutions that make tactical and strategic decisions, as well as raising their awareness to understand the hazards and associated risks, warnings and associated uncertainties.

Monitoring

To prevent natural disasters, to eliminate the consequences that they entail, deep knowledge is needed about their nature, causes, mechanism and causes of refugee. Constant monitoring of the situation, accurate timely forecast are the most important conditions for ensuring protection of the population from emergencies. It is one of the key elements of the risk management process.

Source:https://www.earthmagazine.org/article/hazards-paradise-indonesia-prepares-natural-disasters

Monitoring contributes to the identification and evaluation of existing hazards, vulnerabilities, and exposure of communities and livelihoods. Based on the identified hazards and risk evaluation, proactive structural and non-structural measures need to be identified, evaluated, prioritized, funded and undertaken to mitigate the impact of disasters.

Preparedness.

This pillar pertains to the series of multi-sectoral and multi-level measures that help ensure and enhance the state of readiness of APEC economic systems and communities as the pillar's main goals minimizing damage to infrastructure and property, and enhancing capacity to build back better. Preparedness harnesses regional cooperation to strengthen early warning mechanisms for transboundary hazards in the region such as tsunamis and typhoons. This pillar focuses on establishing and strengthening the capacities of communities to anticipate, cope, and recover from the negative impacts of disasters. It involves enhancing urban and rural planning using risk and hazard mapping techniques and information, and strengthening critical infrastructure, including social and cultural infrastructure. It involves cooperation between government and businesses to increase the resilience of supply chains. It includes utilizing current and advanced Information and Communications Technologies for comprehensive disaster management system. It also includes the development and promotion of financial tools, such as microinsurance and catastrophic risk insurance, to help protect households, Micro, Small, Medium Enterprises (MSMEs), livelihoods such as agriculture, critical infrastructure, and communities from the financial and economic losses that each disaster brings, and promotion of business continuity planning.

Recently, planning methods based on emergency risk analysis are being actively used. Its main tasks are:

- Detection and identification of potential sources of natural disasters in a particular area.
- Estimation of frequency / probability of occurrence of an emergency.
- Prediction of the effects of hazardous factors on the population.

Today, the following types of monitoring are carried out:

- Sources of anthropogenic influence on the environment.
- Flora and fauna.
- The aquatic environment at the sites of discharge and water intake.
- Dangerous geological phenomena.

Among the main tasks of the monitoring centers are:

- forecasting of emergency situations and their scale;
- organizational and methodological management, coordination of activities and monitoring of the functioning of the relevant elements of the regional and territorial level of the system for monitoring and forecasting emergency situations;
- organization and conduct of control laboratory analyzes of chemical, radiological and microbiological state of environmental objects, foodstuffs, food, fodder raw materials and water, which represent a potential danger of emergency situations;
- creation and development of a data bank on emergency situations, geographic information system;
- organization of information exchange, coordination of activities and monitoring of the functioning of territorial monitoring centers.

ICT in Disaster Management

Today, the situation in the field of protection of the population and territories from emergency situations and threats of a natural and man-made nature is characterized by a high degree of concentration of threats, intensity of development and changes in the structure of both the objects creating threats and the objects called upon to eliminate such threats. In these conditions, information and communication technologies (ICT) are one of the main components of an effective system of monitoring, management and interaction of forces and means involved in the process of eliminating threats and consequences of emergency situations. Modern information exchange networks, means of accumulating, storing and processing information, means of visual presentation of various information, means of mathematical modeling of emergency situations have a high degree of development. It includes utilizing current and advanced ICTs for comprehensive disaster management system.

Disaster management and monitoring need drastic improvements in its sources to decrease damage and save the life of people. To achieve this main object, disaster management has to face challenges for data collection, data management, translation integration and communication. ICTs play crucial role in this respect. The advanced techniques of information technology such as remote sensing, satellite communication, Geographic Information Systems (GIS) etc. can help in planning and implementation of disaster management.

With an increase in the perception towards spreading a culture of prevention in the disaster management scenario, considerable emphasis is now being placed on research and development activities in the area of information technology for disaster preparedness and prevention. This has brought in a significant positive change even though the multitude and frequency of disasters in the economy has increased. In most critical phases of some major disasters like earthquakes in Kobe, Japan; Northridge, California and Turkey role of ICTs has provided the most effective means of connection with the rest of the world. The changing trends have opened up a large number of scientific and technological resources and skills to reduce disaster risk.

Internet provides a useful platform for disaster mitigation communications. The role of Internet is becoming increasingly important because of the following reasons:

- facilitation of opportunities to enhance the capabilities of addressing hazard awareness and risk management practices before, during, and following emergency events.
- provision of increasing array of information related to various hazards.
- provision of a new and potentially revolutionary option for the rapid, automatic, and global dissemination of disaster information. A number of individuals and groups, including several economy-wide meteorological services, are experimenting with the Internet for real-time dissemination of weather observation, forecasts, satellite and other data.
- network equally provides the means of access to more reference and resource material to more people, in more ways.
- compilation, retrieval and redistribution of information by centers of interest, of the use by alternative forms of media can expand the utility of the information at the local, economy-wide, regional and global levels of interest.

Geographic Information Systems and Remote sensing (RS) support all aspects of disaster management. GIS and RS are essential as effective preparedness, communication and training tool for disaster management. Disaster planning can be very powerful when modeling is incorporated into GIS. Most potential disasters can be modeled. Modeling allows disaster managers to view the scope of a disaster, where the damage may be the greatest, what lives and property at highest risk, and what response resources are required and where GIS can play a very important role in this exercise. The specific GIS applications in the field of Risk the assessment are: - Hazard Mapping - Threat Maps - Disaster Management - Records Management Nevertheless satellites have several limitations in their application for response operations. The most obvious is that a number of satellites cannot see through clouds. Many large scale disasters such as cyclones and floods are generally associated with periods of heavy cloud cover, and consequently the ability to image the ground is greatly restricted. In addition a disaster event must coincide with the overpass of the satellite if it is to be imaged.

Geographic Information Systems

GIS is a modern computer technology for mapping and analyzing natural objects as well as events. This technology combines traditional database operations, such as query and statistical analysis, with the benefits of full-fledged visualization and geographical (spatial) analysis provided by the map. These capabilities distinguish GIS from other information systems and provide unique opportunities for its application in a wide range of tasks related to the analysis and forecasting of phenomena and events of the surrounding world, with understanding and highlighting the main factors and causes, as well as their possible consequences, with planning strategic decisions and current effects of actions taken.

Geo-information technologies and technologies for collecting and processing information from remote sensors using network communications technologies are widely used. An important and necessary condition for the application of these technologies is their availability and reliability. GIS technology provides a new, more relevant, effective, convenient and fast approach to analyzing and solving problems facing humanity as a whole or a group of people in particular. It automates the analysis and forecasting procedure. GIS allows for generalization and full-fledged analysis of geographic information in order to make informed decisions based on modern approaches and means. GIS is used in many areas of activity, including monitoring of natural and social processes, such as overpopulation, pollution of the territory, reduction of forest land, natural disasters.

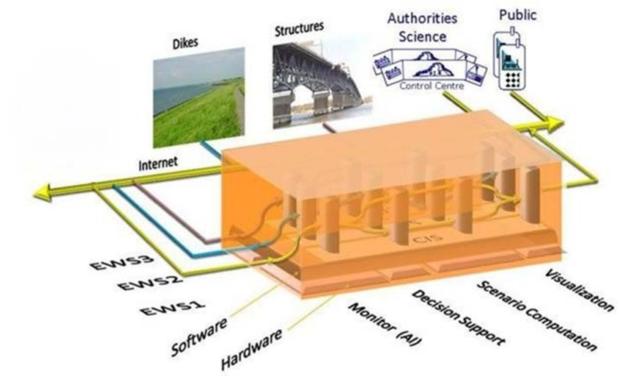
An advance system of forecasting, monitoring and early warnings plays the most significant part in determining whether a natural hazard will assume disastrous proportions or not. As for earthquakes GIS and RS can be used for preparing seismic hazards maps in order to assess the exact nature of risks. Floods satellite data can be effectively used for mapping and monitoring the flood inundated areas, flood damage assessment, flood hazard zoning and post-flood survey of rivers configuration and protection works.

Conclusion

Disaster management activities depend on large volumes of accurate, relevant, on-time geoinformation that various organizations systematically create and maintain. The advantages of ICTs in the form of Internet, GIS, RS, satellite communication, etc. supports planning and implementation of hazards reduction schemes. For maximum benefit, new technologies for public communication should be made use and natural disaster mitigation messages should be conveyed through these measures. GIS can improve the quality and power of analysis of natural hazards assessments, guide development activities and assist planners in the selection of mitigation measures and in the implementation of emergency preparedness and response action. Remote Sensing, on the other hand, as a tool can very effectively contribute towards identification of hazardous areas, monitor the planet for its changes on a real time basis and give early warning to many impending disasters. Communication satellites have become vital for providing emergency communication and timely relief measures. Integration of space technology inputs into natural disaster monitoring and mitigation mechanisms is critical for hazard reduction. There should be a greater emphasis on development of new technologies in disaster mitigation. The disaster preparedness and awareness is the only effective way of mitigating the impact of future disasters.

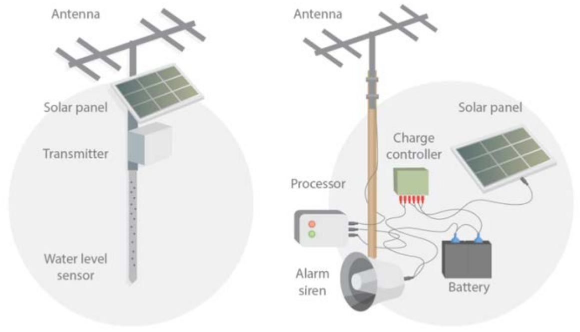
Flood Risk Reduction Strategies and the Early Warning Systems for Alerting the Population in Western Balkans

Early Warning Systems (EWS) can play a crucial role in mitigating flood risk by detecting conditions and predicting the onset of a catastrophe before the event occurs, and by providing real time information during an event. EWSs thus fulfil multiple roles as general information systems, decision support systems and alarm systems for multiple stakeholders including government, companies, NGOs and the general population.

