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Evaluation of Effective Parameters in Disaster Risk Reduction Plans with Multi Criteria Decision Making Method: An Analysis on Selected Country Samples

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Abstract

The occurrence of natural and man-made disasters in the world is increasing day by day. In addition to causing physical, economic, social and environmental losses, these disasters stop or disrupt normal life and human activities. Disaster risk reduction is defined as analyzing and managing the factors that cause disasters with systematic efforts. Disaster risk reduction studies have an important place in increasing the resilience of individuals, society, cities and sectors against disasters. Countries have a national plan that will provide roadmap for them to be resilience to disaster risks is a critical in terms of the applicability of risk reduction studies and their contribution to sustainable development process. For this reason, every country should have strategic plans that determine priorities in order to ensure that measures are taken and implemented to eliminate or minimize risks. National strategic plans designed to provide optimum benefit with limited resources according to the determined priorities bring success in disaster risk reduction. In disaster risk reduction studies, there are multi-perspective approaches, including deterministic and statistical methods, in evaluations that determine the success of countries in this field and reveal the state of the country. Multi-criteria decision making method rather than statistical methods; in cases where there are more than one criteria in the decision-making process, it provides an approach to decision-makers to solve problems. Multi-criteria decision making method which is one of the statistical methods; in cases where there are more than one criteria in the decision-making process, it provides an approach to decision makers to solve problems. In disaster risk reduction plans each country has its own characteristics. These features make countries different from one another. Seven key parameters, such as Risk Identification (B1), Risk Reduction (B2), Response and Recovery (B3), Economic Disaster Risk Management (B4), Disaster Preparedness (B5), Governance (B6) and Compliance of Policies and Plans (B7), were selected as the main criteria. 36 important components of the main criteria have been selected as sub-criteria. Then, these effective parameters have then been weighted using one of the methods of the multi-criteria decision-making process called the "Analytical Hierarchy Process. As a result of weighting, the importance degrees of the parameters were determined as B2, B1, B3, B4, B5, B6 and B7, respectively. Within the scope of the study high risk of disasters in Japan, Turkey, the Philippines and New Zealand country samples were selected. The disaster management systems of these countries and their disaster risk reduction plans have been examined in detail. The country's performance rankings were made for these four country after an assessment of the existence of the main criteria and sub-criteria weighted with the "AHP" methodology by the country's experts. At the end of the analysis, Japan was determined as the country with the best DRR plan and implementation, while our country was ranked 2nd, New Zealand ranked 3rd and Philippines ranked 4th. As a result, this study will provide a resource that will contribute to theoretical knowledge systems on disaster risk reduction. As well as, it is also aimed to examine the results of the applications in the country plans by assessing the order of importance of the effective criteria that will bring countries successful in reducing the risk of disasters.

Keywords: Disaster, Disaster Risk Reduction, Disaster Risk Reduction Plan, Analytical Hierarchy Process (AHP)

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1. Introduction

Disaster management can be defined as the management of resources in line with these common goals with a multidisciplinary approach in order to plan, coordinate and implement the activities that should be done before, during and after the disaster in order to prevent disasters and reduce their negative effects (Kadıoğlı 2012). Disaster management includes many levels. It is a comprehensive, multi-phase, multidisciplinary management style that starts from the individual and extends to the international level. Disaster management is the discipline of dealing with and avoiding risks, including usually four phases: Mitigation, Preparedness, Response and Recovery. The circular model for disaster management is generated to reduce the complexity of non-linear nature of disaster events (Kelly 1998) .

Cyganik (2003)defines mitigation, preparation, response and recovery as four phases of disaster management. This model portrays response as the biggest and most visible phase of disaster management. In this study, the phase of disaster risk reduction is studied. Identification and analysis of hazards, risks and vulnerabilities, determination of resources and priorities to prevent or reduce risks, preparation and implementation of policies, strategies and action plans include key elements in disaster risk reduction (Taştan and Aydınoğlu 2015). Disaster Risk Reduction (DRR) is the discipline that deals with reducing our risks from disasters. DRR studies, which require a multidisciplinary approach, consist of activities that need to be planned and implemented before, during and after the disaster (Charlotte, John, and Rossetto 2007).

Therefore, DRR's activities are "identification, analysis and evaluation of hazards and risks, establishment of early warning systems, spatial planning, education, information and awareness of the society, development of disaster insurance, strengthening of critical infrastructures, institutional structuring, development and supervision of legal documents such as laws and regulations, and eliminating inequality between regions, creating a perception of DRR in society" (IPCU 2014).

Although we intuitively know that the impact of disasters is much greater than the direct economic cost, it is only when the economic cost of these indirect and intangible effects is taken into account that it can be seen what these events really cost the country's economy. DRR activities to be carried out will reduce the economic losses that countries will experience after disasters. On average, every euro spent on DRR activities saves between four and seven euros in disaster response (ECHO 2017) .Investments without considering disaster risks cause socio-economic damage in the long run after disasters. If we are not prepared for disasters, the material and moral gains that countries have achieved for many years are destroyed in a short time due to disasters (Doroteo 2015)

Studies on DRR are carried out on a country basis in order to minimize the resources spent and the work done to compensate for the damage and economic losses caused by disasters, to increase the effectiveness of disaster management and to strengthen the capacity. In this context, one of the ways to cope with disasters is to make DRR plans according to each country's own dynamics. The DRR plan is defined as "the plan of project work managed by risk management, which forms the basis for the implementation of the objectives and specific objectives of institutions and organizations for disaster risk reduction and the short, medium and long-term policies, strategies and actions to achieve them"

DRR plans help countries build their capacities by identifying the underlying causes of their vulnerabilities. The need to develop up-to-date action plans for existing and new DRR with the gains from past disasters also clearly demonstrates the importance of DRR plans. The scope and complexity of disasters, existing and new risks, and the evolving and changing world strengthen the dynamic nature of DRR plans.

Within the scope of the study, under the title of "Country Examples", the disaster management systems of Japan, Turkey, the Philippines and New Zealand, which are among the countries with high disaster risk, and their plans and documents related to DRR were examined. Then, criteria selections were made by examining the criteria in the DRR strategies and plans of the countries examined. The weights of the criteria were determined by using the opinions of the experts who worked on DRR through a questionnaire. In the conclusion part of the study, 4 countries were ranked by scoring with a holistic approach in line with the main criteria and sub-criteria determined by the plans and strategies of the selected countries for DRR. In line with the results, suggestions were made to improve our draft DRR plan.

2. Country Samples

2.1 Japan

Japan is a country located on islands in the western Pacific Ocean. Japan has been exposed to natural disasters (earthquake, volcanic activity, heavy rain, snowfalls and typhoons) from past to present due to its geographical location, topography, geological structure, climate and other factors, (Akyel, 2007). Although the country covers only 0.25% of the planet's land area, the number of earthquakes and the distribution of active volcanoes are quite high due to its location in the "Pacific Ring of Fire". 110 active volcanoes in the region constitute about 10% of all active volcanoes in the world. Japan is one of the countries with the highest natural disaster risk in the world due to its susceptibility to earthquakes and tsunamis (Jimee, Meguro, and Dixit Mani 2019).

Disasters in Japan are generally categorized into two groups, natural disasters and accident-type disasters. earthquake, tsunami, storm, flood, volcanic eruptions, heavy snowfall have been Natural disasters; accident disasters include marine, aviation, railroad, road, nuclear, hazardous materials, large-scale fire and forest fire (Cabinet Office 2015).

As a result of frequent earthquakes and typhoons in the 1940s and 1950s in Japan, the necessity of increasing the capacity of the society to respond to disasters and developing disaster risk management systems emerged. There have been changes in the systematic approaches adopted in disaster management, and the changes have also been reflected in the laws. The necessity of taking measures before disasters has been put into practice by law, and the country's disaster management system has been strengthened within the scope of the experiences gained after the disasters. Especially; the Ise-wan Typhoon that occurred in 1959 was a critical development in the country's disaster management approach, after which the Basic Law on Disaster Measures (1961), which had a comprehensive and strategic structure, was enacted. Roles and responsibilities related to disaster management within the scope of the law; clearly defined at the national, state and municipal as well as community level. The law has been constantly reviewed and updated since its first entry into force.

Japan's disaster management system covers all stages of disaster management (prevention, mitigation, preparedness, response and recovery), and the public and private sector, whose duties and responsibilities at the national and local level are clearly defined, and the relevant stakeholders are based on cooperation and solidarity in taking measures against disasters. In Japan, the system of distribution of authorities and responsibilities is implemented, and there are many stakeholders at the national and local level in the administration of disaster management.

A well-structured disaster management system has been developed in Japan. As part of the government reform in 2001, the State Ministry of Disaster Management was established in the Council of Ministers to integrate and coordinate disaster risk management policies. In the Cabinet Office (Figure. 1), the Director General of Disaster Management, who is responsible for ensuring wide-ranging cooperation between relevant government agencies, is responsible for planning basic disaster management policies and carrying out overall coordination as well as large-scale disaster response (Saya 2017).

