

# Preparing International Joint Project: use of Japanese flood hazard map in Bangladesh

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**Abstract:** Both Japan and Bangladesh suffer from floods, and variety of measures have been developed in each country. In addition to the structural measures such as embankment, non-structural measures such as flood hazard map and warning system have been developed and used for evacuation effectively in Japan. However, flood hazard map is not a common measure in Bangladesh. In Bangladesh, different measures such as raising/elevating their houses with plinth, placing sand bags on the riverbank and migration are common. The major reason of this difference is because of the different flood phenomena. For example, the flood phenomena in Japan is more destructive in short term compared to the flood in Bangladesh because of the difference of the topography. In Japan, the river velocity is fast because of the steep river bed, therefore, even one hit is possible to destroy buildings and deprive of people's lives sometimes. However, flood in Bangladesh is not able to destroy buildings and deprive of people's lives in short term. Long inundation period such as a few months makes people impossible to secure food by farming and deprive of human lives by starvation. Thus, understanding the different flood phenomena is the base of starting project. However, many researchers and members in international joint projects start without noticing the different phenomena and perception toward river and flood. In addition, understanding the background of each country is also needed, since the technology for flood disaster risk reduction have been developed under the social condition of each country. Since the flood in Japan is destructive in short term, Japanese are afraid of flood, thus flood disaster risk reduction has been considerable interest for government and local people. Government has been developing measures and legislation, and local people are cooperative to the government. However, Bangladeshi are not afraid of flood itself, the flood-conveyed fertile soil is even welcome by farmers. They pay attention to the duration of flood, since it is related to the available duration of farming and securing food. Thus, government and local people in Bangladesh did not choose the way of controlling the river flow by structural measures like Japan.

In this research, river floods in Bangladesh and Japan are compared for clarifying the differences. Since social background is also important factor for developing the flood measures, it is also reviewed and compared, such as land use, population, education and disaster risk reduction system. Then the possibility of adjusting Japanese hazard map to the condition in Bangladesh are discussed.

**Keywords:** *Flood Hazard map, Technology transfer, Social background, Japan, Bangladesh*

## 1. Floods in Bangladesh and Japan

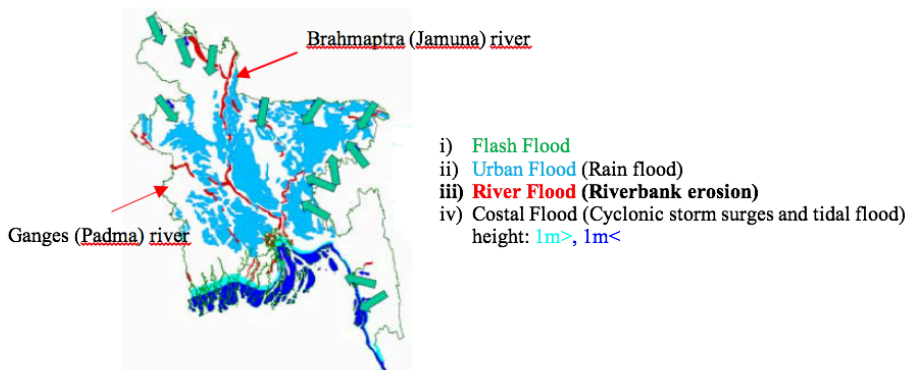
Recognizing the difference of rivers and floods in Bangladesh and Japan is the basic background for starting joint project. Therefore, rivers and floods in Bangladesh and Japan are compared first.

### 1.1. Comparison of river speed and slope

Generally, Bangladesh experiences four types of flood, i) Flash Flood, ii) Rain fed Flood, iii) River Flood, and iv) Coastal Flood (cyclonic storm surges flood and tidal flood) (Figure 1). This research focuses on iii) river flood, which are also called as river bank erosion or monsoon flood. River flood occurs along major rivers during the monsoon from June to September every year. According to the Bangladesh Water Development Board about 1,200 km of river banks are actively eroding and about 100,000 people living on the river banks are affected (Zimmermann et al. 2009).