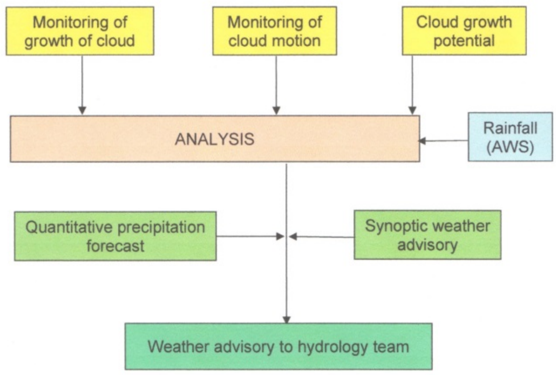


Model of EWS

Meteoalarm EU (www.meteoalarm.eu) provides the most relevant information needed to prepare for extreme weather, expected to occur somewhere over Europe (today or tomorrow). This information is presented consistently to ensure coherent interpretation as widely as possible throughout Europe.



Community based flood early warning system



Monitoring of meteorological data

The Balkans is one of the world's most dynamic and complicated systems. The nature of this region is extremely fragile and sensitive to climate changes. Climate changes gradually intensify frequency and the scale of extreme weather events and natural calamities in the region, which has already resulted in a higher risk level for the population of the Western Balkans.

As the issue of waterflood risk mitigation is critical for economies in the APEC region with its water-abundant rivers, it makes sense to provide a detailed description of measures taken in the countries within the European Union.

Pouring rains and catastrophic waterfloods that struck Bosnia and Herzegovina, Serbia and Croatia in the spring 2014 were unprecedented in the history of the region. Over a few days the amount of accumulated precipitation in some areas was equivalent to one third of the average annual amount. These areas faced severe human and material losses. Over 18 years of the 21st century the Western Balkans witnessed 22 disastrous waterfloods. In 2017 the Government of the Republic of Serbia approved the Water Management Strategy for the territory of Republic of Serbia until 2034. This Strategy creates the basis for sectoral reforms to achieve the required standards of water management. Structural measures (construction of flood protection such as regulation of streams and barrage reconstruction or construction of new barrages) were the most popular measures applied in Serbia in the previous period. Structural measures supposed to be implemented within the frame of EU instruments to facilitate entry into Program 2014-2020 (IPA 2) and the World Bank. Out of 39 areas for which a high risk of waterfloods was identified, the planned implementation of the above-mentioned program will cover 15 areas.

It is suggested that nonstructural measures should be implemented in the other 24 areas in 19 municipalities. Nonstructural measures cover the activity that may be classified as nonphysical (planning and designing of structural measures, measures to ensure readiness, environmental protection measures, governmental and legislative measures, as well as financial measures) or physical (emergency response measures).

The protection system applied in the Republic of Serbia relies primarily on passive measures. Thus, about 2,500 km of dikes, about 1275 km of line structures and

58 barrages have been erected in the Republic. In spite of such critical infrastructure facilities, the flood control has become unstable lately, especially after waterfloods events reordered in the last ten years.

The majority of Balkan countries have only recently developed maps of waterfloods risk and only for some areas. Absolutely different methods were used for preparation of these maps, although all of them referred to the EU Floods Directive (EU, 2007). This prevents from using a consolidated tool for risk assessing. Still there are no waterflood maps for many rivers or they are based only on previous waterflood data (Macedonia). To some extent the waterfloods risk map may be used as a planning tool for future waterflood protection. The EU waterflood program for the Western Balkans recognizes the importance of investing into the future and taking reasonable decisions allowing for risk. In view of this, development of waterfalls and landslide risk assessment for the housing sector in the Western Balkans was initiated. The overall number of people residing in the areas with a high risk of waterfloods (hazard maps category 4) is 283,777 people, whereas the overall number of people residing in the areas of a substantial risk of landslides (hazard maps category 4) is 260,731 people.

The Meteorological Service Department of the Republican Hydrometeorological Service of Serbia as a part of the World Meteorological Organization monitors certain aspects of weather on a 24-hour basis: Aircraft Monitoring Section carries out measurement of meteorological parameters of the air and at height, accumulates the data and prepares reports. Radiosounding is the main technique applied for measurement and observations over the top air carried out with the use of airborne radiosondes. The density of the meteorological network is too low for Bosnia and Herzegovina and for Montenegro. The Serbian meteorological network is composed of 458 stations, although only 28 of them are automatic. Manual stations are attended 3 times a day (53 stations) or once a day (390 stations).

Besides, Serbia is covered with 15 Doppler radars. The Radar-Locating Meteorology Section uses the radar located in Kosutyak monitors clouds and cloud systems in the area of 300 km around Belgrade. It is a very accurate method of position and time assessment of precipitations and extreme weather events. The Weather Forecast section includes the work of all other divisions of the Weather Department aimed at preparation of real-time forecasts. The Numeric Weather Forecasting Section carries out a fact-based analysis, initialization of meteorological fields and preparation of boundary conditions for synoptic and mesoscale numeric weather models (ETA model) with application of the collected and processed data.

Some of the models are used for streams forecasting of various rivers. For large rivers the combination of statistical methods and river routes is mainly used, whereas HBV model is applied for small and moderate-size basins. For catchment areas with no developed models forecasts depend on the expert evaluation based on the hydrologist’s experience. Several weather forecast models, including global models (ECMWF) and restricted-area models (WRF Europe, WRF Balkan, NMMB Europe, NMMB Balkan and ETA) are used.

A waterflood is often a transboundary issue, and all economies cooperate with neighbors. It is also characteristic of the APEC economies. All economies under evaluation covered by the existing European Flood Alerting System (EFAS) are partners of EFAS. EFAS is a partner service under the auspices of the Copernicus Emergency Management Service with regard to monitoring and forecasting of waterfloods in Europe. This system provides probabilistic forecasts for 1-10 days for all rivers over 2000 km2 in addition to forecasts of flash floods and related functions: precipitation forecast, remote sounding, as well as soil humidity and snow depth assessment. Serbia is a party to bilateral agreements with Rumania and Hungary and a partner of the Sava Floods Forecasting and Warning System (Sava FFWS). Two of them are located in the Balkans: in the Sava River basin and the Drin River basin. One example project "Adaptation to Climate Changes in the Western Balkans". The project focuses on the Drin River implementing the waterfloods forecasting model in Macedonia, Albania, Montenegro, and Kosovo. In spite of measures for waterflood risk mitigation taken and described in her report, losses have a tendency to growth, and she agrees that the use of natural sensors on the basis of IoT may result in a radical change in such dreadful situation.

Tsunami hazard assessment in the Pacific Ocean tsunamigentic regions.

The current option for tsunami assessment is that the tsunami hazard is mitigated only by collecting and analyzing the statistics concerning tsunami generation, develop, prepare and provide reliable, yet probabilistic/deterministic assessment of tsunami hazard, including the probability that a tsunami of a certain intensively (I) or height (H) occurs during certain time intervals in the area of interest. The deployment of various sensors and GPS stations providing real-time data allow capturing surface displacements with sufficient precision required for earthquakes and tsunami monitoring purposes. Meanwhile, there is a significant lapse in the completeness and quality of data collected over more remote periods of time, which requires scientists to use less precise interpolation methods in analyzing the entries. As for the last 20 years of observations in the Pacific Ocean, it is believed that some of the tsunami hazard parameters might be more useful for the purposes of creating an IoT-based monitoring system, than the others. As such, the assessment of tsunami hazard via future ICT-based monitoring systems may be designed in a way well suited to include the following probabilistic parameters:

- Maximum regional intensity of tsunami (Imax) b (or β = b.ln10) is the ratio of frequency intensities to the average activity rate (λ);
- Number of tsunami events per year for specific tsunami intensity;
- Return periods of a specific tsunami event in each zone;
- Probability of tsunami occurrence with intensity I = 2 (Havg = 2.83 m) and I = 3 (Havg ≥ 5.66 m) during the next 10, 20 and 50 years in ten major zones of the Pacific

Ocean area, where tsunami occurrence is probable.

As the result of the analysis of these parameters zones with maximum tsunami intensity (Imax) over 4.5 (Havg ≥16.0 m) can be identified, which represent the most hazardous areas of the Pacific Ocean where tsunami occurrence is most probable. Low return periods (<30 years) and high occurrence likelihood (> 0.75) for tsunami intensity I = 2.0 are observed in zones with a high hazard level comparing with other zones in the Pacific Ocean.

The prepared maps of tsunami hazards are useful to prepare probability maps of tsunami hazard and risk assessment. There is an urgent need to launch at the local scale continuous monitoring of tsunami events in these high-intensity tsunami regions to mitigate the tsunami risk.

