Pre-Estimation of Vulnerability to Society & Economics due to Natural Disasters & Hazards: A Case Study of Ulaanbaatar, Mongolia

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Abstract. As of 2018, the population of Ulaanbaatar city has reached 1,491 thousand people, which is 387 thousand families due to increased movement from rural areas to urban areas, and around 60% of them belong to Ger areas. This survey included about the people living in the 9, 10, 12 Khoroo territories of the Chingeltei district as well as in the vicinity of Denjiin myanga. For, sociological research estimated their property damage caused due to flood risk, explosion near areas of petrol stations, & expansion of settlement zones. The expansion of the settlement zone of Denjiin myanga has been determined by three factors. Such as size of territory, surface slope, average height of surface. The settlement zones of the ger areas have constantly expanded from 1975 to 2010 and thus increased 4.6 times and became 5.6 km2 as of 2010. The surface slopes of Ger areas were divided into four categories i.e. Very suitable (less than 30), suitable (3-60), poorly suitable (6-80), and not suitable (more than 80). 51.2% of the Ger area is in the Very suitable zone and 48.8% area is in the poorly suitable and not suitable zone. The average height of the settlement zone of Ger areas has increased between 1975 & 2010 at 1330 m and 1510 m, respectively. Therefore, the increase in height over the 35-year span was 180 m. The pre estimated damages and risks caused by natural disasters, flood and explosion risks of petrol stations, and the initial results were obtained for the living area of Denjiin myanga. The estimation showing that the possible danger would hit 717 people of 171 families, thus the risk would count 989 million tugrugs. Finally, based on the assessment, it is proven that a certain extent of loss and damage from possible risks is likely to occur when this assessment is calculated in only small areas of Denjiin Myanga of Chingeltei District. As research continues, there will be a possibility of risks from mountain and rain floods, as well as the risk of a petrol station in the vicinity of the six districts of Ulaanbaatar.

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1 Introduction

The population of our planet is increasing year by year, and as of today there are 7.6 billion people living in the territories of 148.9 ml square km. As the number of population is on the increase, it demands to use renewable and non-renewable resources in the biosphere. According to the prognosis of the United Nations, by 2050, the number is about to be 9.7 billion and 11 billion at the end of this century. For the last 100 years, the number of people living in cities around the world has increased rapidly, making it half of the entire world population [1].

Although there are many positive social aspects and services for living in cities, we face a lot of risks, such as environmental degradation, ecological pollution, and the safety of health and food products [2]. Due to natural and anthropogenic processes, the regularity and number of natural disasters are increasing considerably in cities and settlements, so it has become the main reason for poverty by influencing the sustainable development of the country [3].

Therefore, around the world, international conferences are held to reduce the risks of natural disasters and to strengthen the potential to combat disasters, and many countries have taken an active part therein assuming an obligation [4].

Ulaanbaatar is the capital of Mongolia and is considered one of the largest metropolitan cities in the world, so the above-mentioned problems of big cities occur also in UB city. Namely, due to disorderly movement from the countryside to UB, too much density occupies the capital, and nowadays 46% of the entire population is in UB and urbanisation has reached 67.6% [5]. Some indicators of air and soil pollution have been surpassed several times over standards, especially during the winter season [6].

2 Methods

In recent years, unplanned land was granted in the vicinity of the UB districts so that the sphere of suburb settlement has spread out, and then there are many families facing risks of mountain floods, probable danger of explosions of petrol stations and earthquake. As for this issue, so far, not many measures have been taken in the city to estimate the possible damage to rise, by means of conducting certain surveys [7].

Therefore, we have chosen some areas of 9, 10 and 12 khoroos of Demjiin myanga, Chingeltei district, in order to ascertain 3 probable factors such as mountain floods, expansion of settlement areas, and explosion of petrol stations. By simultaneously using ways of systemic analysis, stretch, statistics, mathematics, sociology and geomorphology, a methodology to pre-estimate damages to society and economics, of the above mentioned 3 factors, has been elaborated. Therein: i). method of ascertaining boundaries and changes of settled areas, ii). Method to estimate

probable risks of mountain floods, iii). Method for estimating the risks of explosions in petrol stations [8].

2.1 Method of determining boundaries and changes in settled areas:

However, to determine the surface height, using the digital height data by SRTM, the heights of settled area in the vicinity of Denjiin myanga have been taken as follows 1300 m above sea level, 1301-1400 m, and more than 1501 m, and then expansion of the square changes is determined in comparison with 1975, 1990 and 2010. To estimate the surface slopes of ger areas, very suitable (less than 30), suitable (3-60), poor suitable (6-80), and not suitable (more than 80) respectively [9].