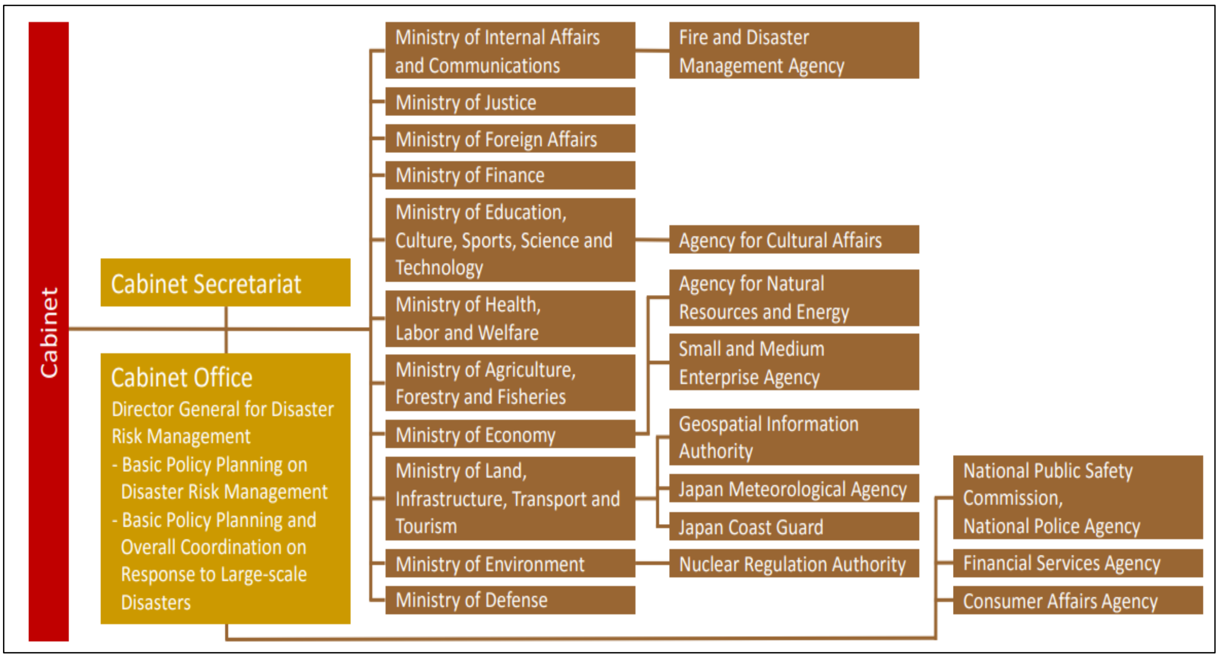

Figure 1.The relationship of Japan ministries and agencies related to Disaster Risk Management (Baba 2013).

2.2 New Zealand

New Zealand is exposed to geological hazards such as earthquakes, landslides, volcanic activity and tsunamis, as it extends along the boundary of the Australian and Pacific tectonic plates. While flooding is the most common hazard, earthquakes and tsunamis are potentially the most damaging and devastating threats New Zealand faces. While volcanic eruptions have been rare and relatively minor since human settlement, the effects of eruptions have been significant (Britton and Clark 2000).

In addition to being a geologically active country, New Zealand is a coastal country affected by weather conditions from Antarctica, Australia and the tropics. Climate change; cause extreme weather events and sea level rise. Drought is one of the most common and costly hazards in the country as a result of the dry period that usually lasts for 3-4 months. Drought is an alarming danger for the country, as the country's electricity generation is largely supplied by rivers and lakes. These natural hazards occurring in the country often damage land and buildings, as well as important infrastructure systems of the country, including energy and communication networks, roads and water systems. In the last 10 years, natural hazard events in the country have cost the insurance industry $28,333 billion (Saunders et al. 2020).These disasters in New Zealand in the last ten years have shown the magnitude of the damage and the costs to the country. It is important to note that the reported costs are usually only direct costs. According to a recent study, when the indirect and intangible costs of disasters were calculated, it more than doubled the total reported cost of each of the three events examined ((MCDEM 2019) . New Zealand's disaster management system is based on sound disaster management principles and one of international best practices. There are many strengths in the country's emergency management system. The system was established to deal with "all dangers and risks" (Ulutürk 2006).

As a result of a series of conferences, workshops, reports and researches that questioned the effectiveness of New Zealand's disaster management practice since the early 1990s, it was decided that a transformation from a rigid and reactive model to a coordinated proactive disaster management (Britton and Clark 2000).

• In 1996, endorsement of a set of principles as the basis for a comprehensive disaster management framework

• Redefining the principles, roles and responsibilities of all institutions in the sector

• Establishment of a new ministry called the Ministry of Civil Defense and Emergency Management (MCDEM) in 1997

• Adoption of the Civil Defense Emergency Management (CDEM) Law in 2002, which replaced the 1983 Civil Defense Law Transformations began with the MCDEM established in 1999 and the CDEM Law enacted in 2002, which redefined the duties of central and local governments? The primary purpose of the law is to promote the sustainable management of hazards and risks towards building a resilient and self-reliant society.

The law transferred most of the authority and responsibility to local units by giving priority to local interventions and administrations (Ulutürk 2006).

The following diagrammatically (Figure. 2) represents the structure at regional and local level. Powerfully the CDEM Group, that is the governing body is composed of all the elected Mayors of the region and the Coordinating Executive Group responsible for Group Plan and the implementation of the plan is composed of the Chief Executives of district local government and the senior executives of the regional emergency services. Groups all have a working party structure under the CEG, supported by the Group CDEM office, which covers, variously: Reduction (linked into other local government accountabilities); preparedness and response, and recovery (linked into central government and Non-Government Agency welfare and other agencies).

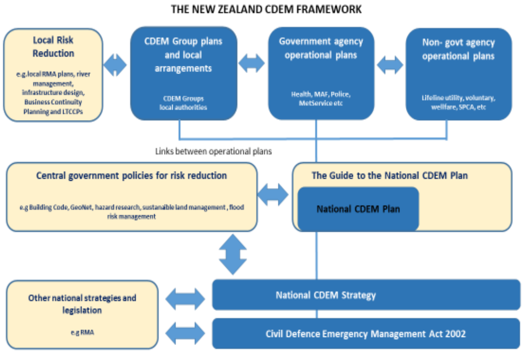

Figure 2. The New Zealand CDEM framework (MCDEM 2008).

2.3 Philippines

Located in Southeast Asia, the Philippines is one of the largest island groups in the world, comprising more than 7,000 islands. Located at the edge of two tectonic plates, the Philippines ranks 4th in the list of countries most prone to natural disasters based on UNISDR's 20-year assessment. Philippines; It is exposed to various natural disasters such as earthquakes, volcanic eruptions, landslides, floods, droughts and typhoons.

The country has a tropical climate. The country is vulnerable to extreme weather events as it is located in the Pacific Typhoon Belt. Some of the devastating floods and landslides are triggered by typhoons that occur. Other factors triggering landslides are volcanic eruptions, earthquakes and increased monsoon precipitation. Wide coastlines also cause disasters such as tsunami, flood, landslide and drought. Since the country is located in the Pacific Earthquake Belt, it is frequently exposed to earthquakes and volcanic activities (Doroteo 2015). 8 of the 10 cities in the world most exposed to natural disasters are located in the Philippines. This is evident in the estimated $23 billion in damage and the loss of 70,000 Filipinos in 565 natural disasters. Total losses from natural disasters are estimated to cost the Philippines $6.5 billion each year (World Economic Forum 2016).The National Disaster Risk Reduction and Management Council of New Zealand (NDRRMC), formerly known as the National Disaster Coordinating Council, has expanded its membership and functions to deal with the complexities of today's disasters. Philippine disaster risk reduction and management structure is shown in Figure 3.

NDRRMC; The highest coordinator of disaster management is the national council, according to the law numbered RA 10121, strengthened with the functions of policy making, coordination, supervision, monitoring and evaluation for disasters or emergencies. The law designated the NDRRMC as the top policy-making body for coordination, integration, supervision, monitoring and evaluation (Azuela et al. 2020).