Flood Prevention and Warnings Program in Malaysia

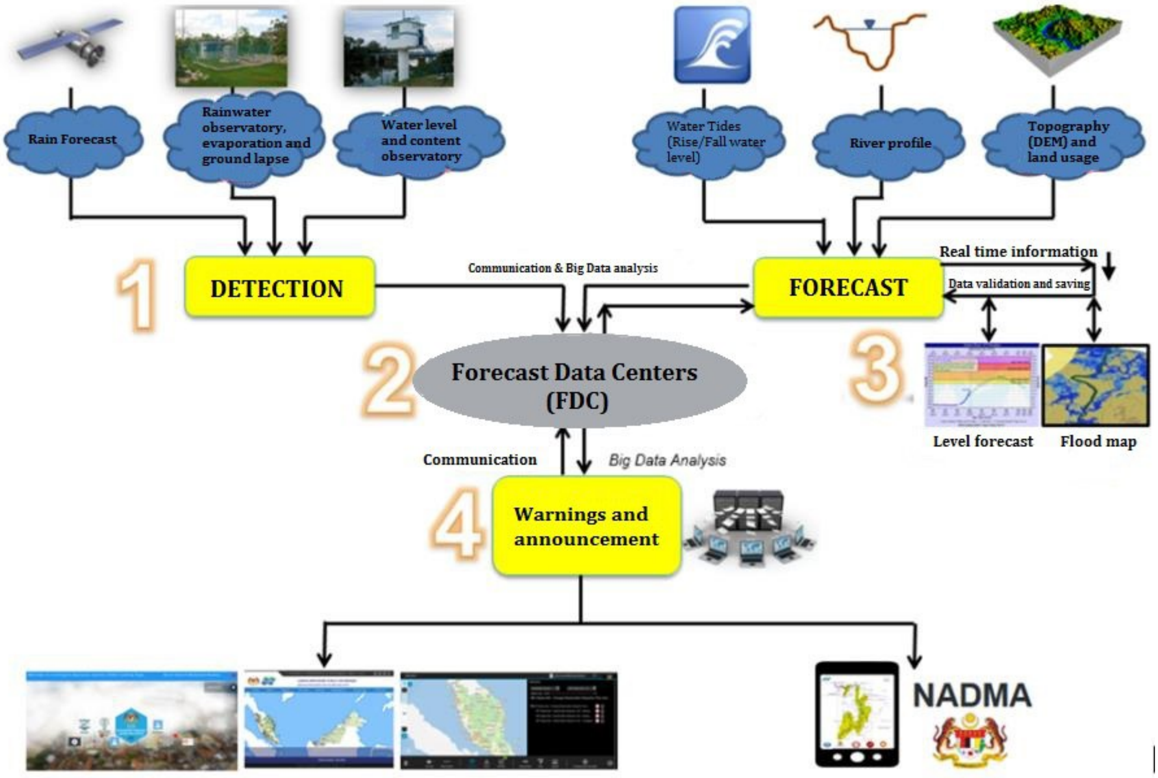
Flood Prevention and Warnings Program (PRAB) has been created following the massive floods that occurred in December 2014 which hit 8 states namely Kelantan, Terengganu, Pahang, Perak, Perlis, Johor, Sabah and Sarawak. The flood has recorded a total of 25 deaths with more than 500,000 transfers and the cost of destruction exceeded RM 2.85 billion. Through the PRAB under Department of Irrigation & Drainage Malaysia (DID) the forecast for waterfloods is 7 days ahead. Whereas the warning will be disseminated in 2 days earlier.

To achieve the PRAB objective program, there are four (4) major components that will be implemented in an integrated manner using the latest technology. The components are as follows:

- Developing System Tracking Data Hydrology;
- Developing a Database and ICT Infrastructure System;
- Developing Predictive System and Flood Modeling;
- Enhancing Warning and Announcement System.

As a result of such activities, it is expected that monsoon floods predictions' horizon could be expanded to 7 days before the catastrophic phase.

- Fortifying monsoon floods 7 days earlier based on weather forecast data from the Malaysian Meteorological Department.



- Enhances the alert system's capabilities and monsoon floods from 6 hours to 2 days ahead of the agency of interest and residents affected by floods.
- Improve accuracy flood alert accuracy by reducing predictions and varying reality of water level over 1 meter to less than 0.5 meters.
- Develop a system that's capable of raising and alerting flash flood events to the public within 1 to 3 hours ahead of weather forecast data from the Malaysian Meteorological Department. This forecast only focuses on overflowing river water.

There are projects that require contribution and involvement of National Hydraulic Research Institute of Malaysia (NAHRIM), Department of Irrigation & Drainage Malaysia (DID) & The Department of Survey and Mapping Malaysia (JUPEM) for designing monitoring system and analyzing data obtained from sensors such data collected for sea level rise, rainfall, water level and streamflow in Malaysia. This dataset been analyzed to improve warning system as well as to support strategic planning in infrastructure development (flood mitigation plan) in 11th Malaysia Plan.

Study conducted by NAHRIM for EPU titled "Economics of Climate Change for Malaysia – Water Resources Sector", one of the recommendation from the findings is adaptation measure to the climate change should be mainstreamed in all development design and planning. The adaptation measures should address socio-economic benefits, environmental and ecosystem protection in an equitable manner. The adaptation measure whether structural or non-structural, might be costly at the beginning of implementation or construction period however in long run, it would gain the tangible and intangible benefits and consequently the cost of property damages, loss of lives and risks reduction due to climate change impacts could be significantly reduced.

Usage of IoT and AI in emergency monitoring system is currently conducted by NAHRIM for project “Building an Early Flood Warning and Disaster Prevention System by Artificial Intelligence Techniques for Kemaman River Basin” to create real-time multi-step-ahead flood inundation maps during storm events using an integrated methodology that couples flood inundation simulation and machine learning models. The forecasted regional flood inundation map can be shown on Google Earth to help decision-makers and residents take necessary countermeasures against flooding.

Through NAHRIM Big Data Analytics (BDA) program named “Malaysia Climate Change Knowledge Portal” (N-HyDAA), there is a necessity to incorporate IoT in the portal for a better data retrieval and analysis which can speed up the process of preparing hydro climate projection data and to conduct analysis at minimum of time based on scenarios. The output from this portal can be used to support Malaysia Adaptation Index for Vulnerability and Adaptation on Climate Change (MAIN) initiative that helps Stakeholders, Government and other entities understand the status of vulnerability and adaptation for each state in Malaysia in combating impact of climate change which is including extreme floods and drought events where the input for both program required contribution from various interagency in Malaysia.

N-HyDAA created to detect, visualize, trace and identify water related risk and disaster using 1450 simulation years based on historical and projection dataset from 1970-2100. Through this project, it able to resolve and uncover hidden pattern, unknown correlation and projections for trends of future hydro climate which is to enhance risk management, technology & engineering practices that strengthening climate change mitigation & adaptation action by decision makers and stakeholders.

For the purpose of pilot project, R&D emphasizing on IoT in WF (flood and drought) is welcomed by focusing on the idea of integrating N-HyDAA with MAIN by based on data availability and domain that have direct impact on the economy.

System of individualized rescue in Russia

In 2012 Russian Radio Research and Development Institute (NIIR) initiated implementation of a new paradigm of personalized rescue of people in case of natural and man-made emergencies, if the disaster phase (Tk) of the emergency occurs not before than 10 minutes after its onset (T0) –Tk- T0>10 min. A new paradigm of personalized rescue of people from the emergency zones was included into TELMIN 9 Declaration.

However, despite the tremendous efforts, catastrophes continue and bring great material and human losses. Moreover, large human losses are observed for people with disabilities and chronically ill people. With the help of modern ICT, such people adapt to the conditions of modern life, but they are doubly helpless if they find themselves in an emergency zone.

Regional monitoring systems began to be developed in Russia. An example of such a system is the "Unified State System for Environmental Monitoring of the Russian Federation" (ESSEM) and its territorial subsystems, which they began to create in the 90s of the 20th century to adequately address the tasks of managing territories. However, following the Ministry of Ecology in 2002, USSEM was abolished and currently only departmental disparate observing networks exist in Russia.

The created system of individualized rescue of people in the event of an emergency has the ability to take into account all the peculiarities of a person in the emergency area, it determines its location at the time of the emergency and controls its rescue from that moment, indicating the safe way out and the necessary procedure Emergency monitoring system is technically based on the use of IoT technologies, which has become possible for realization as a result of the powerful technological breakthroughs of recent years with the active participation of APEC economies:

1. Transition to the new system of IP address assignment - IPv6, which gives practically unlimited access of IoT to a single converged information environment over IP;
2. Convergence of communication networks, including sensor networks;
3. Ubiquitous mass user access to broadband channels of a single CIS;
4. Development of mass subscriber wireless access systems;
5. Development and practical use of big data processing;
6. Development and practical use of cloud computing; Transition of telecom operators to broadband (LTE standards, etc.);
7. Development of technology, production and use of wireless sensor networks;
8. The rapid development of mass subscriber devices.

In spite of the developed network of seismic stations within Russia (the North Caucasus, Kamchatka, Altai, and Eastern Siberia), forecasting technologies are far from perfect, as their predictive potential is extremely low. Particularly this important and relevant task was selected by the authors to make the first step in their cross-disciplinary cooperation. Taking into consideration capacities of CIE, to achieve a radical increase in predictive potential in the future, it would be reasonable to combine earthquakes monitoring with environmental and geological control. It has been suggested that the solution should use the capacities of IoTs for a radical increase in predictive potential of existing earthquakes monitoring systems. The hybrid monitoring system has been developed, in which IoTs of various living (including humans) and non-living natural objects of the outside world (see Fig. 2) connected to CIE are located in territorial proximity to the existing seismic control stations.

The fact that IoTs used as sensors would have physical nature different from the sensors of seismic stations is of crucial importance. Signals from these IoTS sensors come to the nearest point of seismic control and are processed there using the synchronization method specially developed by Prof. Dr. Alexey Lyubushin (Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences) to reveal weak signals – earthquake precursors. This measure is expected to radically enhance the efficiency of disaster forecasting, which will reduce human losses from emergencies in several times. This solution was approved as a recommendation of ITU-T.

Improvement of forecasting results in this system is achieved, for example, on the basis of the following:

- registration of weak recurrent impacts (foreshocks),
- change in parameters of geophysical fields (magnetic, electric, gravity and other fields),
- signals of land surface deformation,
- change in hydrogeochemical parameters of the environment;
- change in behavior of animals and plants.

At a later stage it is reasonable to transfer from quality signs of behavior expressed by non-living and living natural objects (including a human being), used as IoTs sensors in the hybrid monitoring system to quantitative criteria based on such parameters as gas composition, concentration of mercury, selenium and other chemical elements, conductivity, turbidity, etc. – for non-living objects, pulsation, heart rate, temperature, muscle tension, blood composition, hormone level, etc. – for living objects. It is expecting that real-time monitoring and study of correlation of living objects' dynamic characteristics and seismic sensor values to improve predictive sensitivity of created hybrid monitoring systems to a higher level. However, it requires a solid amount of research and technical solutions, which are planned to be launched at the economy range we will describe below.

Proceeding to monitoring of earthquakes and other natural-technogenic disasters to environmental issues, we should highlight a pressing need to develop biological and environmental research. The efficiency of ecosystem biogeochemical monitoring depends on the research methods. If at the end of the 19th century statistical methods were mainly employed, today scientists start applying dynamic methods to assess the processes happening in ecosystems. These methods include territory screening from the space and various methods of IoTs application. The latter allows solving the issues of complex dynamic monitoring of territories, which influences energy saving, efficiency of cultivated land utilization, augmented productivity of agricultural crops, and quality of food-stuffs and fodder.

