Evaluación de Riesgos Naturales
- América Latina -
Consultores en Riesgos y Desastres

ERN

DEVELOPMENT OF DISASTER RISK INDICATORS AND FLOOD RISK EVALUATION

Operation ATN/OC-11718-GY

GUYANA

INDICATORS OF DISASTER RISK AND RISK MANAGEMENT

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INTRODUCTION

Disaster risk is not only associated with the occurrence of intense physical phenomena but also with the vulnerability conditions that favour or facilitate disasters when such phenomena occur. Vulnerability is intimately related to social processes in disaster-prone areas, and is usually related to the fragility, susceptibility, or lack of resilience in the population when faced with different hazards. In other words, disasters are socio-environmental by nature, and their materialization is the result of the social construction of risk. Therefore, their reduction must be part of decision-making processes. This is the case not only with post-disaster reconstruction, but also with public policy formulation and development planning. Due to this, institutional development must be strengthened and investment in vulnerability reduction stimulated in order to contribute to the sustainable development process in different countries.

In order to improve disaster risk understanding and disaster risk management performance, a transparent, representative, and robust System of Indicators, easily understood by public policymakers, relatively easy to update periodically, and which allow cluster and comparison between countries was developed by the Institute of Environmental Studies (IDEA in Spanish) of the National University of Colombia, Manizales. This System of Indicators was designed between 2003 and 2005 with the support of the Operation ATN/JF-7906/07-RG "Information and Indicators Program for Disaster Risk Management" of the Inter-American Development Bank (IDB).

This System of Indicators has three specific objectives: *i)* improvement in the use and presentation of information on risk. This assists policymakers in identifying investment priorities to reduce risk (such as prevention and mitigation measures), and directs the post-disaster recovery process; *ii)* to provide a way to measure key elements of vulnerability for countries facing natural phenomena. It also provides a way to identify national risk management capacities, as well as comparative data for evaluating the effects of policies and investments on risk management; and *iii)* application of this methodology should promote the exchange of technical information for public policy formulation and risk management programmes throughout the region. The System of Indicators was developed to be useful not only for the countries but also for the Bank, facilitating both the individual monitoring of each country and the comparison between the countries of the region.

The first phase of the Program of Indicators IDB-IDEA involved the methodological development, the formulation of the indicators, and the evaluation of twelve countries from 1985 to 2000. Subsequently, two additional countries were evaluated with the support of the IDB's Regional Policy Dialogue on Natural Disasters. In 2008, a methodological review and the updating of the indicators for twelve countries were conducted in the framework of the Operation RG-T1579/ATN/MD-11238-RG. Indicators were updated to 2005, or for the most recent date according to the available information (2007 or 2008) for Argentina, Bolivia, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Jamaica, Mexico, Peru, and Trinidad and Tobago[1]. In addition, Barbados and Panama were included in the programme. Subsequently, in the framework of other operations of the IDB, other evaluations of the System of Indicators have been made for Belize, El Salvador, Guatemala, Guyana, Honduras, and Nicaragua. This report has been made using the methodologies formulated in the Program of Indicators IDB-IDEA,[2] with some adjustments which are referenced in the description of each indicator.

The System of Indicators mentioned above attempts to facilitate access by national decision-makers to relevant information on a country's vulnerability and risk, through the use of relative indicators to help the identification and proposal of effective disaster risk management policies and actions. The underlying models attempt to represent risk and risk management schemes at a national scale, allowing the identification of their essential economic and social characteristics, and a comparison of these aspects and the risk context in different countries.

The proposed System of Indicators allows disaster risk and risk management evaluation and benchmarking of each country in different time periods. It assists in advancing a more analytically rigorous and data-driven approach to risk management decision-making. This measurement approach enables:

- Representation of disaster risk at the national level, allowing for the identification of key issues relating to their characterization from an economic and social point of view.

- Risk management performance benchmarking of different countries to determine performance targets for improving management effectiveness.

Due to a lack of parameters, the need to suggest some qualitative indicators measured on subjective scales is unavoidable. This is the case with risk management indicators. The weighting of some indices has been undertaken using expert opinion at the national level. Analysis has been achieved using numerical techniques that are consistent from the theoretical and statistical perspectives.

Four components or composite indicators reflect the principal elements that represent vulnerability and show the advance of different countries in risk management. This is achieved in the following way:

1. The Disaster Deficit Index, DDI, measures country risk from a macro-economic and financial perspective when faced with possible catastrophic events. This requires an estimation of critical impacts during a given exposure time, and of the capacity of the country to face up to this situation financially.

[1] Usually, the most recent values in the different databases are not definitive since they are subject to change, thus, the last considered year (which is different for each indicator) is in some cases tentative or preliminary.

[2] More information and details of methodologies can be found in Cardona (2005). "System of Indicators of Disaster Risk and Risk Management: Main Technical Report". Program of Indicators for Disaster Risk and Risk Management IDB – IDEA, Universidad Nacional de Colombia, Manizales. http://idea.unalmzl.edu.co

2. The Local Disaster Index, LDI, identifies the social and environmental risks that derive from more recurrent lower level events, which are often chronic at the local and sub-national levels. These events particularly affect the more socially and economically fragile population and generate a highly damaging impact on the country's development.

3. The Prevalent Vulnerability Index, PVI, is made up of a series of indicators that characterize prevailing vulnerability conditions reflected in exposure in prone areas, socioeconomic fragility, and lack of resilience in general.

4. The Risk Management Index, RMI, brings together a group of indicators related to the risk management performance of the country. These reflect the organizational, development, capacity and institutional action taken to reduce vulnerability and losses, to prepare for crisis, and to efficiently recover.

In this way, the System of Indicators covers different aspects of the risk and takes into account aspects such as: potential damage and loss due to the probability of extreme events; recurrent disasters or losses; socio-environmental conditions that facilitate disasters; capacity for macroeconomic recovery; behaviour of key services; institutional capacity and the effectiveness of basic risk management instruments such as risk identification, prevention and mitigation measures, financial mechanisms and risk transfer; emergency response levels; and preparedness and recovery capacity (Cardona 2008). Each index has a number of variables that are associated with it and are empirically measured. The choice of variables was driven by a consideration of a number of factors including: country coverage, the soundness of the data, direct relevance to the phenomenon that the indicators are intended to measure, and quality. Wherever possible, direct measurement of the phenomena that are being captured are sought; however, in some cases proxies[3] have to be employed. In general, variables with extensive country coverage are sought, but in some cases the use of variables with narrower coverage are necessary in order to measure critical aspects of risk that would otherwise be overlooked.

This report presents the results for Guyana; methodological explanations will not be found because these were not within the scope of this report. Detailed information relating to the methodology of the System of Indicators can be found at: http://idea.unalmzl.edu.co, where details on conceptual framework, methodological support, data treatment and statistical techniques used in the modelling are presented (Cardona *et al* 2003a/b; 2004 a/b).

[3] Due to the lack of detailed information for coarse grain results, alternative values of related data are used to reflect, indirectly, the desired information.

System of Indicators for Guyana

1 National Context

Guyana is a sovereign state on the northern coast of South America, with an area of 214,970 km^2. It is the third-smallest (independent) state on the mainland of South America. It is bordered to the east by Suriname, to the south by Brazil, to the west by Venezuela, and to the north by the Atlantic Ocean. Guyana is subject to Atlantic swells on a year-round basis, heavy seasonal rainfall, and high humidity.

The country is divided into ten regions, from an administrative rather than geographical perspective, each having varying levels of population and development (Figure 1). The most populous of these is Region 4 (310,320 people), which includes the capital, while the least populated is Region 8 (with 10,095 people). The most recent census data of 2002 estimates the population of Guyana at 751,223. Close to 90% of the country's population live within a relatively narrow strip of land (approximately 25 km wide), which though it only comprises 5% of the land area, is the administrative, agricultural, commercial and industrial centre of the country. Figure 1 presents an estimate of population for the different regions, and their variation since 1980.

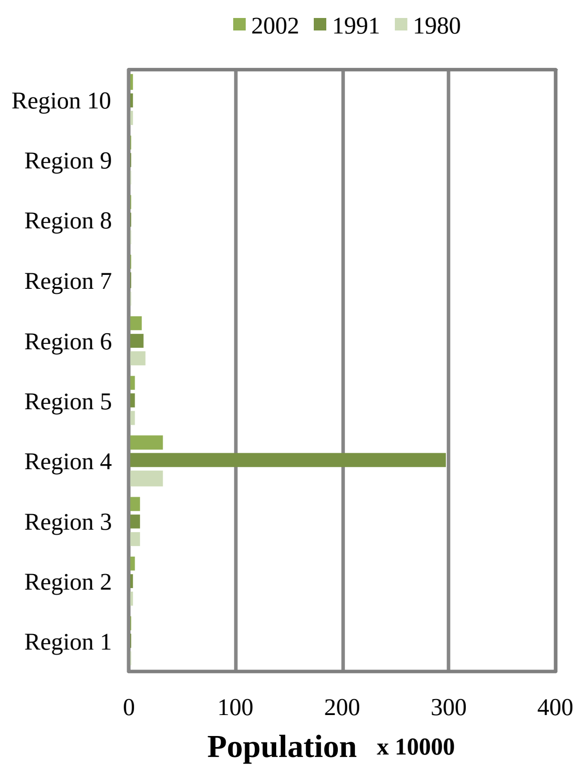


Figure 1. Population by regions (Source: Bureau of Statistics, Guyana[4])

[4] http://www.statisticsguyana.gov.gy

Regarding its economy, the GDP of Guyana was US$1.6 billion in 2008; its growth rate was 5.4% and 3% in 2007 and 2008 respectively. In this period, current account and trade balance was in a deficit near to 12% and 15% of GDP respectively. The inflation rate was over 8% in 2008 but decreased to 4.4 in 2010, and the unemployment rate was 11.7% (2002). The gross capital formation as proportion of GDP rose since 2000 and was closer to 40% in 2008. The exchange rate in 2010 was 202 Guyanese Dollars (GYD) per United States dollar. Table 1 presents a summary of the macroeconomic variables of the country. With regard to the social characteristics, the illiteracy rate of the population over 15 years old was around 8.2% in 2002. The number of hospital beds per one thousand inhabitants was 2 in 2002.

