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Landuse and Community-based Assessment of 2014 Flood Damages in Tehsil Phalia, Punjab

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Abstract: In this study the response and feedback from the flood-hit community of Phalia (Mandi Bahauddin) obtained through local interviews and filling of questionnaires have been analyzed. Secondary data were obtained from Pakistan meteorological and local revenue departments were also statistically analyzed. Several types of damages including houses, crops, diseases, economic loss, and livestock have been considered. Pre- and Post-flood changes in the landuse, by high resolution satellite data (Landsat 8 OLI) delineated coverage of inundation of 186.85 km^2 area. It has been demonstrated that Phalia tehsil was severely damaged in 2014 rainfall induced flood in Chenab river which left lasting impacts on the socio-economic lives of local communities. The major damages experienced by the people of the study area included; house damages, crop damages, diseases, economic losses and livestock damages. It is necessary that government revises the flood prevention policies based on the community response to mitigate the disaster.

Keywords: Socio-economic impact, damage assessment, flood 2014, Landsat 8 OLI.

Introduction

World is facing natural disaster as a common phenomenon nowadays. Every disaster has its unusual nature of influence that depends on the strength and capacity of areas (Pielk and Downton, 2000). The heavy monsoon rainfall is the most significant factor causing floods in south Asian countries, particularly in Pakistan and India (Monirul and Mirza, 2011). This region received 80% rainfall throughout monsoon spell. Severe floods that have occurred in history were because of climate change (Bouwer, 2007). While, the occurrence and volume of floods would increase in future, as the continuous change is occurring in climate and economic sector (UNISDR, 2011; IPCC, 2012; Visser, 2014). It has two main types of floods, namely flash and riverine (Atta, 2010). The riverine flood, mostly occurs due to glacier melting as well as extreme rainfall events in mountainous region, but it allows adequate time to happen (Chang, 2009). Extreme weather events are responsible for originating flash flood with less duration and intense impact. These floods usually originated during monsoonal spell (July to September) in the south Asian countries (Sardar et al., 2008). Floods have severe damaging impact in the south Asian region, resulting in loss of livelihood and lives, considerable damage to property, loss of infrastructure, damaging the agriculture land and crops during the most recent 30 years (Jha et al., 2011). Presently, it is very much acceptable decision that increasing floods are because of environmental change (Bouwer et al., 2010). Pakistan is among the most flood events experienced country since 1973 during monsoon period from late July to late September. Severe floods occurred in the years of 1955, 1973, 1976, 1980,1988, 1992, 2010, 2011, 2012 and late 2014 (Malik, 2011). About 41 million individuals had been influenced by these ten significant floods (Mehboob et al., 2015). The Damage Needs Assessment (DNA) across the nation recorded as $9.7 billion worth of damaged homes, agricultural land and infrastructure, in which reconstruction costs also included for energy, water system, communication, sanitation, transport, health, irrigation, social defence, and public administration services (ADB, 2015). The government of Pakistan declared the 2010 flood as a super flood (Haq, 2010; Atif et al., 2015). The northern area of Pakistan received ample monsoonal rainfall in the early September 2014 that caused the flood in the catchment area of Pakistan's eastern rivers Jhelum, Chenab, Ravi, Sutlej and causing flash flood in Azad Jammu and Kashmir (AJ&K), Gilgit-Baltistan and Punjab. The flood killed 367 individuals, influenced more than 2500 thousand people and damaged 129.88 million houses. About 250 million farmers and more than 404686 hectares of cultivated land was affected by flood. While, in non-agricultural sectors, many small manufacturing enterprises, businesses and daily wage workers were also affected because of disturbance of the economy (GOP, 2014). Thus, strengthening the capacity of people against the flood has become important, specifically in under developing countries like Pakistan (Kirsch et al., 2012; Few, 2003).

South Asia region faces the high risk of flood occurrence and volume due to continuous climatic and man-made changes. Measures adopted by government are insufficient to address protection from the increasing risk of floods in these countries (Mustafa, 2015). Various strategies are adopted to protect both humans and infrastructure on permanent basis. In past flood mapping based on field survey and climatic observations were common but these old methods are time taking and costly because it is difficult to take more climatic observations timely in worse weather conditions (Abubakr, 2013; Danee, 2015). The best alternate method is the use of GIS/RS technology for the flood monitoring and risk assessment (Felix, 2013).

