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Measurement of fiscal vulnerability from natural disasters – the case of Albania

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Abstract: Natural disasters bring destruction and severe effects in the countries they hit. In small countries like Albania, where the insurance market is underdeveloped, the main role in absorbing disaster effects is often responsibility of the government. In this approach, the government is exposed from a fiscal point of view to the risk of natural disasters. This paper aims to measure the level of fiscal vulnerability in a country like Albania, caused by disasters that time after time hit the region, such as earthquakes or flood. This has been realized by calculating the disaster deficit index for earthquakes and flood, and the annual expected average loss from earthquakes. The results show for a high level of fiscal vulnerability in case of floods with a return period of 100 years and in case of earthquakes with a magnitude higher than 6.5 on Richter scale.

Keywords: Disaster, Fiscal Vulnerability, Risk, Disaster Deficit Index

1. Introduction – Definition of the Problem

The vulnerability of an economy to disasters can be measured considering several variables. For a small economy as the Albanian one, the role of the government in economy is of great importance. The government of a small country like Albania can't be risk neutral based on Arrow-Lind theorem (1970). This brings to the government taking a fundamental role in financing disaster effects, compared to private financing (insurance). Being a developing country, with a recent history of a socialist regime, with a fragile economy and a very low penetration of insurance products, the government would probably have to take the burden not only of public infrastructure loss, but also to help the households and/or businesses (mainly micro businesses of 1-4 employers) to restore from disaster effects. This would certainly bring heavy difficulties to the government budget and the economy could suffer the consequences. For this reason, is important to measure the vulnerability towards natural disasters from a fiscal approach.

From this situation some questions arise, which we will try to answer.

First, how would the situation of the government budget and public finance in the case of a disaster event of certain severity look like?

Second, what is the annual value that should be saved/invested in order to afford a future disaster event?

To answer these questions and to make the necessary recommendations we will focus in the calculation of some indexes that determine fiscal vulnerability. We will use two of these indicators, named originally DDI and DDI' (Cardona et al. (2004, 2007) as measures of fiscal exposure to natural disasters.

The hypothesis we will raise to answer the problem we presented is:

Hypothesis : Albania presents a relatively high level of fiscal vulnerability to natural disasters. Alternatively this hypothesis can be presented as: DDI > 1

As the value of this measure depends on the severity of the disaster, the problem can be laid in a different way: For which level of disaster severity (earthquake intensity or flood level) the hypothesis is proved to be true? In this way we can define the limit beyond which we should worry about public finance vulnerability from disasters. It is quite likely that the hypothesis may be proven to be true in case of large scale disasters (for example events with a return period of 500 years), however it remains to try if they are also true for shorter return periods.

2. Literature Review

Fiscal vulnerability has been often studied as part of more broad indices of vulnerability from disasters and risk management. There are several studies that use various indices. to measure economic vulnerability. Most of them have been built by organizations trying to compare countries between them. UNDP (2004) uses a series of indices made of 24 variables called DRI (Disaster Risk Index) part of which are also some economic parameters . However this is more an index for economic vulnerability in general and not focused on the fiscal part. The same index is discussed in detail by Perduzzi et al (2009). Briguglio (2003, 2004) presents measures of economic vulnerability to shocks, measuring vulnerability and resilience, however the vulnerability is measured to various economic shocks and not to disasters in particular.

Most known measures in this focus we are interested, are those presented by Cardona et al. (2004, 2007), a set of indicators that measure exposure to disasters from a fiscal, economic and social perspective, and also the level of disaster risk management in a country. The main indicator in this list is the DDI (Disaster Deficit Index) presented by Cardona et al (2004, 2007) and improved by Cardona et al (2011). In this paper we will use this methodology to calculate fiscal vulnerability.

Actually there are is not any study or discussion about fiscal vulnerability in Albania. The only resource for risk assessment is a study produced by UNDP (2003) which focuses more on emergency planning and has been used to develop some national risk mitigation measures. In this paper we are going to focus only on fiscal vulnerability as a very important measure in a country where the government role is central to disaster risk management.