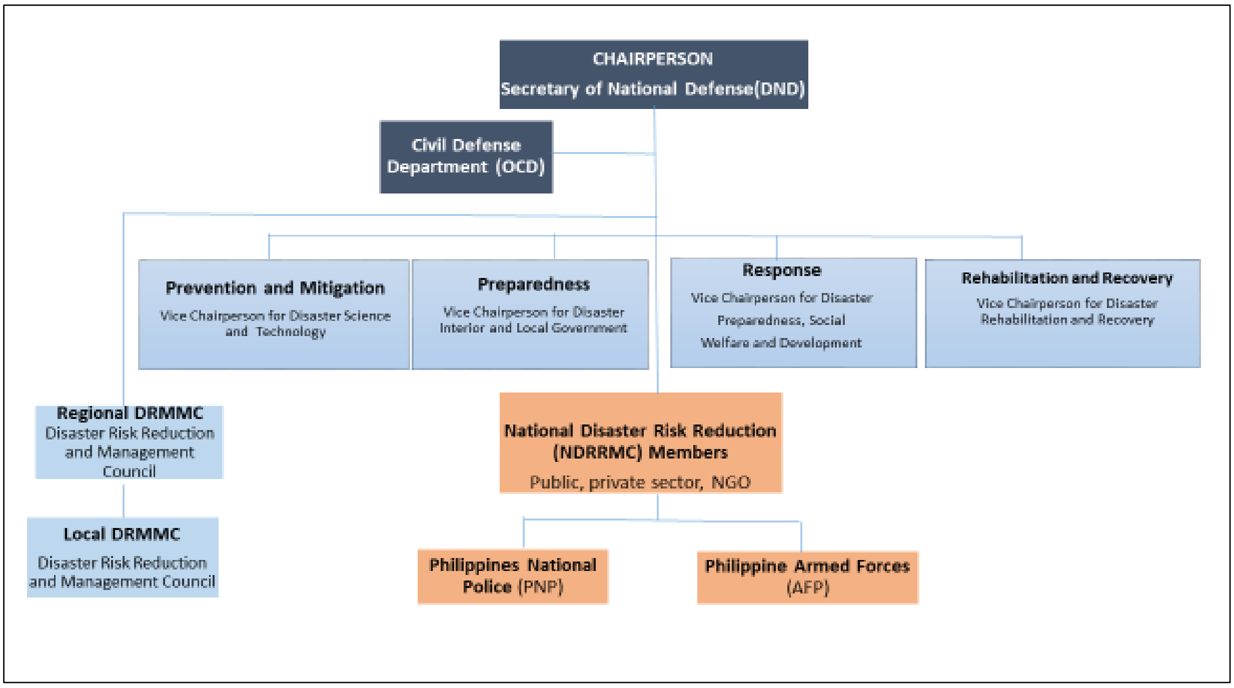

Figure 3. Philippine disaster risk reduction and management structure (NDRRMP, 2011)

2.4 Turkey

Turkey is exposed to natural disasters such as earthquakes, floods, landslides, avalanches, droughts, forest fires and man-made disasters due to its high physical, social and economic vulnerability as well as its geological structure and climatic characteristics. Turkey is in the Mediterranean, Alpine, and Himalayan seismic belt, which is one of the most active seismic belts of the earth, and is located between three large tectonic plates such as Europe-Asia, Arabia and Africa, and two small plates such as the Aegean and Anatolian plates (Şengör and Yilmaz 1981). This belt is an active zone in which approximately 20% of the earthquakes in the world occur and causes a devastating earthquake in the country on average every five years (AFAD 2020).

Turkey ranks first among OECD countries in terms of loss of life, property and economic losses caused by disasters. According to the statistical data of the last 60 years, losses caused by natural disasters, directly or indirectly, correspond to approximately 3-4% of GDP.

The Law No. 5902 on the Organization and Duties of the Disaster and Emergency Management Presidency, which was enacted in 2009 in order to eliminate the complexity and coordination problems in the disaster management system and to remove the multi-headedness, was adopted and entered into force after being published in the Official Gazette No. 27261. With this law; "a. To carry out services related to disasters and emergencies and civil defense, b. To ensure coordination between institutions and organizations that have a role before and after the disaster, c. three general directorates (General Directorate of Disaster Affairs, General Directorate of Civil Defense and General Directorate of Emergency Management of Turkey) were abolished and AFAD affiliated to the Prime Ministry was established in the center in order to create and implement policies in disaster management. The organization chart of AFAD, which manages the process in disasters and emergencies in Turkey, is as follows in Figure 4.

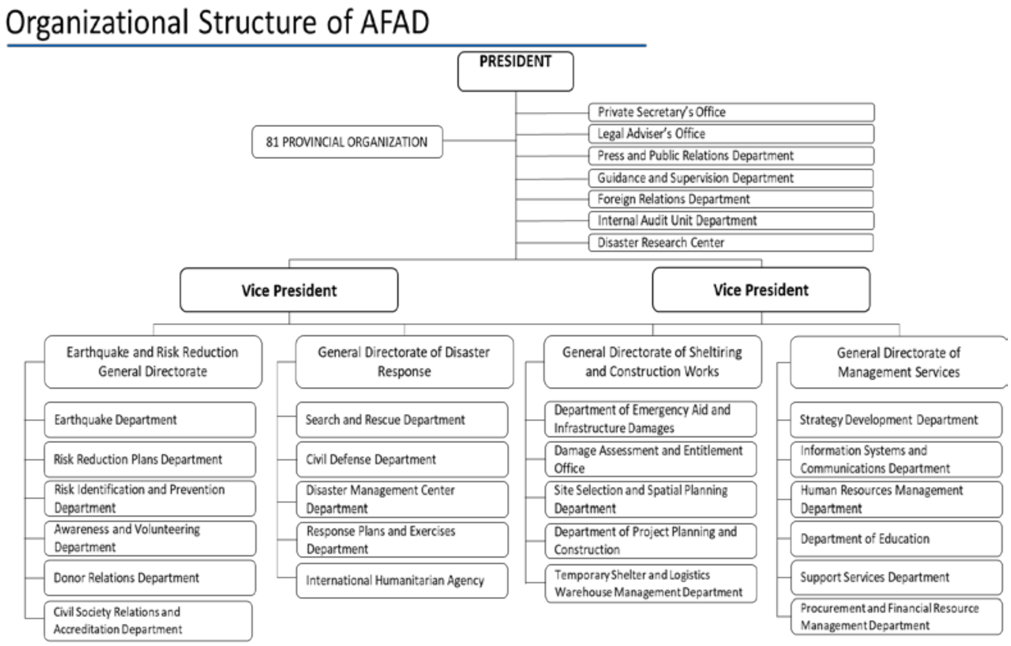

Figure 4. Organization chart of AFAD Turkey

3. Methodology

Decision makers are faced with more than one alternative while making a decision in the process of examining the existing plans and documents of the countries related to DRR. Many criteria in the examined DRR plans and documents have been evaluated, and Japan, Turkey, Philippines, New Zealand appear as our alternatives on a country basis (Figure. 5).

In the application, firstly, the decision problem is defined. Here, the process of collecting information about the application problem is also mentioned. Thus, the necessary data to be used during the analysis and resolution of the decision problem, to create the decision hierarchy, were obtained. In the next process, a decision hierarchy was established that includes the purpose of the application problem, the comparison criteria and the alternatives to be compared, and the solution of the application problem was started. The methodology used in this study was generally carried out in 3 stages. In order to understand how to evaluate the best DRR plan among the country samples, the AHP (Analytical Hierarchy Process) method, which is one of the multi-criteria decision making (MCDM) methods, was decided at the analysis stage. In Stage 2, the disaster management systems and current DRR plans of the selected countries according to certain factors were examined. The data set of the criteria and sub-criteria that are effective in the DRR in the country plans examined in the 3rd stage were determined. The opinions of the country experts were taken by developing the questionnaire and the results were analysed using the AHP method.

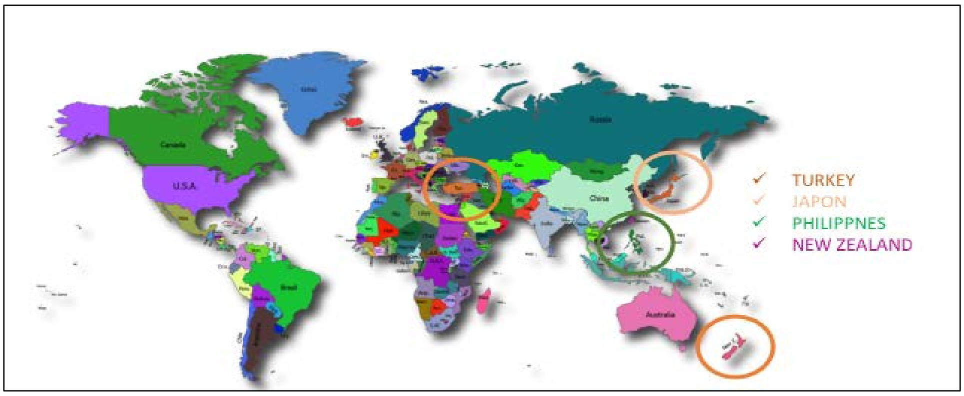

Figure 5. Locations of the studied countries on the map

3.1 Analytical Hierarchy Process

In this study, MCDM methods were examined and it was decided that AHP would be the most appropriate methodology in terms of classification of data, compliance with strategic planning during the implementation of DRR plan principles, and comparing the practical applicability of other country sample plans.

