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A Framework to Estimate GDP Loss due to Extreme Water-related Disaster in Kangwon-do

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Abstract

Large scale flood disasters bring human losses and properties, which lead to the decrease of our productive value and change social environment. Human loss and economic damage are considered to be the same system but they are viewed as separated systems. The total amount of human loss can be represented as the total amount of economic damage estimated in the frame of social system while it will be possible to make mutual changing by clearing the relations between social and economic systems. In this regard, an attempt to estimate economic loss considering per capita Gross Domestic Production (GDP) caused by flood-related mortality was carried out to the typhoon Rusa of 2002 in Kangwon-do. The proposed method tried to capture quantitative factors which are affecting the loss of per capita GDP. The approach has great importance not only to set up governmental policy but also methodological progress in the research due to impact of disaster-related mortality on GDP loss.

key words : flood disaster, GDP loss, typhoon Rusa, water resource management, Kangwon-do

1. Introduction

The Emergency Disaster Database maintained by the World Health Organization report 4,024,211 people killed by extreme weather-related disasters including typhoon, flood, and drought etc. from 1960 to 2004.The number of killed people in Asia accounted for 73% of the total number as compared to 24% for Africa and 3% for Americas (UNESCO-PWRI, 2005). According to some researches, disasters continue to impose substantial human and economic losses on the developing countries. In a sample of large natural disasters over the period 1980 to 2004, fatalities per event were higher by orders of magnitude in low- and middle-income countries compared with high-income countries; similarly, losses as a percentage of gross national income (GNI) were highly negatively correlated with per capita income (Bayer,et al., 2005 Mills, 2005). It means that weather or water related hazards and disasters in Asia are still the most prevailing obstacles toward sustainable development. Most of the Asian countries have proposed and adopted numerous policies and strategies to mitigate the impact of weather related disasters. However, flood still occur periodically and flood damages are exponentially increasing. The main reason is the rapid population growth and property concentration in hazardous area. In these countries urbanization will make progress continuously and the storage capacity of waters in catchment area will reduce gradually (Department of Economic and Social Affairs of United Nations, 2002). Recent weather-related disaster also gives a lesson that it will break out anywhere (Ushiyama, 2005).

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In case of Korea, the risk of flood has been increased due to social and economic reasons mainly, which has been resulted in the decrease of flood retention capacity in the wet zone (Kang, 2003; Kang and Noguchi, 2003). The damages of buildings, agricultural land and infrastructure have increased significantly since the rapid economic growth period of 1980s. But flood mitigation budget remains for only 0.07% of Gross National Product (Kim, 2006). The necessity, of how the disaster influences on social sphere, has been discussed many times before but still the researching of them are not activated (Kawada et. al., 1999). But recently, this kind of research has been focused on due to the change of social and natural environments (Blöchl and Braun, 2005).

Large scale disasters follow numerous human losses and property damages occur. Therefore, our common question will be human life and economic problems (Kawada et. al., 1999). More over as disaster reflects their social environmental conditions, it can be considered that disaster is the problem in the relations between social outcome as GDP and natural disasters. But, the estimation of human economic loss by disaster has been challenging sector for several uncertainties.

According to this point, this paper presents quantitative framework of human loss by weather-related disaster using GDP as social outcome. The main aim of this study is to awake our understanding of the relations between weather-related disaster and their impact on GDP to minimize the human loss scale and to precede preventive investments.

2. The situation of water-related disaster in Korea

In case of Korea, over 80% of total disaster is weather-related especially by flood. Figure 1 shows the trend of weather-related disaster from 1925 to 2003 (NEMA, 2006). Recently, the frequency of big human loss has decreased but is still high (see Figure 2). The recent characteristics of flood damages from the storms such as Typhoon Rusa in 2002 shows increased risk and damages to the local downstream populations (Lee, et al., 2003). There are two major reasons for the increasing damages: the first is the rapid urbanization, and the second is the policy to river restoration project. The flood damages from large rivers are controlled by continuous investigation on the river management system such as construction of better flood control facilities and multi-purpose dams. But, the flood damage in the middle or small-sized mountainous river basins are gradually increasing due to the continuous urbanization and local torrential rainfall (Kang 2002, 2003). Furthermore, in these kinds of rivers, structural flood control measures such as improving levees are still emphasized than non-structural ones. In spite of the enforcement of flood control facilities, potential flood risk in small-sized mountainous river basins has always remained high (Ushiyama, et al., 2002). In 2002 Typhoon Rusa struck Kangwon-do area of Korea and caused the most extensive flood damages with new record of single event rainfall in some areas (see Figure 2 and Table 1.) Many cities were inundated, crippling critical facilities and resulting in 147 deaths. These damages were among the worst that the Korean people experienced. It means that both structural and non-structural measures should be considered together to reduce flood damages.