Figure 1: Flood affected area

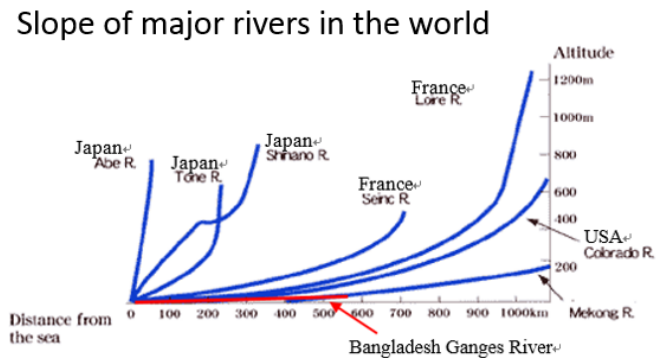
Source: arranged from (WMO/GWP 2003)



Bangladesh has the total area of 144,000 km<sup>2</sup>, and about 10,000 km<sup>2</sup> (about 7%) of the total area is covered with water. The area is 820 km from north to south and 600 km from east to west, and approximately 80% of the area is within 10 meters above mean sea level. Thus, the flood plains make up 80% of the country, and large areas are annually flooded during the monsoon season from June to September. Therefore, velocity of the major rivers in Bangladesh is slow. **Figure 2** is the comparison of the slope of major rivers in the world. For example, the Ganges river in Bangladesh runs slowly.

On the contrary rivers in Japan are very fast and shorter than rivers in Bangladesh. Topography of Japan is rugged with many mountains, gorges, rivers, lakes, marshes and a complex coastline. The island is long with high mountain ranges in the center, and rivers flow from the high mountains to coasts. The precipitation in mountains and hills are high and the distance from the mountains to coasts is short generally, therefore, the flow is rapid.

Figure. 2: Slope of major river in the world  
Source: based on (MLIT 2001)



### 1.2. Flood inundation period

Rivers in Bangladesh have gentle slope and flow slowly. Though the flood is the cause of erosion, it does not hit buildings, land and people. As a result, they are able to live in the inundated place as long as it exists (**Figure 3**), and there is enough time to prepare for evacuate / migrate. Sometimes they do not need to leave their land. However, the erosion affects large area. It deprives people of their farm land and crop resulting starvation.

Figure 3: Villagers walking flooded path (Sundarganj, Gaibandha in Aug. 2014)



On the contrary, the river flow in Japan is rapid even in dry season if it is compared to the river flow in Bangladesh. If heavy rains fall in Japan, water flows from upstream to oceans in short time, and there is high risk to hit people, buildings, and properties. This phenomenon is called “flood” in Japan. Floods in Japan are more destructive in short time. Even one hit of flood is possible to destroy embankment, buildings, etc. and take people’s lives directly. However, the flood duration is much shorter, within a several hours to a few days in most cases. Thus the flood duration in Japan and Bangladesh is different.