The proposed research is an attempt to apply GIS and RS techniques on flood hazard mapping and assessing the impacts of floods. The high resolution of Landsat 8OLI images and Global Positioning System (GPS) survey data were used in this study, which played a significant role in monitoring the flood 2014 and examine the influence of flood on socio-economic lives of people in Phalia tehsil of Punjab Pakistan.

Study Area

Phalia is a tehsil of Mandi Bahauddin district located between the rivers Jhelum and Chenab at 73°35'0" east longitude; 32°26'0" north latitude. It lies 205 meters above the sea level and covers the total area of 1137 sq. km. The total population of Phalia tehsil is 553,416 persons. It consists of 21 union councils sand four towns of (Phalia Ameer, Phalia Keenan, Phalia Bogotá and Phalia Mehman (TMA, 2014). It is an agricultural land with citrus fruits, wheat, sugarcane and rice as the major cash crops. The climate is moderate with average highest temperature 45°C in summer and average lowest temperature below 5°C in winter. Average rainfall is 50 mm in the tehsil, which is considered as an active flood plain and has experienced server flood in last ten years. Qadirabad and adjacent villages were under flood due to over flow of Chenab river (PMD, 2014) and it badly affected the Phalia tehsil with nearly 122 to 152 centimeters standing water.

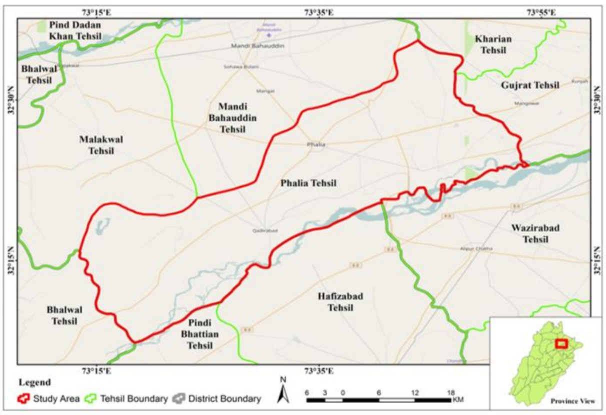

Fig. 1 Location of study area (Phalia tehsil).

Materials and Methods

Data Collection

A survey was carried out to complete 300 questionnaires to collect primary data regarding community perceptions about flood risk, causes and consequence of flood on socio-economic lives of people (Fig. 2). Flood related secondary data were collected from different relevant departments such as mean monthly data of rainfall and temperature were obtained from Pakistan Meteorological Department Lahore (PMD) whereas, data related to socio-economic losses were obtained from the district revenue office and Punjab disaster management authority.

Table 1 Information about Landsat data.

Data of images	Satellite / Sensor	Resolution	Reference system / Path / Row
25-Aug-14 7-Sep-14	Landsat 8 OLI	30 meters	WRS/149/38

Two Landsat 8 OLI images were downloaded from USGS website in 2014 (Table 1). GIS/RS base technique was used for monitoring the extent of flood. Regression model was applied to show the relationship between flood causes and related damages by using SPSS and preparing graphs on Microsoft Excel (Fig. 3).

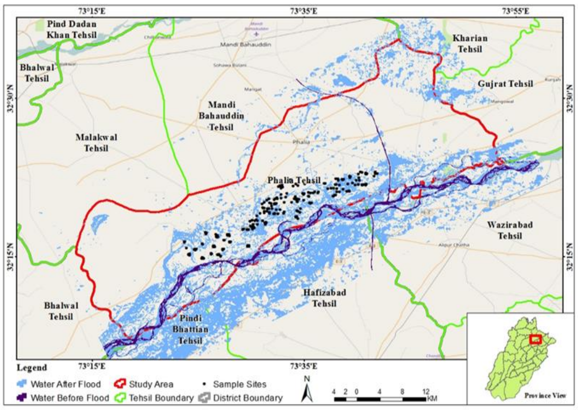

Fig. 2 Locations of sampling sites.