2.2 Method to estimate probable risks of mountain flood:

Ravines at the recess of Denjiin maynga that might cause mountain floods have been determined by means of aerial and space cartography, and estimation of surface height and slopes in topography with M1:100 000 scale, thus making profiles at the beginning, in the middle, and at the end of the valley by fixing boundaries of possible danger. Researches of the population, properties and families that have a probability of being in danger and live near the flood dam were carried out and then estimates of probably economic damages have been made in advance by methods of sociology, questionnaire, observation and counting [8].

2.3 Method to estimate risks of petrol station explosions:

Multi-factors have to be regarded by having determined, in detail, possibly damages from petrol stations to buildings and facilities nearby. The risk areas that are responsible for the explosion of the “Petrovis” petrol station company located in Denjiin myanga due to wrong technological and anthropogenic processes were determined by sociology, observation, counting of the population and families living in the risk area. In the research, the hypocenter of the three layers R1, R2, R3 exist depending on the explosion of capacity and reserves of the petrol tanks (Fig. 1).
First zone: R1- Extra pressure equal to 1700 hP, second zone: square of spraying fuels more than first zone 1,7 times, third zone: The R3 air stroke wave zone exists. The radius of the boundaries depends on the daily weather (pressure. wind velocity, directions).

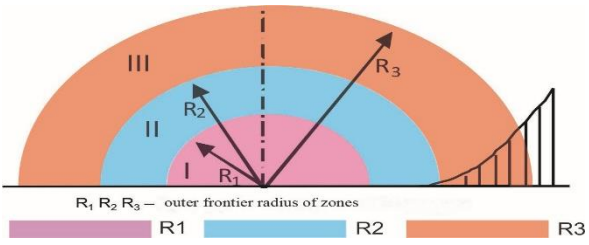

Fig. 1. Explosion hypocenter.

The radius of the explosion zone of the petrol station is determined using the following formulas [10]. where:

$$R_1 = 17.5 \cdot \sqrt[3]{Q} \quad (1)$$

R_1 – radius of the first zone by metres
Q – Fuel mass by tons

3 Results

3.1 Expansion and possibly risks of settlement zone of ger areas

In 2008, the population and families of Chingeltei district used to be 140.2 thousand and 30.3 thousand, respectively, and in 2018, with an increase of 159 thousand of the population and 40.5 of the families, during this period, the population increased by 13.5% and the number of families by 33.6% have increased [11].

The settlement zone of Chingeltei district has increased 3.1 times between 1975 and 2010. Namely, in 1975, it was 4.3 km^2 and in 2010, it increased by 17.8 km^2 thus showing that the expansion of the settlement zone in regardless of surface slopes and heights is extending. This process opens up the condition to be subject to risks of natural disasters later on.

In 2010, about 4000 families and 16000 people live in the Denjiin maynga settlement zone, where research is being conducted. The size of the settlement zone of the the square of ger area located in the research field has continuously increased [12]. For example, in 1975, increased by 1.2 km^2, in 1990 by 1.5 km^2 and in 2010, by 5.6 km^2 (quadrate) respectably. That is, square of settlement area has increased by 4.6 times between 1975 and 2010 in the research area (Fig. 2).

Apart from expanding squares of the settlement zone of the ger area, families from the countryside to the city settled in the suburbs regardless of surface slopes and height of the mountains. Therefore, as the average height of the settlement zones of the ger area was determined, it has continuously increased from 1957 to 2010. Namely, the average height of settlement zone was on the increase by 1330 m in 1975, by 1370 m in 1990 and by 1510 m in 2010 thus the height extended by 180 m during the period.

The expansion of the settlement areas of the the boundary zones of ger area was determined using two fundamental elements of geomorphology as follows the surface slope and heights. To estimate the surface slopes of the ger areas, very suitable (less than 30), suitable (3-60), poor suitable (6-80), and not suitable (more than 80) respectively, based on digital height data of SRTM, as well as based on the classification of suitability for use for economy [8]. 51.2% of the ger area is in a very suitable zone, 48.8% - poor suitable and not suitable slope places (Table 1).