To date, due to technogenic transformation of biosphere taxons, development of digital technologies, long-term monitoring of natural-technogenic processes, and the use of the Internet of things system to create a global experimental base. It seems necessary to implement the following tasks:

- in the area of environmental and biogeochemical monitoring: monitoring of water cycles in the biosphere, water inflow/outflow balance using special sensors seems promising;
- monitoring of changes in the atmospheric composition (CO2, CH4 and N2), which allows identification of the gas balance and predictive assessment of changes in the biosphere;
- development and use of special sensors monitoring manifestation and development of microelementosis (deficiency of Se, J). Iodine and selenium concentrations may be measured in the atmospheric air under assessment of the environmental status of microelements – cardio-vascular and endocrine pathologies;
- traching changes in the electrical conductivity of water, pH, turbidity to forecast mudslides, landslides and avalanches in mountainous areas;
- approbation of special landscape chromaticity sensors to assess bioproductivity of landscapes and phytobiodiversity;
- assessment of physiological sensor utilization to study response of animals to adverse environmental and biogeochemical factors;
- enhancement and approbation of special sensors measuring elemental mercury and radon flows in mine reservoirs;
- study of mechanic-chemical and biochemical communications in the system non-living body–organism–non-living body.

Monitoring of biogeochemical parameters may be performed at various time levels:

continuous monitoring of parameters, discrete measurements (every hour, day, month, year) with application of the system of existing detectors and sensors:

- Stevens Hydra Probe Field Portable (portable soil monitoring system),
- VAISALA GMT220 carbon dioxide sensor,
- RADEX MR107 radon indicator,
- UKR-1MTs mercury analyzer,
- 3000 IP mercury sensor Portable Analyzer of Mercury Vapor in Air and Other Gases,
- ORP meter (Redox) - oxidation-reduction potential pH S406 DG,
- S423/C/OPT digital optical oxygen sensor,
- S461/T digital turbidity sensor (Electrode),
- S494/2/CL2 amperometric free chlorine sensor with a membrane,
- pH controller or Redox and temperature controller SERIES 4238,
- S401 V/G pH sensor,
- S411/C/0.5 temperature-compensated conductivity probe ,
- S411S conductive conductivity sensors,
- SERIES 3523 conductivity and temperature controller,
- Turbimax CUS52D turbidity sensor,
- turbidity and suspended solids sensor,
- turbidity metering system 4670,
- intellectual dual-input analyzer,
- electric conductivity sensor 4905,
- liquid conductivity sensor DEI-3290-01, DEI-3290-02, DEI-3290-01A, DEI-3290-02A, etc.

It should be noted that today there are almost no sensor monitoring changes in the elemental composition of most chemical elements. Taking into account a high demand for such devices, scientists work on their development, as well as on their application technologies.

Another important issue is knowledge stitching. Co-processing of seismic signals and signals from IoTs sensor illustrates one of possible methods of knowledge stitching – signals from seismic sensors and synchronous changes in process parameters in IoTs related to developing earthquake processes. Next, the report goes on to describe the work performed by the cross-disciplinary team.

It was decided to arrange the economy-scale field center for complex environmental and biogeochemical research at the Geological Base in Nizhny Unal settlement, North Ossetia. The Base is located in a highly seismic mountainous area at height of 900 m a.s.l. in the spur of the Skalisty range. Snow avalanches, glacial floods, landslides, mud slides, earthquakes, and waterfloods are common in the catchment of mountainous rivers of North Ossetia. Today the Base is used by local geologists monitoring mudflow processes, processes of glacial melting, water level in mountainous rivers, etc.

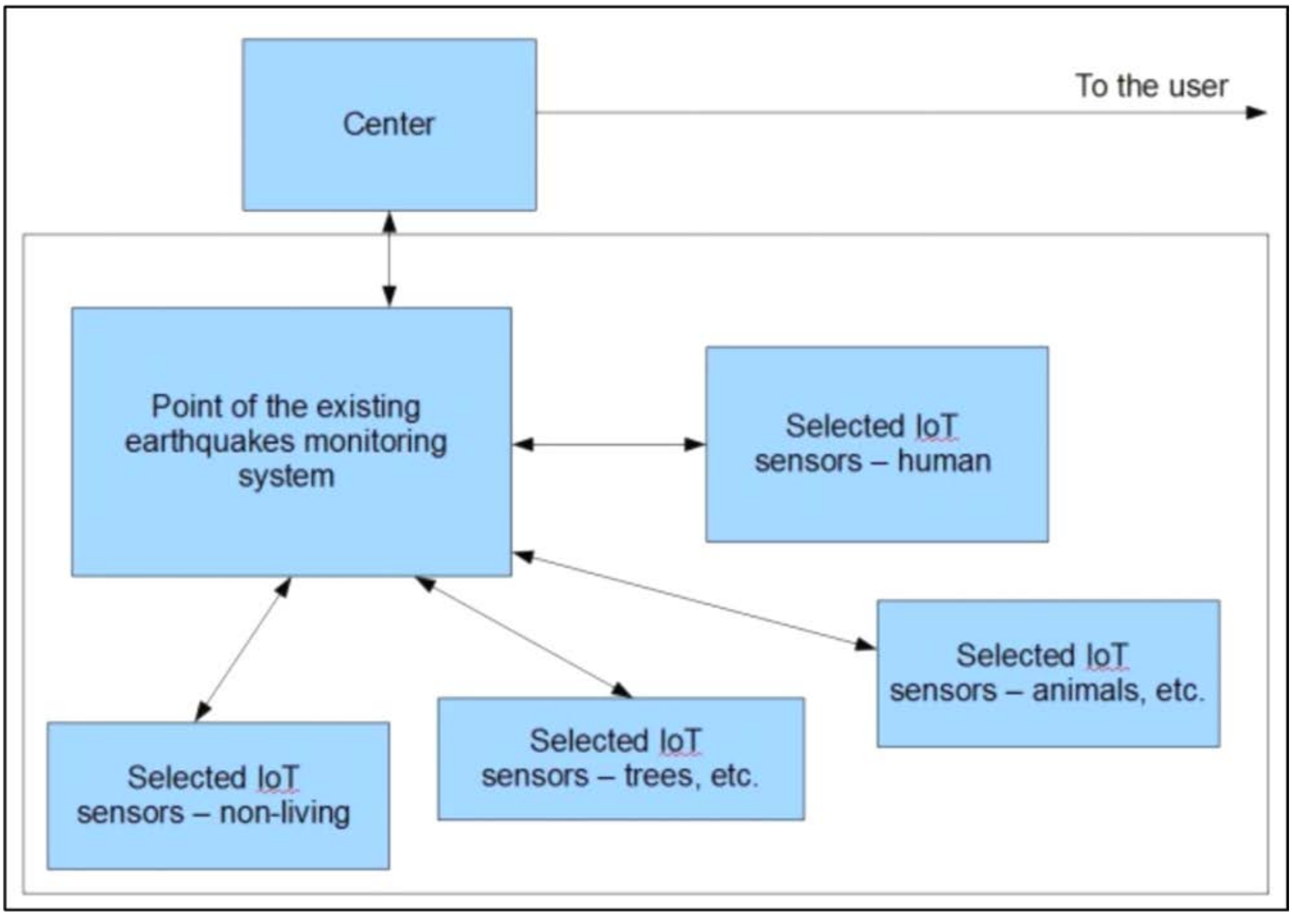
Recently active upgrading of the station equipment has started. The station is provided with modern devices applied to study heat flows, to assess hydrosphere and atmosphere parameters, including study of the carbon-dioxide balance of ecosystems, meteorological, seismic and climatological devices.

Field and laboratory research were carried out at the Geological Base of Lomonosov Moscow State University in July 2018, and then at Environmental Biogeochemistry Laboratory of V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences. This research work made allowed revealing the metal concentration gradient (Pb, Zn, Cu, and Cd) in the soil-cover complex conducting statistic biogeochemical and environmental research. At the next stage the scientists will study correlation of these data and the data on seismic activity obtained at seismic monitoring stations located in close proximity to the base. Application of new methods of biogeochemical indication and geochemical environment allowed revealing specific response of plants and animals to a change in the level of heavy metal composition (Pb, Cd, Cu, Zn, etc.).

Predominant landscape pollution of the Ardon River's flood plan with and arsenic was found. The scientists also found a high positive correlation between the amount of metals in soil and plant mowing amount (r= + 0.998). On man-made plots the number of plant species, mowing biomass, and phyto coverage tend to reduce. A new kind of metallophytes – Cladochaeta candidissima (M. Bieb.) DC – was found. The overall content of SH-compounds and amino acids in the roots of plants was higher than in leaves. Presence of phytochelatins was found during in vitro experiments with application of cadmium chloride and reduced glutathione due to a decrease in glutathione concentration.

Fluctuating asymmetry of silver birch leaves (Betula alba) was assessed in landscapes with various technogenic load. The above-mentioned responses of organisms are mainly determined by physical-chemical characteristics of soils, climatic, biological and technogenic factors. For further assessment it is necessary to establish relation with the core product of organism's metabolism – carbon-dioxide balance. That is why it is reasonable to consider this factor in further tests, and simultaneously carry out dynamic assessment of change in landscape chromaticity, using special CO2 sensor and optical sensors for this purpose.

An increased level of plumbum and arsenic in the soil and plants of the Ardon River's floodplain causes an increase of their concentrations in the blood and hair of animals and may be considered as a risk factor with regard to their adverse effect on physiological processes in the body of animals under study.



The findings of the performed work may provide valuable information on the dynamics of environmental and biogeochemical processes in one of mountainous sub-regions of the biosphere and responses of organisms to various manifestations of natural disasters. Utilization of the obtained data in the microelement monitoring will provide reliable and objective information on environmental condition of the area, peculiarities of chemical elemental composition of organisms and their habitat and allow monitoring of changes in various parameters.

An improved dynamic model of environmental and biogeochemical research with the use of IoT technologies is a whole new strategy applied to study impacts caused by various processes in this ecosystem.

The obtained research results may be used not only to improve scientific methodology but also in preventative medicine, ecology, epidemiology and economy.