3. Presentation of Measures of Fiscal Vulnerability from Disasters

The first indicator we are going to use is the DDI, or the disaster deficit index, presented initially in 2004 by Cardona et al. Later on the same authors (2007, 2011) have improved the methodology of calculation. DDI measures the fiscal vulnerability of a country, as it compares the maximum loss from a disaster event with the possible economic resources that can be used to finance it. The value of DDI is calculated as (Cardona et al. 2007):

$$DDI = \frac{\text{Maximum event loss}}{\text{Economic Resiliency}} = \frac{L_R^P}{R_E^P} \quad (1)$$

where :

$$L_R^P = \varphi L_R \quad (2)$$

represents the maximum loss from the disaster that is responsibility of the government, calculated as a part Φ of the total loss LR . Maximum loss from disaster is calculated as a function of several elements:

$$L_R = EV(I_R F_S)K \quad (3)$$

where E is the value of inventory exposed to the risk of natural disaster, V is the vulnerability function, depending on disaster intensity I_R and from a correction factor F_S that corrects for regional effects, and the coefficient K that corrects for uncertainty in the vulnerability function.

Meanwhile the denominator of the index represents economic resiliency, measured as the sum of the possible resources used to finance losses:

$$R_E^P = \sum_{i=1}^{n} F_i^P \quad (4)$$

The various resources that can be used to finance losses are those represented in table 1. It is clear that not all resources are applicable in a given country. Actually in Albania the possible resources include those coming from the government budget, foreign aid, contingency loans and the increase of public debt, the use of other resources is foreseen in the future. In calculating these index we have used only those elements that are actually possible and operating, excluding resources that are simply not available, or can be available in a near future (like the regional disaster facility, which is planned to start operating in 2014 in Albania, through the Europa Re insurance products).

If the value of DDI is greater than 1, it means the country is vulnerable from a fiscal point of view, as the loss exceeds the possible financing resources. The bigger the value of the index, the greater the country fiscal vulnerability.

The second indicator that we are going to calculate is a complementary of the first one. It has also been presented by Cardona et al (2004, 2007) and aims to measure the ration of annual average losses from disasters and capital expenses in the government budget. The index is calculated as:

Table 1. *Elements of economic resilience*

i	Description	Applied
1	Government budget – contingency funds	YES
2	Budget reallocations (central and local)	YES
3	Foreign aid from donors	YES
4	Internal debt	YES
5	External debt	YES
6	New taxes	NO
7	Disaster fund (or public insurance funded program)	NO
8	Contingency loans	YES
9	Catastrophe bonds	NO
10	Reinsurance (of government sponsored funds)	NO
11	Regional disaster funds	NO

$$DDI' = \frac{\text{Annual expected loss}}{\text{Capital Expenses}} = \frac{L_Y^P}{E_C^P} \quad (5)$$

The numerator of this index is nothing more than "the technical annual rate premium" for the risk from natural disasters. It can be interpreted like the annual average loss from disasters, or like the amount that should be saved/invested every year to finance future disaster losses. Compared to the annual capital expenditure of the government, the ratio shows what part of capital expenses should go for the pure annual premium of disasters, or expressed in another way: what part of its annual investments should the government save in order to fully finance losses from future disasters. It is crystal clear that the higher this index, the bigger the fiscal vulnerability of the government.

4. Basic Data and Calculations

To define the value of the elements that we need for calculations we have found their values in Albanian currency (ALL) and in percentage of GDP. As both losses from disasters and sources of financing can be expressed in absolute value and percentage of GDP, the form that they will be compared will be in percentage of GDP. This because some elements can be easily calculated in this way.

The first element that is requested to be calculated in the model is the maximum loss from a disaster event. For this we used data generated from an aggregate loss model from earthquakes/flood in Albania (Lito, 2013). Some modifications have been made to this model, in order to better represent the situation and the responsibilities of the government in case of disasters (not every type of loss is covered by government). Losses have been calculated for different return periods of disasters, that means for different levels of severity. Based on aggregate loss model, we have calculated this measure for 4 basic return periods: 50,100,200 and 475 years for earthquakes and 100 years for flood. Compared to the original aggregate loss model (Lito, 2013) these adjustments have been made:

- We have considered only the maximum vulnerability scenario (the original model had 5 scenarios). Again, it needs to be stressed that the DDI is an indicator measuring vulnerability in case of the "worst scenario" and so we have to get the worst case in calculations.
- From the indirect losses (for earthquakes) we considered only demand surge, in a level of about 20% caused by rising of prices in construction costs and 5% in case of flood. Losses from the interruption of activity or secondary losses in equipment are not taken into consideration.
- We considered infrastructure and public property in the case of earthquakes. This includes public buildings, transport infrastructure, water pipes, etc that are usually property of the government, or in a certain way a public responsibility. The infrastructure variable is presented in the form of a correction factor in the loss calculation. In the case of flood this has not been considered, as damage to infrastructure is generally not significant compared to total loss.
- We considered also private property insurance from homeowners or businesses (or even for public property). From the data of the AMF [1] on a regional basis (AMF – Geography of Insurance in Albania, 2011), we have calculated a regional index of property insurance, that has been used in the calculation of the coefficient for loss adjustments (corrections). This coefficient is calculated as:

In case of earthquakes: $K = (1 - I_S + INF) * I_K$ (6)

In case of flood: $K = (1 - I_S) * I_K$ (7)

where: I_S – insurance index (% of property under risk that is insured), I_K – demand surge, INF – correction factor for public infrastructure.

- Losses calculated in the aggregate loss model have been corrected with this coefficient, to value the part of total losses that are directly or indirectly a "burden" of the government.[2]
- Again the data is presented on a regional basis, so that we can make differences between risks exposure in different areas of the country. In the case of floods, only 8 from the 12 regions of the country are considered (as we consider only river floods, the major flood risk in Albania).

In figure 1 are shown data for the maximum possible loss for every region in the case of a flood with a return period of 100 years.

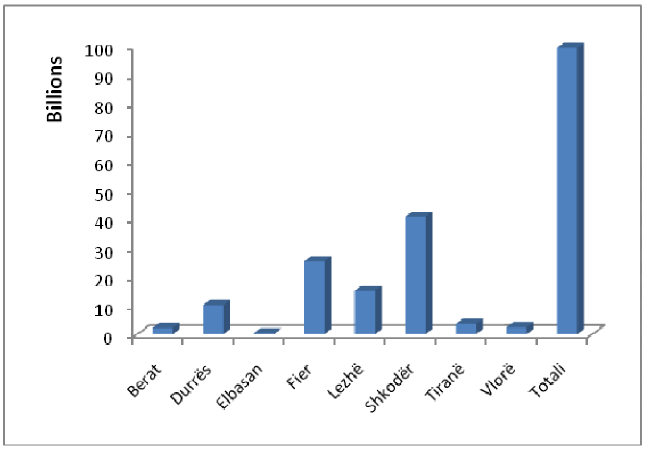

Figure 1. *Maximum loss from 100 years return period flood (billion ALL)*

In figure 2 are shown data for the maximum possible loss for every region in the case of an earthquake with return periods of 50,100,200 and 475 years.

Below is given the information for the elements of table 1, which are used in calculating DDI. To calculate this indicator data are gathered from the Ministry of Finance for fiscal statistics and from the Albanian Financial Supervising

[1] AMF – Financial Supervision Authority of Albania.

2 The government may need to intervene not only to recover losses in public infrastructure and property, but also to help for the reconstruction of private property lost from the disaster.

Authority for insurance market data. Fiscal data includes the period 2004-2013, while insurance data is for the period 2007-2012.

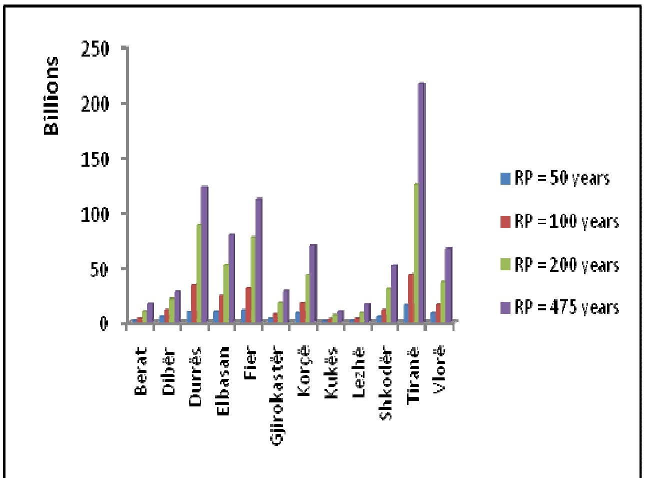

Figure 2. *Maximum loss from 50,100, 200 and 475 years return period earthquakes (billion ALL)*

- *Budget contingency funds =0.65% of GDP*

There are 4 elements to take into consideration: the reserve fund of the Council of Ministers, the contingency fund for preserving the budget deficit, civil emergency funds and other contingency funds (mainly for salaries and bonuses). We can easily notice that there is a lack of stability in the value of these funds, even more when compared to GDP. After a maximum in 2009, there is a decrease thereafter, mainly because of the economic slowdown that followed. Data from the recent decade suggest for an average level of 0.65% of the GDP for the contingency funds, with a standard deviation of 0.3%.