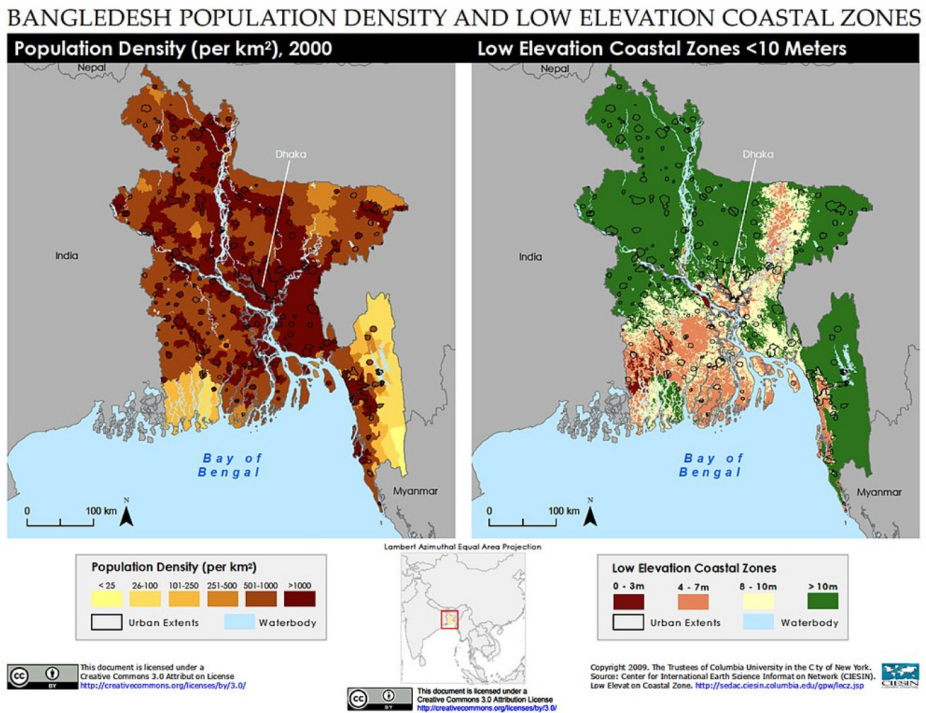
## 1. Social background

Understanding social background of each country is also important for successful joint project.

### 1.1. *Population density and land use*

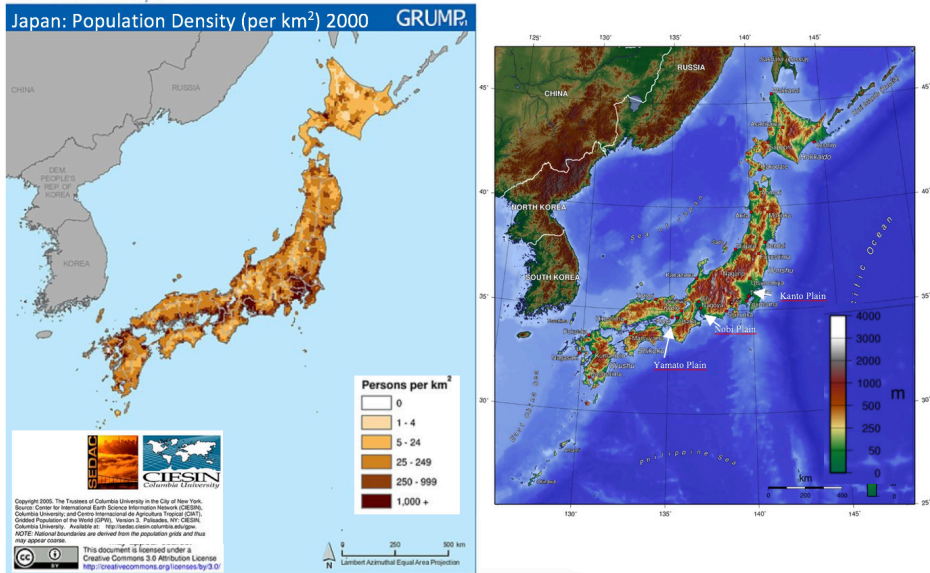
Bangladesh is densely populated country as **Figure 4** shows. Since the country is flat (**Figure 4**, right), people are able to live in and cultivate most of the area, except the south coastal area which is Shunderban Forest, a World Heritage Site, and the east area next to India and Myanmar which is hilly.

Figure. 4: Bangladesh population density (left) and low elevation topography (right) <http://sedac.ciesin.columbia.edu/downloads/maps/lec/lec-urban-rural-population-estimates-v1/bangladesh-population-density-and-lec.jpg>



Japan is partially densely populated as **Figure 5** (left) shows. This is because of the topography. About 73% of Japan's area is steep mountainous, volcanic land, and hills, which locates interior of Japan (**Figure 5** right). It is difficult to live in and around mountain ranges because of frequent mountain disasters such as landslide, debris flow, flash flood and so on, and especially it is difficult to build large cities in such steep slope areas. Therefore, less than 10% of the population live in the rural/mountainous parts.