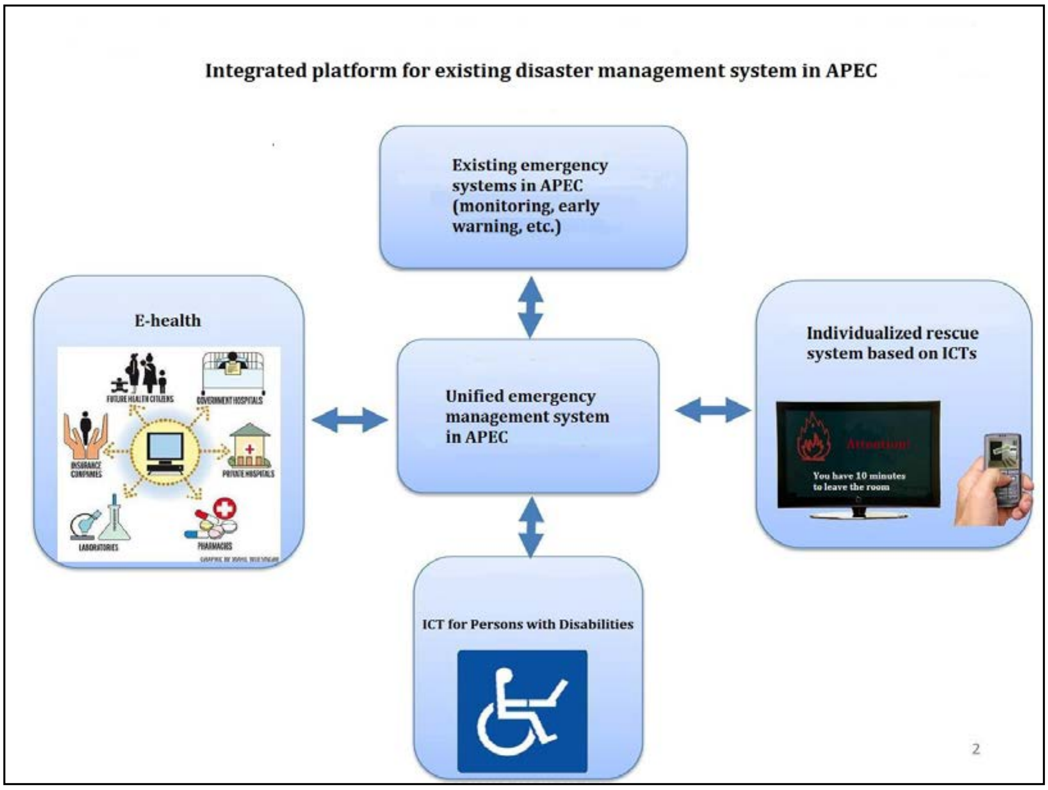
The work is performed with participation of post graduate students and young specialists from laboratories of concerned institutes. Further plans include arrangement of joint academic symposiums, conferences and publication of monographs on modern environmental–biogeochemical and IoT-innovations. The cross-disciplinary team aspires to establish cooperation with research teams from China, Serbia, Kazakhstan, and Kyrgyzstan, as well as with scientists from the APEC economies.

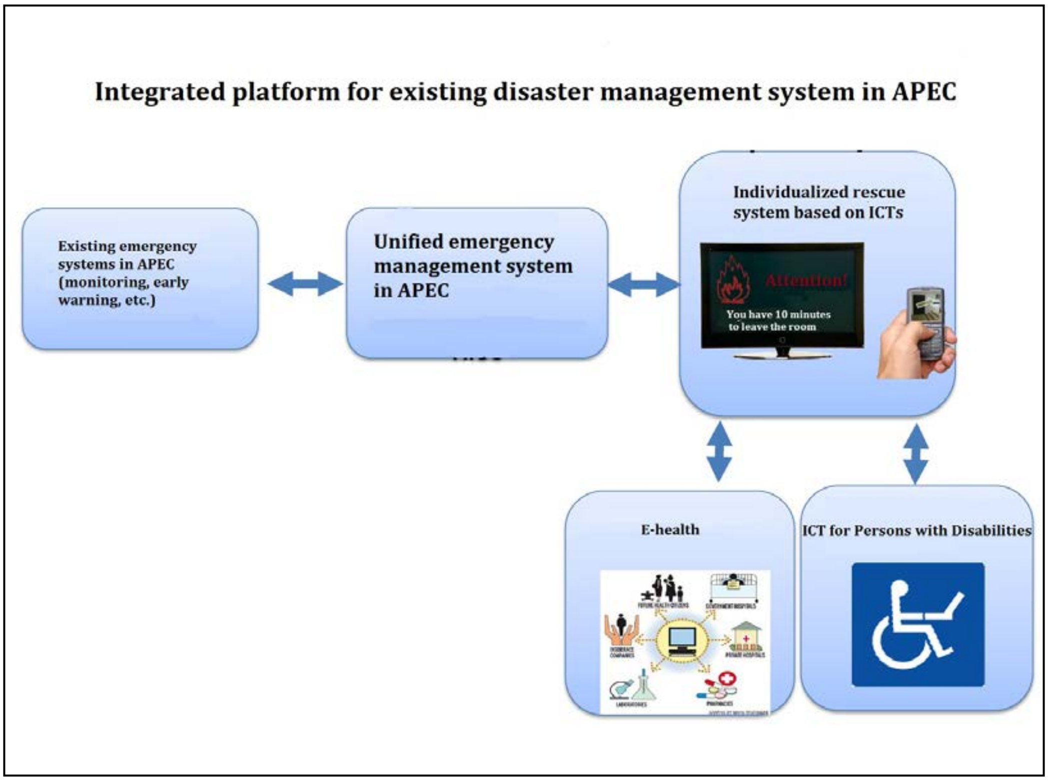
It is expected that the use of IoT capacities will allow scientists to acquire a global testing site to study the environmental impact on dynamic characteristics of natural objects, and the use of research findings to study natural and man-made processes opens opportunities of direct information interaction among all natural objects within the biosphere and the nearest outer space.

In general, CT along with biogeochemical technologies will promote reduction of CO2 emissions into the air, environmental enhancement, and efficient and effective information exchange.

In past years Russian scientists and researchers explored the effects of internal Earth noise synchronization. The source of internal Earth noise is processes inside it. It turned out that the analysis of geophysical monitoring data provided by modern systems from 1997 on revealed some effects that may be interpreted as demonstration of collective synchronous component in chaotic time series of internal Earth noise. Some of the revealed synchronization effects may be interpreted as precursors and trends of severe seismic event occurrence. It is interesting that in this case the Earth in whole acts as IoT, and wide-band seismic stations of the global GPS network are used as sensors. Calculations on the basis of long-term sensor readings obtained in these global networks demonstrate a high probability of extreme seismic activity in Japan and on the US West Coast.

The tilt sounding radius of the Russian ionospheric station "Rainbow" is over 3,000 km, which makes it possible to use it for forecasting and timing of earthquakes and tsunamis on the basis of ionospheric changes above the ocean and along the fault line of lithospheric plates. The project is also based on the IoT concept, where the ionosphere and troposphere of the Earth's regions are used as the thing, and ionospheric stations and stations of the existing global hydrometeorological monitoring networks are used as sensors.





Any and all existing monitoring systems and alerts about the occurrence of emergencies have economically insignificant predictive potential and cannot predict emergencies with sufficient accuracy as they generate alert signals based on the findings of the central situational center after some time after the occurrence of an emergency. Even if the emergency signal reaches all people who are in the emergency zone at the same time, people who are in the subject of an emergency will be in an unequal position in relation to the opportunities to escape, as they can be, for example, tourists who do not know the language and terrain.

In order to expand the possibility of using the Service in case of emergencies in case of close to zero time between the beginning of an emergency and its catastrophic phase (Tk0), it is necessary to significantly increase the predictive potential of existing monitoring systems for such types of emergencies. An increase in the predictive potential is associated with the search and fixation of the signals of emergency precursors with Tk0, for example, earthquakes, that is, the search for predictive information. However, the sensors used today are not very sensitive to earthquake precursors, and in the sensors they are reflected against the background of noises.

The developed system works well if man-made emergency occurs in a particular object. In this case, the sensory system and sensors based on IoT technology are able to provide the necessary amount of time between the start of control and the onset of the catastrophic emergency phase. If an emergency occurs outside the object, then it is very important that the signal about this emergency appears as soon as possible in the internal control system of individualized rescue of people, so that it starts generating control signals for subscriber devices of people who are trapped within this particular object corresponding to this particular type of emergency.

The main difficulty in shaping the high predictive potential of existing monitoring systems is the lack of comprehensive analysis and monitoring of emergencies only before and after it occurs, while the course of the emergencies falls out of sight. At this time, the person in the emergency zone is left to himself and he makes a decision about his behavior under the conditions of time and stress.

It can be stated that today, in the formation of smart cities, the use of ICT to minimize risks and losses in the event of an emergency does not receive enough attention. This is evidenced by the indicators of recent losses and casualties from emergencies in the APEC economies - a fire in California, flooding in Japan, a tsunami in Indonesia.

The entire strategy of work to mitigate the risk of waterfloods, tsunami and other water-related emergencies involves data acquisition, their processing to reveal their cyclical nature (for example, seasonal) of emergency occurrence and their probabilistic forecasting. Besides statistical analysis, the possibility to forecast waterfloods and tsunamis is determined by the fact that these emergencies are expended in space: tsunami moves from its generation point at a certain end speed and residents of a certain area may be timely warned about the danger. Which means at any point of the spatially extended territory there are zones where the emergency occurs not sooner than 10 minutes ($T_k > T_0$ at least 10 minutes) after warning. The same is relevant to waterfloods.

Identified gaps

In order to expand the possibility of using the Service in case of emergencies in case of close to zero time between the beginning of an emergency and its catastrophic phase (Tk_0), it is necessary to dramatically increase the predictive potential of existing monitoring systems for such types of emergencies. An increase in the predictive potential is associated with the search and fixation of the signals of emergency precursors with Tk_0, for example, earthquakes, that is, the search for predictive information. However, the sensors used today are not very sensitive to signals — precursors of earthquakes; they are reflected in the sensors against the background of noises. There is always some blind zone event using the most advanced instruments. Therefore, the work on making observed data into information intelligence to identify disaster hotspots in advance might be a dimension to look into in the future.