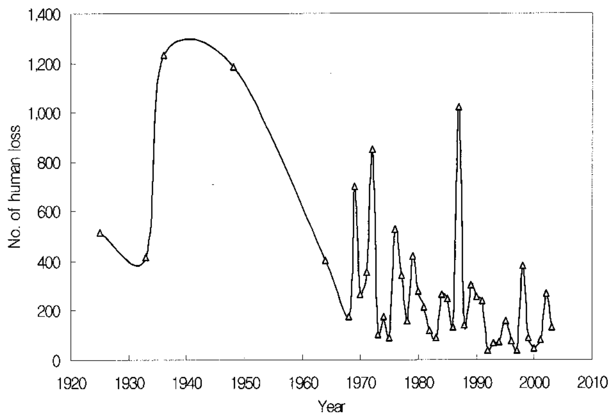

Figure 1. Dramatic change of human loss in Korea (1925-2003)

Table 1. New record of rainfall caused by typhoon Rusa event in Korea (Unit: mm)

Order	Area	Rusa event(date)	The past Maximum(date)
1	Kangnung*	870(31 August, 2002)	301(24 September 1921)
2	Daegwallyeong*	713(31 August, 2002)	349(10 August 1993)
3	Donghae*	320(31 August, 2002)	215(17 June 1996)
4	Habchon	288(31 August, 2002)	224(30 September 1998)
5	Sangju	192(31 August, 2002)	173(6 August 2002)

* Kangwon-do areas

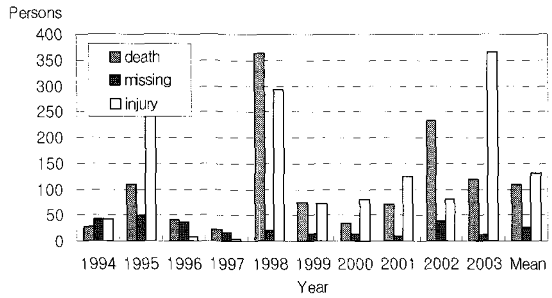

Figure 2. Annual human damage in Korea (1994-2002)

3. Procedure of human damage estimation

3.1 The classification of damage loss

We can reckon up that the main prevalent cause of flood damage in urban areas is the rapid tendency of urbanization following with transformation of land use, big concentration of population & social infrastructure, and the lack of a disaster aware mind. More over the peculiar feature of flood damages is the tendency toward the disaster's localization and short-term concentration. In a result, to minimize the flood damage and provide the insurance, first we need to define the type of damage. The classification of damage types caused by disasters can be represented as follows:

1) Direct damage (human loss, construction damage)
2) Indirect damage (decline of urban facilities, economic aggravation caused by disasters, negative image of damaged area)
3) The 2nd grade damage (mental stress etc.)

Korea has been classifying the disaster damages by human loss, building damage, inundation damage, damage of public and private facilities. The case of 1), the government has been rewarded their damage by disaster. But cases 2) and 3) have been disregarded due to uncountable. Furthermore, the reward of human loss depends on the contribution by a citizen or enterprise. So although there was a criteria to support human loss, it was changeable by social conditions.

3.2 Quantitative analysis of human damage

Disasters bring difficulty and troubles in people's life and impact the economic system's functioning that leads to the decrease of value output changing our daily environment. Human loss and economic damage are considered to be the same system but they are viewed as separated systems. The total amount of human losscan be represented as total amount of economic damage estimated in frame of social system while it will be possible to make mutual changing by clearing the relations between social and economic systems. According to this point, quantitative analysis of human loss can be represented by processing the conversion of damage point by disaster. Quantitative analysis of human loss can be represented as a process while every system's indicators will be selected and then compared to thetwo. In this study all convertible process in social system are represented by an average life index, and the decrease of output due to the functional decline of economic system is represented by a GDP index.