– Budget reallocations =1.6% of GDP

In this element theoretically we may include different funds reallocated by the government budget, in order to use them for financing disaster losses. From the analysis of the budget elements in the last decade (2004-2013), we judge that the most possible and reasonable elements to take into consideration are: the funds for new wage increases, maintenance expenses and capital expenses. From the analysis, we notice that these elements are the ones that have been mostly reviewed during budget mid-year changes. Maintenance expenses are about 2.5% of the GDP and have little deviation (standard deviation 0.3%). The funds for new wage increases are about 0.1% of the GDP, and are not present every year. What are the most volatile are the capital expenses, which follow an economical and business trend, and even a political or electoral one. They are higher in electoral years. On average the capital expenses are about 6.35% of the GDP, with a standard deviation of 1.25%. Of course, the level of these elements can change depending on various factors and situations, and some assumptions are necessary here. First we can assume that the funds for new wage increases will be totally reallocated (0.1% of GDP). Maintenance expenses can be reallocated of about 20%, (from 2.5% to 2% of PBB), so we have a reallocation level of 0.5% of GDP to finance losses. Finally, reallocation of capital expenses may reach 1% of GDP. In total we can arrive at a level of 1.6% of GDP from reallocations. It is clear that excessive reallocation can have negative effects, because it may stop investments and affect negatively the economic growth, however we judge the above assumptions as reasonable in case of natural disasters.

– Foreign aid from donors =0.25% of GDP

On average the Albanian government takes about 0.68% of the GDP in the form of grants, with a standard deviation of 0.22%. Also for this element it is necessary an assumption on the value of funds that can arrive from foreign donors in case of a disaster. The level of 0.25% of the GDP is assumed as an emergency financing from foreign donations in case of a disaster (grants not credit)..

– Internal debt increase & - External debt increase = 1% of GDP

Both these elements are connected with the possibility of the government to increase the level of public debt, and we are treating them together, as they are closely connected. The problem of the public debt has been debated a lot recently, both on a political and academic background. Albania has exceeded the "ceiling" level of 60% of the GDP lately (2012 and also 2013[3]) for its total public debt. What is noticeable is an increase of the external public debt, which has grown after 2008 with about 5-6% of the GDP, to reach a level of 26.57% of the GDP in 2012. In the actual situation, we consider that the possibility to rise funds available for loss financing by using public debt is very small. At least for medium term period (3-5 years) experts judge that this situation cannot be improved much. We judge that a level of 1% of the GDP is actually the maximum level that can be considered as an extra resource in an emergency situation, with such costs that do not make the situation of the public finances deteriorate further. For our calculations it is not important if it is achieved through internal or external debt, although internal debt increase seems more possible, because of lower costs and also the possibility of the banking system to finance it. For the sake of simplicity we will consider all the increase in debt to be internal

– Increase of taxes =0

Because of the actual economical situation, but also the situation in tax administration, this variable has not been considered, and we give it a 0 value.

– National government sponsored insurance program = 0

There is no such program in Albania and this variable has a 0 value in the formula.

– Contingency loan =0.25% of GDP

The agreement between IBRD and the government of Albania includes a DDO-CAT [4] loan with a maximum of

[3] Preliminary data for the year 2013 (July) show that the public debt level has reached 63% of the GDP.

[4] DDO – CAT are loans that allow the receiving country to postpone payments in the case of a disaster event.

0.25% of the GDP, that becomes effective in case of a national disaster..

– *Catastrophe bonds =0*

They cannot be used as long there is no insurance based program.

–*Reinsurance payments =0*

Not applicable in Albania.

– *Regional disaster facility =0*

The SEEC-CRIF program and the reinsurance company Europa RE are forecasted to start operating in Albania in year 2014. Albania has been the first shareholder of this facility and after all the regulatory infrastructure is ready, the disaster insurance products should start to enter the market in 2014. Actually we will not consider this resource.