The solutions can work well if an emergency occurs within the boundaries of previously explored and mapped particular object. In this case, the sensory system and sensors based on IoT technology are able to provide the necessary amount of time between the start of control and the onset of the catastrophic emergency phase. If an emergency occurs outside the object, then it is very important that the signal about this emergency appears as soon as possible in the internal control system of individualized rescue of people, so that it starts generating control signals for subscriber devices of people who are trapped within this particular object corresponding to this particular type of emergency. In our opinion, this is due to the fact that the work for the prevention and elimination of consequences of emergencies is held in different working commissions, where they consider individual issues of this problem without a comprehensive link, and most importantly, these groups consider activities only before and after emergencies. And the occurrence of an emergency falls out of sight, at this time a person in an emergency zone is left to himself and he makes a decision about his behavior in the face of a lack of time stress. In this state, many people forget all the instructions and make fatal mistakes. People with disabilities and special needs are especially vulnerable during an emergency.

For many economies, the overall disaster monitoring comes down to the basic non-integrated instruments, such as seismometers, accelerometers, GPS and tilt meters. The benefits of improving the systems are largely founded on the long-term, rather than short term, which is one of the reasons behind the argument that the monitoring should remain a marginal activity in terms of financing and staffing.

However, even for the developed economies with smart cities, the use of ICT to reduce the risk of losses remains outside the focus. Conducting a comparative analysis of the results of the previous work can be useful, to understand the expanse of their effectiveness in particular cases of each APEC economy. This should be done by the local clusters of scientific knowledge, as the particularities in a diverse Asia Pacific are well away from being homogenous.

As evidenced by the figures of recent losses from emergencies this year in the APEC economies — a fire in California, a flood in Japan, a tsunami in Indonesia – at the time of the start of an emergency people did not know where to run to escape. With full responsibility it can be argued that these victims could have been avoided if the victims (and these are residents of developed economies) had access to an individualized rescue management service (self-evacuation management) using modern ICTs, which was also supported by the APEC Ninth Telecommunications Ministers Meeting (TELMIN9) Declaration in 2012. These services are complementary to building an integrated platform, which would serve as a single entry point for all DRR activities. At present, the observed weaknesses belong to the monitoring and early warning. Thus, the issue of improving the predictive potential has a potential to substantially strengthen the overall disaster management capacity of APEC economies. Using natural objects (living, including humans) and non-living ones as indicators on the basis of IoT technology, characteristics of which could be continuously monitored and allow forecasting a forthcoming event in advance (for several months) in case of change in environmental conditions. In this case the risk of human and material losses may be minimized.

As the alerting in the existing systems is available to the population generally consisting of residents and nonresidents staying at this moment at any point of this space extended territory, every person may have a question “Where to hide?”. For example, Indonesia faced the same problem after the emergency warning; the number of fatalities and victims there amounted to over 2000 thousand people, provided that the most of these people were nonresidents of the places where they were caught by tsunami.

Low ICT capacity of personnel, especially for the technician/junior-level is also identified as a weak point in many instances from and outside APEC region. The solutions are largely without bearing the fruit, if the human resources lack the necessary capacity or skills to use specialized equipment. The continuous learning for analysts and policy-makers is also a concern, as the decisions are often not based on the available data, or this data is not pre-processed and is not well equipped to shift to realize the true data-driven management.

The main lines of work are necessary to close the gaps to be implemented in the near future to ensure transformation of the region’s environment into IoT can be identified:

Explore the current application of IoT sensors and requirements to their data by conducting an economy-wide survey;
Develop a road map for capacity development to render assistance to APEC economies in creation of the relevant data;
Promote open data to create safer trade environment;
Define and develop the mechanism of open data exchange to enhance readiness to emergencies and develop a road map for IoT promotion.
Summing up, the entire strategy of current work to mitigate the risk of waterfloods, tsunami and other water-related emergencies involves data acquisition, their processing to reveal their cyclical nature (for example, seasonal) of emergency occurrence and their probabilistic forecasting. Besides statistical analysis, the possibility to forecast waterfloods and tsunamis is determined by the fact that these emergencies are expended in space: tsunami moves from its

generation point at a certain end speed and residents of a certain area may be timely warned about the danger. Which means at any point of the spatially extended territory there are zones where the emergency occurs not sooner than 10 minutes ($Tk > T_0$ at least 10 minutes) after warning. The same is true about waterfloods. All of these facts tell the need to strengthen the ICT-monitoring aspect, to design next generation systems with integrated solutions in mind, to strengthen the quality of human resources, to cooperate more, and share valuable experience from pilot projects.

CHAPTER 3. TOWARDS BUILDING NEW ICT-BASED MONITORING SYSTEMS

Today there is an abundance of all necessary hardware and software required to build wireless networks communication between the natural objects, and they are scalable, meaning that the level of IoT network can be elevated to the required Intranet or Internet connection regardless of its size. Based on the structure of a standard IoT network, such systems are capable of sending signals from its sensors to network, while also being able to receive signals, including control signals, coming from outside. It means that the architecture of such systems should be able to provide network the signal-response ability to communicate efficiently.

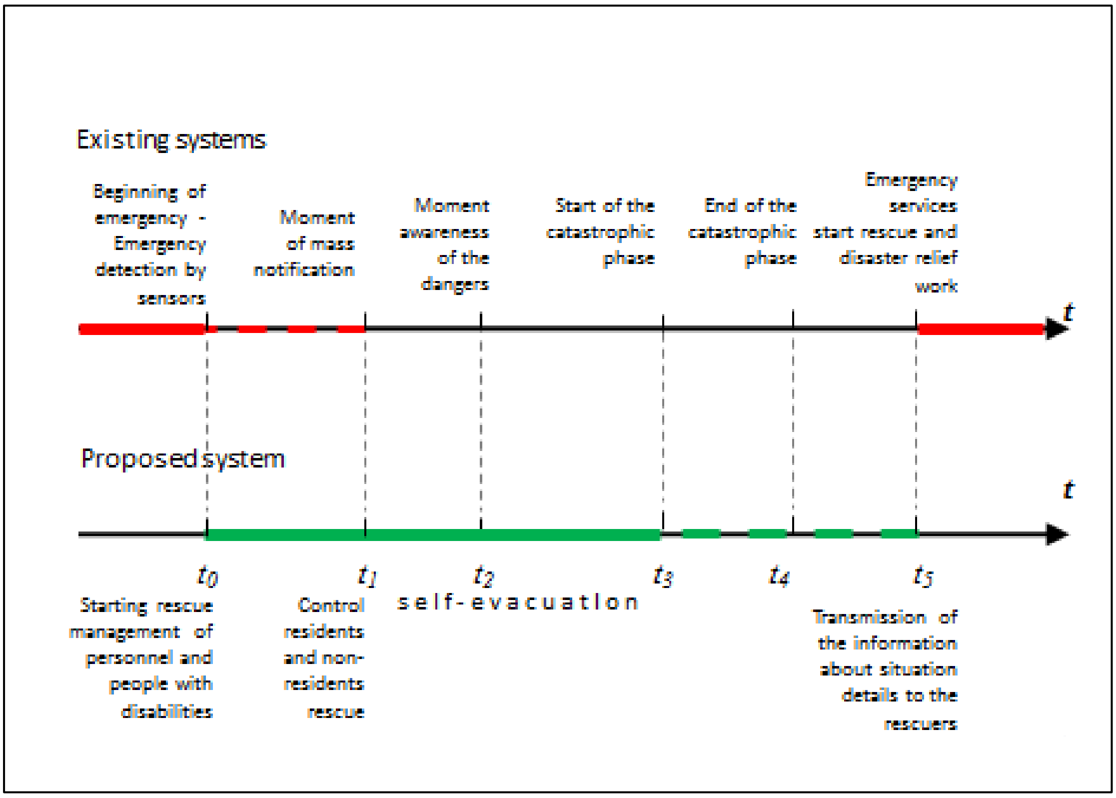
The main idea of improving sensory capabilities of existing DRR systems is the expansion of the reachable area of sensory interaction of a person equipped with an intelligent subscriber device (smartphone) networked with the smart environment, which at the right time informs him with warning signals about the upcoming disaster. Such systems use the developed models of possible emergency situations tied to a specific location, a digital map of this locality and the users coordinates, forms and reports individually for him the route of moving him to a safe place. Such solution is optimal, as it includes the unification of existing systems creating a synergetic effect. The proposed hybrid DRR system focused on global processes monitoring is projected to increase the predictive potential of existing monitoring systems measurable in terms of economic damages, while preventing human and material losses.

Furthermore, the implementation of the proposed technologic solution will not require considerable material and financial means, which is important especially for developing APEC economies. Moreover, it is recommended that the developing economies, interested in hosting the proposed systems on their territories, to be provided with the required technical consultations in coordination with the relevant global foras.

The reinforced predictive potential of the existing monitoring systems with the use of sensors, based on the IoT will allow APEC economies to free up the considerable financial resources, provided or reserved for recovery from emergencies, into their prediction and preventive measures for disaster risk reduction timely application. Reduced number of losses from earthquakes, waterfloods, other emergencies and technogenic catastrophes that regularly occur in the APEC economies will have positive impact on trade in the region, since the implementation of the proposed methodology will allow taking preventive measures for the reduction of damage to infrastructure, enterprises and for evacuation of local inhabitants. This, in turn will secure the partially or entirely integrated and interconnected production via resilient supply chains.

The damage caused by extraordinary situations is huge. It depends on the scale of the catastrophes, but even the death of one or a group of people is a tragic and irreplaceable loss. This equally applies to the transformation of territories as a result of earthquakes, floods, volcanoes, mudflows, avalanches, landslides. For example, as a result of the descent of glaciers in North Ossetia on September 20, 2002 entire settlements (120 inhabitants) were destroyed.

