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Review: Understanding of Natural Disaster Risk Management and Where Turkey Stands in the Picture

Tuba Tatar[1,2*]
[1] Sakarya University, Kemalpaşa Esentepe Kampüsü, 54050 Serdivan/Sakarya
[2] Syracuse University, Syracuse, New York, 13244, United States

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Abstract

Disaster risk management stays a continuous multi-layered understanding, evaluating, controlling, and measuring of the process of the natural catastrophe. Disaster risk management consists of four stages which are identifying the hazard, assessing the risk, controlling the risk, and measuring the risk control. Hazard will refer in the paper the natural perils. Meantime, it is proved that global warming affects the frequency and the magnitude of extreme natural hazards. And the natural disaster profile of Turkey is also influenced. Unfortunately, the country suffers immensely in loss of human, economic, and time and it steps forward to prevent the following losses. Turkey is also one of the countries which signed on the Sendai Framework that guides countries to manage and overcome the possible due to natural hazards in the globe. To avert the risk at any level, identification and prevention of the existing risks, control and monitor of the risk, mental and physical preparedness, and avoidance of new risk constructions are vital. It needs to be emphasized that the involvement of people at each stage is essential to reach success.

Key words: Hazard, Risk Management, Assessment, Reduction

1. Introduction

Disaster can be described as an event or situation which is greater than the local capacity and causes great damage, devastation, human suffering, and requires aids of external (can be national or international level) assistance. Most of the time, it occurs suddenly and unforeseen and people face such an event unprepared. Disasters are collected in databases around the globe according to the main type and subgroups if 10 or more people are killed, or 100 people are reported affected, or international assistance is called or a state of emergency is declared [1, 2]. The disaster can be listed into two groups, *natural*, for instance: geophysical, climatological, hydrological, biological, meteorological and t*echnological* disasters such as bridge collapses, dam failures, and industrial, maritime, and aviation accidents [3, 4].

Future always involves uncertainty. When the theme is natural hazards, it is immensely challenging to predict the time, magnitude, duration, and location. There is still limited knowledge on when natural perils happen, how long they take, where they occur. It is obvious that the collection of data is more organized and reachable now compared with the past, though the assembled data inevitably confirms that the number of natural disasters is an increasing trend around the globe. Every year, we face more natural hazards and need to reinforce vulnerable ones against them. As a consequence of the natural disasters, between 1980-2020, over 2.5 million people lost their lives due to natural disasters in the world; it is equivalent to

* Corresponding Author, e-mail: ttatar@sakarya.edu.tr

the population in Porto Rico, as a one-single country [3]. Direct economic loss in 1998-2017 among disaster-hit countries is reported as US$ 2,908 billion, of which climate-related disasters caused US$ 2,245 billion or 77% of the total [5]. At this stage, disaster risk management (DRM) emerges its importance over the time due to the increase in the human population and simultaneously in the prosecution of the number of assets. The natural disasters that affect Turkey are mainly geophysical, meteorological disasters such as earthquake, flood, frost, avalanche, snow, storm, landslide, rockfall, lightning, heavy rain, drought, and fog [6]. The geophysical, climatological and geomorphological characteristic of the country causes the variety in the disaster profile. The Global Assessment Report (GAR) states the disaster profile of the country between 2005-2013 and it shows that the combined economical loss due to disasters is over 93 million $ per year [7]. On average, each year, 6870 houses got damaged, and 8 houses are destroyed, 128 people lost their lives within the same time frame.

This paper aims at the understanding of the steps of disaster risk management, and providing some information on risk assessment, and looking at the natural hazards and their trends, specifically in Turkey, and delivering some information and improvements on the disaster risk management in Turkey including the natural disaster perspective.