Table 1. Main macroeconomic and social indicators

Indicator	2000	2005	2008
GDP (USD million)	**	824.88	1,159.24
Trade balance (% GDP)	-11.5	-12.13	-15.33
Total debt service (% Exports and income)	**	4.9	2.6
Unemployment (%)	**	11.7	**
Human Development Index	0.552	0.585	0.611*

Sources: The World Bank, ECLAC
* *Data of 2010*
** *No data available*

2 NATURAL HAZARDS

Figure 2 presents the classification by mortality risk established by the International Strategy for Disaster Reduction, ISDR. These figures illustrate the events that can be considered as triggers for the estimation of the Disaster Deficit Index, IDD. Other frequent and isolated phenomena such as landslides and floods, that are less visible at the national level, are causes of recurrent effects at the local level, and may have an important accumulative impact. These kinds of phenomena are considered for the estimation of the Local Disaster Index. Appendix I presents a general description of the country's hazards.

The most significant natural hazards for the country are floods which would cause the major losses in the future in Guyana. There are other natural phenomena that have a lower probability of affecting the country, such as hail storms, storm surges, and lightning. However, these hazard events are able to result in significant local damage. This information is especially important for the estimation of the Disaster Deficit Index, DDI. On the other hand, most recurrent and isolated phenomena such as landslides causes frequent effects at the local level that are not easily noticed at national level. These events also have also great impacts on population, and, if they are accumulative, can be important too.

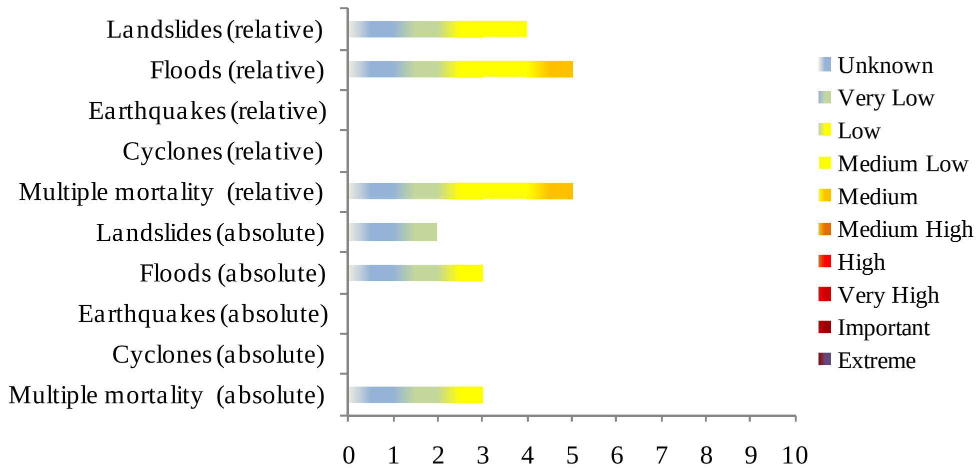


Figure 2. Classification by mortality risk (Source ISDR 2009)

The mortality risk index established by the International Strategy for Disaster Reduction - ISDR, is based on hazard modelling (tropical cyclones, flooding, earthquakes and landslides), taking into account the frequency and severity of the hazard events, the human exposure, and the vulnerability identification. The absolute mortality risk index refers to the average of deaths per year; the relative mortality risk index refers to the average of deaths in proportion to the national population. Low indices of 1 mean low mortality risk with 10 as the maximum value meaning high mortality risk. According to Figure 2, relative values indicate that mortality risk is concentrated at medium-high due to floods, while landslides are at a medium-low level. Likewise, the absolute mortality risk shows that floods are classified as medium-low and landslides as very low concentrated.

3 INDICATORS OF DISASTER RISK AND RISK MANAGEMENT

A summary of the results obtained from the System of Indicators application for Guyana for the period 2001-2005 and for the last available year in the databases is presented in this section. These results are useful in order to analyze risk and risk management performance in the country, based on information supplied by different national institutions.

3.1 DISASTER DEFICIT INDEX (DDI)

The DDI measures the economic loss that a particular country could suffer when a catastrophic event takes place, and the implications in terms of the resources that would be needed to address the situation. This index captures the relationship between the demand for contingent resources to cover the losses caused by the Maximum Considered Event (MCE) that the public sector must assume as result of its fiscal responsibility, and this sector's economic resilience (ER).

Losses caused by the MCE are calculated with a model that takes into account, on the one hand, different natural hazards, - calculated in probabilistic terms according to historical registers of intensities of the phenomena - and, on the other hand, the current physical vulnerability that present the exposed elements to those phenomena. The ER is obtained from the estimation of the possible internal or external funds that government, as the entity responsible for recovery or as owner of the affected goods, may access or has available at the time of the evaluation.

A DDI greater than 1.0 reflects the country's inability to cope with extreme disasters, even by taking as much debt as possible. The greater the DDI, the greater the gap. An estimation of a complementary indicator, DDI'_{CE} is therefore made, to illustrate the portion of a country's annual Capital Expenditure that corresponds to the expected annual loss or the pure risk premium; i.e. what percentage of the annual investment budget would be needed to pay for future disasters (IDEA 2005; Cardona 2005). The DDI'_{IS} is also estimated with respect to the amount of sustainable resources due to intertemporal surplus; i.e. the saving which the government can employ, calculated over a ten-year period, in order to best attend to the impacts of disasters. The DDI'_{IS} is the percentage of a country's potential savings at present values that corresponds to the pure risk premium.

3.1.1 Reference parameters for the model

Even though there is no detailed data useful for modelling public and private sector inventories, it is possible to use general information about built areas and/or the population to make estimations of these inventories of exposed elements. This technique or proxy method allows a coarse grain assessment of the volume and cost of the exposed elements required for the analysis. The parameters for shaping a homogeneous and consistent information structure for the specific objectives of the project are shown in Figures 3 and 4: (i) cost of square metre of some construction classes, (ii) built area –in each city related to the number of inhabitants– and (iii) distribution of built areas in basic groups for analysis, such as the public and private components, which would be under the charge of or would be fiscal liabilities of the government in case of disaster. In addition, the rest of private goods, that constitute capital stocks, are considered as well in order to provide a general view of the potential impact in the country.

Figure 3 shows estimations of built areas in different components and its variations in time (from 2000 to 2010). Figure 4 presents a similar graphic related to the exposed values of the whole country. The techniques used for a country's exposure estimation, vulnerability and hazard assessment and risk models are explained in Ordaz & Yamin (2004) and Velasquez (2009). These technical explanations are available at http://idea.unalmzl.edu.co.

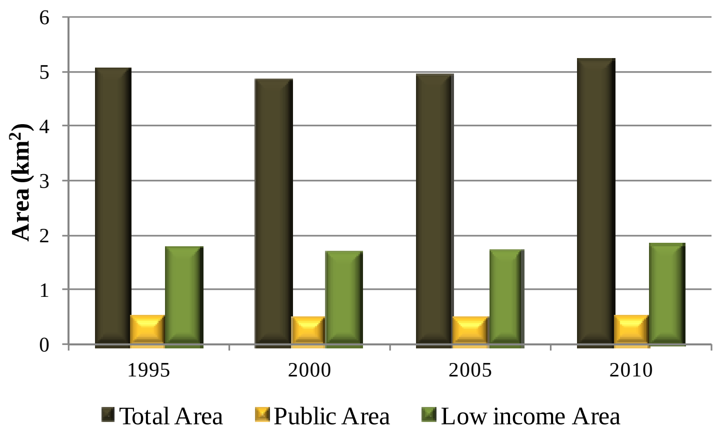


Figure 3. Total built areas by component in square km

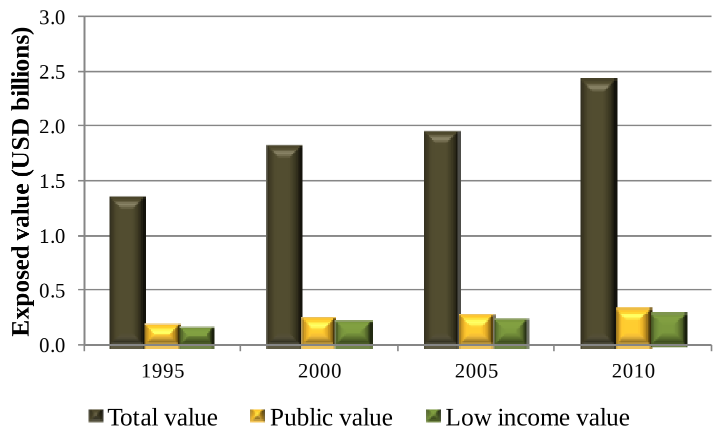


Figure 4. Exposed value by component in billion dollars ($US)

The values of the built areas include (i) total value (public and private built areas), (ii) public value (the buildings of the government and public infrastructure) and (iii) low income value (buildings of the low-income socio-economic homeowners). The properties mentioned above usually are the sovereign or fiscal liabilities.