The Analytic Hierarchy Process (AHP) is a math and psychology-based method for organizing and analyzing complex decisions. In the AHP Hierarchy Model, the top level of the hierarchy consists of a single item or goal, which is the overall goal. At the level below the goal, there are factors that affect and contribute to the decision, known as criteria or variables, in order to achieve the stated goal (Saaty 1980).

At the next level, there are sub-criteria (if any) containing the details within the criteria (Fig. 6). There are alternatives with decision options at the lowest level in the hierarchy (Razmi, Rahnejat, and Khan 2000).

After the hierarchical model is established, pairwise comparison matrices should be created in order to determine the importance of all criteria relative to each other. During the creation of the matrices, the relative importance of each pairwise comparison matrix is determined separately by the decision maker. In Table1, the relative importance of the criteria is determined by assigning values between "1" and "9" to the matrix and transforming the verbal values into numerical values (Wollmann et al. 2014).

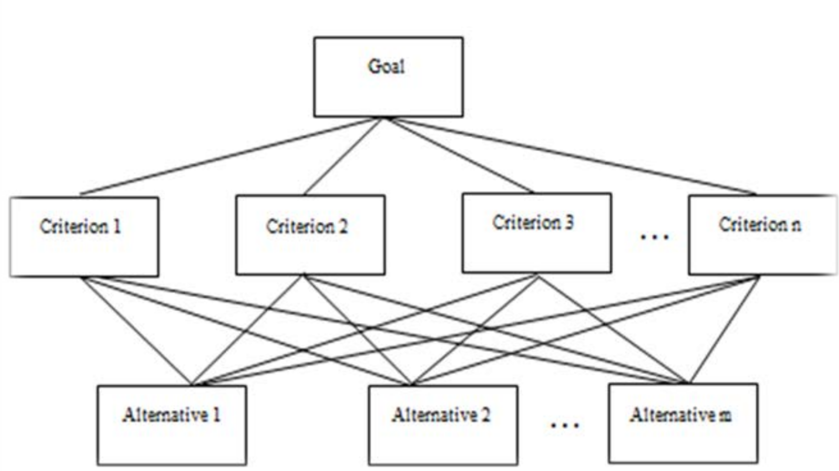

Figure 6. Hierarchical model of AHP study

Decision makers obtain the pairwise comparison matrix shown in Equation 1 through the comparison scale given in Table 1 in the light of their value judgments, knowledge, experience and equipment. RI values according to the dimensions of the comparison matrices shown in Table 2 was carried out in Microsoft Excel.

Table 1. Preference scale for pairwise comparisons in AHP

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the property
3	Moderate importance	Experience and judgment slightly favor one over the other
5	Essential or strong	Experience and judgment strongly favor one over another
7	Very strong importance	An element is strongly favored and its dominance is demonstrated in practice.
9	Extreme importance	The evidence favoring one element over another is one of the highest possible order of affirmation
2,4,6,8	Intermediate values between two adjacent judgment	Comprise is needed between two judgments

Table 2. RI values according to the dimensions of the comparison matrices

n	**1**	**2**	**3**	**4**	**5**		**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
RI	0	0	0,58	0,9	1,12		1,24	1,32	1,41	1,45	1,49	1,51	1,54	1,56	1,57	1,59

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn} \end{bmatrix} \quad \text{(Equation.1)}$$

A: Pairwise comparison matrix

n = Number of criteria in evaluation

a_{ij} = importance of criterion i over criterion j

In the binary comparison matrix, the sums of each column will be taken and the matrix will be normalized by dividing each value in the matrix by the related column sum and ensuring that the sum of the values in each column is 1.00 (IDEA, 2005). The comparison matrix shows the importance levels of the criteria relative to each other within a certain logic. Column vectors forming the comparison matrix are used to determine the weights (percentage importance distributions) of these criteria. B column vectors with n and n components are created. B column vectors are calculated with the help of the formula shown in Equation 2.

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad \text{(Equation.2)}$$

When the above-mentioned steps are repeated for other criteria, B column vectors will be obtained as much as the number of criteria (Equation 3).

$$B_1 = \begin{bmatrix} b_{11} \\ b_{21} \\ \vdots \\ \vdots \\ b_{n1} \end{bmatrix} \quad \text{(Equation.3)}$$

B column vectors are combined in a matrix format, the C matrix shown in Equation 4 below will be formed.

$$C = \begin{bmatrix} c_{11} & c_{12} & c_{13} & \cdots & c_{1n} \\ c_{21} & c_{22} & c_{23} & \cdots & c_{2n} \\ c_{31} & c_{32} & c_{33} & \cdots & c_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ c_{n1} & c_{n2} & c_{n3} & \cdots & c_{nn} \end{bmatrix} \quad \text{(Equation.4)}$$

After the normalized pairwise comparison matrix is created, the criteria weights are obtained by taking the arithmetic average of the row values in the C matrix. Thus, the W column vector, also called the eigenvector, is obtained (Equation 5).

$$W = \begin{bmatrix} W_1 \\ W_2 \\ \vdots \\ \vdots \\ W_n \end{bmatrix} \qquad W_i = \frac{\sum_{j=1}^{n} c_{ij}}{n} \quad \text{(Equation.5)}$$

Although the AHP method has a consistent systematic, the accuracy of the results will depend on the consistency of the criteria in comparison by the decision maker. The Consistency Ratio (CR) should be calculated for the pairwise comparison matrices, allowing the consistency of the AHP method to be measured after the comparisons between the criteria and the determined priorities. In order to calculate the CR value, first of all, the coefficient called "Consistency Index (CI)", which is one of the many methods, should be calculated in order to determine whether a matrix A, which is formed as a result of pairwise comparison judgment, is consistent. The CI coefficient is calculated by the formula given in Equation 6.

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad \text{(Equation.6)}$$

In order to calculate the CI value, the largest eigenvector of the matrix, that is λmax, must be calculated. The formula in Equation 7 is used to calculate the value of λmax given in Equation 6.

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{\sum_{j=1}^{n} a_{ij} * wj}{w_i}\right)$$

(Equation.7)

For the calculation of λmax, firstly, the D column vector shown in Equation 8 is obtained from the matrix multiplication of the comparison matrix A and the priority vector W.

$$AxW = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \square & a_{1n} \\ a_{21} & a_{22} & a_{23} & \square & a_{2n} \\ a_{31} & a_{32} & a_{33} & \square & a_{3n} \\ \square & \square & \square & \square & \square \\ a_{n1} & a_{n2} & a_{n3} & \square & a_{nn} \end{bmatrix} x \begin{bmatrix} W_1 \\ W_2 \\ \square \\ \square \\ W_n \end{bmatrix} = D = \begin{bmatrix} x_1 \\ x_2 \\ \square \\ \square \\ x_n \end{bmatrix}$$

(Equation.8)

As defined in the formula above, the E value for each evaluation criterion is found from the division of the reciprocal elements of the D column vector and the W column vector found. In the formula given in Equation 9 10, which is the arithmetic mean of these values, it gives the basic value ($\lambda_{\max}$) for the comparison.

$$E_i = \frac{x_i}{w_i} \qquad i = 1,2,\square\ ,n$$

(Equation.9)

$$\lambda_{\max} = \frac{\sum_{i=1}^{n} E_i}{n}$$

(Equation.10)

After calculating the CI value with the help of the formula shown in Equation 6, the randomness indicator (RI) values, which consist of fixed values according to the number of criteria (n) used for different matrix sizes in the pairwise comparison, are given in Table 2 to complete the calculation of the CR value (Saaty 1980) .

After CI and RI values are determined, “CR” is calculated.

$$CR = \frac{CI}{RI}$$

(Equation.11)

Based on the upper limit of CR 0.1 (CR ≤ 0.1), the consistency level of the pairwise comparison matrix is acceptable for the reliability of the results; If the CR value is greater than 0.1, the consistency level cannot be accepted due to the inconsistency of the decision maker's judgments. In this case, the decision maker should review the criteria values and repeat the steps of the AHP method described above and recalculate the consistency test After the previous steps were calculated for all levels in the AHP method, the mx1-size S column vectors (Equation 12) created according to the importance values of the n criteria to the alternatives calculated separately for each criterion were brought together and the pairwise comparison matrix of the m x n size alternatives and criteria was Durbin- Watson   (DW). Decision matrix is obtained (Equation13).

$$S_i = \begin{bmatrix} s_{11} \\ s_{21} \\ \cdot \\ \cdot \\ \cdot \\ s_{m1} \end{bmatrix}$$

(Equation.12)

$$DW = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n} \\ s_{21} & s_{22} & \cdots & s_{2n} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ s_{m1} & s_{m2} & \cdots & s_{mn} \end{bmatrix}$$

(Equation.13)

Finally, with the help Equation 13, the L column vector (Equation 14) is created by adding the row in which it is found by multiplying the value of each alternative in the alternatives matrix with the weight score of that criterion. The L column vector represents the percentage distribution of decision options, and the sum of the values in the vector is 1. The decision option with the highest weight in this vector is determined as the decision option that should be preferred for solving the problem (Equation 14).