2. Disaster Risk Management (DRM)

DRM is an appliance of disaster risk reduction policies and strategies, to prevent new disaster risks, reduce existing risks and manage residual risks, contributing to the strengthening of resilience and reduction of losses in terms of human, monetary, time [1]. In a general concept, DRM consists of four main priorities: ***identifying the hazard, assessing the risk, controlling the risk, and measuring the risk control***, which are discussed forward in this section. Each step of DRM entails a great amount of knowledge, research, time, and investment. The lack of understanding and monitoring the natural disasters, low resilience of the exposed assets, lack of data from the past natural disasters outcome devastating results in terms of lives, resources, and economy. Despite limited knowledge, the destructive consequences of the hazards require to be understood, managed, and monitored to contribute to the decision-making process. Whilst inquiring DRM, understanding, and characterizing the risk components; hazard, exposure, and vulnerability are the significant obstacles on a trustable assessment due to lack of available data. Since the world faces immense loss every year on the subject of people, money and time due to the natural hazards, the application of DRM ought to be arisen to understand the impacts of the peril, reduce the risks of events, plan emergencies of lives and manage insurance and other financial commitments. Following, a brief explanation of each step of DRM can be found.

Identifying the hazard, natural hazards are the theme of this paper, is the first step of risk management. Hazard can be described as probabilistic or deterministic aspects. Since we talk about the natural hazard, uncertainty at each point must be get involved in the picture. Depending on their natures, there are two different types of uncertainty that are generally recognized: Epistemic and Aleatory. The transparent quantification of risk due to natural hazards and involvement of uncertainty would aid to evaluate the various mitigation strategies. In order to express the uncertainties, mathematical expressions are derived. The uncertainties related to the state of knowledge about the hazard under consideration are known as epistemic uncertainties. The uncertainty related to the inherent variability in the behavior of the hazard is known as an aleatory uncertainty (also can be referred to as “randomness”). The epistemic uncertainties can be reduced by increasing the number of tests, improving the measurement methods, refining the modeling algorithm, collecting additional relevant information, enlightening the state of knowledge, etc. Meanwhile, the aleatory uncertainties cannot be

reduced and in principle, those cannot be dealt with employing the deterministic approaches. In the probabilistic risk assessment, both epistemic and aleatory uncertainties are faced in an advantageous manner.

The second step is *risk assessment*. The general mathematical definition of risk is expressed by frequency multiplying with a magnitude which is given by Eq.1. Risk assessment stays a multidisciplinary domain that involves a combination of three major components: hazard, exposure, and vulnerability. It can be described as an assessment of the probability of loss that contains damage, fatalities, repair costs, or indirect economic losses due to peril within a given time-span and location. At the same time, it provides the first step of hazard mitigation which consists of understanding what contributes the most to the losses, what the admissible loss levels, and how these losses can be effectively reduced. The assessment process provides meaningful information to stakeholders and decisionmakers on the hazard risk level of the assets and leads them to step towards taking any action if necessary. Decisions involve both engineering and economic studies within the consideration of social priorities [8].

$$\boldsymbol{Risk}\left(\frac{Consequence}{unit\ time}\right) = \boldsymbol{Frequency}\left(\frac{event}{unit\ time}\right) \times \boldsymbol{Magnitude}\left(\frac{Consequence}{event}\right) \qquad 1$$

If risk assessment involves the loss calculation due to a single, deterministic hazard for an asset/a collection of assets within a given region, it is called "***Scenario-based risk assessment***" and the Disaster and Emergency Management Presidency (AFAD in Turkish) is using this methodology based-software for risk management and potential loss estimation. However, in order to incorporate the probability of potential likelihood events in the concept of randomness into the analyses for a given region while quantifying uncertainties, there are two possible approaches based on the probabilistic perspective which are event-based probabilistic risk assessment and classical probabilistic risk assessment