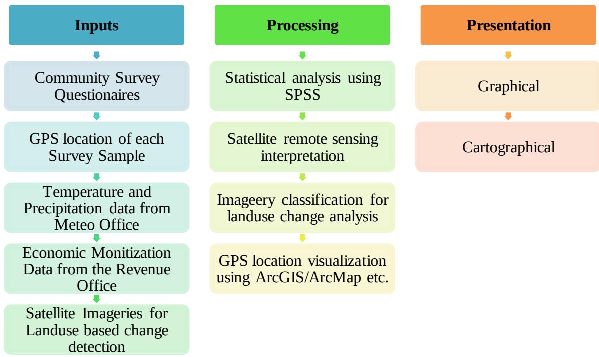

Fig. 3 Methodological framework.

Results and Discussion

Causes and Extent of 2014 Flood

Mandi Bahauddin has the semi-arid climate with hot summer period of April to September. The average minimum and maximum temperatures of hottest months (May, June and July) are 23°C, 35°C and 40°C, respectively. Likewise, maximum precipitation ($2/3^{rd}$ rainfall) of total annual rain was during monsoon period of July to August in the area. Winter season continues between November and March. The average lowest and highest temperatures of winter are 5.5°C and 21.5°C respectively (Fig. 4). In 2014, Mandi Bahauddin district experienced the unusual rainfall with 176.9, 186.9 and 234 millimeters in July, August and September, respectively (Fig. 5). Heavy rainfall in different districts of Punjab such as Mandi Bahauddin, Hafizabad, Gujrat and Gujranwala badly affected many settlements and forced people for migration.

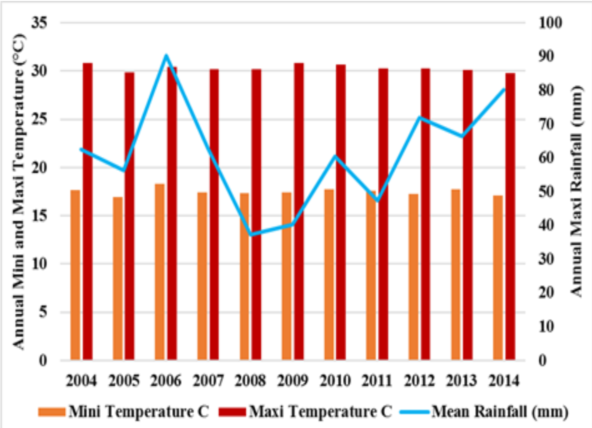

Fig. 4 Trend of mean annual temperature and rainfall 2004-2014 (PMD, 2014).

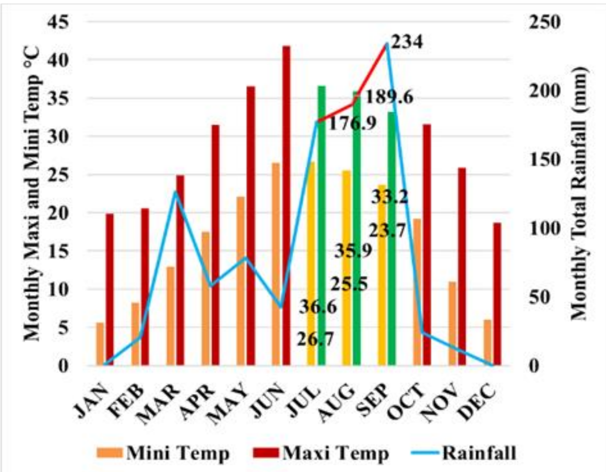

Fig. 5 Monthly mean temperature (°C) and mean rainfall (mm) in 2014, highlighting the monsoonal period.

The extreme rainfall experienced during monsoon period is the main cause of flood in the northern Pakistan (Webster, 2011). The survey result shows a common perception in the area that unusual and heavy rainfall and poor infrastructures are the main cause of flood in Phalia area. About 60% respondents considered heavy and unexpected rainfall a cause of flood in the area. While, 35% believed that heavy rainfall and poor drainage system are the main factors for flood and 5% considered the poor drainage system as a cause of flood.

Landsat 8 OLI images have been used to see the area covered by flood 2014. Figure 6 shows the original and normal flow of river Chenab passing from the southern border of tehsil Phalia, district Mandi Bahauddin. The flood water covered almost half of the district but Tehsil Phalia covered more area with 223.60 sq. km as compared to other two tehsils (Fig. 8).