Figure 5: Japan population density (left) and rugged topography (right)  
 Source based on: (left) <http://sedac.ciesin.columbia.edu/downloads/maps/grump-v1/grump-v1-population-density/jpndens.jpg>  
 (right) <https://www.worldofmaps.net/typo3temp/images/topographie-japan.jpg>



Scattered plains and basins among mountains cover only about 27% (Statistical Bureau, 2016). Japan has three major plains areas all in the main island. The largest is the Kanto plain with the capital Tokyo. Second is the Yamato plain with Kyoto and Osaka. Third is the Nobi plain with Nagoya. Tokyo is the largest metropolitan area in the world, and Osaka and Nagoya are the second and third-largest metropolitan areas in Japan. Throughout Japanese history, these three plains provided the greatest agricultural potential and served as the economic, political and cultural centers. Japan's population is concentrated in these three major plains and plains / basins along the south coast, and to a lesser extent the north coast. Thus, the interior of Japan, which is mountainous area, is practically depopulated (Figure 6).

Figure 6: A typical mountain village in Reihoku area, Kochi prefecture (left) and typical greater Tokyo area (right)  
<https://www.uniquejapantours.com/how-big-is-tokyo/>



Therefore, Japan's habitable and arable area is extremely limited. The habitable land, including agricultural land about 12%, is about 33% (Statistic Bureau, 2016) and more than 90% of the population live there. The interior mountainous area is difficult for people to live because of the steep slope topography and mountain disasters such as debris flow, landslide, and flash flood. Thus, because of the topography, people in Japan are forced to live in flood plain areas and Japan's urban areas is densely populated. Today, about 50% of the population and 75% of properties are located on flood plains, which is about 10% of the country (Yoshikawa 2011).

## 1.2. Population

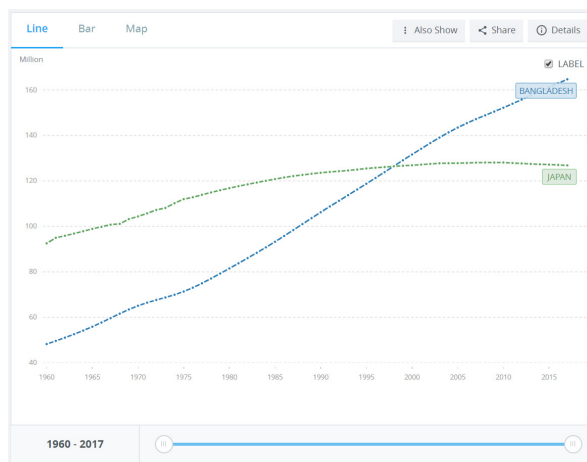
The population is increasing Bangladesh (**Figure 7**) and it makes people more difficult to survive the food shortage during floods. Food production is being disrupted by floods more frequently and more severely than before due to climate change (Douglas 2009). Climate change is expected to change the frequency, intensity, duration and magnitude of floods (IPCC 2007). It is also likely to pose problems on food supplies, because Bangladeshi are highly dependent on the monsoon farming (Shukla 2003). In addition, as the population increase, more and more people are forced to live in flood risk area. Thus, the increasing population affects the number of flood victims, and the possibility of starvation caused by flood is increased.

Japan's population steadily increased through the 20th century. Because of the rapid increase, urbanization was accelerated. Foot hill of the mountains has been also developed where people did not live because the area is moun-

tain disasters-prone area, such as landslide and flash flood. After many years of slowing population growth, the number of people who live in Japan has begun to decrease. The fall began in 2004, and it has accelerated since then (Figure 7).

Figure 7: Bangladeshi Population <164.76 million in 2017> and Japanese Population <126.79 Million in 2017>

Source: World Bank (<https://data.worldbank.org/indicator/SP.POP.TOTL?locations=BD>)



## 2. Different needs for flood disaster risk reduction

Because of the different flood phenomena in Japan and Bangladesh mentioned in section 1, and the different condition depended on the topography in Japan and Bangladesh mentioned in section 2, the major initial purpose of flood disaster risk reduction is different. However, the final purpose is the same. It is saving lives.

