J. Basic. Appl. Sci. Res., 3(8)801-807, 2013

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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Zonation the Risk of Occurring Natural Disasters in the Province of Golestan by Emphasizing on Flood

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ABSTRACT

The goal of this study is to zonate of the flood occurrence in Golestan province and determining the number of residents in risk areas including village and urban population. Annual instantaneous peak data of hydrometer stations during, 1986-2009 is used to study floods in province Golestan.The potential flood coefficient of the 25-year recurrence interval of annual instantaneous peak Flow for each station was calculated by applying Hager Equation. The results indicated that PasPoshte station in Minoodasht Township and Bandar Torkman station had the highest and lowest potential flood coefficients of 3.6 and 0.36, respectively. According to these results, Golestan province is divided into four categories including very high, high, medium, and low risk of flood. As a result, 20.5%, 20.7%, 39.6% and 19.3%of the province are located in the areas of very high, high, medium and low risk of flood, respectively. Moreover, 18.6%, 14.5%, 11.9% and 6.6% of the village population live in zones of very high, high, medium and low risk of flood, respectively. On the other hand, 9.9%, 10.2%, 18.9% and 9.1% of the urban population reside in the areas of very high, high, medium and low risk of flood, respectively.
KEYWORDS: Zonation, Natural hazards, potential flood Coefficient, Flood, Golestan province

1. INTRODUCTION

The natural phenomena that formed the current feature of the Earth are known as hazards since they confront human beings with life and financial losses. Population growth and consequently increasing of demands led the Earth to face limitations in providing services. In addition human for providing his needs used some sites which were the origin of these phonemona. This caused to every year conflict of human with several types of natural phenomena called natural hazards or disasters. The main consequences of human encroachment in these phenomena are economic, social and life losses. Most of academic communities discuss the environmental processes which are as the hostile factor for human life and somehow are controllable; define as environmental hazards (Bryant, 2005: 1)

Smith and Petley (2008) state that: the risk is the process or event that potentiality does loss and the risk probability means human or their invaluable appurtenance confrontation with risk which is mostly considered as a combination of probability and loss. Fritz (1961) defines risk as "an event which occurs in time and place and effect on part of the society which results in some environmental and human beings' damages by itself. The impacts might be physical-monetary or social-organizational"(Crumb, 2006: 13).

The annually economic costs of natural hazards have been estimated as 10 to 50 billion dollars and even in some years, it has been over 450 billion dollars (Sadough, 2005: 25). According to the United Nations' reports, 35% of devastating earthquakes, 25% of destructive floods and fierce storms and 43 % of volcanoes occurred in Asia. It is even estimated that annually 300 hazard happen which lead to 250000 people's death and directly influence more than 200 million ones (Ramezanzadeh, 2008: 16). In this regard, Iran, with 31 recorded cases of 40 types of natural disasters in the world and 6% casualties is known of as one of the vulnerable countries (Biroudiyan, 2006: 15).

Natural disasters caused by water challenge human societies in two forms of flood and drought. Floods are one of the most threatening hazards for human societies so that their damages have increased as a result of huge floods within the last 50 years. This hazard might cause thousands of people to die, demolish of properties, disturbance of the communication systems and washing out the farms. Among 5 sources of natural disasters, usually one is the flood (Ramezanzadeh, 2008).

Smith and Ward (1998) define the river flooding as a high flow of water descending from the natural or artificial dams of a stream.

Ghayour (1996) describes flood as the partially high rising of water in a river or stream which is relative and is mainly measured in relation to the usual or normal system.

Flood causes the most prevailing and costly natural disasters. Moreover, it made an impact on the society beyond the costs and facilities including family and society disturbance, disorder, damages and unemployment.

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On the other hand, among the natural disasters, flood encompasses both merits and demerits (Smith & Ward, 1998). Floods usually entail pervasive impact since the rivers are considered as the focus of population density and development. The natural rivers make the sea, the water and watering, the potential supply of drinking water, the power source and fertile land to be easily accessible. They also play a primary and secondary role in drainage the lands and garbage disposal, respectively. 41% Of the total floods occurred within the period of 1900-2006 in Asian countries, i.e. Asia has maximum of flood in the world. Table 1 presents 10 most devastating, fatal floods.