On the other hand, to calculate the DDI' indicator it is necessary to know two elements: the pure annual disaster risk premium (or the annual average loss from disasters) and the capital expenses. For the last one, data from the Ministry of Finance show that the average of the last decade is about 6% of the GDP. To calculate the annual average loss from disasters (earthquakes only [5]) we followed this procedure:

- The probability curve is used to get the probability of an event with a given intensity in Albania based on the study of Aliaj et al (2010). From this study, which uses a probabilistic approach for determining seismic risk in Albania, there is 99% probability to have each year an earthquake with a magnitude of 4.5 on Richter's scale, there is 17% of probability for an earthquake with a magnitude of 5.5, 2% for a magnitude of 6.5 and 0.06% for a devastating event of 7.2 magnitude, considered as the maximal possible event
- Average vulnerability for every level of earthquake intensity has been calculated by using exponential interpolation and extrapolation, in order to build the entire function and fill in the missing values from former studies. The vulnerability function shows the average % of loss caused by each level of earthquake intensity.
- The average loss is calculated based on the vulnerability function and the cost of damage for unit.
- Average loss = % loss from vulnerability function * nr properties * area * cost for m2
- The average loss has been corrected to take account for the actual level of private insurance (the part of losses that is covered by private insurance) and demand surge, that increases losses

$$\text{Correction factor} = (1- I_S)*I_K \qquad (8)$$

- The average loss for every level of earthquake intensity is multiplied with the annual probability of occurrence of each level, to get the annual expected loss, or the pure annual risk premium from earthquakes. In figure 3 it is presented the possible loss for each level of intensity. The distribution of the annual expected loss can be approximated to a normal distribution with an expected value of 3.4 billion of ALL (equivalent of 24.3 million Euros) and a standard deviation of 2.4 billion of ALL (17.1 million Euro).

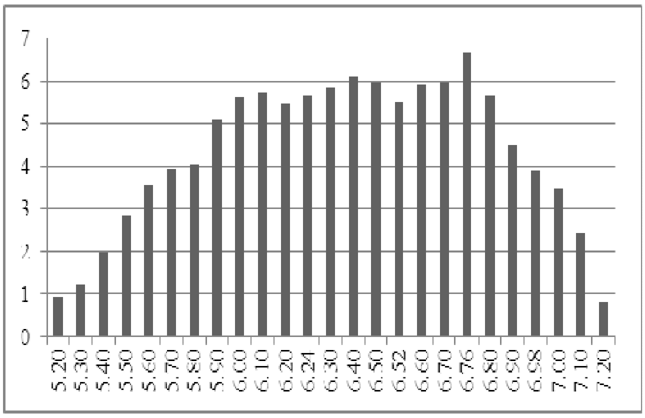

Figure 3. *Annual expected loss for every earthquake intensity (billion ALL).*

5. Main Findings, Interpretation and Discussion of Results

In table 2 are presented results for the first vulnerability measure, the DDI, for one type of disasters (earthquakes) for 4 return periods (50 years, 100 years, 200 years and 475 years). Results are presented detailed for every region in Albania and also aggregated on national level. We notice that for a return period of 200 years (which corresponds to an earthquake with a magnitude of about 6.7 on Richter's scale) the DDI is greater than 1 for 4 regions verifying the hypothesis. In the case of an earthquake with a return period of 475 years (magnitude 7 on Richter's scale) this result (DDI >1) is present for 7 from 12 of the regions in the country.

The most exposed region is of course Tirana, in which the fiscal vulnerability presents higher levels and the DDI exceeds 1 for an earthquake with a magnitude of 6.5 on Richter's scale. In case of an earthquake with a return period of 475 years (magnitude 7) in Tirana, the fiscal possibilities of the government would not cover even one third of the losses. The less exposed region to earthquake risk is the region of Kukes, where even in the case of a severe earthquake (return period 475 years) the fiscal resources to cover losses are more than enough.

On a national level, we can say that an earthquake with a return period higher than 200 years faces the government to a very high level of vulnerability, in most cases the DDI >1 and the hypothesis is proved right. We can take this level of disaster severity as a threshold in the case of earthquakes for the country. More severe disasters would result in an impossibility of the public resources to cover possible losses from the disaster.

[5] There is no study or data to make possible the construction of the vulnerability function in Albania for flood. The existing data are only for a scenario with a return period of 100 years.

Table 2. DDI for earthquakes of various return periods.