In Japan, avoiding destructive direct hit by flood in short term is needed for saving lives and properties.

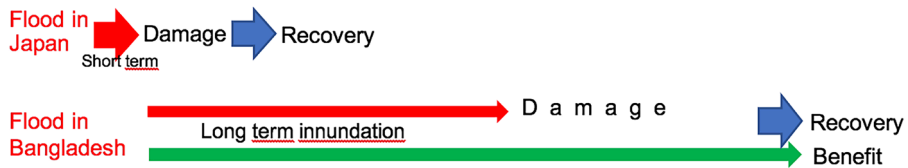
In Bangladesh, floods are not destructive and cannot deprive people's lives in short term. Though long-term inundation causes difficulty of farming and food shortage, inundation caused by flood bring following many beneficial effects:

- fertile soil
- increased growth of fisheries
- favorite condition for ecosystem



**Figure 8** is the image of comparing flood event in Japan and Bangladesh. Destructive flood in Japan gives damages on properties and human in a short term. However, flood in Bangladesh gives both damage and benefits such as fertile soil after long flood / inundation period.

**Figure 8: Flood as a short-term event in Japan and a long-term event in Bangladesh**

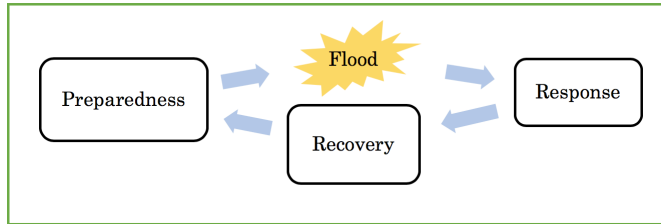


Thus, floods are even considered the benefit especially for agriculture. Since farmers rely on flood conveyed fertile soil for farming, it is not expected to control flood totally in Bangladesh. However long-lasting inundation causes the lack of available farm land and causes food shortage. Then it causes starvation. Therefore, protecting farm land from long lasting inundation is considered to secure food and to save lives.

### 3. Measures for flood in Japan

Protecting lives and properties from floods is essential for Japan to develop the country. Structural and non-structural measures have been developed for protecting lives and properties from destructive hit. Self-help, mutual-help and public-help is also common. In addition, the system of preparedness, occurrence, response, recovery have been improved (**Figure 9**). Now, integrated management for flood disaster risk reduction is common in Japan.

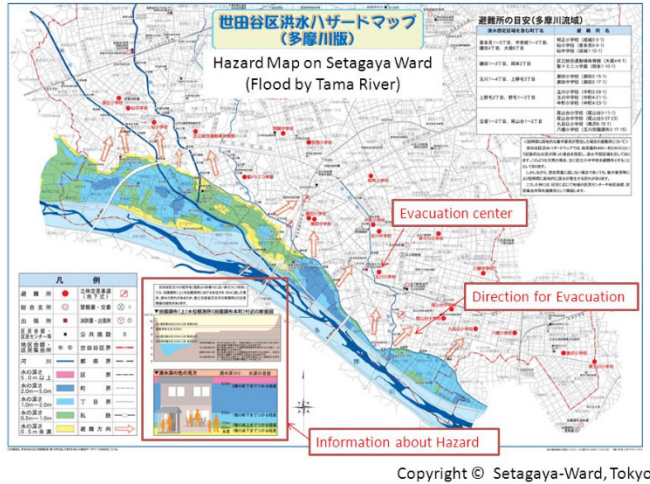
In preparedness stage, structural measures such as embankment, dams, reservoirs etc. are prepared by government, and non-structural measures such as hazard map is also prepared. People are educated how to interpret the local hazard map. During flood, central and local government provide supports, and local people receive warning issued by government through leaders of local communities. Then, people are able to evacuate following the hazard map information. In addition to the local people, external helps such as NGOs, government, volunteers are available especially for response and recovery stages.