In the application part of the study, it tried to determine the efficiency levels of each of them and which ones should be taken into account while creating these plans as a result of comparing the parameters that can be effective in the DRR plans by using the AHP method.

AHP method was carried out in Mircosoft Excel because it is easy to understand and calculate. In addition to using AHP alone, there are many applications in the literature related to its use with different methods. In cases where they are used together, the criterion weights mostly obtained with AHP are used as inputs in the MCDM method used together (Uludağ and Doğan 2016). In the study to be carried out with the AHP method, an expert group of 16 people was determined to weight the criteria and sub-criteria. The distribution of these people's areas of expertise is given in the Table 3. The distribution of the experts participating in the survey is given below and the survey participants consist of AFAD Experts, engineers, social scientists, academicians working in the field of DRR and managers working in the field of DRR abroad.

After the criteria and sub-criteria determined by the AHP, the analysis of the studies related to the criteria was sent to the experts in the field of DRR through e-mail from 4 country representatives in Japan, Philippines, Turkey and New Zealand, and the existence and applicability levels of the projects and practices related to these criteria were asked to be scored. . Scoring systematic “Full score:1; Good level: 0.75; Intermediate: 0.50; Limited application: 0.25; None: 0”, these coefficients are multiplied by the weights of the criteria in the AHP results, and general results in accordance with the hierarchical structure of the main study model were obtained.

Table 3. The distribution of the experts participating in the survey

	AFAD Expert	Engineer	AFAD Head of Groups	Academicians working at DRR	Expert at Social Science	DRR Director
1		x	x			
2	x	x				
3		x		x		
4		x		x		
5		x		x		
6		x		x		
7	x		x			
8		x				
9	x	x			x	
10	x	x				
11	x				x	
12		x				x
13		x				x
14		x				
15		x				
16	x	x	x			

3.2 Determination of Criteria

In the process of determining the criteria, the literature reviews on DRR, the high-scale strategic plans of the countries related to DRR and the opinions of experts who worked on DRR within AFAD were used. Within the scope of the study, the criteria in the DRR strategies and plans of the countries that are the subject of the analysis were examined and criteria selections were made. The seven main criteria determined are as follows: Risk Identification (B1), Risk Reduction (B2), Response and Recovery (B3), Economic Disaster Risk Management (B4), Disaster Preparedness (B5), Governance (B6) and Compliance of Policies and Plans (B7), were selected as the main criteria. 36 important components of the main criteria, which explain each one in detail and systematically cover the process, were chosen as sub-criteria. The detail model of criteria are shown in Figure 7 and the detail names of identified criteria are given in Figure 8.

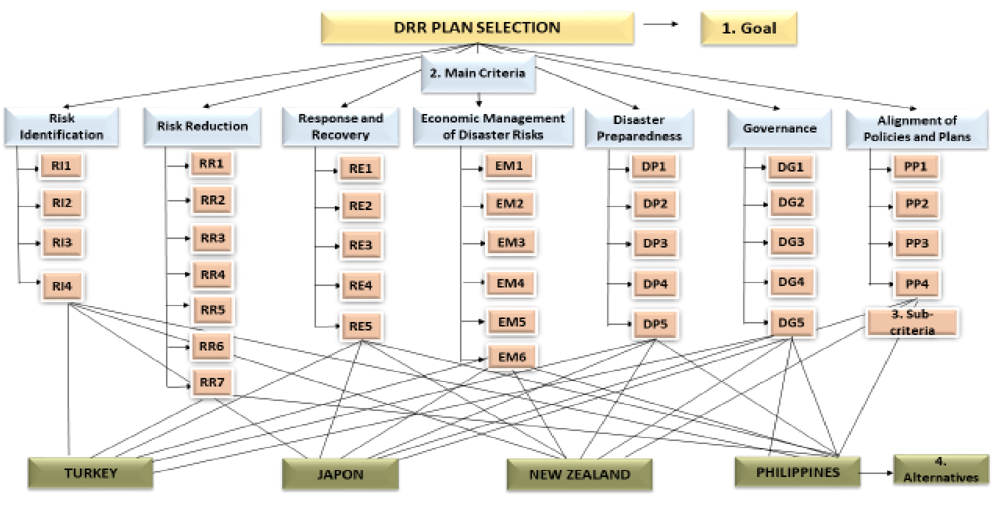

Figure 7. The hierarchical structure of the AHP Ranking of this study

3.2.1 Risk Identification

Risk identification is an important component of disaster risk management. Models, maps, indexes, etc., which are important for decision makers, to recognize and size the existence of disaster losses and to intervene in risk should be represented by Risk identification; Provides tools to evaluate specific policies and measures needed to develop DRR plans and strategies. The sub-criteria representing the risk identification are listed below;

1. Systematic Disaster and Loss Inventory - Data Collection - Data Bank
2. Hazard Monitoring and Estimation Methods
3. Hazard Assessment and Mapping Systems
4. Vulnerability and Risk Assessment Analysis

3.2.2 Risk Reduction

Disaster risk management specifically aims to reduce risk. It is the act of foresight to prevent or reduce the economic, social and environmental impacts of potentially dangerous physical events. It refers to the planning processes, the implementation of measures that change the existing risk conditions and, where possible, hazard control. The sub-criteria representing risk reduction are listed below;

1. Considering DRR in Land Use and Urban Planning
2. Hydrological Basin Intervention and Environmental Protection (Flood/Flood Prevention Structures)
3. Making Critical Facilities Disaster Resistant
4. Development of Information and Decision Support Systems in Disaster Risk Management
5. Building Stock - Updating Safety Standards and Building Rules
6. Strengthening and Upgrading Public and Private Assets
7. Development of Forecasting and Early Warning Systems

3.2.3 Response and Recovery

Response activities in disaster risk management include the rapid identification of the disaster situation and emerging needs, the ability to establish multi-directional communication with stakeholders, the rapid access of sufficient number of correct equipment and equipped personnel to the disaster site, the work of emergency health services and daily life support teams. On the other hand, DRR approaches aim to ensure that those who are exposed to disasters return to their normal lives as soon as possible, to rebuild the structures in disaster-resilient ways, and to create a disaster-resilient society by taking the state of development to an advanced level. Sub- criteria representing intervention and improvement are listed below;

1. Organization and Coordination of Emergency Operations
2. Disaster Response Planning
3. Logistics System Planning and Equipment, Vehicle and Infrastructure Equipment
4. Simulation, Inter-Agency Intervention Testing and Updating
5. Integration of DRR into Recovery and Reconstruction Planning Processes

3.2.4 Economic Disaster Risk Management

Expenditures made to return the system, which is deteriorated / lost due to disasters at any time, to normal as soon as possible, and the management of existing resources is expressed as "Disaster Economy". The place of disaster economy in DRR is the management part of the budget allocated for risk reduction measures and measures before disasters occur. In order for DRR to be sustainable, it is necessary to determine the economic losses caused by disasters and to know the investments made here. Disasters cause serious effects on development, public finance and growth in developing countries such as Turkey. For this purpose, quality and reliable information is required for monitoring investment budgets and determining the economic losses that occur in disasters. The international community supports this issue with global and regional research and information systems on the economic management of disaster risks. The sub- criteria representing the economic management of disaster risks are listed below;

1. Conducting Studies on the Economic Results of Investments Made in DRR
2. Allocating Resources (Funds) for Institutional Strengthening
3. Budget Allocation and Mobilization
4. Implementation of Social Safety Nets and Intervention with Funds
5. Insurance Coverage of Public Assets
6. Housing and Private Sector Insurance and Repetitive Insurance Coverage

3.2.5 Disaster Preparedness

Disaster preparedness refers to the measures taken to be prepared for disasters and to reduce the effects of disasters. In other words, reducing the risks of disasters and preventing them whenever possible, reducing their effects on vulnerable individuals and responding to their consequences quickly and dealing with them effectively are one of the most fundamental steps in the DRR system. In the disaster preparedness system; Starting from the individual, bringing a culture of disaster preparedness to all segments of the society, raising awareness in individuals, ensuring their participation in volunteer activities, teaching the basic precautions that individuals can take in the places they live, incorporating DRR into the education system, ensuring that individuals learn and practice the correct behavior in disasters with exercises, It is aimed to expand the places where the sectors can receive disaster education and to establish infrastructures that they can easily access, to standardize the disaster education given through various channels throughout the country, to participate in the studies carried out by international organizations and to create accredited education paths with sufficient knowledge and experience. Sub- criteria representing disaster preparedness are listed below;