3.2 Estimation of the indicators

Table 2 shows DDI for 2000, 2005, and 2010 for the Maximum Considered Event (MCE) of 50, 100 and 500 years of return period.[5] In addition, DDI for 2010 for the direct Probable Maximum Losses is included (from the Flood Risk Assessment Report; dam-break case study).

Table 2. DDI for different return periods

DDI	2000	2005	2010	2010 (FRA)
DDI_{50}	1.47	1.37	0.75	0.57
DDI_{100}	2.06	1.92	1.09	0.63
DDI_{500}	2.57	2.41	1.40	0.78

[5] Events that can occur at any moment and which have a probability of occurrence of 2%, 10% and 18% in 10 years.

For extreme events with return periods of 500, 100 and 50 years in all periods the DDI is greater than 1.0; this means the country does not have enough resources to cover losses and/or feasible financial capacity to face losses and replace the capital stock affected. Table 3 shows DDI' values, which corresponds to annual expected loss related to capital expenditure (annual investment budget), and related to possible savings for intertemporal surplus to 10 years, expressed in percentages. DDI_{CE} illustrates that if contingent liabilities to the country were covered by insurance (annual pure premium), the country would have to invest annually 3.7% of 2010's capital expenditure to cover future disasters. The DDI_{IS}, with respect to the amount of sustainable resources due to intertemporal surplus, indicates that for all the periods evaluated savings were negative; that is, annual pure premium value would increase the deficit.

Table 3. DDI' related to capital expenditure and intertemporal surplus

DDI'	2000	2005	2010	2010 (FRA)
DDI_{CE}	7.9%	7.2%	3.7%	2.9%
DDI_{IS}	^D	^D	^D	^D

^D: negative values of intertemporal surplus or lower intertemporal surplus values than the expected annual loss, therefore deficit increasing

Figure 5 illustrates DDI and DDI' values related to capital expenditure. Graphics illustrate that for the 500, 100 and 50-year return period from 2000 to 2010 the DDI and the DDI'_{CE} decreased, although it still remains over 1.00.

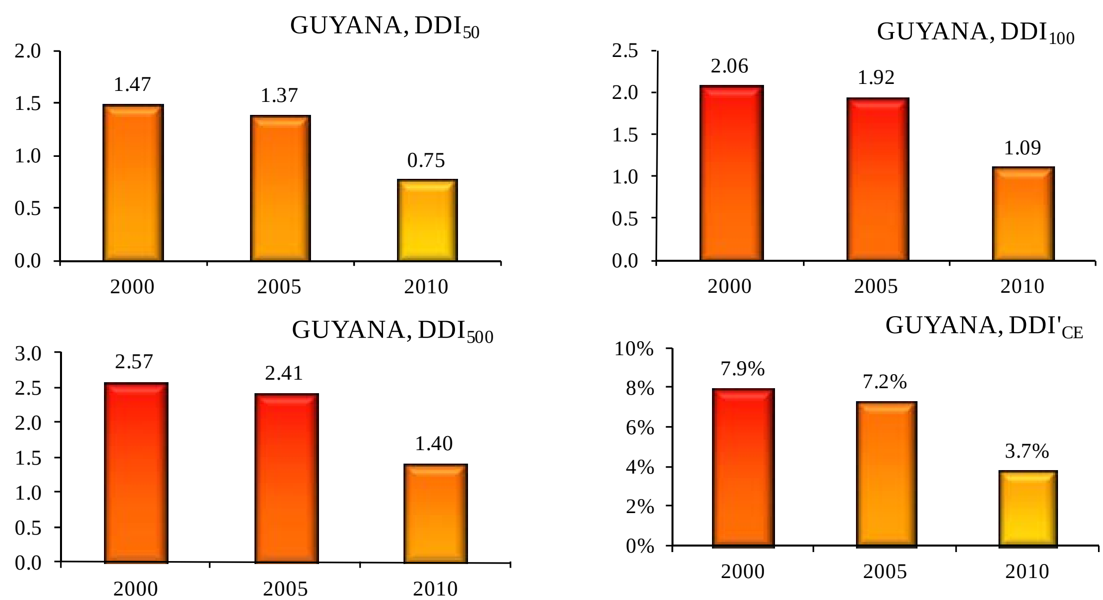


Figure 5. DDI_{50}, DDI_{100}, DDI_{500}, DDI'_{CE}

Table 4 shows the values of the potential losses for the country for the Maximum Considered Event, MCE, with 50, 100 and 500-year return periods. This estimation took into account in retrospective the exposure level of the country for 2000, 2005, and 2010. In addition, Table 4 presents the values of the pure premium or the required annual amount to cover possible future disasters in each period. The DDI and DDI' for the three years of analysis were calculated based on the estimates of the potential maximum losses and expected annual losses respectively (i.e. the numerator of the indicators). The value of losses, obtained for 2010 from the Flood Risk Assessment (FRA) report, is lower because these are direct physical losses (see the figures of the dam-break case study).

These indicators can be estimated every five years and they can be useful in identifying the reduction or increase of the potential deficit due to disasters. Clearly, values of DDI can be more favourable in the future if actions such as investments in mitigation (retrofitting of vulnerable structures), which can reduce potential losses, and a wider insurance coverage of exposed elements, which can enhance economic resilience, are carried out.

Table 4. Probable loss and pure premium for DDI and DDI' calculations

***L* 50**	**2000**	**2005**	**2010**	**2010 (FRA)**
Total – Million US$	195.0	210.0	260.0	194.9
Government – Million US$	97.5	105.0	130.0	97.4
Total - % GDP	27.36%	25.46%	11.83%	8.87%
Government - % GDP	13.68%	12.73%	5.92%	4.43%
***L*100**				
Total – Million US$	292.5	315.0	390.0	226.7
Government – Million US$	146.3	157.5	195.0	113.4
Total - % GDP	41.04%	38.19%	17.75%	10.32%
Government - % GDP	20.52%	19.09%	8.88%	5.16%
***L*500**				
Total – Million US$	390.0	420.0	520.0	288.9
Government – Million US$	195.0	210.0	260.0	144.5
Total - % GDP	54.72%	50.92%	23.67%	13.15%
Government - % GDP	27.36%	25.46%	11.83%	6.58%
***L*y**				
Total – Million US$	14.8	16.0	19.8	15.0
Government – Million US$	7.4	8.0	9.9	7.3
Total - % GDP	2.08%	1.94%	0.90%	0.68%
Government - % GDP	1.04%	0.97%	0.45%	0.33%

Table 5 presents possible internal and external funds that the government needs to access at the time of the evaluation to face the losses in case of an extreme disaster. The sum of these available or usable possible funds corresponds to the economic resilience between 2000 and 2010, for every five years. Based on these estimates (i.e. the denominator of the indicator) the DDI was calculated for the different periods.

Table 5. Economic resilience, funds and resources for DDI calculations

Funds	2000	2005	2010
Insurance premiums - % GDP	0.000	0.000	0.000
Insurance/ reinsurance.50 -***F1p***	0.00	0.00	0.00
Insurance/ reinsurance.100 -***F1p***	0.00	0.00	0.00
Insurance/ reinsurance.500 -***F1p***	0.00	0.00	0.00
Disaster reserves -***F2p***	0.00	0.00	0.00
Aid/donations.50 -***F3p***	9.75	10.50	13.00
Aid/donations.100 -***F3p***	14.63	15.75	19.50
Aid/donations.500 -***F3p***	19.50	21.00	26.00
New taxes -***F4p***	0.00	0.00	0.00
Capital expenditure - % GDP	13.18	13.36	12.08
Budgetary reallocations. -***F5p***	56.36	66.12	159.24
External credit. -***F6p***	0.00	0.00	0.00
Internal credit -***F7p***	0.00	0.00	0.00
Intertemp surplus. *d**- % GDP	-0.180	-0.120	-0.080
Intertemp surplus. -***F8p***	-1.3	-1.0	-$ 2
***R*E.50**			
Total - Million US$	66	77	172
Total - %GDP	9.28%	9.29%	7.84%
***R*E.100**			
Total - Million US$	71	82	179
Total - %GDP	9.96%	9.93%	8.14%
***R*E.500**			
Total - Million US$	76	87	185
Total - %GDP	10.64%	10.56%	8.43%

DDI for 2010 was calculated based on the most recent available information on exposed elements. According to the available statistical information and the estimations of the consultant group, built areas and their physical values were established. Regarding economic resilience (denominator of the index), this was estimated in terms of GDP for each fund, taking as reference the economic information that was available.

Reduction in DDI values in 2005 and 2010 demonstrates that the country has improved its economic resilience. Nevertheless, given that most of the resources to which the government could have access are its own funds and new debt, and, additionally, that government retains the majority of the losses and its financing represents high opportunity-cost, given other needs of investment and the country's other existing budget restrictions, disasters would imply an obligation or non-explicit contingent liability that could have an impact on fiscal sustainability.