Probabilistic risk assessment (PRA) emerges its importance for the cases there is limited data or not even exists. The method is originated in the early 1960s in the USA to perform risk and reliability assessment for aerospace and missile programs and then spread out the other disciplines because of its convenience and suitability to the problems. There are two different perspectives on probability; one is a frequentist view which considers the probability as a property of a process that can be determined from an infinite amount of data. The second view, subjectivist, is based on a probability value at any time that presents the total available knowledge about the process at that given particular time. In the subjectivist view, the new information/knowledge would be added to the poll in a logical and consistent way (Bayes' theorem). The two probabilistic views basically can be explained by a coin-flipping example. Assuming that a coin is flipped 10 times and 8 times tail, and 2 times head are randomly counted. Within a frequentist view, the probability of flipping a coin for a tail for the 11th time is 0.8. The subjectivist, however, would only consider the facts and calculates the probability of flipping a tail for the 11th time 0.5 (either tail or head). It needs to be remembered that both probabilistic perspectives are accepted and widely used.

Event-Based Probabilistic Risk Assessment computes the loss based on probabilistically integrated evaluation of the impact of a series of hazard scenarios and then combining with exposure model and vulnerability. Figure 1 illustrates the risk assessment process and shows the involved parameters. The hazard scenarios are formed in a stochastic or historic set of events in the description of spatial distribution, the annual frequency, and randomness of the hazard intensity, and then the results have incorporated the uncertainties related to each and every part

of the process. Commonly, the Monte Carlo simulation employs the production of a set of scenarios, each scenario created by randomly assigning the parameter by which the hazard is governed. Each scenario is used to generate a matrix that contains all the randomly chosen events. Finally, the hazard curves are calculated for each scenario and the loss is computed for each hazard curve while the results are integrated probabilistically. The risk can be expressed in different terms i.e. average annual loss, loss exceedance curve, etc. The probability of loss can be derived for a set or portfolio of assets based on the probabilistic hazard.

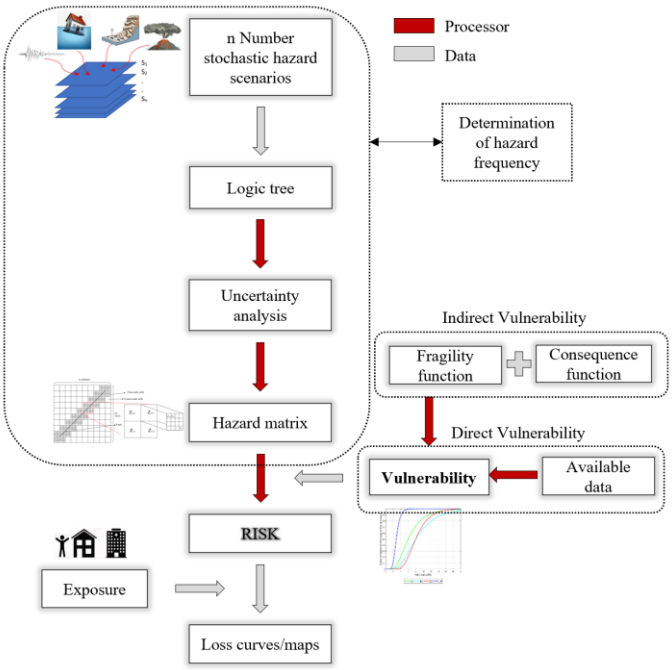


Figure 1: The schema of event-based probabilistic risk assessment

Classical Probabilistic Risk Assessment calculates the loss based on a probabilistic single hazard scenario combining with exposure model and vulnerability (see Figure 2). The difference from the event-based risk assessment is the number of the events and the way that propagates the uncertainty. The same procedure is valid for the loss calculation.