**Figure 9:** Flood management cycle of preparedness, occurrence, response and recovery

### 3.1. Hazard map

Hazard map is effectively used under the integrated management in flood prone areas in Japan. Flood hazard map is prepared based on the provided information by central government and issued by cities, towns and villages in Japan. The local hazard map is distributed to each household. It is also able to download. It includes the information of (1) possible part of dyke break, (2) possible inundation area, and (3) evacuation route and place (**Figure 10**). This information makes local people easily prepare for the possible local flood. Since flood in Japan is destructive, in addition to structural measures for protecting people's lives and properties, non-structural measure such as evacuation is needed for securing people's lives. Today, about 50% of the population and 75% of properties are located on flood plains (Yoshikawa 2011).

Figure 10: An example of flood hazard map (Setagaya-ku, Tokyo, Japan)  
<https://slideplayer.com/slide/5815374/>



Followings are essential condition for preparing and utilizing hazard map.

- (1) Ability of including necessary information in hazard map
- (2) Ability of updating maps
- (3) Ability of interpreting hazard map by local people
- (4) Warning system

Detail of each condition is reviewed as follows.

#### 4.1.1 Ability of including necessary information in hazard map -Contents of hazard map

For preparing flood hazard map, following information is needed.

- possible range and extent of flood damage
- flood danger spot
- evacuation shelter
- evacuation route
- disaster-related public organizations (local government offices, fire stations, police, hospital etc)

Public schools and public centers are designated as evacuation shelters / centers in most cases. People are able to know the safe evacuation route for avoiding the destructive direct hit by flood. The duration of the evacuation is several days in most cases of flood in Japan. Therefore, food for surviving several days are

stocked and conveyed if people evacuate to the designated evacuation shelters / centers. Expected function of evacuation shelter is not only for accommodation, but for getting official and several supports. Since there is the system to provide food, water and some necessary items to stay for several days at shelters, Japanese local people are able to evacuate with minimum necessities.

#### *4.1.2 Ability of updating maps -Frequency of updating map*

Since flat land is limited in Japan, people have to live in limited flat but flood prone area. Flood in Japan has possibility to destroy buildings and deprive people's lives. As a result, structural measures to control the flow have been needed in Japan's rivers, such as high embankment, for protecting the people's lives, assets, infrastructure and buildings. Flood plains are protected by river levees. River levees are important infrastructures that protect our country's people and properties and to prevent such enormous economic and social loss. Japan have a great many rivers. They are short and disconnected. The river flow is controlled to flow straight and rapidly from the mountains to the nearest coast, and do not change the shape (**Figure 11**). River levee is essential for hazard map, since it keeps river shape. Therefore, updating map is easy and not frequent.

Figure 11: Japanese river with structural measure for flowing straight and rapidly  
Source: based on Sabo in Japan (MLIT)



Rivers in Bangladesh have few structural measures (**Figure 12**), since small flood is rather beneficial for farming and so on. Most of the rivers keep natural

condition and people are easily able to access rivers. They live next to rivers and even in rivers (**Figure 13**). People utilize and rely on the flood conveyed fertile soil for agriculture. This natural condition makes it difficult to update map. Since the shape of the river changes every flood, it is needed to update map every after flood if they prepare for hazard map.

Figure 12: Bangladeshi river with few structural measure  
Source: google map



Figure 13: Living in elevated houses with plinth next to flooded river  
(Sundarganj, Gaibandha in Aug. 2014)



#### *4.1.3 Ability of interpreting map*

For utilizing the hazard map by local people, people need to read letters and interpret map. Japan's literacy rate is about 99%. Map education has been compulsory in general primary school since 1908. Tanaka says "In the teaching of map-making, (i) the preparation of distribution map for the statistical map-making became popular in general primary schools, (ii) the national land map-making using ready-made maps was widely practiced in the teaching of their native districts, (iii) the field map-making became popular in general primary schools as a step to the learning of geography" (Tanaka, 1992). Map education continues in junior high schools also. Based on this background, Japanese adults are able to interpret map and utilize hazard map.