Table 1: 10 fatal floods in human history (Source, Ramezanzadeh, 2008)

Number of victims	place	year	Number of victims	place	year
10000	China	1920	400000	Hong Kong	2012
30000	Japan	1768	90000	Hunan	1888
30000	Venezuela	1999	50000	Bangladesh	1970
10000	Japan	1828	30000	China	1642
5000	China, Manchuria	1951	10000	Yangtze	1911

Among some studies conducted with regard to hazard, we can refer to the following ones:

Ramezani (2004) identified the natural and man-made hazards such as landslide, stone falling and floods threatening New Masouleh by documentary studies and Meteorological and hydrological statistics. The results of this study demonstrated that the flood risk, stone falling, and landslide threaten the north and inside the town, mountainsides, and southern mountainsides of this area, respectively

Jabari (2008) examined Iran´s floods risk zoning of and determined the areas with changing patterns of floods. The findings showed that with regard to the losses resulting from the flood, Fars and Golestan province are highly risky areas followed by Kermanshah. Moreover, a significant relationship was observed between increasing of the flood intensity and irregular floods in Golestan province.

Lotfi and Jafari (2011) pointed to the practical immunization model in order to decrease the losses of flood in Tehran and used managerial (software) and operational (hardware) actions to immunize Tehran. In this regard, they also put forth some suggestions.

Camorani et al. (2005) investigated the influence of changing the vegetation on Po river flood in Italy. The findings indicated that changes in vegetation resulting from strong rainfalls have more impacts on the floods in the basin leading to Belonia, Italy.

Nandalal and Ratnayake (2011) applied Phase method and used 100-year recurrence interval of Kalu-Ganga River in Serilanka to evaluate the risk levels of flood. The findings showed that for this basin, Phase method provides more precise results than the other ones.

The study area

Golestan province is located in north-east of Iran, between 53°51' to 56°19' of east longitude and 36°30' to 38°8' of north latitude with an area of 20437.7 which consisted 1/3% of Iran area. This province has climate diversity so that northern area has cold climate with low rainfall, western area has wet and mild climate, central part has semi-wet and mild climate and southern area has semi-cold climate with low rainfall (Montazeri & Bay, 2012). It´s population is about 1615224 which 48.3% live in urban areas and the others 51.7% live in village areas. With regard to economic issues, the pivotal activities are farming and ranching (Noormohamadi, 2008: 3). Fig 1 illustrates many village constructed on the way of the rivers especially in high areas with much stronger flood flows. Taking this into account, each year flood wastes huge amount of wealth mainly in farming and ranching sectors of these area. So that according to the recorded data of the assistance of rescue and aid of the country Red Crescent, Golestan is considered among the three top provinces regarding natural and man-made disasters (Gholami et al, 2011). For example, nearly 300 people of the province residents and passengers lost their life due to flood in 2001 (Hosseinzadeh, Toroghi, 2006).