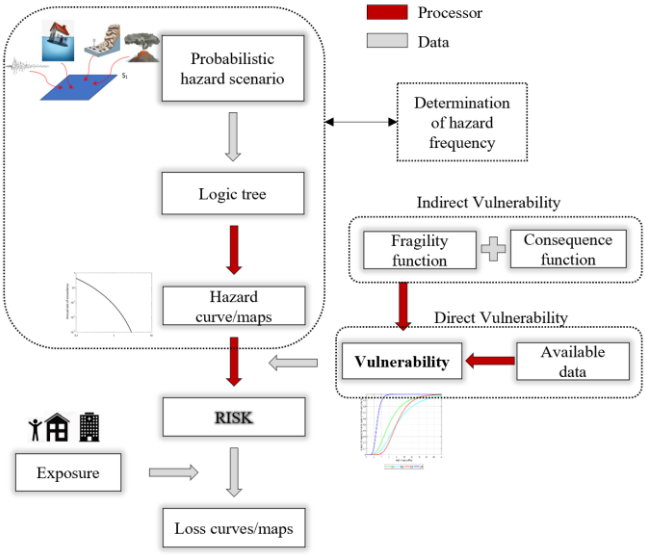


Figure 2: The schema of classical probabilistic risk assessment

In addition to all, natural hazards display complex, variable, full of interactions of nonlinearities, and understanding of their nature and ability to predict their behavior are still limited. Despite that the probabilistic risk assessment is employed to manage the risk in a quantitative manner, uncertainties as a part of any assessment originating at every step of the risk assessment (hazard, exposure, and vulnerability), modeling, and estimation must be incorporated. Considering the randomness of the natural hazards, understanding of the process and collection of data sources, the uncertainties are incomplete in the natural hazard assessment. Not all the uncertainties can be addressed in a risk assessment, but the uncertainty analysis allows to quantify the uncertainties through probabilistic calculations. There are different alternative approaches to quantify uncertainties: Monte Carlo, logic tree, first-order second moment, fuzzy logic, etc.

After assessing the risk due to natural hazards, *controlling the risk* is deemed crucial. At this stage, eliminating the risk which is the most effective control shall be done by a practicable approach if possible; if not, at least mitigating the risk in the circumstances needs to be considered. Depending on the peril and exposure, the solutions for the elimination and/or minimization may inevitably vary [9]. The success of this stage depends on previous step, the risk assessment including sensitiveness of the assess to the risk, collected data accuracy, and involvement of uncertainty, cost effectiveness solutions , and satisfaction of the stockholders comprising the minimization of the resistance to the change [10]. The collaboration of people at every level in harmony stays important to reach the success. At the same time, economic analysis of risk control shall provide the ratio between monetary value of the assess with uncontrolled damage over the monetary value of the assess without damage. Also, any additional risk existence must be avoided and prevented.

Besides the identification and reduction/minimization of the risk, *measuring the risk control* shall be done regularly to see whether there have been any significant change, to analyze any additional improvements might be done, to check any additional problems might be reposted and to comprehend any lesson learnt from the past disaster experiences.

The 1999 Marmara earthquakes were a turning point for Turkey and the disaster risk management started becoming more organized. The DRM in Turkey used to be a cooperation of several ministries and some organizations until 2009. Since then, AFAD has been titled responsible in the new organizational schema for preventing disasters and minimizing disaster-related damages, planning, and coordinating post-disaster response, and promoting cooperation among various government agencies under the control of the Ministry of Interior [11, 12, 13, 14]. Each city in Turkey has a branch of AFAD and this is very beneficial, rapid, and practical during each step of the decision process. Nevertheless, the DRM in Turkey is mostly focused on post-disaster emergency and reconstruction. The Ministry of Environment and Urbanization also leads the urban transformation of areas under disaster risks which entered into force in 2012. The scope of the law is to determine the procedures and principles regarding the rehabilitation, clearance, and renovations of areas and buildings at disaster risks in accordance with relevant standards with a view to creating a healthy and safe living environment [15].

After investigating each step of the DRM, it should be emphasized that readiness against natural disasters shall be parallel to the changes in disaster profile in local and national regimes.