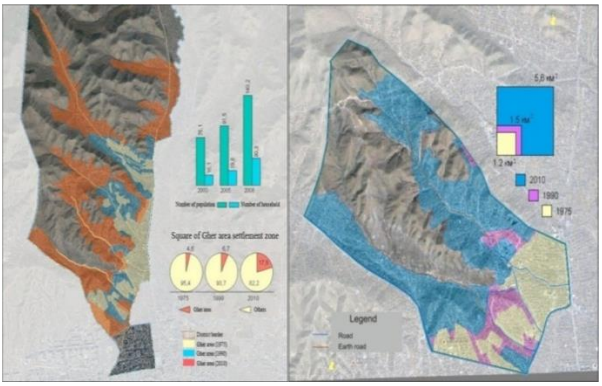

Fig. 2. Changes in the settlement zone of the Ger area of Denjiin maynga

Table 1. Expansion and of the of the surface slope Denjiin myanga settlement zone.

Slope (degree)	Km^2	Square of settlement zones (%)
less than 30	0,86	15,3
3-60	2,01	35,9
6-8	1,01	17,9
More than 80	1,73	30,9
Total	5,60	100

3.2 Probable risks and consequences of mountain floods.

In the sphere of research, the present situation was determined by choosing the flood dam of Denjiin myanga. The design project for the flood dam protection system in the Denjiin Maynga area was carried out in 1965, with the purpose of protecting from mountain floods that descend from ravines of the southern and southern western mountains 'Chingeltei'. In addition to protecting Ulaanbaatar city from floods, it was focused on creating a microclimate and water environment by establishing 'Nogoon nuur'. This system belongs to the western mountain flood protection system [13].

The flood drain dam from Denjiin myanga to the “Sudalt” trade centre road located at the “32 toirog” junction, khoroo 12, Chingeltei district where research was carried out, has been full of household waste and natural alluvium from the streams, therefore families located in the southern part of the dam are at high risk of being subject to floods, because they do not have the capacity to drain water when there are natural disasters and mountain floods.

Drainage pipes and channels are filled with household waste and snow in winter and then families living nearby have risks of being subject to floods when the snow and ice melt during spring (Fig. 3). The boundaries of the effect zone are fixed by means of surface slope, space and aerograph (Fig. 4). As profiles have been made four

times in the vicinity of living area of families that may be subject to floods, a height difference of up to 1 m from the north to the south has been observed (Fig. 5).

Fig. 3. Dam covered with ice and filled with household waste.

In order to pre-estimating possibly risks of mountain floods at the research area, social and economic (location, population, properties) researchers for the families have been carried out by using methods of sociology, questionnaire, space, and aerograph.

In addition to having carried out the property counting of families living in the vicinity of dangerous areas of floods, questionnaires were taken from the families. As of 2010, about 290 people from 69 families lived in the probably risky area, according to our research. As well as 45 houses, 24 gers, 3 food stores, 58 storages and 19 vehicles in 35 yards were registered so that assets worth 407.8 ml tugrugs are in the risk area (Table 2). As there is a dense population, it makes the risk of exposure more complicated.

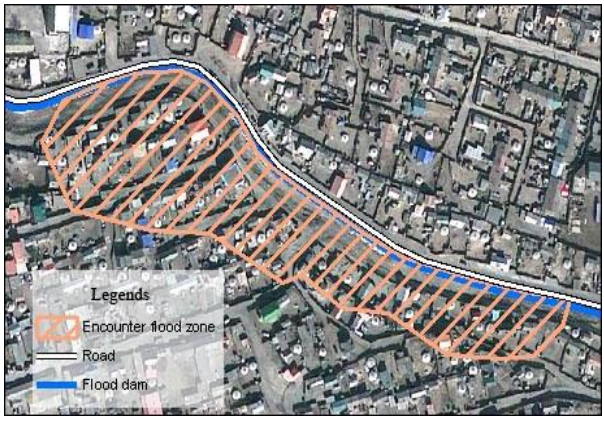

Fig. 4. Families subject to floods.

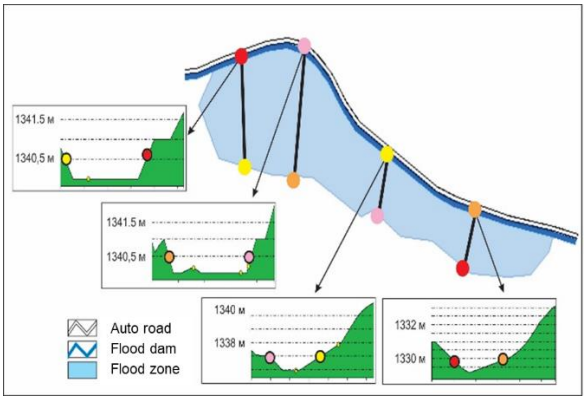

Fig. 5. Surface profile.

3.3 Estimation of the danger of rising from the petrol station.

An inevitable factor to estimate risks in Ulaanbaatar city is an issue on safety, location, and sealing of petrol stations.