Whereas the meteorological conditions cannot be controlled, early warning, preparedness and response to floods are essential to reduce the damages from earthquakes and floodings. Meteorological and flood records can give an indication of flood risk and help in developing flood forecasts. Real-time monitoring, access to meteorological forecasts and a capacity to issue qualitative or quantitative forecasts will give more time for evacuation, and in many cases, also for installation of temporary flood protection measures along rivers. Developing comprehensive economy-wide monitoring tools and early warning systems for flood response at local and regional level requires not only an effective monitoring infrastructure for hydrometeorological variables, but also specific expertise, adequate IT and a solid administrative and legal framework.



The capacity for flood monitoring and modelling is highly diverse across the region. While some economies have a large number of automatic meteorological and hydrological stations, others are still relying on manual stations. Some economies have good modelling tools for many watersheds, whereas other economies are relying on expert interpretation of weather forecasts. Developing, implementing and maintaining flood early warning and monitoring systems requires a wide range of highly specific skills from hydrology, meteorology and ICT. One of many needs is more automated technological means in meteorological and hydrological stations (especially in the high-risk environment, such as mountainous regions). Also, more ICT-skilled human workforce would be necessary to implement and run models. Overall, there is a need and demand for training and capacity building in all areas (monitoring, forecasting, modelling, etc.).

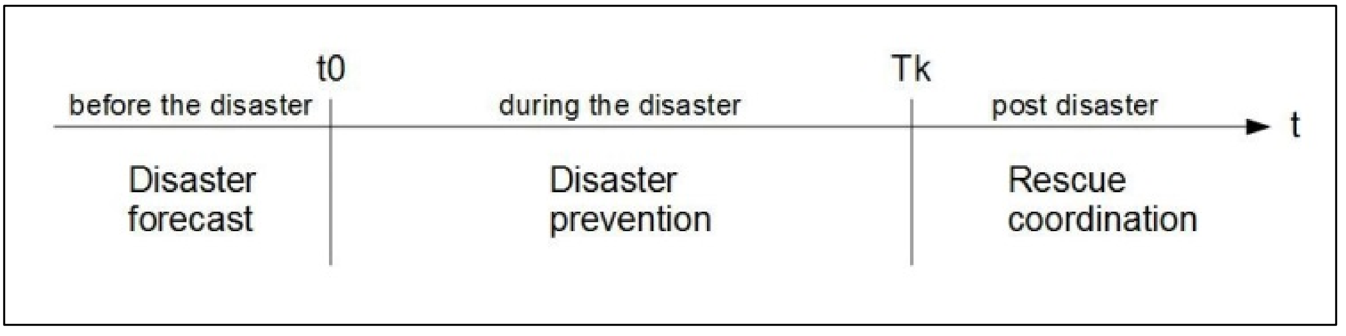
There is a significant difference in the approach proposed from traditional development. The info-communication service is designed to be available to a mass user for individualized management of one's rescue which is being transmitted automatically to subscriber device after the occurrence of an emergency has been detected. The subscribers working in the factories or other production capacities can receive additional corresponding service, outlining the instructions on what this person should undertake in accordance with his professional competence in order to prevent the negative impact of the emergency on the production processes. The accompanying emergencies resulting from this can be a source of large additional human and material losses. It is important to note that the notification services can only be applied in places where the subscriber has broadband access.

In order to describe the scenario and business model of disaster management, consider the time stages of an emergency:

1. Period before the occurrence of an emergency, including the time to predict the place and time of an emergency.
2. Period of an emergency, including a catastrophic phase.
3. Period of emergency response.

The services provided today for rescue purposes (for example, emergency notification services) in practice do not extend to real-time management of the rescue during the course of an emergency, although the greatest human losses occur precisely during the course of an emergency.

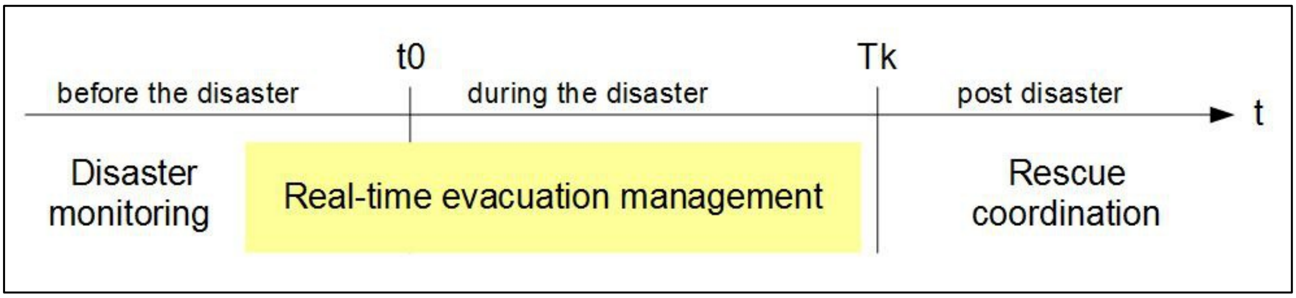
During the occurrence of an emergency using ICT-based notification services contribute in case of emergencies in which the time interval between the start of the emergency and its catastrophic phase is at least 10 minutes. These can be man-made emergencies, for example, fire, leakage of harmful substances, etc. that may occur in a facility, in a separate building or in a city. Upon detection of the first signs of an emergency, the IoT sensors located in a certain area and integrated into self-organizing sensor networks, begin to interact with the terminal of each subscriber, determining its coordinates, and inform the terminal of the change in its characteristics under the influence changes

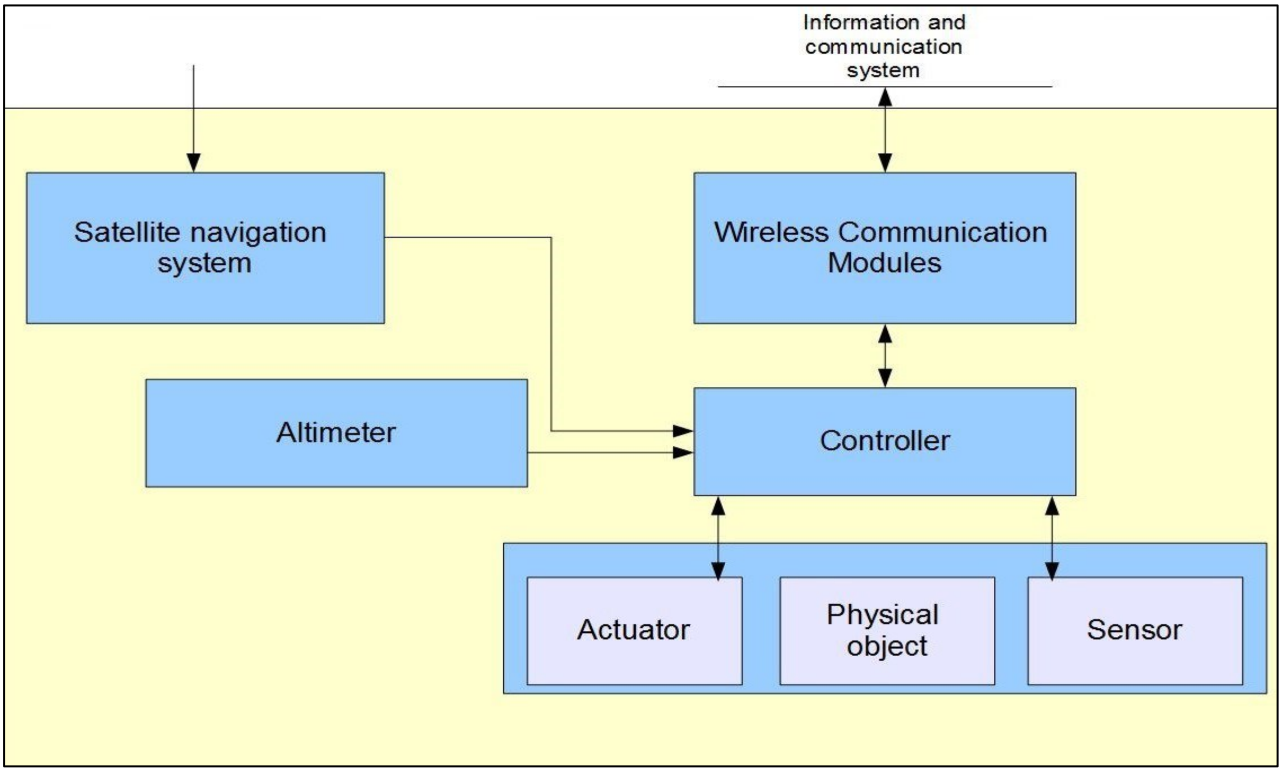


in environmental parameters. A model of the development of this type of emergency, and the data regarding the efficiency of rescue action is compiled and recorded in the memory of the subscriber terminal. Furthermore, an automatic correlation of the obtained data with the existing models of the initial stage of an emergency is recorded. The sensors used (or the sensor line) must have a greater predictive potential (greater sensitivity) than existing sensors and thereby increases the time between the moment of fixing the onset of an emergency and the moment of its catastrophic phase. At the same time, all transactions between subscribers and IoT sensors of the sensor self-organizing network are transmitted through a cellular communication terminal, which is connected to the sensor network to the center of the MES. These data will be very useful for Emergency Situations Ministry employees at the emergency response stage.

As seen from the architecture of an hybrid system proposed above, to make the system work it is imperative to expand the possibility of using the Service in case of emergencies in case of close to zero time between the beginning of an emergency and its catastrophic phase (Tk0), it is necessary to dramatically increase the predictive potential of existing monitoring systems for such types of emergencies. An increase in the predictive potential is associated with the search and fixation of the signals of emergency precursors with Tk=0, for example, earthquakes, that is, the search for predictive information. However, the sensors used today are not very sensitive to signals — precursors of earthquakes; they are reflected in the sensors against the background of noises.

- During the present time the actionability of received information does not allow for modern ICT systems to be





deployed with maximum efficiency. The issue of using natural sensors might be one of the possible solutions. In assessing earthquakes, GEOKHI RAS applied devices for "continuous" measurement of elemental mercury, helium and radon concentrations in the air of special stations. An assessment was also made of changes in the chemical composition of surface and groundwater.