3.3 LOCAL DISASTER INDEX (LDI)

The LDI captures simultaneously the incidence and uniformity of the distribution of local disaster effects; i.e. it accounts for the relative weight and persistence of the disaster effects at regional scale. The total LDI is obtained by the sum of three LDIs that are calculated based on the information available in the DesInventar database,[6] regarding deaths, affected people, and economic losses in each region of the country. If the relative value of the index is high, the uniformity of the magnitude and the distribution of the effects of various hazards among regions is greater. A low LDI value means low spatial distribution of the effects among the regions where the events have occurred. The scale used for each LDI is from 0 to 100 and the total LDI is the sum of the three components. A low LDI value (0-20) means high concentration of small disasters in few regions and a low spatial distribution of their effects between the regions where they had taken place. Medium LDI values (20-50) means small disaster concentration and distribution of their effects are intermediate; high LDI values (greater than 50) indicate that the majority of regions suffer small disasters and their effects are similar in all affected regions. High values reflect that vulnerability and hazards are more wide-spread across the territory. Original methodological formulation of the LDI (IDEA 2005) encompassed the effects of all the events (both small and big) occurring in the country; i.e. effects both of small and frequent events and extreme and rare events. However, during the first evaluation made in 2005, it was realized that reflecting the influence of extreme events was not the objective of this indicator. Therefore all further evaluations would take into account only the small and moderate events, as is the case for the Guyana evaluation here. Thus, this updating of the methodology excluded extreme events from the database through statistical identification of outliers (Marulanda and Cardona 2006).

The LDI' that measures the concentration of aggregate losses at regional level has been formulated in a complementary way. Its value is between 0.0 and 1.0. A high LDI' value means that a high economic-losses concentration due to small disasters has occurred, but in few regions. For example, an LDI' equal to 0.43 and 0.79 means that approximately 10% of regions of the country will have a concentration of approximately 35% and 70% of the losses respectively. Table 6 shows LDI for deaths, affected people, and losses, as well as total LDI and LDI' for all the events that took place in the country in the periods 1981-1985, 1986-1990, 1991-1995, 1996-2000, 2001-2005, and 2006-2011. Details of these above-mentioned technical issues are available in the Main Technical Report of the System of Indicators (IDEA 2005).

Table 6. LDI values

	1981-85	1986-90	1991-95	1996-00	2001-05	2006-11
LDI_K	0.00	0.00	45.48	0.00	41.27	0.00
LDI_A	9.47	63.68	60.17	5.36	5.45	50.58
LDI_L	20.86	7.73	30.63	2.50	66.67	5.48
LDI	30.33	71.41	136.28	7.86	113.38	56.06
LDI'	0.67	0.73	0.66	0.76	0.76	0.76

[6] The DesInventar database was developed in 1994 by the Network for Social Studies in Disaster Prevention in Latin America. http://www.desinventar.org

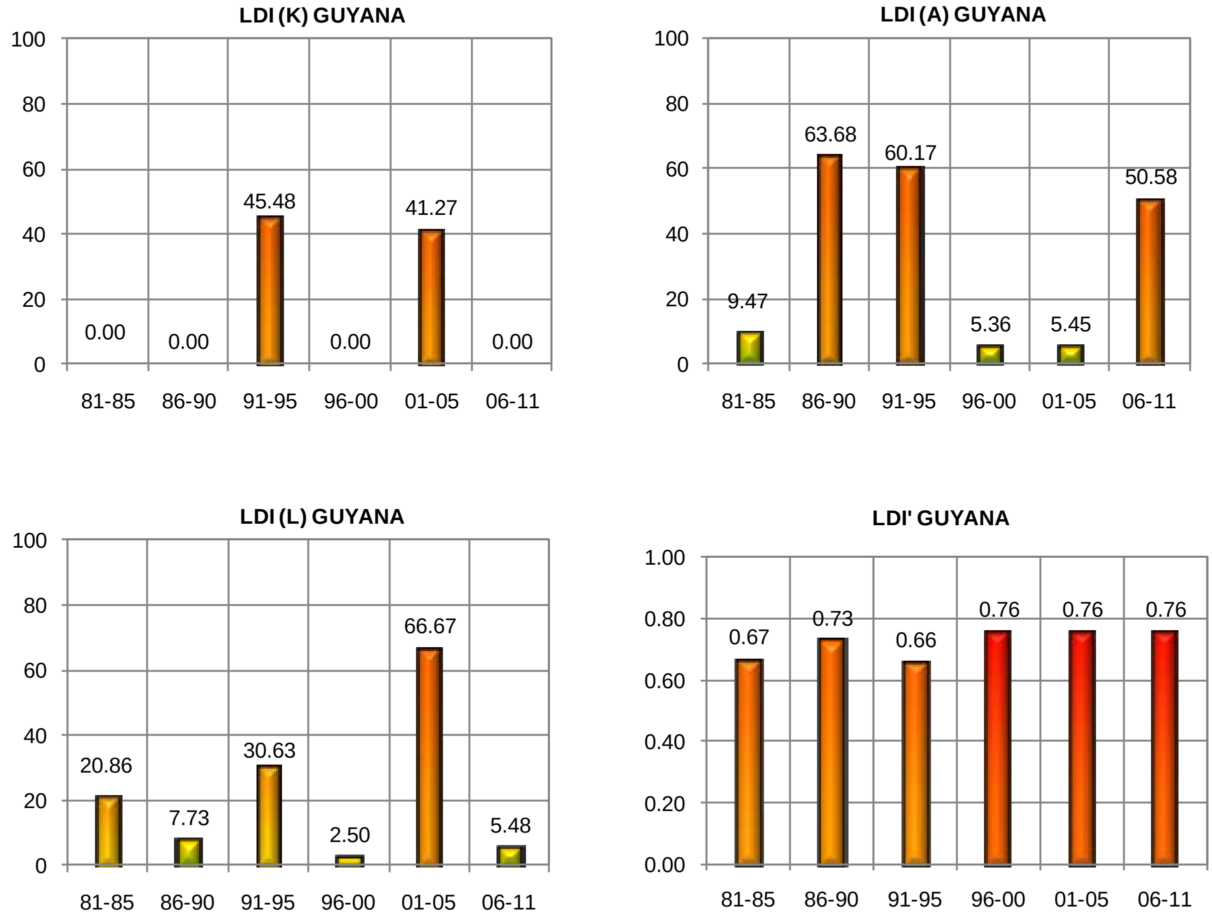


Figure 6. LDI for deaths (K), affected people (A) and losses (L), and LDI'

Figure 6 illustrates LDI values, according to the type of effects in different periods. The LDI for deaths between the period 1991-1995 and 2001-2005 indicates that low-scale disasters caused deaths in a more regular way in the territory. During the other periods it shows that no deaths occurred due to small or moderate disasters. Regarding the LDI for affected persons, the periods 1986-1990, 1991-1995, and 2006-2011 showed a more regular and uniform effect across the territory, while for the other periods effects were more concentrated in only some regions of the country. In the case of the LDI of economic losses the only period that presented a more uniform behaviour across regions was the period 2001-2005. The economic losses in the other periods were more concentrated in only a few regions of the country. The results of the LDI' show medium-high values which mean the concentration of the economic losses are not very well distributed within the country.

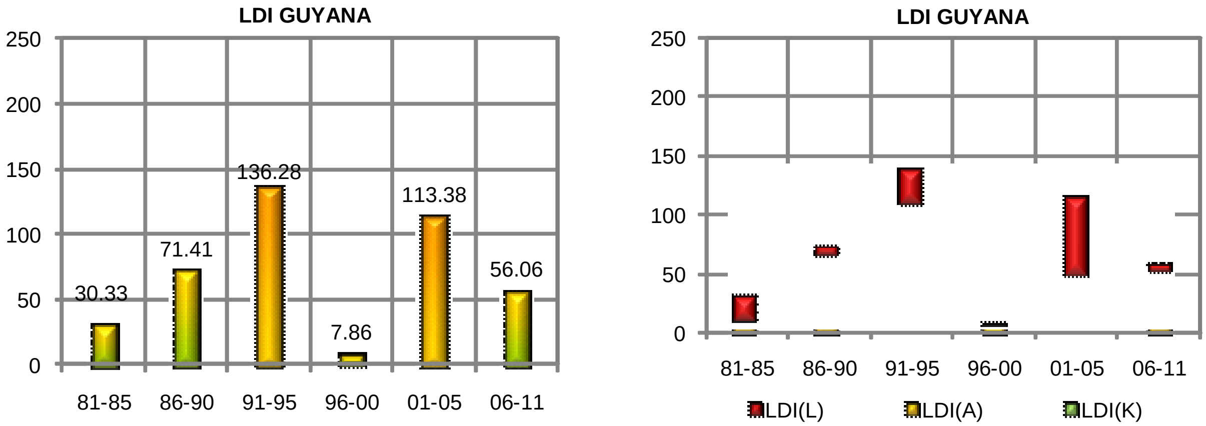


Figure 7. Total LDI and aggregated presentation

In general, as the LDI illustrates in Figure 7, low-scale disasters caused more regular and distributed effects between all regions of the country at the beginning of the 1990s and beginning of 2000 than in the 1980s, and especially in the period 1996-2000. At the end of the 1990s this regularity decreased, i.e. effects became more concentrated.