1. Increasing Community Awareness and Capacity on DRR
2. Developing DRR Trainings Based on Priorities Determined for Main Sectors
3. Inclusion of DRR in the Education and Training Program
4. Coordination and Cooperation of DRR Volunteer Activities
5. Performing Exercises and Simulations

3.2.6 Governance

Disaster risk governance defines it as the way of coordinating the authorities responsible for DRR, public institutions and organizations, media, private sector, non-governmental organizations, universities at regional, national and international levels to manage and reduce the risks related to disasters. The sub- criteria that examine the different governance issues related to DRR from global, regional, national and local perspectives and represent the needs of disaster governance at different levels are listed below;

1. Interagency, Multisectoral and Decentralized Organization
2. Legislative Infrastructure Regarding DRR
3. Presence and Consolidation of the DRR National Platform
4. International Cooperation for DRR
5. Existence of Gender Responsive DRR Strategies

3.2.7 Compliance of Policies and Plans

In order to strengthen the DRR plans, integrate them with the response stages, and be better prepared for disasters, it is essential that all policies in the field of DRR and all documents on a global scale are compatible with country strategies. Communities become more resilient to disasters with the implementation of the goals and objectives included in the DRR plans. If a country's sustainable development goals include the existence of local plans, adaptation policies to existing climate change agreements, and adaptation programs to global-scale strategies, the easier it is to implement DRR mechanisms. The existence of these plans and policies, their periodic evaluation and the creation of monitoring and evaluation systems that will report to the public, can be measured by their effects on DRR processes. For this reason, the sub-criteria representing the Compliance of Policies and Plans are listed below;

1. Integrating Climate Change Policy, Plans and Adaptation Programs with the DRR Strategy
2. Availability of Local Level DRR Plans
3. Compliance of the DRR Plan with the Post-2015 Agenda (Sendai, Sustainable Development
4. Goals, etc.)
5. Preparation of Business Continuity Plans

After the criteria were determined, a 4-level hierarchical structure consisting of purpose, criteria, sub-criteria and alternatives was created as follows. The purpose at the top level of the hierarchical structure is stated as “Choosing a

Disaster Risk Reduction Plan". At the second and third levels, there are main criteria and sub-criteria in accordance with the purpose. At the lowest level, the countries whose DRR plans are examined are listed as alternatives. Among main criteria, B1 (Risk Identification), B2 (Risk Reduction), B3 (Response and Recovery), B4 (Economic Management of Disaster Risks), B5 (Disaster Preparedness), B6 (Governance), B7 (Alignment of Policy and Plans). As can be seen in Figure 9 a, the order of importance is B2, B1, B3, B4, B5, B6, B7, starting from the highest. Risk Reduction" has the highest weight among the main criteria.

As can be seen in Figure 9b; Ranking of importance among our risk identification sub-criteria RI1 (Systematic disaster and loss inventory- Data collection-Data bank), RI2 (Hazard monitoring and estimation methods), RI3 (Hazard assessment and mapping systems), RI4 (Vulnerability and risk assessment analysis) RI2, RI1, RI3, RI4, starting from the highest. As can be seen in Figure 9c, Risk reduction sub-criteria RR1 (Considering DRR in land use and urban planning), RR2 (Hydrological Basin Response and Environmental Protection (Flood/Flood prevention structures), RR3 (Making critical facilities resistant to disasters), RR4 (Development of information and decision support systems in disaster risk management), RR5 (Building stock - Updating safety standards and construction rules), RR6 (Strengthening and improving public and private assets), RR7 (Developing forecasting and early warning systems) from high to RR1, RR7, RR2, RR3, RR6, RR4, RR5 respectively.

As can be seen in Figure 9d, response and recovery sub-criteria RE1 (Emergency response planning), RE2 (Logistics system planning and equipment, vehicle and infrastructure equipment), RE3 (Simulation, inter-agency response testing and updating), RE4 (DRR's improvement and reconstruction planning processes), RE5 (Organization and coordination of emergency operations), starting from the highest order of importance, RE3, RE1, RE5, RE2, RE4 respectively.

As can be seen in Figure 9e, our sub-criteria of economic management of disaster risks are EM1 (working on the economic results of investments made for DRR), EM2 (reserving funds for institutional empowerment), EM3 (budget allocation and mobilization), EM4 (Implementation of social safety nets and intervention in funds), EM5 (insurance coverage of public assets), EM6 (working on the economic consequences of investments in DRR) in order of importance EM2, EM3, EM6, EM5, EM1, EM4 respectively, starting from the highest.

As can be seen in Figure 9f, among our disaster preparedness sub-criteria, DP1 (increasing the awareness and capacity of the society on DRR), DP2 (Developing DRR trainings based on the priorities determined for the main sectors), DP3 (inclusion of DRR in the education and training program), DP4 (Coordination and Cooperation of DRR Volunteer Activities), DP5 (Performing exercises and simulations), starting from the highest order of importance, were DP3, DP1, DP5, DP2, DP4, respectively.

As can be seen in Figure 9g, our Governance sub-criteria DG1 (Inter-agency, multi-sectoral and decentralized organization), DG2 (regulatory infrastructure related to DRR), DG3 (existence and aggregation of the DRR national platform), DG4 (International Cooperation for DRR), DG5 DG3, DG2, DG1, DG5, DG4 were in order of importance, starting from the highest (existence of gender-sensitive DRR strategies).

As can be seen in Figure 9h, among our sub-criteria of compliance of policies and plans, PP1 (Integration of policies, plans and adaptation programs related to climate change with DRR strategy), PP2 (Existence of DRR plans at local level), PP3 (DRR plan to the post-2015 agenda (Sendai, Sustainable Development) Purposes, etc.), PP4 (Preparation of business continuity plans), starting from the highest order of importance, were PP2, PP3, PP4, PP1 respectively.

The plans and strategies of the selected countries for DRR were examined, and 4 countries were ranked with a holistic approach using the AHP methodology in line with the main criteria and sub-criteria determined (Figure 10). For each criterion put into the analysis, the success ranking of the countries changes and the general evaluation results of the countries are as in Table 4. The determined criteria and sub-criteria were sent to the experts in the field of DRR by e-mail and the countries were asked to be scored. Scoring systematic "Full score: 1; Good level: 0.75; Intermediate: 0.50; Limited application: 0.25; none: 0" and the general result of the hierarchical structure of the model was obtained as a result of the multiplication of the weights of the criteria.

The existence of the main criteria and sub-criteria weighted using the AHP methodology was evaluated in these four country plans by country experts, and the countries' success was ranked. According to the findings, Japan had the best DRR plan, with a score of 0.959. Our country was ranked second with a score of 0.717, New Zealand was third with a score of 0.691, and the Philippines was fourth with a score of 0.664.