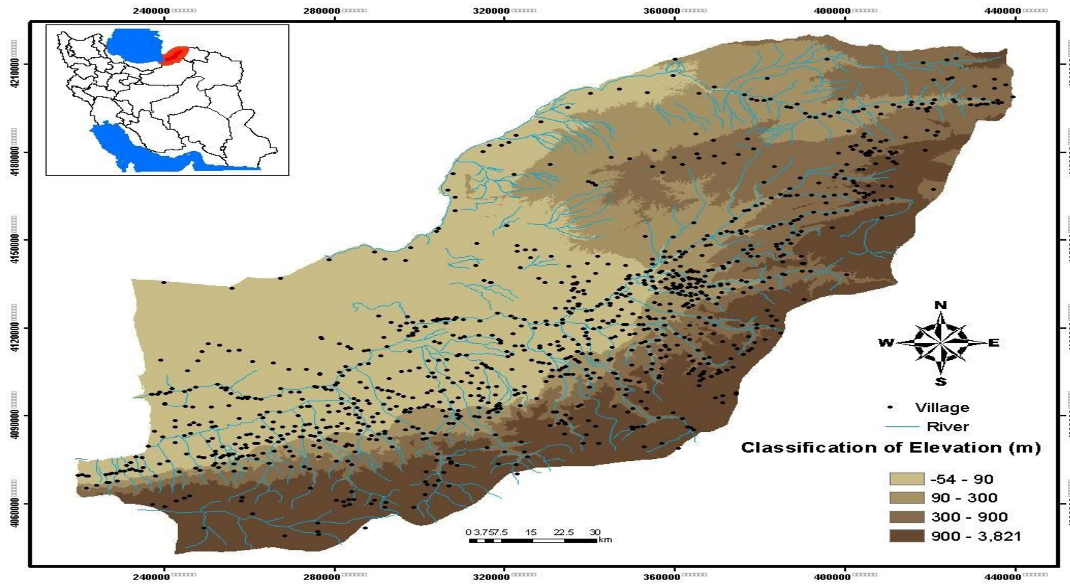

Fig 1. Geographical location of Golestan province and its village

METHODOLOGY

In this study the floods of Golestan province is investigated by the annual instantaneous maximum Flow data of the hydrometric stations of Ministry of Power within 1986-2009 (see Fig 2).

The aims of the study:

The following aims are addressed in this study:

1. Providing a zoning map of the risk of flood
2. Identifying the township located in each risky zone
3. Determining both urban and village population in each risky zone

For providing the zoning map of the flood risk, first:

- The hydro stations were selected within the statistical period (1986-2009) (see Fig 2 and Table 2)
- Then, the best statistical distribution was selected for each area through applying the fit-goodness test. The results indicated that Log Pearson distribution type 3 was the best statistical distribution in most stations.
- After determining the best statistical distribution, potential flood coefficient of the annual instantaneous maximum Flow data for 25-year recurrence interval was determined for each station. To this end, Hager's Equation was applied (Equation 1).

Equation 1
$$K_T = 10^* \left(1 - \frac{\text{Log (Qt)} - 6}{\text{Log (A)} - 8}\right)$$

In this Formulas, $K_{T,}$ Q_T, T and A stand for potential flood coefficient, Flow, recurrence interval and year, respectively.

The potential flood coefficient is indeed a factor which eliminates the influence of the basin area on Flow Peak rising. Hence, this coefficient makes it possible to compare the potential flood of hydrometric stations (Hager, 1988: 1996).

- Finally, Krijing geo statistical method of the interpolation and the potential flood coefficient for the hydrometric stations was used to provide the zoning map for the flood risk.

Krijing is the best linear unbiased estimator based on weighty, moving average logic (Hassani Pak, 1998: 1810). The methodology of Krijing model embodies covering the experimental area. In other words, it is local (not public) and is more intended to offer much better local products than its neighbor observations (Beers & Klijnen, 2004: 113). In this methodology, a specific weight is considered for each inside and outside stations of the zone according to its distance and location so that the estimated variance is minimized. Accordingly, for each estimated value, a validity range can be calculated. The Krijing estimator is defined as a weighty, mobile average as follows:

$$z_v^* = \sum_{i=1}^{n} \lambda_i z_{vi}$$

Equation 2

in which z_v^*, λ_i and z_{vi} stand for the estimated value, weight or importance of the qauntity dependent on ith sample, and ith sample size (Hassani Pak, 1998: 182). According to Krig K. J. (cited in Ghohrudi, 2002: 97) the Krijing estimator is one of the most significant linear unbiased estimators since first it has no systematic error and second its estimation variance is minimum. In Kring method, it is assumed that spatial changes of the phenomena such as rain within one range has random distribution and encompasses three factors: spatial correlation, trend and random error. The presence or absence and the type of each factor have resulted in several Krijing methodologies. The spatial correlation and its value are defined based on the semi-change index. The weight coefficients of the control points for the value of unknown point can be obtained by analyzing this factor and the relevant changes.