3. Does Climate Change Influence the Natural Disaster Profile?

After the industrial revolution, notably in the last five decades, the climate regime has been changing swiftly, and extreme climatological incidents are likely to happen more. Due to increasing greenhouse gas emission (such as carbon dioxide, methane, nitrogen oxides, and chlorofluorocarbons), mostly to blame for, global warming all over the world causes changes in average conditions including climate variability and weather extremes; i.e. sudden heavy rains or heat waves can be observed more often in recent [16, 17, 18, 19]. Estimations of such extreme events can be more predictable for large-scale and slow events, such as droughts, while there are no reliable projections for small-scale, localized, and rapid extremes like lightning, thunderstorms, hailstorms, etc. Food, water, energy crises are initiated already. Projections for the coming century show that the number of extremely hot days will be kept increasing and the number of cold days will be stayed decreasing around the globe [20]. Especially in Africa and Asia, severe dried seasons cause drought and eventually migration of people seeking new settlements (this can be at national or international level). Most of those people will informally resettle in poor conditions in new regions in which there are no urban planning and that show an exposed profile against natural hazards. This inevitably forms a loop of global warming-movement-natural disasters-vulnerability-loss.

Each country displays alike profiles regarding the natural hazards, impacts from global warming regarding regional patterns, and risk and response levels from climate variability and changes. During the last 20 years, Turkey displays a great improvement in the economy and its population has increased from 57 to 84 million within the same time frame [1]. Even though it is considered as positive progress, the country simultaneously became more vulnerable to natural hazards, specifically for the insurance and reinsurance businesses. Due to the need for more dwellings, informal settlement and insufficient, improper, and unplanned urbanization of the neighborhoods require additional attention while the natural hazards are considered. Figure 3 illustrates the country natural hazard profile by year that is in an increasing trend and according to a report in 2018 published by the World Bank, four dominant natural hazards arise attentions in Turkey that are earthquake, flood, landslide, and wind [1].

Almost all over Turkey lays on seismically active faults and earthquakes display the most hazardous peril profile in the country. The Desinvanter Database lists that between 1900-2020, 196 earthquakes occurred all over Turkey, and they caused the death of almost 100,000 people. The greatest death toll in Turkey due to the earthquake that happened in 1939 in Erzincan district caused the death of 32962 people [21]. The magnitude of the earthquake was 7.9 Richter scale and affected many cities in Eastern Anatolia. The 1999 Marmara Earthquakes were another lessons-learned for the country. Since 71% of the population in Turkey lives in areas prone to seismic actions [15], academy, government, policymakers, decision-makers pay great attention to this subject and tries to make sure that the country is ready for the next expected earthquake. At the same time, the consequences of other perils; flood, landside, and wind may be seen more at a regional level and the loss in any type, however, can be devastating for the locals. Besides, climate change has altered the number of infrequent extreme weather-related hazards. Some researches represent that the variability of seasonal and urban precipitation series can be observed in the country, and due to the results that more frequent and severe floods, specifically in urban, can be forecasted [22, 23]. A report on global warming and climate change written by World Bank in 2015 states that 3 million people in Turkey may be affected by a 100-year flood recurrence. The affected number becomes 20 million people when a 250-year flood recurrence is deemed [24]. Landsliding, respectively a less documented peril, may occur more frequently and causes severe local loss in the country and in this sense, the hazard requires more

attention. This is because of many factors such as hazard underestimation, poor risk reduction measures, application of single-hazard and risk methods and approaches. In addition, the Desinvanter Database illustrates that 15% of the total number of destroyed or damaged houses occurred due to landslides which clearly indicates that landslides cannot be omitted in the country [21]. Effective and long-term structural landslide risk reduction measures and/or planning strategies at various scales should take into account the correlation among landslides and other climate-related and geophysical events that, along with mass movements, usually affect mountainous areas, in a multi-hazard perspective. Regarding frequency, climatological hazards are the most common hazard types in Turkey. Wind also causes a great amount of monetary loss locally throughout the country. In June 2020, Istanbul, the most crowded city of Turkey, has experienced a tornado, which is a very unusual event [25]. Figure 4 investigates the natural hazards data regarding two parameters: Occurrence of the hazard and the number of human loss. Figure 4-a) illustrates the distribution of natural hazards in the country and displays the most frequent hazard seen city by city. It clearly shows that in terms of recurrence, landslide and wind cannot be omitted in the country. Strong wind and landslides cause damages more in small areas and that can be devastating for the locals. Figure 4-b) shows that the main cause of death regarding the four selected perils is earthquakes in the country meaning that they still are the most hazardous natural peril in the country, but the remaining perils do still have an explicit impact on financial and human losses.