Table 7 shows the numbers of total deaths, total affected persons and total economic losses in US dollars for the four periods evaluated.

Table 7. Total of deaths, affected persons and losses

	1981-85	1986-90	1991-95	1996-00	2001-05	2006-11
Total deaths	1	3	5	3	15	1
Total affected persons	468	717	2,492	6,063	5,777	810
Total losses (USD)	1,067,521	115,987	79,090	714,546	319,232	67,331

Figure 8 shows these values to illustrate changes from one period to another. Deaths were less in 1990s as compared to the 2001-2005 period whereas the economic losses were very high in the 1981-1985 period, and high for the period 1996-2000. The numbers of affected persons were high for 1990s and for the period 2001-2005. Taking into account the results of the LDI_L and the LDI' for this period, it can be seen that the economic losses were very concentrated, either spatially or by type of event.

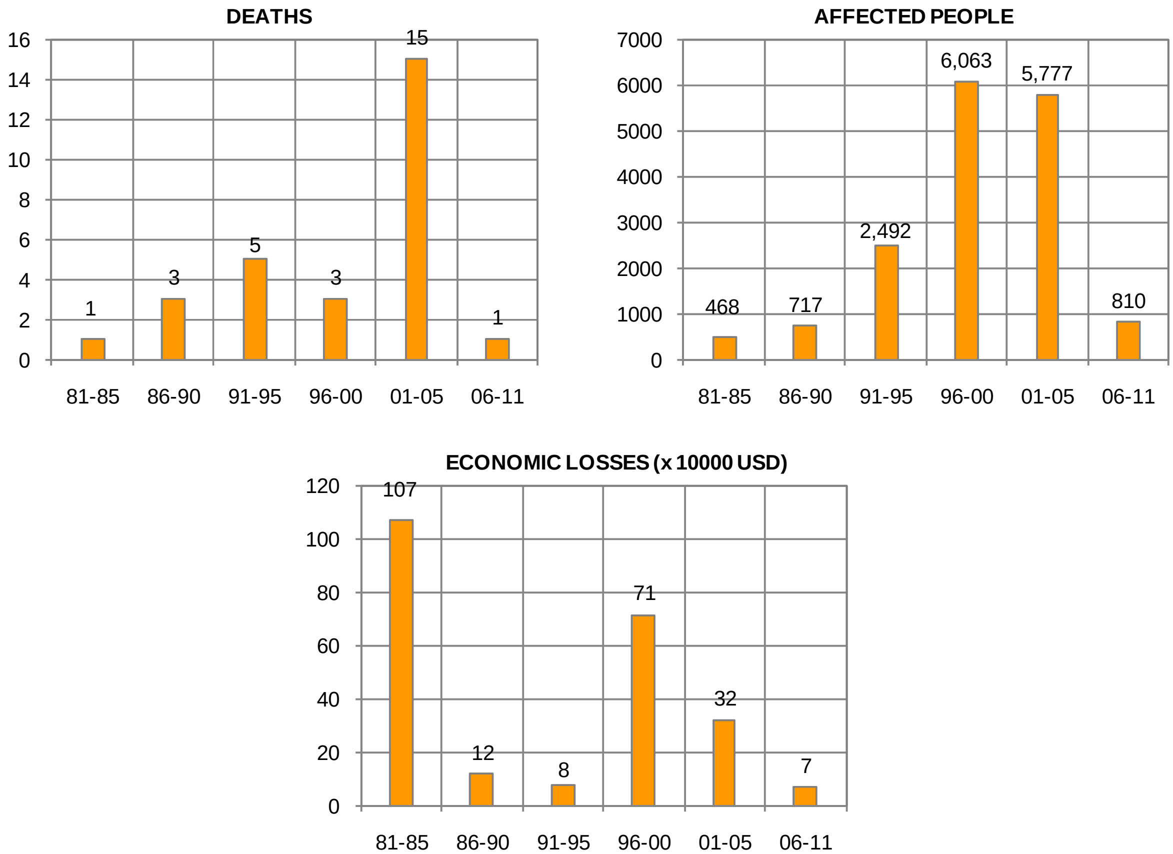


Figure 8. Total deaths, affected people and losses

It should be taken into account that the LDI has been built based on the effects presented in different types of events. Nonetheless, it is important to indicate that the LDI is a measure that combines persistence, incidence, and regularity of events on a territorial level. This is the reason why in order to determine the index, values have been normalized using the area of the regions.

These indices are useful for economic analysts and sectoral officials, related to the promotion of rural and urban policy development, because they can detect the persistency and accumulation of effects of local disasters. They can stimulate the consideration of risk problems in territorial planning at the local level and intervention, as well as the protection of hydrologic basins, and they can justify resource transfers to the local level with the specific goals of risk management and the creation of social security nets.

3.4 PREVALENT VULNERABILITY INDEX (PVI)

PVI characterizes predominating vulnerability conditions reflected in exposure in prone areas, socio-economic fragility, and lack of social resilience; aspects which favour both direct impact and indirect and intangible impact in case of the occurrence of a hazard event. This index is a composite indicator that depicts, comparatively, a situation or pattern in a country, and its causes or factors. This is so to the extent that the vulnerability conditions that underlie the notion of risk are, on the one hand, problems caused by inadequate economic growth and, on the other hand, deficiencies that may be intercepted via adequate development processes. The PVI reflects (i) susceptibility due to the level of physical exposure of goods and people, (the PVI_{ES}) that favours direct impact in case of hazard events); (ii) social and economic conditions that favour indirect and intangible impact, (the PVI_{SF}); and (iii) lack of capacity to anticipate, to absorb consequences, to efficiently respond, and to recover, (the PVI_{LR}) (IDEA 2005; Cardona 2005).

The PVI ranges between 0 and 100. A value of 80 means very high vulnerability, from 40 to 80 means high, from 20 to 40 is a medium value, and less than 20 means low.

3.4.1 Indicators of exposure and susceptibility

In the case of exposure and/or physical susceptibility, the PVI_{ES}, the indicators that best represent this function, are those that represent the susceptible population, assets, investment, production, livelihoods, essential patrimony, and human activities. Other indicators of this type may be found in population, agricultural and urban growth, and densification rates. These indicators are detailed below:

- ES1. Population growth, avg. annual rate, %
- ES2. Urban growth, avg. annual rate, %
- ES3. Population density, people (5 km^2)
- ES4. Poverty-population below US$1 per day PPP
- ES5. Capital stock, million US$ dollar/1000 km^2
- ES6. Imports and exports of goods and services, % GDP
- ES7. Gross domestic fixed investment, % of GDP
- ES8. Arable land and permanent crops, % land area.

These indicators are variables that reflect a notion of susceptibility when faced with dangerous events, whatever the nature or severity of these. 'To be exposed and susceptible is a necessary condition for the existence of risk'. Despite the fact that in any strict sense it would be necessary to establish if the exposure is relevant when faced with each feasible type of event, it is also possible to assert that certain variables comprise a comparatively adverse situation where it is posited that natural hazards exist as a permanent external factor, even without precisely establishing their characteristics.

3.4.2 Indicators of socio-economic fragility

Socio-economic fragility, PVI_{SF}, may be represented by indicators such as poverty, human insecurity, dependency, illiteracy, social disparities, unemployment, inflation, debt, and environmental deterioration. These are indicators that reflect relative weaknesses and conditions of deterioration which would increase the direct effects associated with hazardous phenomena. Even though such effects are not necessarily accumulative, and in some cases may be redundant or correlated, their influence is especially important at the social and economic levels. Those indicators are the following:

- SF1. Human Poverty Index, HPI-1
- SF2. Dependents as proportion of working-age population
- SF3. Social disparity, concentration of income measured using the Gini index
- SF4. Unemployment, as % of total labour force
- SF5. Inflation, food prices, annual %
- SF6. Dependency of GDP growth on agriculture, annual %
- SF7. Debt servicing, % of GDP.
- SF8. Human-induced soil degradation (GLASOD).

These indicators are variables that reflect, in general, an adverse and intrinsic[7] predisposition of society to be affected when faced with a hazardous phenomenon, whatever the nature and intensity of these events. 'The predisposition to be affected' is a vulnerability condition, although in a strict sense it would be necessary to establish the relevance of this affirmation when faced with all and individual feasible types of hazard. Nevertheless, as is the case with exposure (as reflected by the PVI_{ES}), it is possible to suggest that certain variables reflect a comparatively unfavourable situation, supposing that the natural hazards exist as a permanent external factor, irrespective of their exact characteristics.

3.4.3 Indicators of resilience (lack of)

The lack of resilience, PVI_{LR}, seen as a vulnerability factor, may be represented at all levels by means of the complementary or inverted[8] treatment of a number of variables related to human development levels, human capital, economic redistribution, governance, financial protection, collective perceptions, preparedness to face crisis situations, and environmental protection. This collection of indicators on their own, and particularly where they are disaggregated at the local level, could help in the identification and orientation of actions that should be promoted, strengthened, or prioritized in order to increase human security.

- LR1. Human Development Index, HDI [Inv]
- LR2. Gender-related Development Index, GDI [Inv]
- LR3. Social expenditure; on pensions, health, and education, % of GDP [Inv]
- LR4. Governance Index (Kaufmann) [Inv]
- LR5. Insurance of infrastructure and housing, % of GD [Inv]
- LR6. Television sets per 1000 people [Inv]
- LR7. Hospital beds per 1000 people [Inv]

[7] This is also defined as inherent vulnerability. It means the socio-economic conditions peculiar to the communities which then favour or facilitate the occurrence of such effects.
[8] The symbol [Inv] is used here to indicate a reverse or inverted dealing of the variable (¬R = 1- R).