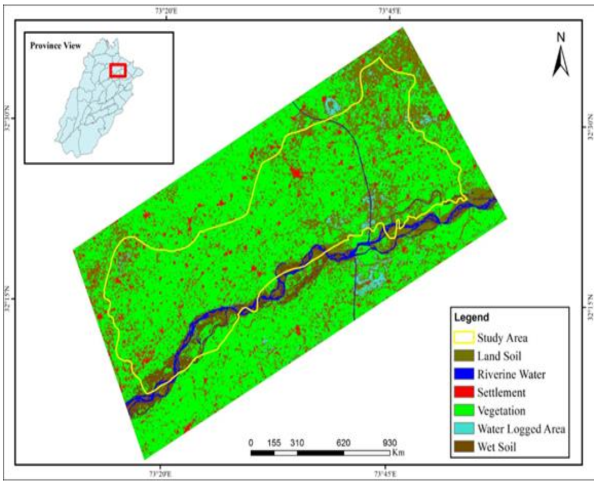

Fig. 6 River channel before flood 2014 in study area.

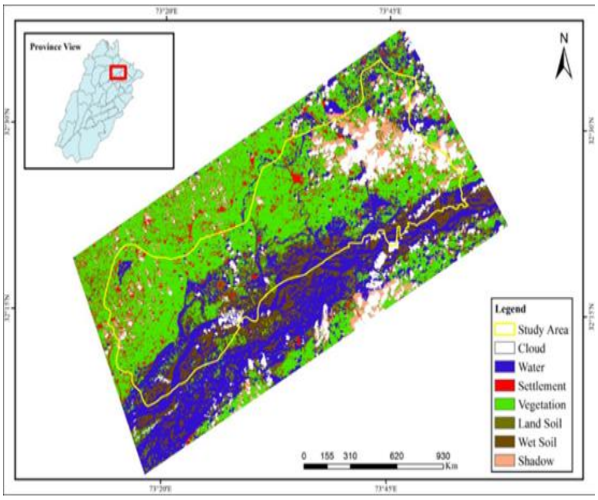

Fig. 7 River flow after flood 2014 in study area.

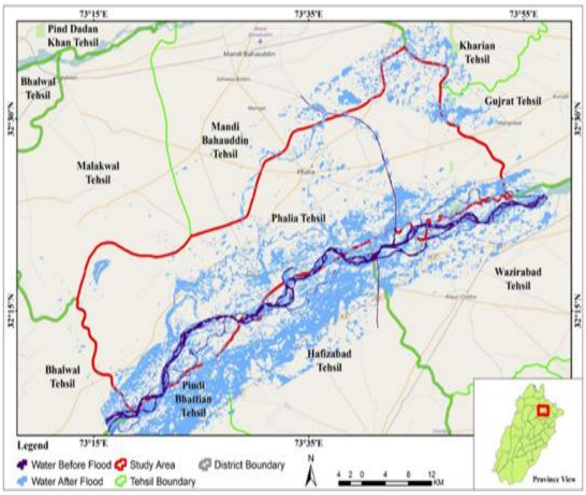

Fig. 8 River flow before and after flood 2014.

The area covered by land soil was 21% before flood in the study area, but after flood it was reduced to

10%. More than half of the area of soil was affected by flood water. The area covered by water was 3% before the flood and after the flood it increased to 10%. The settlements were in the 6% of the area, but after flood these were reduced to 5%. Moreover, the area of wet soil increased to 9% from 3% after the flood. The vegetation cover was reduced by 41% to 67% in post flood period (Table 2, Fig. 9).

Table 2. Changes in the area before and after flood 2014.