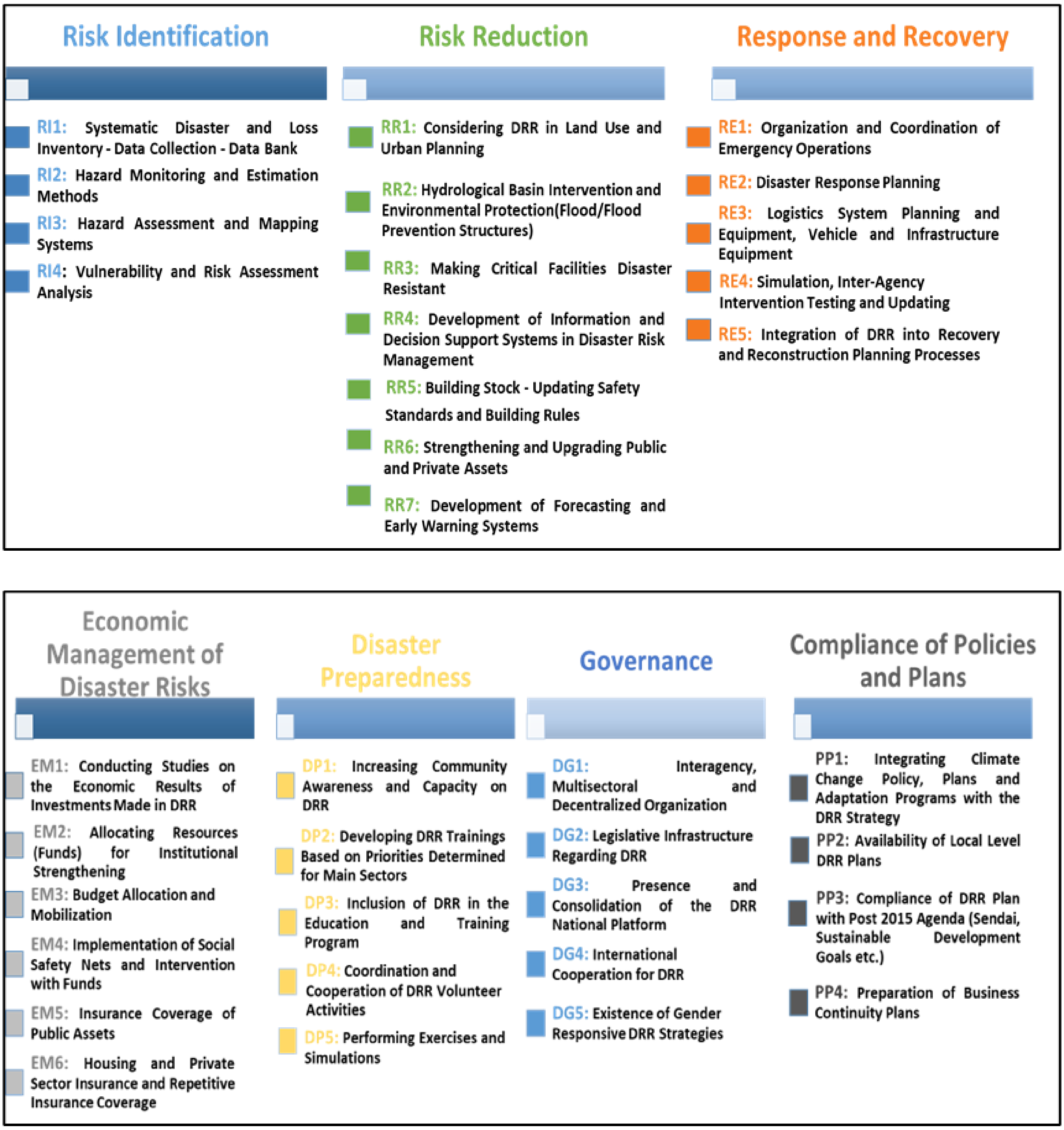

Figure 8. The detail names of identified criteria

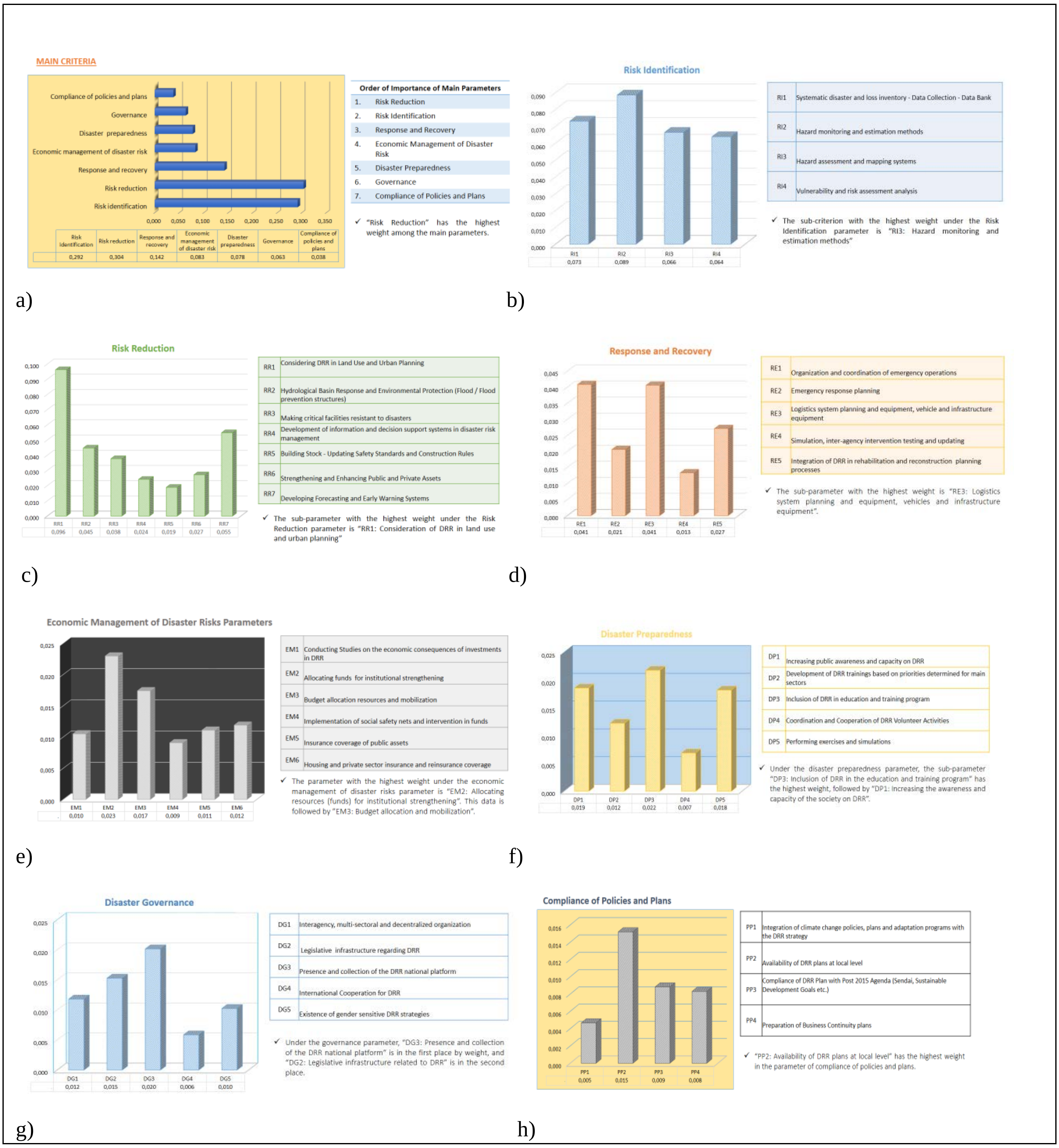

Figure 9. Ranking charts of relative importance vectors of criteria and sub-criteria

Table 4. General assessment results of countries on the basis of AHP

MAIN CRITERIA	SUB CRITERIA		W=Weight	PHILIPPINES	NEW ZEALAND	JAPAN	TURKEY
Risk Identification Parameters	RI1	Systematic disaster and loss inventory - Data Collection - Data Bank	0,073	0,75	0,75	1	1
	RI2	Hazard monitoring and estimation methods	0,089	0,75	0,75	1	0,75
	RI3	Hazard assessment and mapping systems	0,066	0,75	0,75	1	1
	RI4	Vulnerability and risk assessment analysis	0,064	0,5	0,5	1	0,25

Risk Reduction Parrameters	**RR1**	**Considering DRR in Land Use and Urban Planning**	**0,096**	**0,5**	**0,75**	**1**	**0,5**
	RR2	**Hydrological Basin Response and Environmental Protection (Flood / Flood prevention structures)**	**0,045**	**0,5**	**0,75**	**1**	**0,75**
	RR3	**Making critical facilities resistant to disasters**	**0,038**	**0,5**	**0,5**	**1**	**0,5**
	RR4	**Development of information and decision support systems in disaster risk management**	**0,024**	**0,75**	**0,75**	**1**	**1**
	RR5	**Building Stock - Updating Safety Standards and Construction Rules**	**0,019**	**0,5**	**0,75**	**1**	**0,75**
	RR6	**Strengthening and Enhancing Public and Private Assets**	**0,027**	**0,75**	**0,75**	**1**	**0,75**
	RR7	**Developing Forecasting and Early Warning Systems**	**0,055**	**0,75**	**0,75**	**1**	**0,75**
Response and Recovery Parameters	**RE1**	**Organization and coordination of emergency operations**	**0,041**	**0,75**	**0,75**	**1**	**1**
	RE2	**Emergency response planning**	**0,021**	**0,75**	**0,75**	**1**	**1**
	RE3	**Logistics system planning and equipment, vehicle and infrastructure equipment**	**0,041**	**0,75**	**0,5**	**0,75**	**1**
	RE4	**Simulation, inter-agency intervention testing and updating**	**0,013**	**0,75**	**0,5**	**0,75**	**1**
	RE5	**Integration of DRR in rehabilitation and reconstruction planning processes**	**0,027**	**0,75**	**0,5**	**1**	**0,25**

Table 3. Continued

Economic Management of Disaster Risks Parameters	**EM1**	**Conducting Studies on the economic consequences of investments in DRR**	**0,010**	**0,75**	**0,75**	**1**	**0,75**
	EM2	**Allocating funds (funds) for institutional strengthening**	**0,023**	**0,5**	**0,5**	**0,75**	**1**
	EM3	**Budget allocation and mobilization**	**0,017**	**0,5**	**0,75**	**0,75**	**1**
	EM4	**Implementation of social safety nets and intervention in funds**	**0,009**	**0,5**	**0,75**	**0,75**	**0,25**
	EM5	**Insurance coverage of public assets**	**0,011**	**0,5**	**0,75**	**1**	**0,75**
	EM6	**Housing and private sector insurance and reinsurance coverage**	**0,012**	**0,5**	**0,75**	**1**	**0,5**
Disaster Preparedness Parameters	**DP1**	**Increasing public awareness and capacity on DRR**	**0,019**	**0,75**	**0,75**	**1**	**0,75**
	DP2	**Development of DRR trainings based on priorities determined for main sectors**	**0,012**	**0,75**	**0,75**	**1**	**0,75**
	DP3	**Inclusion of DRR in education and training program**	**0,022**	**0,75**	**0,75**	**1**	**0,75**
	DP4	**Coordination and Cooperation of DRR Volunteer Activities**	**0,007**	**0,75**	**0,75**	**0,75**	**0,75**