- LR8. Environmental Sustainability Index, ESI [Inv]

These indicators are variables that capture in a macro fashion the capacity to recover from or absorb the impact of hazardous phenomena, whatever their nature and severity. ‘To not be in a capacity to’ adequately face disasters is a vulnerability condition, although in a strict sense it is necessary to establish this with reference to all feasible types of hazard. Nevertheless, as with exposure (as reflected by the PVI_{ES}) and fragility (as reflected by the PVI_{SF}), it is possible to admit that certain economic and social variables reflect a comparatively unfavourable situation, from the supposition that natural hazards exist as permanent external factors, without establishing their precise characteristics.

3.4.4 Estimation of indicators

In general, PVI reflects susceptibility due to the degree of physical exposure of goods and people, PVI_{ES}, which favour direct impact in case of hazard events. In the same way, it reflects conditions of socio-economic fragility which favour indirect and intangible impact, $PVI_{SF.}$ Also, it reflects lack of capacity to absorb consequences, for efficient response and recovery, PVI_{LR}. Emphasis on these aspects should be made, since the purpose both of the human sustainable development process and risk management is the reduction of these kinds of factors.

Table 8 shows the total PVI and its components related to exposure and susceptibility, socio-economic fragility, and lack of resilience. It is important to point out that in order to include sub-indicators for which there were no recent figures, the option was made to use the same value in all periods,[9] in order to avoid affecting the relative value of indices. Hopefully the value of these sub-indicators will be published in the future.

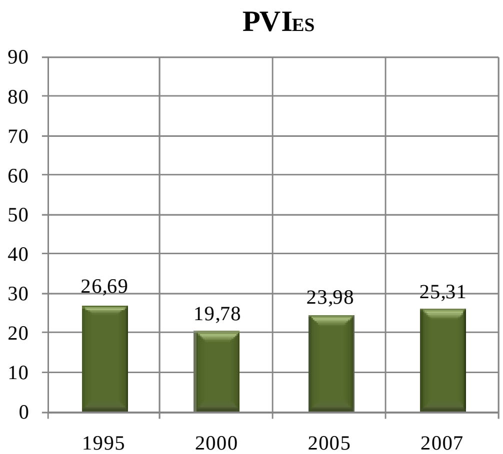
Therefore, although this evaluation was developed in 2011, the most recent available indicators for Guyana were for 2007, so the presented results correspond to the years 1995, 2000, 2005, and 2007.

Table 8. PVI values

	1995	2000	2005	2007
PVI_{ES}	26.69	19.78	23.98	25.31
PVI_{SF}	38.25	32.36	32.25	32.68
PVI_{LR}	49.68	45.03	43.61	43.75
PVI	38.21	32.39	33.28	33.92

Figure 9 shows non-scaled sub-indicator values which compose the $PVI_{ES,}$ and their respective weights, which were obtained using the Analytic Hierarchy Process (AHP).

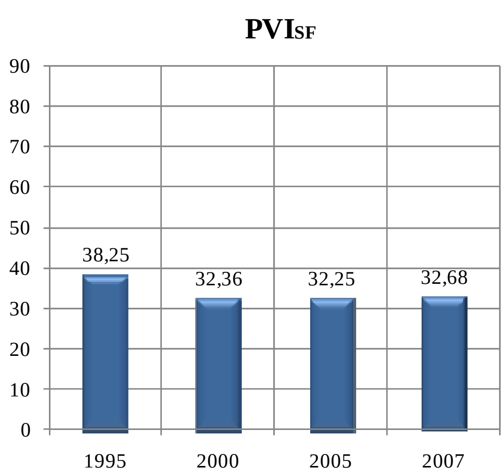
[9] In the case of exposure and susceptibility, the sub-indicator of arable land and permanent crops (ES8) presented the same value from 2000 to 2007. In the socio-economic sub-indicator, fragility corresponded to human-induced soil degradation (GLASOD) (SF8) from 2000 to 2007.



	1995	2000	2005	2007	W AHP
ES.1	0,24	-0,01	0,15	-0,02	5,01
ES.2	-0,03	-0,36	-0,13	0,19	12,37
ES.3	19,27	19,21	19,40	19,41	8,99
ES.4	8,10	3,00	3,00	3,00	25,39
ES.5	13,25	14,49	15,11	17,46	12,35
ES.6	213,33	206,77	203,83	154,11	11,71
ES.7	33,23	23,78	32,33	39,93	12,38
ES.8	2,56	2,43	2,29	2,29	11,82

Figure 9. PVI_{ES}

Generally speaking, growth in Prevalent Vulnerability Index (PVI) values indicates, negatively, more vulnerability in a country; decreases in PVI values (positively) indicate a lessening in vulnerability. Vulnerability due to exposure and susceptibility in the country was relatively constant in all periods; there were slight variations in time. The capital stock (ES5) showed an increasing trend towards vulnerability during the years evaluated. In 2000 all the indicators, positively, with the exception of the ES5, decreased their value; this is reflected by the value of the PVI_{ES}. Positively, for imports and exports of goods and services (ES6) as well as for other indicators such as poverty-population (ES4) and the arable land and permanent crops (ES8), the values decreased in 2000, and in the following years they maintained the same values. In general, when the values of the sub-indicators in 1995 and 2007 are compared, it can be seen that four of the eight sub-indicators reduced their values, but in differing degrees. This fluctuation in the sub-indicator values is reflected in the PVI_{ES} results. Figure 10 shows non-scaled sub-indicator values which compose the $PVI_{SF,}$ and their respective weights, which were obtained using the Analytic Hierarchy Process (AHP).

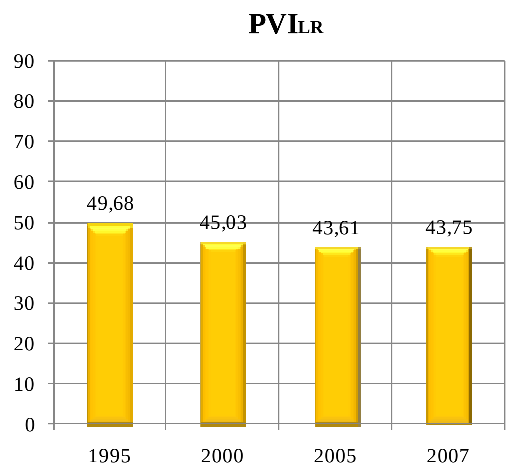


	1995	2000	2005	2007	WAHP
SF.1	11,40	11,40	14,00	14,00	20,91
SF.2	61,72	55,64	57,92	57,26	8,50
SF.3	40,20	40,20	40,20	40,20	16,40
SF.4	12,00	12,00	9,10	9,10	12,52
SF.5	12,21	6,15	6,93	12,30	9,44
SF.6	41,23	31,09	34,60	31,14	9,58
SF.7	45,35	16,20	16,20	16,20	9,63
SF.8	7,21	7,21	7,21	7,21	13,02

Figure 10. PVI_{SF}

Vulnerability due to socio-economic fragility had no significant changes in the periods evaluated. The PVI_{SF} decreased between 1995 and 2000, and then it presented slight changes. In 2000 the PVI_{SF} decreased due to some positive changes in sub-indicators such as dependents as proportion of working-age population (SF2), inflation (SF5), dependency of GDP growth on agriculture (SF6), and debt servicing (SF7). Social disparity (SF3) and the human-induced soil degradation (SF8) maintained the same value. The total PVI_{SF} had a very slight decrease in 2005. The causes of this positive change were in decreasing of unemployment (SF4), social disparity not increasing (SF3), debt servicing (SF7), and human-induced soil degradation not increasing (SF8), although, negatively, there was growth in other indicators such as the Human Poverty Index (SF1), the dependent population (SF2), inflation (SF5), and the dependency of GDP growth on agriculture (SF6). In 2007, the PVI_{SF} had a slight growth, but for the most part the indicators presented the same values as in 2005.Only inflation (SF5) increased, whereas, positively, the indicators of dependent population (SF2) and the dependency of GDP growth on agriculture (SF6) decreased. Finally, social disparity (SF3) and human-induced soil degradation (SF8) retained the same value for all years.

Figure 11 shows the figures for non-scaled sub-indicators which compose the $PVI_{LR,}$ and their respective weights, which were obtained using the Analytic Hierarchy Process (AHP).



	1995	2000	2005	2007	WAHP
LR.1	0,70	0,71	0,75	0,76	21,91
LR.2	0,63	0,70	0,74	0,76	10,53
LR.3	15,41	15,41	15,39	14,26	13,56
LR.4	0,52	0,46	0,40	0,43	15,05
LR.5	1,85	3,26	6,65	6,63	12,90
LR.6	0,24	0,94	0,83	0,92	3,70
LR.7	3,10	2,95	2,80	1,90	9,17
LR.8	62,90	62,90	62,90	62,90	13,18

Figure 11. PVI_{LR}

Vulnerability due to lack of resilience has the opposite meaning of resilience or capacity, obtained from the sub-indicators selected. In this case most of the sub-indicators reflect small changes in their values. The PVI_{LR} slightly decreased between 1995 and 2005, and then, in 2010, it had a very small increase. The most considerable changes were found between 1995 and 2000, where the indicators of Human Development Index (LR1), Gender-related Development Index (LR2), Insurance of Infrastructure and Housing (LR5) and Television Sets (LR6) increased their values, thus positively reducing this lack of resilience. Figure 12 shows the total PVI value obtained from the average of the component indicators, and the aggregated format which illustrates the contribution of each indicator.