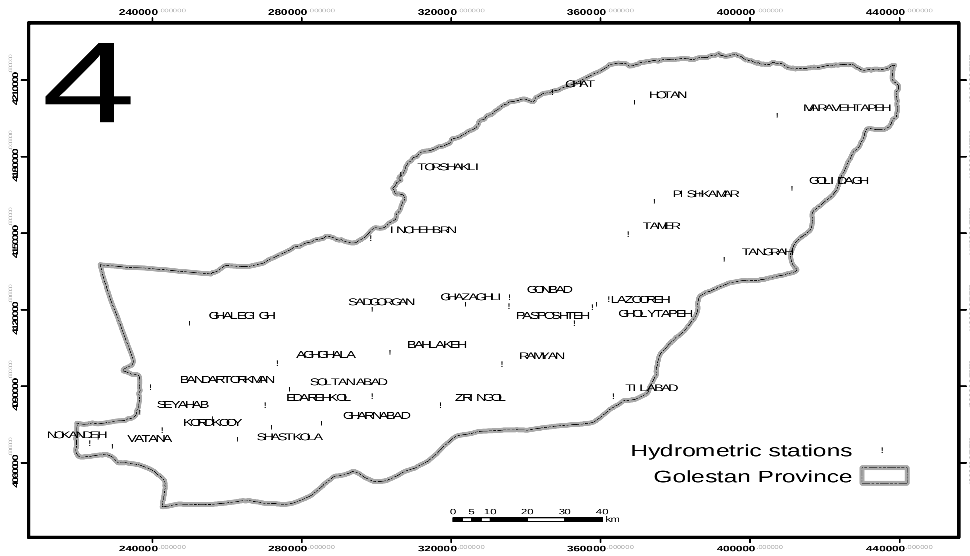

Fig 2- The position map of the hydrometric stations of Golestan province

RESULTS

Statistical analysis

After calculating the potentil flood coefficient for 25-year recurrence interval of the province (Table 2), the average potentil flood was 1.67. As Table 2 illustrates, PasPoshte station in Minoo Dasht and Bandar Torkman station have the maximum and minimum flood potentiality of 3.6 and 0.36, respectively.

Table 2- The hydrometric stations in Golestan province and their 25-year potential flood coefficients

elevation	index of flood incidents	Station name	elevation	index of flood incidents	Station name
180	3.6	Pasposhte	100	1.42	Yasaghi
190	3.42	lazore	20	1.41	Salin tapr
50	3.34	khanjarakhond	287	1.35	Karim ishan
200	3.2	Ramian	250	1.32	Ghale hasan
280	2.94	Zaringol	12-	1.25	Agh ghala
350	2.86	Tange gol	600	1.25	Marave tape
187	2.84	Ali abad	6	1.083	Kordkuy
40	2.76	Arazkose	155	1.039	Hottan
250	2.66	Galikesh	940	1.01	Golidagh
40	2.5	Gonbad Ghabos	12	1	Soltanabad
210	2.211	Fazelabad	23-	0.81	Gomishan
130	92.15	Tamar	150	0.77	Mazrae nemone
30	2.15	Ghezghli	25-	0.76	Siah ab
250	1.98	Gharn abad	22-	0.69	Ghale jigh
24	1.96	Bailakedashli	150	0.62	Shast kolah
230	1.95	Pishkamar	30	0.54	Jafakande
75	1.87	Gorgan	1	0.46	Nokande
80	1.71	Chat	100	0.45	Vatan
976	1.53	Til abad	0	0.39	Inchboron
25	1.49	Torshakli	20-	0.36	Bandartorkaman
12	1.43	Sad gorgan			

Spatial analysis

The Krijing method used for interpolation of the flood coefficients that estimated by Hager formulas for hydrometric station of Golestan province. Thus, at first normal spatial distribution of data of point were tested. Then potentil flood of Golestan province was divided into four categories by Krijing estimator that includes very high, high, medium, and low risk.