There are approximately 140 petrol stations in the city of UB as of 2010. In order to completely prevent probable risks from petrol stations, it should completely estimate the start of technical conditions to be taken when accidents and prevention occur.

Probable risks from petrol stations are divided into two factors, natural and anthropogenic process. A 'Petrovis' petrol station is located in Denjiin myanga. As the petrol station is located along the auto road where there are bus stations, banks, schools, shops, creches, and wells in the middle of the ger areas, as well as there is dense population, it is a reason to increase the danger and the range of possible risks (Fig. 6).

Probable risks to families, population, buildings and facilities nearby, and socio-economy have been pre- estimated, when fire danger comes from explosion of petrol stations located in vicinity of Denjiin myanga area, due to natural and anthropogenic processes. Depending on explosion capacity and fuel reserves contained in petrol station tanks, a hypocenter with three layers is created, and calculated using the formula 'Taylor' [10].

As the specific weight of diesel fuel is considered as 0.830 gr/ cm^3, full tanks with 400 m^3 diesel fuel capacity come to 332 tons. As if the specific weight of benzene is considered 0.725 gr/cm^3, total weight of benzene A-80 will be 290 tons. The total amount of 622.0 tons of fuel is contained in petrol stations. According to this statement, 148.7 m – 1st zone (R1= 148.7 m), 258.2 m – 2nd zone (R2= 148.7 m*1.7) and the 3rd zone are the air stroke zone (Fig. 7).

According to the research, the 1st zone of explosion: 5 gers, 3 storage houses, 8 household yards and 25 people in 6 families, 2nd zone: 8 vehicles, 16 storage houses, 13 gers, 21 houses, 23 household yards and 143 people of 34 families, 3rd zone: 16 vehicles, 56 storage houses, 2 shops, 20 ger, 42 houses, 51 household yards, and 260

people of 62 families have involved respectively. Apart from 428 people of 102 families living in the 1st, 2nd and 3rd risks zones of entire explosion, and as assets of the families are calculated according to average market evaluation at that time, it comes to 582.2 ml tugrugs. There are 2 factors with possible risks in the settlement zone of Denjiin myanga where the research was carried out. They are: mountain flood and petrol station explosion. Aggregate research has been carried out to assess the damage that is caused to the social economy of two risk factors (Table 2).

Fig. 6. Petrol station 'Petrovis' company.

Fig. 7. Explosion boundary zone of a petrol station

Table 2. Aggregate evaluation of probable risks causing the settlement zone of Denjiin myanga.

Elements of Risks	Situation of Population		Types of dwellings			Main Assets			Evaluation (ml tugrugs)
	Household	Population	House	Ger	Vehicle	Yard	Shop	Storage houses	
Flood zone	69	289	45	24	19	35	3	58	407.5

Explosion zone of the petrol station	102	428	64	38	24	82	2	75	582.2
Total amount	171	717	109	62	43	117	5	133	
Amount of prices (ml tugrugs)	-	-	654.0	49.6	150.5	760.5	20.0	39.9	989.7

According to the investigation, since the two risk factors (mountain flood, petrol station) in a small area, on the territory of three khoroos of the Chingeltei district, there has been an estimate of damages worth 989 ml of tugrugs and risks to involve 717 people of 171 families. It is necessary to pre-estimate probable social economic damages in districts of UB city, by means of surveying probable risks of natural disasters like earthquakes, mountain floods and explosions of petrol stations. Therefore, there will be a possibility of involving the citizens of UB in prevention measures with less risks.

4 Conclusions

The rural population is continuously moving towards the urban centre in a rapid manner. Therefore, urban population and area are increasing. In addition, it becomes a reason to increase not only the population of the city, but also the number of families to live in the risky places with more surface slopes and heights. Increase the volume of assets damages as well as people's lives due to natural and anthropogenic factors of risks.

A methodology was used to pre-estimate the damages to the social and economy caused by natural disasters such as mountain floods and petrol station explosions and initial results were shown for the research zone of the 'Denjiin myanga'. As the aggregate evaluation of the two factors mentioned above is carried out, there has been a risk worth approximately 989 ml tugtugs and involving 717 people of 171 families.

Finally, to draw the conclusion, there have been determined to be considerable risks in the small area in the vicinity of the ninth, 10th and 12th khoroos, 'Denjiin myanga'. In accordance to the methodology further on, we considered that there is a possibility to prevent the population and those properties from natural disasters mentioned above by estimating social economic damages in advance.

5 Acknowledgements

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