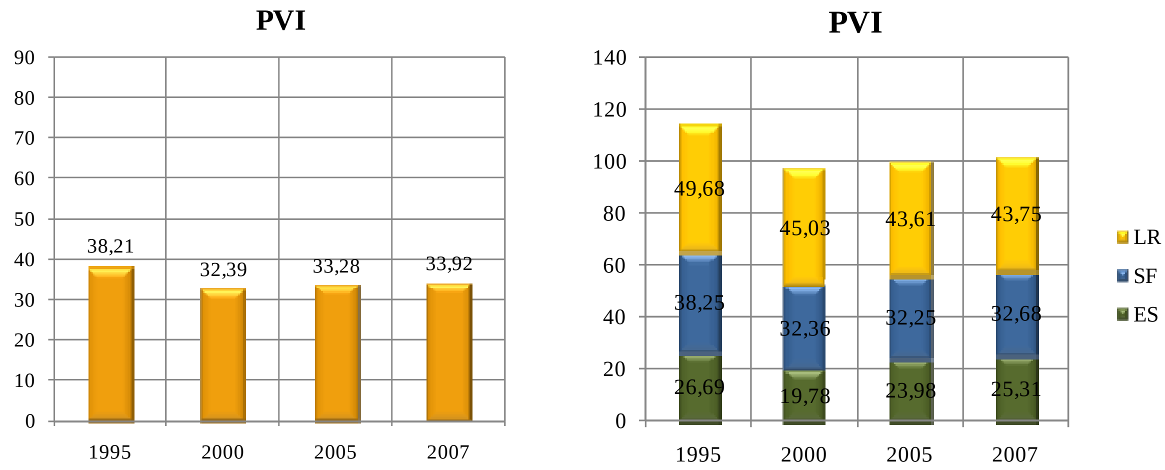


Figure 12. PVI

PVI figures illustrate a reduction in the prevalent vulnerability in 2000, due to the decreasing of the three components of the index. The PVI_{LR} indicator is the component with most contribution to the country's prevalent vulnerability. In 2007, the PVI increased due to the growing of exposure and susceptibility and the lack of resilience.

The PVI illustrates the relationship between risk and development, either because the development model adopted reduces it or increases it. This aspect makes evident the necessity of explicit risk reduction measures, because development actions do not reduce vulnerability automatically. This evaluation can be useful to institutions related to housing and urban development, environment, agriculture, health and social care, economics and planning, to mention a few.

3.4 RISK MANAGEMENT INDEX (RMI)

The main objective of the RMI is the measurement of performance of risk management. This index is a qualitative measurement of risk based on pre-established levels (targets) or desirable referents (benchmarking) towards which risk management should be directed, according to its level of advancement. For RMI formulation, four components or public policies are considered: risk identification (RI), risk reduction (RR), disaster management (DM) and governance and financial protection (FP).

Estimation of each public policy takes into account six sub-indicators that characterize the performance of management in the country. Assessment of each sub-indicator is made using five performance levels: *low, incipient, significant, outstanding, and optimal,* that corresponds to a scale of 1 to 5, where 1 is the lowest level and 5 the highest. In this methodological focus each reference level is equivalent to a 'performance objective'; thus, it allows the comparison and identification of results or achievements towards which governments should direct the efforts of formulation, implementation, and evaluation of policies in risk management.

Once performance levels of each sub-indicator have been evaluated, through a non-lineal aggregation model, the value of each component of the RMI is determined (IDEA 2005; Cardona 2005). The value of each composed element is between 0 and 100, where 0 is the minimum performance level and 100 is the maximum level. Total RMI is the average of the four composed indicators that represent each public policy. When the value in the RMI is high, performance of risk management in the country is better.

3.4.1 Institutional Organization

The institution in charge of planning and conducting operations related to the different types of disasters in Guyana is the Civil Defence Commission (CDC), established in 1982. By 1985 a comprehensive National Disaster Preparedness Plan was documented and put into use. At the time of its establishment the Commission operated under the authority of the Office of the Prime Minister. Responsibility for the CDC was subsequently moved to the Office of the President in 1992.

The CDC was reconstituted in 1997, and two committees were created: the National Disaster Committee, and the Essential Services Disaster Committee, both headed by the National Disaster Co-ordinator. The establishment of permanent Headquarters and staffing from the Joint Services was also decided. The terms of reference of the Commission were defined as follows: i) to identify disasters according to established criteria and classification; ii) to produce plans for the Management of National Disasters; iii) to identify and implement mechanisms for disaster response and mitigation; iv) to maintain a permanent body, to enhance the national capacity for disaster management services; v) to train human resources involved in disaster response mechanisms; vi) to educate at all levels in the tenets of disaster responses.

In September 2001, the Standard Operation Procedures for the National Emergency Operations Centre were upgraded to meet new challenges of the worsening domestic and international disaster situation (CDC 2012). Figure 13 shows the organizational structure of the CDC.

The CDC manages different plans and procedures as tools of disaster management in order to structure and guide emergency action. The primary plans and procedures cover the following: *Disaster Plans*, including preparedness plans prepared on the basis of known risks, estimated impact areas, and predicted needs; *Contingency Plans*, which involve actions planned in anticipation that something unexpected might occur; *Forward Planning*, which concerns the development of specific plans to meet an immediate emergency; and *Standard Operating Procedures (SOPs).* SOPs are developed within an organization to provide standard responses to anticipated situations (CDC 2012).

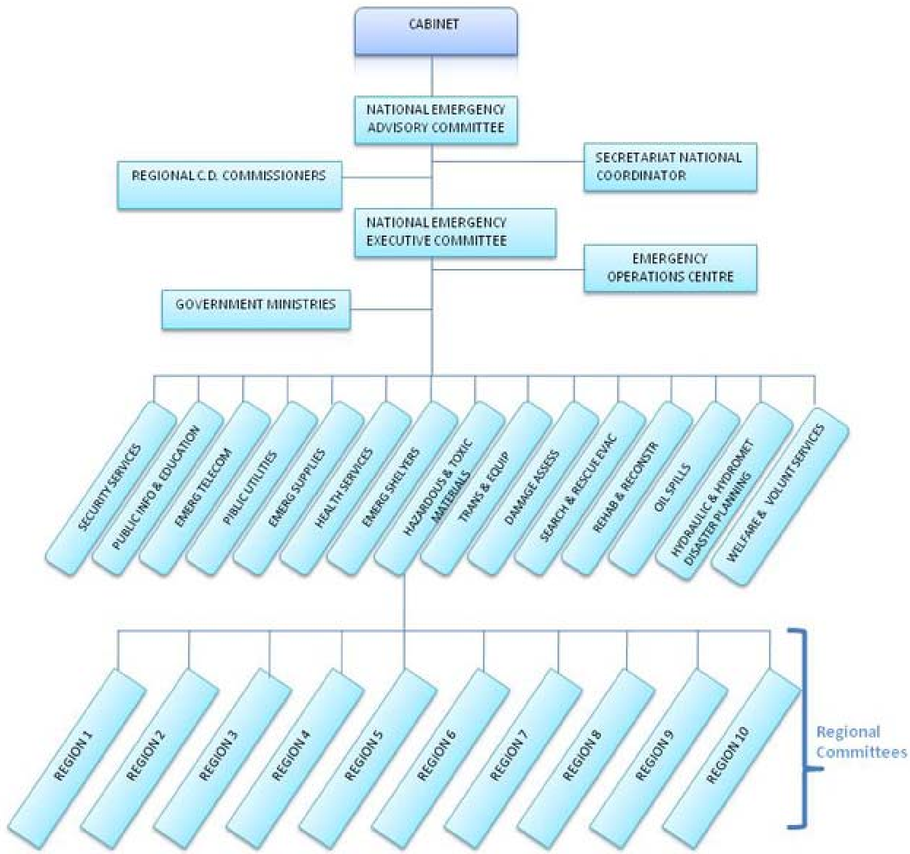


Figure 13. Organizational structure of the CDC (Source: CDC[10])

The functions of the CDC are as follows (CDC 2012):

- *Service Provider*- providing services to local authorities/communities, and therefore developing programmes designed to enhance those services.
- *Planning and Implementation*- ensuring the promotion and development at national level of disaster planning and management and, in co-operation with local authorities, facilitating the implementation of disaster management measures.
- *Loss Reduction and Mitigation*- promoting the adoption of disaster loss reduction and mitigation policies and practices at the national and local authority level.
- *Voluntary Service*- promoting and developing voluntary service as an integral aspect of disaster management.
- *Training and Education*- establishing and promoting the development, maintenance and improvement of the tenets of disaster management training and education.
- *Permanent Staffing*- maintaining a permanent body to enhance the national capacity for disaster management services.

[10] http://www.cdc.gy/new/index.php/en/component/content/article?id=56

Responsibility for disaster management in Guyana extends to every individual, family, community, government, and private sector organizations. The Civil Defence Commission co-ordinates the national system with these bodies and is committed to initiating and supporting the disaster management process throughout Guyana (CDC 2012).