However, in Bangladesh the literacy rate of adult (% of people ages 15 and above) is 73% (WB, 2016), and map education is not common like Japan.

#### *4.1.4 Warning system*

Warning and hazard map is well related in Japan. After the warning is issued, people are able to evacuate following the hazard map information such as evacuation route and shelter. Since the flood speed is rapid, the evacuation time is limited. Therefore, the warning system have been developed. People are able to receive information through several media, such as TV, Internet, mobile phone and local media system.

#### *3.2. External help*

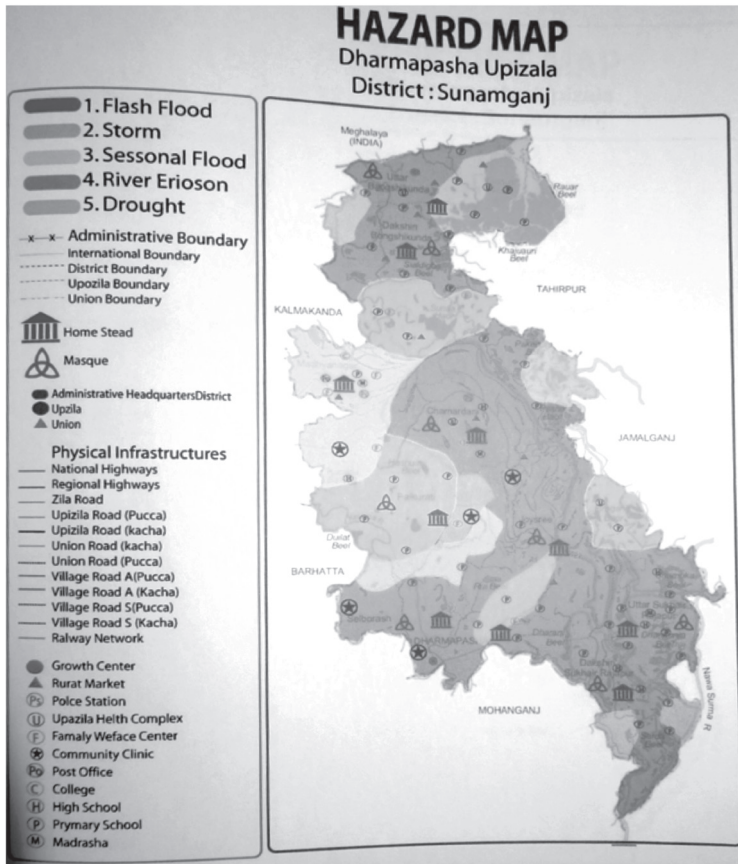
External help is also systematically developed. Usually after evacuating to the designated evacuation centers or shelters, evacuees are able to receive housing information, food, water, daily necessity etc., since NGOs, government, volunteers and related organizations are well organized and linked.

### **4. Hazard map in Bangladesh**

Various flood hazard map is already introduced to Bangladesh and all over the world with different names and different approaches such as GIS based hazard map, based on flood affected frequency, based on flood depth and velocity etc. (Osti 2008). It is technically possible to prepare for hazard map similar to Japan's hazard map, however the contents are different. The user is also different. Local people in Bangladesh do not use hazard map usually. It is used by local government and not local people. **Figure 14** is a hazard map of Dharmapasha

Upzila, Sunamganj district, Bangladesh. Hazard map is not distributed to local people because of the social background. There is difficulty for local people to interpret hazard map since literacy rate is about 70% and map education is not common in Bangladesh, and people are not able to interpret map. In addition, since there is enough time to prepare for evacuation such as a few weeks, and inundation period is long like a few months, they rather migrate than evacuate based on their experience (Fujita 2017). They seasonally move for finding safe area to live and job. Usually, the linkage with the local government is weak, and there is no support for migrants to move and settle to new places, except during emergencies (Martin et al., 2013).