Before Flood		After Flood		
Class	Area(Km^2)	Class	Area (Km^2)	Change (after-before)
Land Soil	241.63	Land Soil	110.48	-131.15
Water	36.75	Water	223.60	186.84
Settlements	63.34	Settlements	62.43	-0.91
Wet Soil	37.83	Wet Soil	100.99	63.16
Vegetation	762.66	Vegetation	468.22	-294.44
Cloud/ Shadow	0	Cloud/ Shadow	176.50	
Total	1142.21		1142.21	

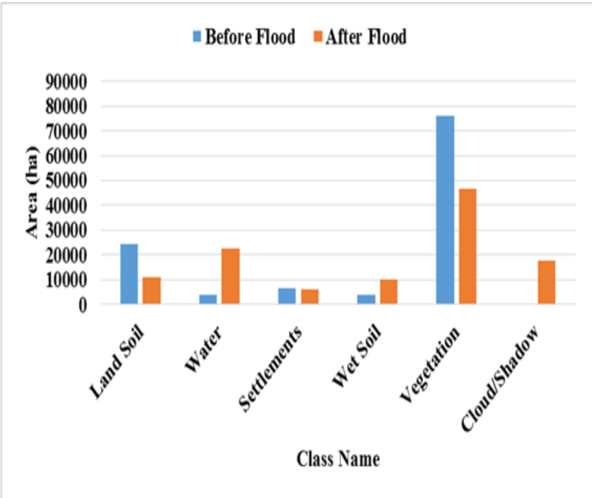

Fig. 9 Classification of land before and after flood.

Mostly three type of houses were found in the study area in which 7% of the respondents have katcha house and 69% have pucca house type, while 24% own semi-pucca house types. Thus, total 31% of houses made-up of katcha and semi-pucca materials are more likely to be damaged due to flood. About 44% houses remained safe, 40% were partially damaged and 17% houses were completely damaged. Almost 7809 residents were evacuated from the area during flood. The damage can be described in the form of money, as 22% households faced the damage cost of <50,000; 11% <100,000; 4% <150,000 and 19% had to spend more than 150,000 rupees, respectively (Fig. 10).

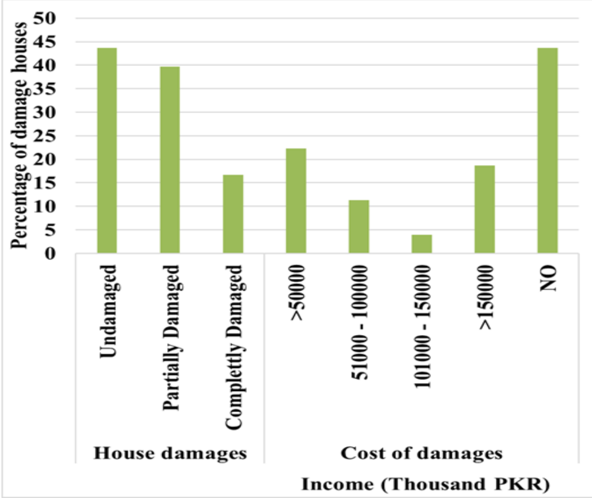

Fig. 10 Houses damaged due to flood.

Table 3 Coefficients (dependent variable: houses damaged by flood)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.237	.083		2.843	.005
	Flood causes	1.243	.053	.804	23.304	.000

Regression result showed an association between flood causes and houses damaged. The P-value .000 that is less than α (alpha) value 0.05 indicates the statistical significance between variables. Because p< α, the floods were the main causes of houses damaged in the area.

Large agricultural land about 833.67 km^2 was damaged due to 2014 flood. It has been observed that almost all the main crops (rice, sugarcane and sesame) were damaged in the area by flood water. About 11, 66% of respondents lost their main crop. While, 27% people suffered the losses of <100,000, 16% <150,000 and 23% people >150,000 rupees, respectively.

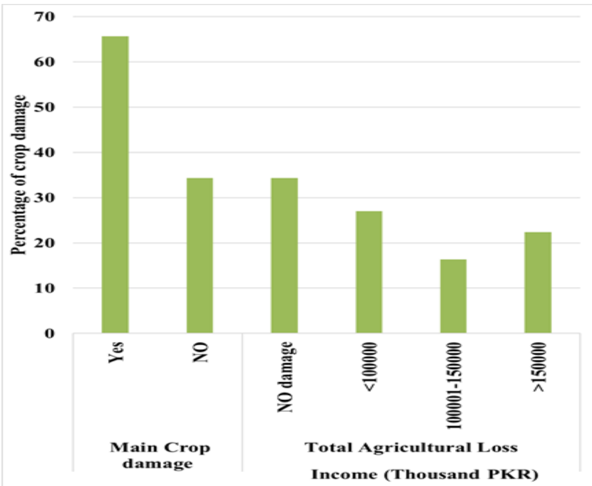

Fig. 11 Agriculture land damaged due to flood.