- Water turbidity sensors, changes in its composition, level, flow rate, as well as data on the amount of precipitation, ground state, and the state of the water reservoirs are applicable to the prediction of floods. It is possible to use electrical conductivity, pH, Eh, and space observation sensors.
- Measurement of the change (increase) in the electrical conductivity of the atmosphere in the zone of the forthcoming earthquake.
- Development of monitoring, forecasting and warning systems on the occurrence of emergency situations of natural and man-made origin using the new ICT technology of the Internet of things (IoT);
- Development of systems to prevent accidents and man-made disasters by improving the efficiency of monitoring using IoT technological safety of production processes and operational reliability of the equipment;

- Development of special language support for non-residents (foreigners who arrived to the economy where an emergency situation occurred);
- other questions.

We believe that in the case of the work of this center, the effectiveness of the tremendous efforts being made by the state bodies of the APEC economies in emergency situations will increase.

We note the significant difference between the proposed solutions and traditional developments in this field. As part of this project, it is proposed to develop an information and communication service accessible to the mass user on individualized rescue management (that is, managing the user's self-evacuation to a safe place). This service may include automatic notification to the subscriber device after the occurrence of an emergency. Users who at the time of occurrence of an emergency are in production receive an additional corresponding service, that is, an instruction that contains information on what steps this user should take in accordance with his professional competence in order to prevent the adverse effects of the emergency. The accompanying emergencies resulting from this can be a source of large additional human and material losses.

In the field of ecological and biogeochemical monitoring, it is promising to track special water cycle cycles in the biosphere, the balance of flow and the arrival of water.

- Controlling the changes in the atmospheric gas composition (CO_2, CH_4 and N_2), which will allow to determine the balance of the atmospheric gas composition and carry out predictive estimates of changes in the biosphere.
- Development and use of special sensors to control the development and flow of trace elements (deficiency of Se, J); the measurement of iodine and selenium concentrations can be measured in ambient air when assessing the ecological status of microelements.
- Tracking changes in the electrical conductivity of water, pH, turbidity for the prediction of mudflows, landslides and avalanches in mountainous areas.
- Approbation of special color sensors of landscapes in assessing the bio-

productivity of landscapes and phyto-biodiversity.

- Assessment of the use of physiological sensors to study animal reactions to adverse environmental and biogeochemical factors.
- Improvement and testing of special element mercury level sensors in closed tanks.
- Study of mechano-chemical and biochemical interactions in the system of the stagnant body-organism-inert body.

Biogeochemical parameters can be monitored at different time levels: continuous measurement of parameters, discrete measurement of parameters (in hour, day, month, year). The readings of the sensors of the network of fixed GPS points are used, for which since the beginning of March 2015 there are observations with a time step of 5 minutes. The presence of such measurements makes it possible to supplement the analysis of seismic noise properties and to calculate the degree of correlation of GPS data at any point from measurements at neighboring stations. Low-cost systems, IoT application, joint analysis of multidimensional time series from modern geophysical monitoring systems with a purpose for extracting hidden earthquake precursory effects as increasing of coherence and synchronization.

Initially, the Service during the occurrence of an emergency using IoT was possible to create for emergencies in which the time interval between the start of the emergency and its catastrophic phase is at least 10 minutes. These can be man-made emergencies, for example, fire, leakage of harmful substances, etc. that may occur in a facility, in a separate building or in the city as a whole. the bottom line indicates the stages of rescue management of subscribers who have refused in the emergency area. We describe the scenario of providing services for this case. Upon detection of the first signs of an emergency, the IoT sensors located in each room of the object (in a certain area of the territory) and integrated into self-organizing sensor networks where the emergency occurred, begin to interact with the terminal of each subscriber, determining its coordinates, and inform the terminal of the change in its characteristics under the influence changes in environmental parameters. A model of the development of this type of emergency situation in this facility, compiled and approved by the official representatives of the Ministry of Emergency Situations and also an approved digital model of this facility is recorded in the memory of the subscriber terminal. There is an automatic identification of the obtained data with the existing model and the presence of the initial stage of an emergency is recorded. The sensors used (or the sensor line) must have a greater predictive potential (greater sensitivity) than existing sensors and thereby increases the time between the moment of fixing the onset of an emergency and the moment of its catastrophic phase of the building (space) should follow. After he performs the actions provided for by him, he is indicated an evacuation plan. At the terminals of people with disabilities come the control signals, showing him a safe evacuation plan. At the same time, the software of the MICSP service in the terminal of this subscriber, when forming the evacuation plan, takes into account the peculiarities and nature of the limited capabilities of this person. Then, after a pause, the control signals arrive at the subscriber terminals of other people (healthy) who find themselves in the emergency zone and also on the basis of their current location in the emergency zone and the pace and nature of the emergency situation, an individual route is automatically formed in the direction of the safe zone. Throughout the provision of the Service, the subscriber terminal continuously interacts with the IoT sensors. This allows you to automatically adjust in real time depending on the pace and direction of development of an emergency. At the same time, all transactions between subscribers and IoT sensors of the sensor self-organizing network are transmitted through a cellular communication terminal, which is connected to the sensor network to the center of the MES. These data will be very useful for Emergency Situations Ministry employees at the emergency response stage.

Even in the solution of smart cities, the use of ICT to reduce the risk of losses remains outside the focus. Conducting a comparative analysis of the results of the two seminars that were deemed successful, note that their effectiveness is not yet high. This is evidenced by the figures of recent losses from emergencies this year in the APEC economies — a fire in California, a flood in Japan, a tsunami in Indonesia. People at the time of the start of an emergency did not know where to run to escape. With full responsibility it can be argued that these victims could have been avoided if the victims (and these are residents of developed economies) had access to an individualized rescue management service (self-evacuation management) using modern ICTs. And this service was included in 2012 at the suggestion of the Russian economy in the TELMIN 9 declaration. we would like to once again draw the attention of APEC economies to the need for a serious attitude to the possibility of ICT to dramatically increase the adaptive capabilities of an APEC resident in the world of modern man-made and natural significantly reduce the risk of human and material losses. As noted in the unanimously adopted final documents on the past seminars that were deemed successful, it is necessary to deploy comprehensive work in this area in the region.

We assume that we should set the following research tasks for such a center:

- Develop new generation monitoring systems, forecasting and warnings about emergencies of natural and man-made origin using the new ICT technologies, including the Internet of Things (IoT).
- Further explore the link between the occurrence of waterfloods and natural phenomena. Identify natural sensors most suitable for use in ICT-based monitoring and other systems.
- Research how to improve the efficiency of monitoring using IoT in overall readiness, technological safety of production processes, operational reliability of the equipment during accidents and man-made disasters.
- Produce recommendations on the design of an individualized rescue management systems for people, while focusing on the special needs for certain societal groups, such as elderly, youth, persons with disability, foreign non-residents (foreign visitors who came to an economy where an emergency occurred).
- Explore the issue of interoperability and interaction between strands of hardware and software solutions with the

purpose of ultimate integration of existing systems: natural objects monitoring systems, emergency notification systems, individualized rescue systems etc.

- Prepare recommendations on how to adapt and customize e-health solutions for use in the occurrence of an emergency, and the ways of using e-health databases to support the individualized rescue of people in the event of an emergency.
- Develop guidance on specialized ICT solutions for individualized rescue systems, taking into account the needs of the vulnerable groups. (e.g. develop special language support for non-residents).

The identified lines of work point out to the necessity of high-level commitment to further explore this issue. As it was described above, there is a need to assemble the best scientific minds from different fields of science with a view to develop new ways on how to cope with natural disasters and calamities. It is believed, that APEC region, given its diversity, can serve as a main point of reference, and an example of collaboration on this issue, which can further be expanded globally. It is proposed that TELWG proposes the relevant issue to be considered for inclusion into the next APEC Telecommunications Ministers Meeting Declaration (TELMIN 11). The proposed text is:

- We invite APEC working foras, in particular TELWG and EPWG, to strengthen collaboration on the issue of using the ICTs in disaster risk management;
- We address APEC leaders with the proposal to establishing specialized research centres in the interested economies, to gather the prominent researchers from different fields of knowledge and further the scientific breakthroughs in this area.

CONCLUSION AND RECOMMENDATIONS

As evidenced from the data and information received from APEC member economies, the issue of exploring the possible improvement of Earthquakes and Waterfloods Monitoring Systems' predictive potential with the application of emerging technologies, including Internet of things, is a high-impact and relevant activity, which APEC should incorporate into its agenda of regional cooperation.

The current predictive potential of such systems is built mainly on the basis of data from conventional sources collected during the previous emergencies, and the systems in place are used primarily for response and post-emergency recovery planning. Post-emergency statistical evidence suggests that many phenomena, or natural sensors such as groundwater changes, electromagnetic fluctuations, animal behavior, have a distinct and, compared to the sensory capabilities of humans, more articulated reaction to the upcoming waterfloods and earthquakes.

At the same time, the physical link between these phenomena and occurrence of waterfloods and earthquakes is not well understood. Which sensors react earlier, more consistently and with what level of reliability remains an open question for further inquiries. There is a consensus among wide range of stakeholders that the use of new ICTs, such as IoT, presents a good opportunity to create an effective next-generation monitoring systems. While it is plausible that some natural sensors are more suitable than the others in the ICT-based sensor network system, there is a general agreement that the need is there to further explore this issue within the dedicated Research centres in APEC region enabling the dialogue among the wide range of scientists from different disciplines and research backgrounds (such as Telecommunications and ICT, Physics of Earth, Biogeochemistry, Economics, Ecology, Meteorology, Statistics etc.), while engaging other stakeholders, such as policy-makers, business circles and general public.

Member economies also expressed their support for the idea of having the research centres to explore choices in the natural sensors suitable for the use in the system of sensors built upon Internet of things technology. The proposed Research centres can facilitate knowledge sharing, management and monitoring of ongoing efforts, while also providing expert support in formulating strategic planning for future research and development activities. The economies might also want to consider expanding the cooperation via formal setting of use cases and guidelines to achieve a common approach, and serve as directory of standards and best practices for reference.

It is further advised to explore ways to strengthen the partnership within the region, including internal cooperation between APEC foras on the issue of using ICTs in disaster preparedness, namely Telecommunications and Information Working Group (TELWG) and Emergency preparedness working group (EPWG). Feedback from member economies suggests that TELWG and EPWG should also look into information and education tracks for ICT in Disaster Risk Reduction.