Figure 14: Hazard map: Dharmapasha Upazila (ULDMPD 2014)

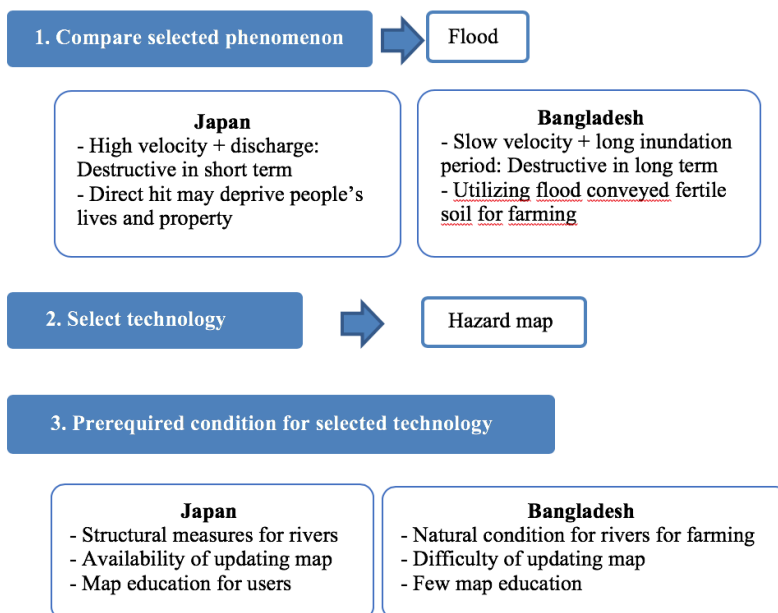


## 5. Conclusion

For successful use of foreign technology, recognizing different disaster phenomena in each country is the basic and key point. Many countries suffer from many disasters, such as flood, landslide, volcanic eruption, tsunami, storm etc. Though these disasters have the same names in many countries, the real phenomena may be different. As the flood phenomena in Bangladesh and Japan is differently recognized, other disaster phenomena are also different in each country and area. After recognizing the difference of the phenomena, the social background is also needed to be compared. Since the technology is developed based on the social background of the original country, recognizing the different social background in each country is needed for utilizing the technology.

Figure 15 is the summary of the steps of preparing for research on hazard map technology transfer from Japan to Bangladesh. In this research paper, flood is the selected disaster and hazard map is the selected technology. Therefore, first, flood phenomena are compared. Then prerequisite condition for utilizing selected technology, hazard map, is reviewed.

Figure 15: Steps for transferring hazard map technology



Since the flood phenomena is different in Japan and Bangladesh, the pur-



pose of flood disaster risk reduction is different. Avoiding direct hit by destructive flood is the major purpose in Japan. For the emergency response, evacuation route and place are the most expected information. Protecting farmland and living place by long lasting inundation is the major reason for flood risk reduction in Bangladesh. Therefore, their most expected information are inundation duration and depth. Thus, it is important to know the difference of flood phenomena, and to clarify the reason /purpose of flood risk reduction before project start.

For the next step, the social background is needed to be compared for analyzing the possibility of transferring the selected technology. In case of transferring Japanese hazard mapping technology, followings are necessary condition.

- preparing evacuation shelter and the route
- ability of interpreting map by local people
- updating maps every after flood
- warning / information system

These conditions are not developed for river flood in Bangladesh. Thus, condition of Bangladesh is not ready for utilizing Japanese type hazard map.

The most important information for the local people in Bangladesh is the duration of flood, since they may lose arable land and living places. However, Japanese hazard map do not have the information of flood/inundation duration. In addition, Bangladeshi local people expect the benefit of flood such as fertile soil, increased growth of fisheries, and favorite condition for ecosystem. Therefore, such as showing / predicting long lasting area is more useful using hazard mapping technology. Thus, there is possibility to use the hazard mapping technology in Bangladesh. In addition, if there are areas where similar flood phenomenon is seen in Bangladesh, Japan's hazard map will be used effectively.

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