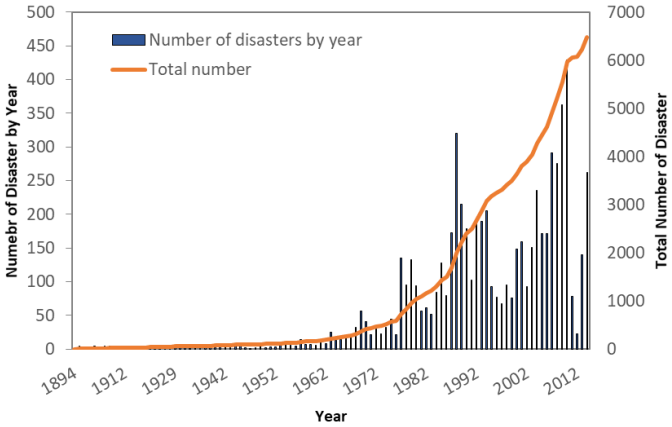


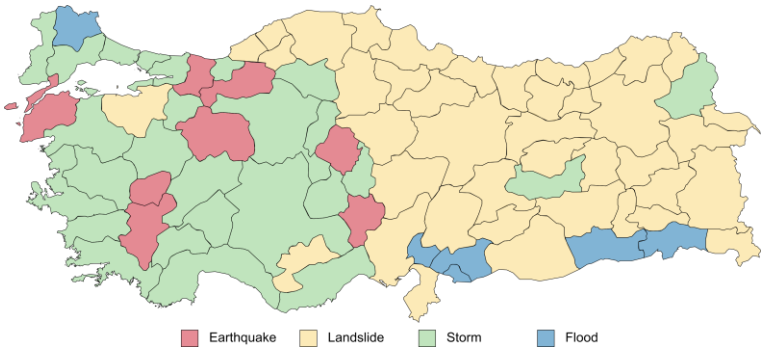
Figure 3: Total number of disasters in Turkey by year, adapted from [21]

4. Where Turkey Stands in the Picture

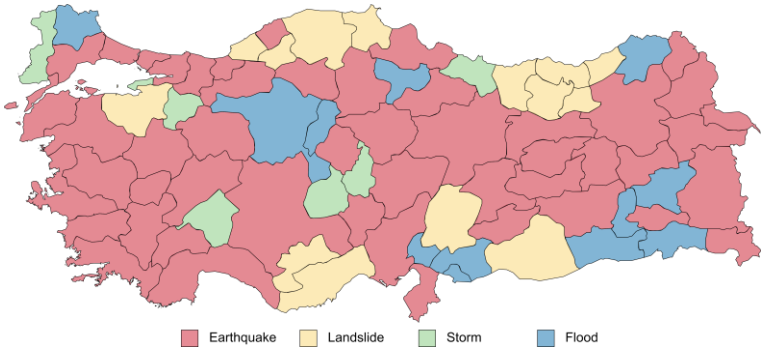
Turkey has committed to the Sendai Framework which intends to mitigate disaster risk between 2015-2030 in the globe. The implementation of the Sendai Framework requires international cooperation, global technology pools, know-how sharing, innovation, research, and access to technology and information on disaster risk reduction. To achieve success in disaster risk management, a broader and more people-centered preventive approach must be carried out. The Sendai Framework acquires the idea of understanding and applying to the advanced technology and tools in disaster risk reduction.