4. Application and discussion

There are individual abilities for GDP generation. In case of individual abilities, it will depend on many variable factors. The model for economic growth is an attempt to capture the essence of changeable factors in a quantitative way, but it is important to recognize that this conceptualization also involves a considerable degree of simplification. The economic human loss method proposed here is based on per capita GDP. In making such a conceptualization, human loss model is premised upon four basic assumptions:

A1 that per the capital GDP of human loss counts from 20 year olds from the event year:

A2 that human losses from excesses in labor force do not count per capita GDP more.

A3 that the Total Economic Human Loss, TEHL were estimated as follows:

$$TEHL = \alpha \int_A [(R_A - D_A)] dA \quad (1)$$

where α is slope coefficient of human loss by disasterbased on Figure 1 (1.67) A is total number of human loss (82 of identified) R_A is average retirement age (65 years old) D_A is the age of disaster-related death (see Table 2).

A4 that the trend of economic growth to calculate per capita human loss GDP estimates following equation with Figure 3 as:

$$Y=434.14(x)-857502(R^2=0.9043) \quad (2)$$

where x is year, y is assumed per capita GDP(US$).

The total economic human loss GDP in 2002 using above assumptions from A1 to A4 was estimated 50,843,472 (US$) with 620,042 (US$) of per capita, respectively as shown in Table 2. It means that the weakness of social disaster potential is converted into the amount of human damage loss. It also reflects social environmental conditions which need more investigation for disaster mitigation. GDP growth affects on the average lifespan as shown in Figure 4. The total loss of GDP by Kawada's method was estimated 59,755,393(US$) with 406,499 per capita loss (US$), respectively. Kawada method for estimating human loss GDP based on that individual loss of GDP maintained average life span, not retired age. This is the reason why there are difference between this study and Kawada method.

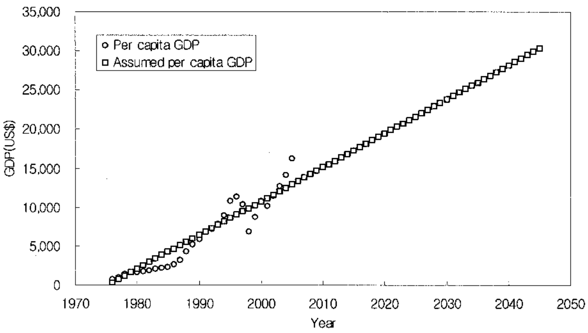

Figure 3. The trend of assumed per capita GDP using per capita GDP in Korea

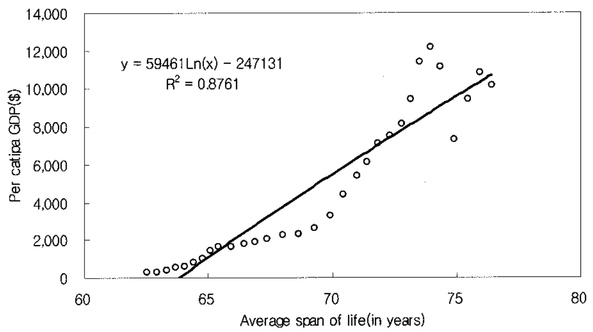

Figure 4. Relationship between per capita GDP and life span in Korea (1975-2001)

Table 2. Total economic human loss GDP of Kangwon-do due to typhoon Rusa

Age of victimes	Loss lobour time (age)	Per capita loss of GDP ("~1000, Won)	Per capita loss of GDP (US$)
9	56	1,345,079.1	1,076,063
11	54	1,273,597.0	1,018,878
13	52	1,203,851.5	963,081

13	52	1,203,851.5	963,081
16	49	1,102,489.2	881,991
17	48	1,069,570.1	855,656
17	48	1,069,570.1	855,656
17	48	1,069,570.1	855,656
21	44	942,234.9	753,788
21	44	942,234.9	753,788
24	41	851,292.0	681,034
25	40	821,846.0	657,477
25	40	821,846.0	657,477
25	40	821,846.0	657,477
26	39	792,834.1	634,267
27	38	764,256.4	611,405
29	36	708,403.3	566,723
29	36	708,403.3	566,723
31	34	654,286.8	523,429
32	33	627,879.8	502,304
32	33	627,879.8	502,304
32	33	627,879.8	502,304
32	33	627,879.8	502,304
33	32	601,906.9	481,526
34	31	576,368.1	461,094
34	31	576,368.1	461,094
35	30	551,263.5	441,011
36	29	526,593.0	421,274
36	29	526,593.0	421,274
36	29	526,593.0	421,274
36	29	526,593.0	421,274
36	29	526,593.0	421,274
37	28	502,356.7	401,885
37	28	502,356.7	401,885
38	27	478,554.5	382,844
38	27	478,554.5	382,844
39	26	455,186.4	364,149
39	26	455,186.4	364,149
41	24	409,752.7	327,802
41	24	409,752.7	327,802
42	23	387,687.1	310,150
44	21	344,858.2	275,887
45	20	324,095.0	259,276
46	19	303,765.9	243,013
46	19	303,765.9	243,013
47	18	283,871.0	227,097
47	18	283,871.0	227,097
47	18	283,871.0	227,097
47	18	283,871.0	227,097