Region	DDI - earthquakes			
	50 years	100 years	200 years	475 years
Berat	3.60%	7.71%	20.17%	33.87%
Dibër	11.04%	22.91%	42.11%	54.89%
Durrës	19.51%	66.17%	174.93%	241.85%
Elbasan	19.63%	46.63%	103.38%	156.55%
Fier	22.05%	61.28%	152.16%	220.78%
Gjirokastër	7.72%	15.24%	36.17%	55.92%
Korçë	17.58%	35.50%	85.55%	137.26%
Kukës	2.99%	6.32%	13.42%	20.27%
Lezhë	3.89%	7.22%	17.46%	33.00%
Shkodër	10.79%	22.77%	60.19%	102.53%
Tiranë	31.86%	85.47%	247.13%	428.17%
Vlorë	17.17%	32.57%	72.39%	132.21%
Country average	13.99%	34.15%	85.42%	134.77%

Table 3. DDI for flood of 100 year return period.

Region	DDI flood, return period = 100 years
Berat	4.33%
Durres	20.06%
Elbasan	0.69%
Fier	50.30%
Lezhe	29.70%
Shkoder	80.58%
Tirane	7.04%
Vlore	4.74%
Total	**196.73%**

In table 3 are given results for this indicator (DDI), for floods with a return period of 100 years. Differently from earthquakes, this scenario presents the possibility that the event may happen simultaneously in several regions (simultaneous flood in all main rivers, already happened in Albania in winter of 1962-63). It was quite expectable that the most exposed region would be Shkodra (most of recent floods have happened in that area) and after that Fieri and Lezha. In the case of a local flood (only one region) the DDI remains in low levels even for longer return periods (100 years) except for the region of Shkoder, but in the case of a massive flood, we see that the value of DDI gets much higher than 1.

In table 4 are presented data for the DDI' indicator, calculated only for earthquakes. The data are shown for capital expenses for the year 2012 and for the forecast of year 2013. Besides the calculated DDI' value we have calculated also a confidence interval with 95% of possibility for the value of this indicator. Differently from the DDI, this indicator is presented only on a national level, not regional. From the results we can see that an average saving of about 6% of capital expenses is necessary each year to cover future possible disaster losses. In 95% of the cases, the pure annual risk premium for natural disasters reaches 11% of the annual capital expenses of the government. Said differently, about 1/10 of the annual capital expenses made by the central government should be "set aside" to cover future possible consequences of natural disasters.

As this is the first study in this field for Albania it may serve as a benchmark for future research. The same type of results to be compared with exist mainly for Latin American countries, which are much more vulnerable than Albania, as they present higher levels of natural hazard. Almost all of the countries for which DDI has been calculated by cardona et al (2004, 2007) present greater values of DDI for all the return periods compared to Albania. This is mainly because of different hazard types. In Albania the bigger risks come from earthquakes and flood, while in Latin American countries hurricanes are also a much present hazard.

Table 4. DDI' value and confidence interval.

Year	Capital Expenses	Annual expected loss from earthquakes	DDI' Confidence Interval 95%		
			DDI' (μ)	μ - 2σ	μ + 2σ
2012	69,872,000,000	4,351,436,933	6.23%	1.13%	11.33%
2013	70,905,000,000	4,351,436,933	6.14%	1.11%	11.16%

Source: Author calculations

6. Conclusions and Recommendations

Albania presents a relatively high level of fiscal vulnerability to natural disasters, mainly earthquakes and floods. In most cases, an earthquake with a return period higher than 200 years results in a index of deficit higher than 1, showing the lack of resources to deal with disaster effects. The same result is present for floods with a return period of 100 years or higher.

The most vulnerable area for earthquake hazard is the capital, Tirana, due to the great accumulation of property and infrastructure in this area. Shkodra and Fier present the highest vulnerability for the hazard of flood.

The results can be improved in precision when a more thorough study of physical vulnerability from disasters is taken throughout the country. The actual data on vulnerability are based partially on simulations and on some level of aggregation which induces some uncertainty error in the figures. This can be an area for further research

The results also bring into attention the need for an improved national strategy on disaster risk mitigation. The actual focus has been mainly on emergency planning and disaster risk reduction. In the future a greater attention should be paid to disaster risk financing, by using a multi-resource strategy to improve economic resiliency and to lower the fiscal vulnerability. A special focus should be given by the government to the insurance industry in general and to the SEE Catastrophe Risk Insurance Facility becoming soon operational in Albania. Continuous education of the public about disaster risk and information on insurance importance can help improve the situation in the future.

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