As a part of the Sendai framework, Turkey is one of countries signed on the agreement and periodically a watch report is issued for each country. The readiness report of Turkey published in 2017 answers the evolution of data regarding taking the hazard, monitoring, collecting, and categorizing data. In Turkey, the hazards are collected into types of geophysical, meteorological, hydrological, climatological, technological, environmental, and man-made hazards [26]. AFAD (Disaster and Emergency Management Presidency) and Turkish Anatolian News Agency are the main sources of the data sets. Desinventar is the methodology used in

collection of data in the country. It is also a free open-source worldwide database (data belongs to more than 89 countries are available) contains country based collected disaster information and managed by United Nations [21]. The data in Turkey can be considered one of the most detailed collection, however, the collected data do not separate the killed, affected, injured, missing people by gender, age, disability, and their income yet. Turkey also formed its own natural disaster database at national level, called "*Türkiye Afet Bilgi Bankası*" in Turkish. The database collects the disasters which cause at least death of 10 people, or injure of 50 people or more, or effects of at least 100 people, or affect the general flow of life, or the disaster has an importance, or 20 hectares or greater area must be affected due to wildfire [11].



(a)



(b)

Figure 4: Disaster profile of Turkey a) Most frequent hazard by city
b) Main cause of death by hazard per city [21]

Regarding natural hazards, Turkey has immensely suffered due to losses in lives, economy, and time. After the 1999 Izmit Earthquake, as lesson-learned, the government has established a catastrophe insurance pool for residential buildings in 2002 that takes the risk from the public sectors to disseminate the international reinsurance markets. Earthquakes, as the most hazardous peril in the country, are the target for this financial mechanism, and the risk/the expected economic loss is computed using an earthquake model for each province. In Turkey, there are 9.8 million structures and 28.6 million dwellings, and it is reported that 1.5 million dwellings in the country, 300 thousand only in Istanbul (the most crowded city in Turkey) are vulnerable and they must be strengthened against earthquakes immediately. Since 2012 in which urban transformation around the country started by the government through the law, 677 thousand dwellings and workspaces at risk are demolished, and 690 thousand dwellings and workplaces are/being reconstructed [15]. According to the source, over 10 million dwellings are insured, which is 56.6% of the building stocks [27]. In addition, this insurance assures people to cover their loss due to earthquake and second hazard due to earthquake such as

tsunami, landslide, or file etc. and it is mandatory to have for each dwelling in Turkey. While understanding, managing, and reducing the risk in stockholders, decisionmakers and policy-makers level, this pool became an example to other countries that are in a high-risk hazard level.

The Ministry of Environmental and Urbanization leads the urban transformations project city by city in Turkey, and there is Spatial Planning Directorate in the ministry. In 2021, Turkey will announce the "Spatial Strategy Plan" which covers the whole country, and one of the aims of the project is to determine spatial strategies regarding the management of settlements considering the natural hazards. This plan will help to control informal settlements and most importantly, the growth path in the country will be planned in advanced while the natural hazards, infrastructures, transportation systems, energy, historical and cultural values are involved. Recently in mid-2020, AFAD completed the pilot study that resulted in the first provincial-level disaster risk reduction plan of Kahramanmaraş province in Turkey. The plan is a part of "National Platform of Disaster Risk Reduction" in Turkey (TARAP) and considers the priorities in the Sendai Framework in order to meet and consists of 3 goals, 21 targets and 225 actions. The platform was established in 2011 in a line with the Sendai Framework and its predecessor the Hyogo Sendai Framework (2005-20015).

Regarding the energy policies (it is important due to the amount of the green gas emission), Turkey seeks an ambitious National Energy Efficiency Action Plan (NEEAP) for the 2017–2023 period cooperating with United Nations, which aims to reduce the its total energy demand (in primary terms) by 14 per cent compared with the 2017 level [28]. The Government has indicated tendency of changing the energy policies by renewable energy investments and of diversifying the green energy sources.