48	17	264,410.2	211,528
48	17	264,410.2	211,528
48	17	264,410.2	211,528
48	17	264,410.2	211,528
48	17	264,410.2	211,528
48	17	264,410.2	211,528
49	16	245,383.5	196,307
49	16	245,383.5	196,307
49	16	245,383.5	196,307
50	15	226,791.0	181,433
51	14	208,632.6	166,906
51	14	208,632.6	166,906
51	14	208,632.6	166,906
51	14	208,632.6	166,906
51	14	208,632.6	166,906
52	13	190,908.4	152,727
52	13	190,908.4	152,727
53	12	173,618.3	138,895
53	12	173,618.3	138,895
54	11	156,762.3	125,410
54	11	156,762.3	125,410
55	10	140,340.5	112,272
55	10	140,340.5	112,272
55	10	140,340.5	112,272
56	9	124,352.8	99,482
56	9	124,352.8	99,482
57	8	108,799.3	87,039
57	8	108,799.3	87,039
57	8	108,799.3	87,039
58	7	93,679.9	74,944
59	6	78,994.6	63,196
59	6	78,994.6	63,196
60	5	64,743.5	51,795
"@"@Total economic human loss GDP			50,843,472.2
"@"@Per capita human loss GDP			620,042.3

5. The lessons from typhoon Rusa's damage

According to recent disasters like the Hanshin great earthquake (1995), Indonesia tsunami (2004), and hurricane Katrina damages (2005), theycome close to our life and till now the situation has not been changed and remains unsolved and full of risk. Though we understand the necessity to deal disaster prevention we can't answer the question completely "How to save human's life and property from natural risk?". But we can observe the small changing symptoms in this problem's solution. Recent disasters give a lesson to us that its damage can't prevent fully, however, we can minimize its damage. Nowadays the daily forecast became the usual procedure and such phenomena as flood downpour can be considerably predicted. The basic course of step planning is to estimate the admitted level of property damage in areas. To achieve the present aims, first we need to concentrate on preventive research and on enforcing the policy measures. But actually this kind of actions in Korea has not been made concrete from the social viewpoint yet. According to the Constitution of Korea, "All citizens must be leaded to health secure and be provided the lowest cultural limits...". But in practice the risk of natural disasters has been increasing. Due to the rapid technology progress we are forced to predict the natural disaster and this problem is in control. If the economic system is in good condition and social preventive potential against disaster will be also reinforced continuously. The right to live can be guaranteed not only in case of normal social condition but also even in natural disaster case.

6. Conclusions

Koreahas been suffering from weather-related disasterlike flood and drought due to topographical, climate and social conditions. Its main reasons are rapid economic growth and urbanization, which led to the lack of storage capacity to control over charge flood in catchment area. The large-scale disaster makes a great impact on the society and we need to activate temporarily the policy measures. Basically our concern about natural disaster managing is how to protect effectively human's lives and property. Disaster reduction is an issue for consideration in the sustainable development agenda and a crosscutting issue relating to the social, economic, environmental and humanitarian sectors. In order to minimize disaster damage, the first step is to build up a damage scale including direct and indirect. But there is no way to assess human loss directly in case of large scale disasters. In this regard, the human loss model due to flood disaster was proposed and adapted to the typhoon Rusa, 2002 in Kangwon-do. The proposed method does not capture the individual differences like incomes which can not be quantitatively transformed to the model. Even if, there is a need for the next research to set up the human loss model by disaster using quantitative micro level costing, the approach in this paper will useful to estimate human economic loss for large scale water-related disasters.

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