Table 4 Coefficients (dependent variable: agriculture loss).

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.069	.112		.616	.538
	Flood causes	1.516	.072	.775	21.171	.000

Regression result showed an association among flood causes and agricultural loss. The P-value .000 which is less than α (alpha) value 0.05 indicates the statistical significance between variables. Because, p< α, the causes of flood were a main reason to damage the agricultural land and main crop in Phalia tehsil (Table 4).

Flu and fever were the most common diseases along with the cholera and malaria among the people due to flood. About 23% of people suffered from cholera, 15% malaria and 62% suffered from flue and 10% had skin infections, respectively.

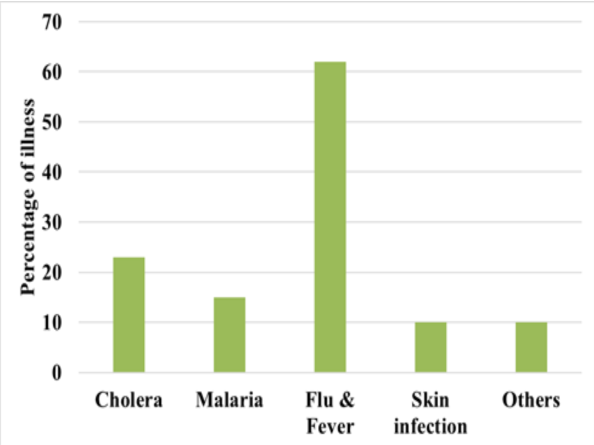

Fig. 12 Impact of flood on health.

Table 5. Coefficients[a] (Dependent variable: diseases due to flood).

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.245	.107		11.666	.000
	Flood causes	.790	.068	.557	11.590	.000

Regression results showed an association between flood causes and diseases due to flood. The P-value .000 that is less than α (alpha) value 0.05 indicates the statistical significance between variables. Because, p< α, the flood had a negative impact on the health of respondents in study area (Table 5).

It was observed that Phalia tehsil has a poor school infrastructure. The education system of the study area was affected by the flood. All the schools remained closed during the flood 2014 due to undrained flood water. Some school buildings were damaged partially or completely. About 60% schools were damaged by flood water in 2014 (Fig. 13).

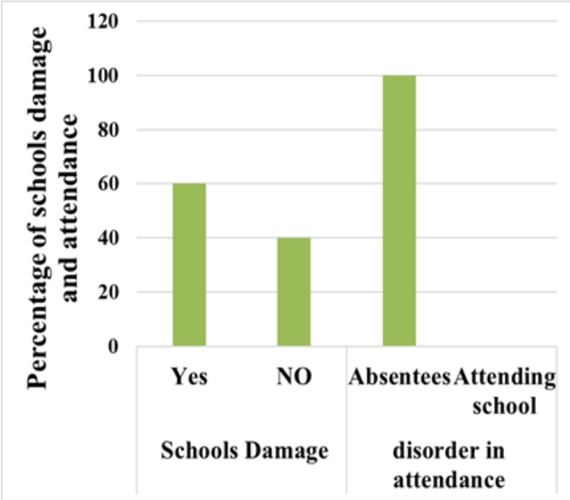

Fig. 13 Schools damaged due to flood.

Conclusion

Study concludes that flood was caused by the heavy rainfall, over flow of water from the original river channel and bursting of embankments of river Chenab. Hence, Phalia tehsil, situated near Chenab river experienced more flood effects than other areas of the whole district. Residents of the study area suffered heavy economic losses as well as from various diseases such as flu, fever, malaria and cholera etc. The medical facilities were not available in every settlement but the emergency medical camps were arranged by the government for the people. Mitigation planning is very important for future. Two preventive measures are necessary to reduce the impact of flood. Firstly, build dams and banks along the river by using flood resistant material for houses. Secondly, train the people to move out safely from the affected areas. All the governments should also revise disaster mitigation policies in the country.

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