5. What Could Have Done for Future?

The question of what to do may need to be divided into two main categories: physical and social. Existing physical risks shall be identified and addressed the foremost. Policies and strategies shall be also formed based on protecting and reinforcing the vulnerable components including the people at any level. This is crucial to prevent and/or minimize the existing risk elements.

Another important point is preparedness. Between 2005-2017, governments and other donors spent 5.2 billion $ on disaster risk reduction and this is equivalent to 3.8% of the total humanitarian financing within the same time frame [1]. Approximately 90% of international funding for disasters has devoted for recovery work such as emergency responses and reconstructions, and only 10% of this funding has spent for prevention and preparedness. Even though researches show that 1$ investment in resilient infrastructures may gain a 4 to 15 $ return, there is still doubt on financial investment on it [1]. It is because the disaster has not happened yet and it is difficult to convince people to spend money on something does not exist yet. Nonetheless, the awareness of public and private sectors is essential. It is crystal clear that we need to put more energy on prevention and preparedness, not paying attention only on emergency response and reconstruction after the disaster occurs. Japan, for instance, offers a course about risk management on curriculum at schools. This also widens the risk management throughout the foundation regarding the knowledge, awareness, preparedness, and basic prevention. Because everything starts by one and mentality is the one needs to be changed in people, governments shall take an action to inform and to integrate people at every stage and to increase the perception towards hazards, specifically natural hazards. If people do not get involved into this battle, success will never come. In Turkey, public awareness must be

established regarding natural hazards including preparedness, actions during the risk exposure, and post-disaster management. Public has relatively more information about seismic hazard. Other aforementioned natural hazards may cause a great amount of monetary loss in the country as well, and awareness must be established against of them. Joint effect in communities needs to be re-established, and since people are more aware of who is the vulnerable in their own communities and once they face a disaster, they can role as the first-responder before the formal react arrives.

To avoid the formation of new risks, grow-path is another issue that must be taken care of during DRM. Instability of the regions/ growing gap between high and low income in countries, lack of nourishment are the main causes of the movement. We should not forget that climate-induced migration is one of the most intensely debated topics in the current discourse on global warming and its consequences [29]. The decisionmakers shall consider supporting the local livelihood to minimize the movement. Social, economic, and educational implementation of preparedness and consciousness shall be implemented by leading of governments. By suggestion that, government, policymakers, and academics also need to understand needs of people, their habitat, and livelihoods. Since every country has its own climatological/geographical/ profile, there is not one solution or approach to resolve this issue, though a single country; there could be regional solutions within the country. In addition to all, not only public, but also private sectors shall also get involved into the DRM. Regarding physical vulnerability, control mechanism for structures must work more effectively to prevent any additional risk elements. This might be slow, but also very effective way to build-up the future.

6. Conclusions

Global warming evidently affects the climate regimes in the world, and countries experience more extreme natural incidents each year. As a developing country, Turkey faces several natural hazards and that causes losses of human lives, time, and economy. In order to minimize or prevent risk in the country, disaster risk management emerges its importance in the globe. The DRM contains four steps and those are identifying the hazard, assessing the risk, controlling the risk, and measuring the risk control. Each step shows its importance during the management process and they need to be addressed and processed carefully.

Four major natural hazards, which are earthquake, landslides, flood, and wind, are dominating the disaster profile in Turkey. Meanwhile, the country has shown great improvement in terms of risk management and reduction. Following up the commitments to the Hyogo and Sendai Frameworks, Turkey has established a new presidency on disaster and emergency management in 2009. The national disaster database is formed and available for the public. Urban transformation has started in 2012 and thousands of dwellings are demolished and reconstructed to be ready for the next earthquake. To be successful in natural disaster risk management, government, policymakers, stakeholders, academics, people at every level must act altogether. Not only the country base but unity in the globe must also be established. In addition to all, multi-hazard risk assessment and management shall be considered and applied to the country.

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