	DP5	**Performing exercises and simulations**	**0,018**	**0,75**	**0,75**	**1**	**0,75**
Governance Parameters	**DG1**	**Interagency, multi-sectoral and decentralized organization**	**0,012**	**0,75**	**0,75**	**0,75**	**0,75**
	DG2	**Legislative infrastructure regarding DRR**	**0,015**	**0,75**	**0,75**	**1**	**0,5**
	DG3	**Presence and collection of the DRR national platform**	**0,020**	**0,75**	**0,25**	**0,75**	**0,5**
	DG4	**International Cooperation for DRR**	**0,006**	**0,75**	**0,75**	**1**	**0,75**
	DG5	**Existence of gender sensitive DRR strategies**	**0,010**	**0,75**	**0,75**	**0,75**	**0,25**
Compliance Parameters of Policies and Plans	**PP1**	**Integration of climate change policies, plans and adaptation programs with the DRR strategy**	**0,005**	**0,75**	**0,75**	**1**	**0,5**
	PP2	**Availability of DRR plans at local level**	**0,015**	**0,75**	**0,75**	**1**	**0,5**
	PP3	**Compliance of DRR Plan with Post 2015 Agenda (Sendai, Sustainable Development Goals etc.)**	**0,009**	**0,75**	**1**	**1**	**0,5**
	PP4	**Preparation of Business Continuity plans**	**0,008**	**0,5**	**0,5**	**0,75**	**0,25**
			COUNTRY SCORE	**0,664**	**0,688**	**0,959**	**0,717**

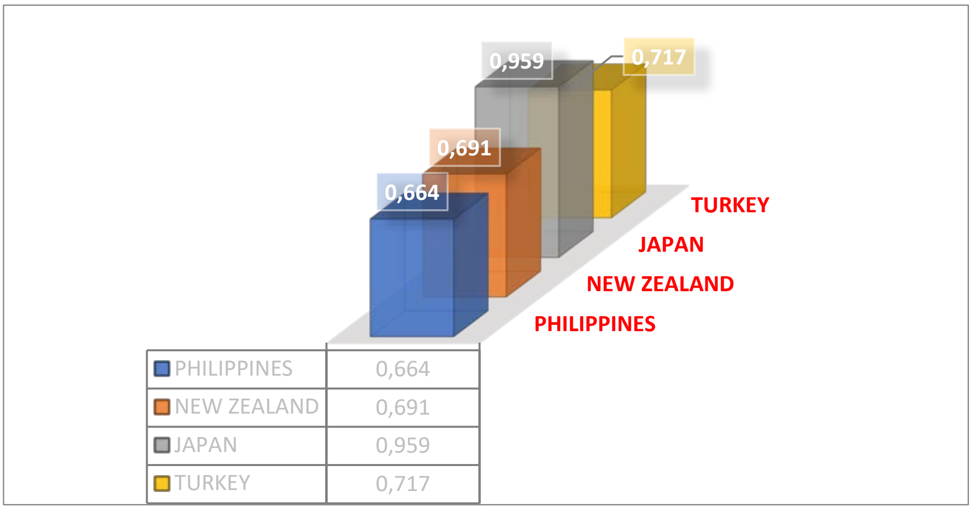

Figure 10. Evaluation ranking of country sample plans analyzed by AHP method

4. Conclusion

Within the scope of the study, disaster management systems and disaster risk reduction plans of Japan, Turkey, Philippines and New Zealand, which are among the countries with high disaster risk, were examined. It is now firmly accepted that a comprehensive DRR plan is necessary for any country in the world to be considered successful in disaster management. A number of monitoring and evaluation systems have been developed to assess the success of national plans, but limited work has been done to synthesize the components that make up these systems and to select the most important ones to use.

It is both practical and less time-consuming to plan locally and see the functionality of the plan in situ. However, more comprehensive and multi-criteria decision-making methods should be used when evaluating the effectiveness of a national plan. For this purpose, within the scope of the thesis study, the criteria in the DRR strategies and plans were examined, and the country strategies, practices and policies based on the implementations were evaluated.

There is a concept that is generally accepted in the world. DRR offers a high return on investment: One dollar invested in disaster prevention can save seven dollars' worth of disaster related economic losses. In this context, DRR is the first and most important stage in the disaster cycle. Each country's DRR strategy and plans may have different stages of importance. These differences both reveal country approaches and help us measure country success.

Knowing, defining, understanding and measuring disaster risks, conducting disaster risk management from the center, existence of effective intervention and improvement works, having a planned policy towards being a disaster prepared society are clearly the most basic pillars of DRR in a country. In this study, Risk Identification (B1), Risk Reduction (B2), Response and Recovery (B3), Economic Management of Disaster Risks (B4), Disaster Preparedness (B5), Governance (B6) and Harmonization of Policies and Plans (B7) are included in the DRR processes.) were chosen as the main criteria.

Multi-criteria decision making method was used to identify and synthesize the Interrelationships of these basic components of disaster management. The process (AHP) method, which includes paired pairwise comparisons of various alternatives, was chosen as the facilitating method. This method offers a versatile approach to decision makers in solving problems and determining the order of importance of effective parameters when more than one criterion is involved in the decision-making process. 36 important sub-components of the main criteria were selected as sub-criteria. As a result of the weighting, the importance levels of the parameters were determined as B2, B1, B3, B4, B5, B6 and B7, respectively.

The importance of the sub-components is; it is of great importance in the evaluation of projects and policies that countries carry out based not only on the success of the existence of their plans, but also on the general plan. Because it is a very superficial approach to say that every country that has a DRR plan is successful in DRR. For example, is the Risk Identification parameter more important in the DRR system or is it the Risk Reduction processes? Expert opinions decide which parameter is important in this binary selection. Then, when evaluating for country

A, the sub-criteria of the main parameter are looked at. If country A has existing projects, strategies and policies covering the relevant parameter, all these are used in the success evaluation of country A. In this evaluation, a scoring technique was used for the final success classification of the countries examined.

This scoring is also applied in the online system to monitor the number of countries that have adopted and implemented national ARA strategies in accordance with the Sendai Disaster Risk

Reduction Framework 2015-2030. Indicators have been proposed to measure the presence or quality of each key element in countries' national DRR strategies, so that the indicator can measure the level at which national DRR strategies are aligned with the Sendai Framework. Sendai Member States will assess the level of implementation for each key element and enter all information into the web-based Sendai Framework Monitor. Countries are compared according to a certain weighting, since each element can be composed of many sub-components in itself. Although a simple measure, it will enable countries to assess gradual or partial progress compared to the baseline and thus monitor the improvement in the quality of the national DRR strategy over time.

The same scoring system was used in this study. The determined criteria and sub-criteria were sent to the experts in the field of DRR by e-mail and the countries were asked to be scored. Scoring systematic "Full score: 1; Good level: 0.75; Intermediate: 0.50; Limited application: 0.25; none: 0" and the general result of the hierarchical structure of the model was obtained as a result of the multiplication of the weights of the criteria.

The results show that, despite having a high disaster risk, Japan has the highest score across all criteria, demonstrating the effectiveness of its DRR approach in all of its implemented projects. DRR is highly valued in this country, both locally and internationally. Despite the fact that our nation has a team with strong governance and strategic thinking skills, some plans have not yet been put into action. The projects it implements based on DRR are what give it a higher score than the Philippines in this case. Despite having an efficient response and recovery system and a high level of awareness regarding disaster preparedness, Turkey faces some challenges in the coordination of policies and plans. Due to this, it occupies second place.

Another aspect of the study is the scoring of the AHP criteria in the presence of country plans. It is crucial for evaluating the projects and policies that nations implement based on both the overall plan and the success of their specific plans. Because that stated that every nation with a DRR plan is successful in DRR is a very basic approach. For instance, which DRR system parameter—Risk Identification or Risk Reduction processes—is of greater importance? Which parameter is most important in this binary data decision-making is determined by the opinion of experts. Then, when evaluating for country A, the sub-components of the main parameter are looked at. If country A has existing projects, strategies and policies covering the relevant parameter, all these are used in the success evaluation of country A. In this evaluation, a scoring technique was used for the final success classification of the countries examined. In this study, New Zealand ranks third in this score due to the availability of DRR plans, while Philipins is ranked fourth in the country ranking due to the presence of projects and strategies based on these plans, as well as DRR plans, being considerably less than other nations.

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