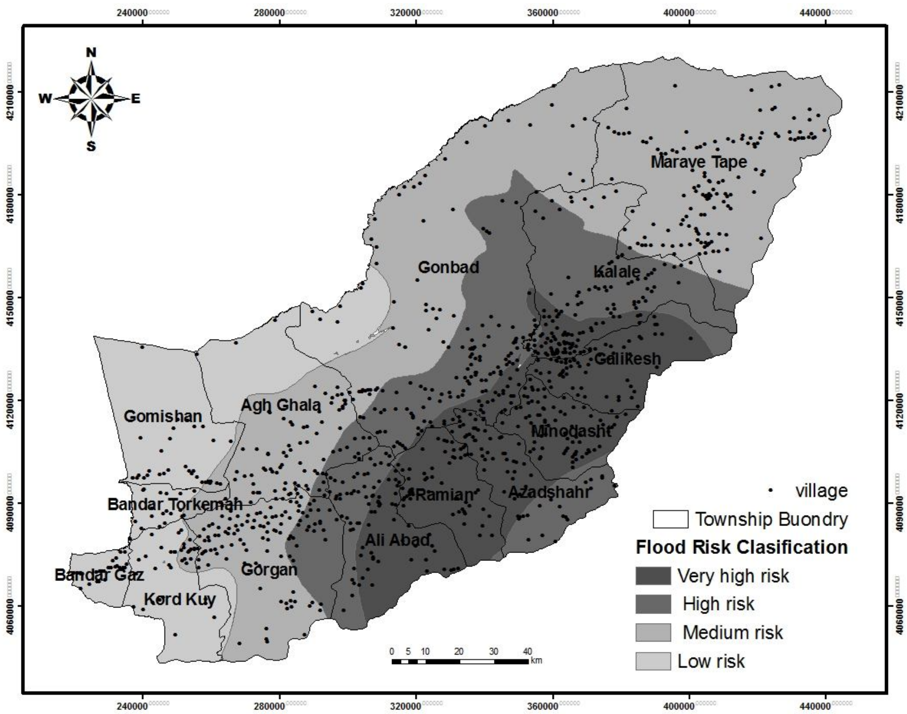

Fig 3- zoning map for the risk of flood occurrence in Golestan province

As Table 3 demonstrates, 20.5% of province of 410.2, 20.7% of province of 4227.6km, 39.6% of province of 8085.2 and 19.3% of province of 3934.2 are located in the zones of very high, high**,** Medium and low flood risk, respectively. In addition, Table 4 illustrates the area, the percentages area and the risk of flood for each city of Golestan province.

Table 3- The area of risky zones for flood occurrence

Table 3: the area of risky categories for flood occurrence

Relative area(percent)	Area(square kilometers)	Risk category
20.5	4180.21	Very high risk category
20.7	4227.6	High risk Category
36.9	8085.2	Medium risk Category
19.3	3934.2	Low risk Category

Table 4- the area and its percentage of the risk of flood occurrence for each city of Golestan province

Relative area (percent)	Area (km)	flood potentiality risk	township	Relative area (percent)	Area (km)	flood potentiality risk	township
49.7	4180.2	Very high risk	Azadshahr	49.7	4180.2	Very high risk	Galikesh
49.7	4180.2	Very high risk	Azadshahr	50.3	4227.6	High risk	Galikesh
50.3	4227.6	High risk	Azadshahr	24.2	3934.2	Low risk	Gorgan
50.3	4227.6	High risk	Azadshahr	26	4227.6	High risk	Gorgan
24.2	3934.2	Low risk	Ag Ghala	49.8	8085.2	medium risk	Gorgan
26	4227.6	High risk	Ag Ghala	32.7	3934.2	Low risk	Gomishan
49.8	8085.2	medium risk	Ag Ghala	32.7	3934.2	Low risk	Gomishan
32.7	3934.2	Low risk	Bandar Torkeman	67.3	8085.2	medium risk	Gomishan
67.3	8085.2	medium risk	Bandar Torkeman	67.3	8085.2	medium risk	Gomishan

100	3934.2	Low risk	Bandar Gaz	19.3	3934.2	Low risk	Gonbad
100	4180.2	Very high risk	Ramian	20.5	4180.2	Very high risk	Gonbad
34.3	4227.6	High risk	Ali Abad	20.7	4227.6	High risk	Gonbad
34.3	4227.6	High risk	Ali Abad	39.6	8085.2	medium risk	Gonbad
65.7	8085.2	medium risk	Ali Abad	34.3	4227.6	High risk	Maravetape
65.7	8085.2	medium risk	Ali Abad	34.3	4227.6	High risk	Maravetape
32.7	3934.2	Low risk	Kordkuy	65.7	8085.2	medium risk	Maravetape
32.7	3934.2	Low risk	Kordkuy	65.7	8085.2	medium risk	Maravetape
67.3	8085.2	medium risk	Kordkuy	49.7	4180.2	Very high risk	Minudasht
67.3	8085.2	medium risk	Kordkuy	49.7	4180.2	Very high risk	Minudasht
25.3	4180.2	Very high risk	Kalale	50.3	4227.6	High risk	Minudasht
25.6	4227.6	High risk	Kalale	50.3	4227.6	High risk	Minudasht
49	8085.2	medium risk	Kalale				

As Table 5 indicates, 18.6% (300431 people), 14.5% (192303 people), 11.9% (235005 people) and 6.6% (106904) of the village population live in zones of very high, high, medium and low risk of flood occurrence, respectively. Moreover, 9.9% (160717), 10.2% (166273), 18.9% (306467) and 9.1% (147144) of the urban population reside in the zones of very high, high, medium and low risk of flood occurrence, respectively.

Table 5- Population distribution in different risky zones for flood occurrence

Urban population (Percent)	Urban population (number)	Rural population (Percent)	Rural population (number)	
9.9	160717	18.6	300431	Very high risk
10.2	166273	14.5	192303	High risk
18.9	306467	11.9	235005	medium risk
9.1	147144	6.6	106904	Low risk
48.3	780601	51.7	834643	sum

CONCLUSION

More than half of the province population lives in the area with very high and high risk of flood. As most of damaged people were from village zones and their key activities are farming and ranching (The researcher's observations) (Fig 4), some steps should be taken to decrease the losses resulting from the flood by taking environmental potentials , strengths and weaknesses of each city into consideration. Among these, regional planning seems to be of beneficial contribution. The regional planning should be based on village and urban, basic and realistic plans and this will not happen unless they are identified both precisely and comprehensively and the planners consider this necessity in each and every aspect and stage of regional planning; in other words, the cities and village characteristics and specialties and even the immigrants of each area are the underlying basis for planning. Taking these points into account would guarantee the future success of the regional planning (Dalir, 2005: 108).

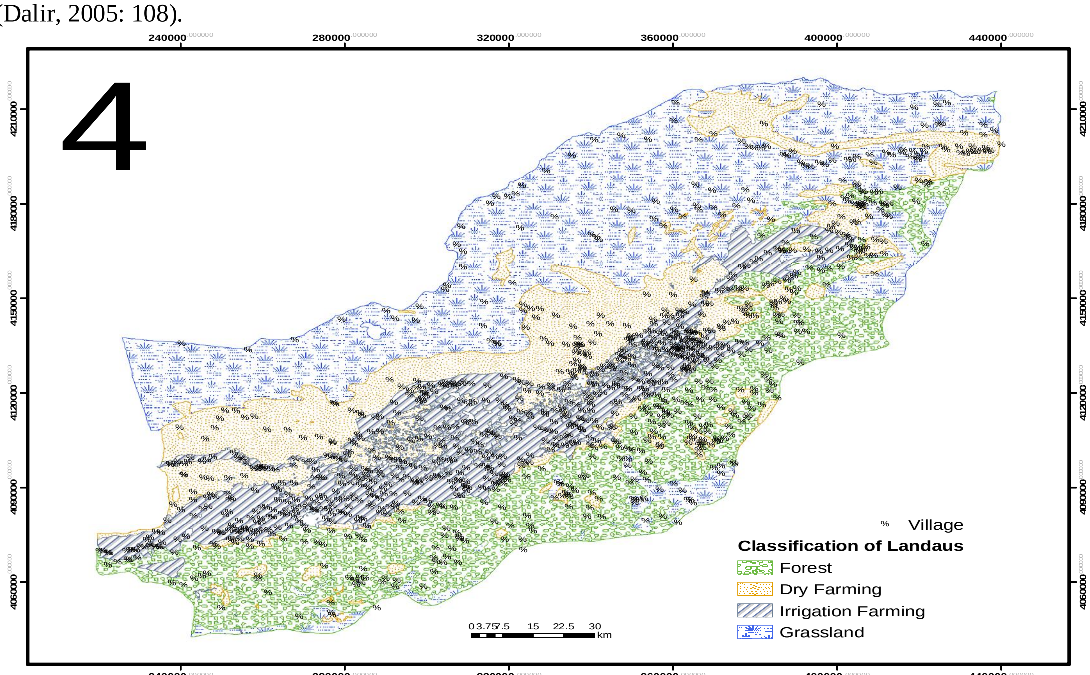

Fig 4- The village distribution map and the plant covering of Golestan province

Suggestions

1. To make the farmers, ranchers and village population understood the usefulness of the expert's suggestions
2. Changing the pathways on the way of the bank or estuary of the torrential rivers
3. Displacing the village on the bank or estuary of the torrential rivers
4. Using traditional methods (fencing, revetment) in addition to modern methods (dam building, river widening) to decrease the flood damages
5. Designing flood management methods (traditional and modern methods) so that general needs are taken into account
6. Supporting the farmers and ranchers such as providing them with insurance for their farming and ranching products
7. Applying flood warning systems, enhancing the substructures and improving the roads and bridges: the most influential method for decreasing the monetary damages and losses is a warning system and reaction to the flood, particularly when construction without any previous planning is done in areas with potential flood or some parts of the society are more vulnerable to the flood.

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