The Government of Guyana is inclined to adopt a comprehensive reform process to modernize the Civil Defence Commission (CDC) and to bring it in line as much as practicable with the policies of CARICOM's umbrella agency for disaster management.

The reform process will involve, among other measures, the revising of the outdated National Disaster Preparedness Plan to make the CDC compliant with global and regional systems such as United Nations International Strategy for Disaster Reduction, and the Caribbean Disaster Emergency Response Agency's Comprehensive Disaster Management Framework. Implementing disaster preparedness legislation and upgrading infrastructural facilities will be completed as well.

The CDC of Guyana is a full member of the Caribbean Disaster Emergence Management Agency (CDEMA), the regional disaster management body formerly known as the Caribbean Disaster Emergency Response Agency, CDERA.

CDEMA replaces and advances the work of CDERA. CDEMA has fully embraced the principles and practice of Comprehensive Disaster Management (CDM), which is an integrated and proactive approach to disaster management. CDM seeks to reduce the risk and loss associated with natural and technological hazards and the effects of climate change in order to enhance regional sustainable development. CDEMA plays a role as facilitator, driver, co-ordinator and motivating force for the promotion and engineering of CDM in all participating States. (CDEMA 2012)

To date, the Government of Guyana (GOG), with the support of the international donor community, has implemented several policy instruments and activities toward improving disaster risk management and coastal zone management in the context of climate change adaptation. In 2002, a national climate change adaptation policy and implementation plan was approved. Following the 2005 floods, the GOG highlighted the need for a comprehensive plan of action for disaster response and risk reduction. A proposal for reform of the Civil Defence Commission (CDC) is under consideration. In 2007, the Global Environmental Facility (GEF) through the World Bank, under the Special Climate Change Fund, provided a grant to GOG in the amount of US$3.8 million, to finance a Conservancy Adaptation Project, which is under implementation. The European Union is also providing support for coastal zone management and sea defence; the GEF for early warning systems, and OXFAM for shelters (IDB 2009).

In spite of these initiatives, several constraints limit Guyana's ability to systematically reduce disaster risk in the face of a changing climate. These include the need to *(i)* more accurately assess the impacts of sea-level rise and climate change; *(ii)* strengthen disaster risk management institutions, including reorienting toward emphasis on ex ante risk reduction; *(iii)* incorporate sea-level rise and climate change in the design of sea defence and flood protection works; and *(iv)* manage flood risk within the context of a comprehensive development framework which integrates climate change adaptation planning, disaster risk management, coastal zone management, and environmental and watershed management. These needs are in line with those expressed in Guyana's National Communication to the United Nations Framework Convention for Climate Change (UNFCCC) (IDB 2009).

In order to address these needs, the GOG requested technical assistance from the IDB to strengthen its capacity in integrated disaster risk management (IDRM), through the application of the IDB risk indicators and country risk evaluation and the updating of its National Disaster Plan to conform with the principles of IDRM, towards investment financing in disaster prevention and mitigation (IDB 2012). These interventions will be designed in co-ordination with existing initiatives being implemented by the World Bank, the UNDP, and other donor agencies. This report is one of the products of this technical assistance.

3.4.2 Indicators of risk identification

The identification of risk generally includes the need to understand individual perceptions and social representations and provide objective estimates. In order to intervene in risk it is necessary to recognize its existence,[11] dimension it (measurement) and represent it by means of models, maps, indexes etc. that are significant for society and decision-makers. Methodologically, it includes the evaluation of hazards, the different aspects of vulnerability when faced with these hazards, and estimations as regards the occurrence of possible consequences during a particular period of exposure. The measurement of risk is relevant when the population recognizes and understands it. In that way, the results can be the basis for risk intervention. The indicators that represent risk identification, RI, are the following:

- RI1. Systematic disaster and loss inventory
- RI2. Hazard monitoring and forecasting
- RI3. Hazard evaluation and mapping
- RI4. Vulnerability and risk assessment
- RI5. Public information and community participation
- RI6. Training and education on risk management.

3.4.3 Indicators of risk reduction

Risk management aims particularly to reduce risk. In general, this requires the execution of structural and non-structural prevention-mitigation measures. It is the act of anticipating with the aim of avoiding or diminishing the economic, social, and environmental impact of

[11] That is to say, it has to be a problem for someone. Risk may exist but not perceived in its real dimensions by individuals, decision-makers and society in general. To measure or dimension risk in an appropriate manner is to make it apparent and recognized, which in itself means that something has to be done about it. Without adequate identification of risk it is impossible to carry out anticipatory preventive actions.

potentially dangerous physical phenomena. It implies planning processes but, fundamentally, the execution of measures that modify existing risk conditions through corrective and prospective interventions of existing and potential future vulnerability, and hazard control when feasible. The indicators that represent risk reduction, RR, are the following:

- RR1. Risk consideration in land-use and urban planning
- RR2. Hydrological basin intervention and environmental protection
- RR3. Implementation of hazard-event control and protection techniques
- RR4. Housing improvement and human settlement relocation from prone-areas
- RR5. Updating and enforcement of safety standards and construction codes
- RR6. Reinforcement and retrofitting of public and private assets.

3.4.4 Indicators of disaster management

Disaster management should provide appropriate response and recovery post-disaster, and depends on the level of preparation of operational institutions and the community. This public policy seeks to respond efficiently and appropriately when risk has been materialized and it has not been possible to impede the impact of hazardous phenomena. Effectiveness implies organization, capacity, and operative planning of institutions and other diverse actors involved in disasters. The indicators that represent the capacity for disaster management, DM, are the following:

- DM1. Organization and co-ordination of emergency operations
- DM2. Emergency response planning and implementation of warning systems
- DM3. Endowment of equipment, tools and infrastructure
- DM4. Simulation, updating and testing of inter-institutional response
- DM5. Community preparedness and training
- DM6. Rehabilitation and reconstruction planning.

3.4.5 Indicators of governance and financial protection

Governance and financial protection is fundamental for the sustainability of development and economic growth in a country. This implies, on the one hand, co-ordination between different social actors that necessarily are guided by different disciplinary approaches, values, interests, and strategies. Effectiveness is related to the level of interdisciplinarity and integration of institutional actions and social participation. On the other hand, governance depends on an adequate allocation and use of financial resources for the management and implementation of appropriate strategies for the retention and transference of disaster losses. The indicators that represent governance and financial protection, FP, are the following:

- FP1. Interinstitutional, multisectoral and decentralizing organization
- FP2. Reserve funds for institutional strengthening
- FP3. Budget allocation and mobilization
- FP4. Implementation of social safety nets and funds response
- FP5. Insurance coverage and loss transfer strategies of public assets

- FP6. Housing and private sector insurance and reinsurance coverage.

3.4.6 Estimation of Indicators

RMI results have been obtained from detailed opinion surveys completed by national experts and representatives of various institutions related to risk management. The surveys were performed with the support of a local consultant and the CDC, who identified a list of potential local experts who had suitable knowledge about disaster risk management in the country. Thus, this index reflects performance of risk management based on evaluations of academics, professionals, and officials of the country. Results for 1990, 1995, 2000, 2005, and 2010 are presented below.

Table 9 shows the total RMI and its components, for each period. These are risk identification, RMI_{RI}, risk reduction, RMI_{RR}, disaster management, RMI_{DM}, and governance and financial protection, RMI_{FP}.

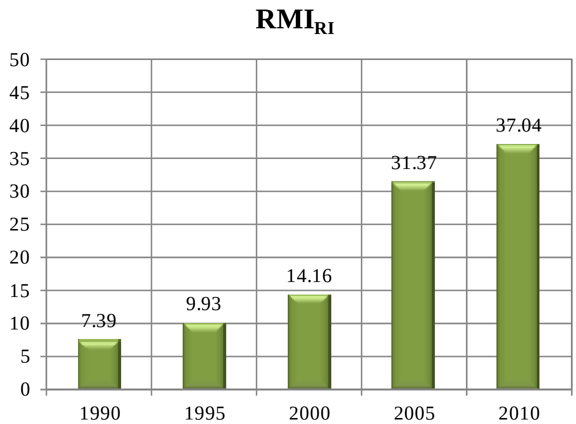
Table 9. RMI values

Year	1990	1995	2000	2005	2010
RMI_{RI}	7.39	9.93	14.16	31.37	37.04
RMI_{RR}	8.13	12.93	12.93	17.21	32.41
RMI_{DM}	5.25	9.32	16.3	17.21	39.51
RMI_{FP}	8.26	9.94	13.46	14.77	17.21
RMI	7.26	10.53	14.21	20.14	31.54

Figure 14 shows the qualifications of sub-indicators[12] that composed RMI_{RI} and their respective weights, obtained using the Analytic Hierarchy Process (AHP).

Management related to risk identification shows a notable progress from 1990 to 2010. From 1990 to 2010 it can be observed that the country had a level improvement from low to significant in hazard monitoring and forecasting (RI2), and in vulnerability and risk assessment (RI4). Hazard evaluation and mapping (RI3), public information and community participation (RI5) and training and education in risk management (RI6) changed from a low to an incipient level of performance. Systematic disaster and loss inventory (RI1) changed from an incipient to a significant level. The most significant indicator according to the used weights, the vulnerability and risk assessment (RI4), had one of the most remarkable changes; this is reflected in the RMI_{RI} results.

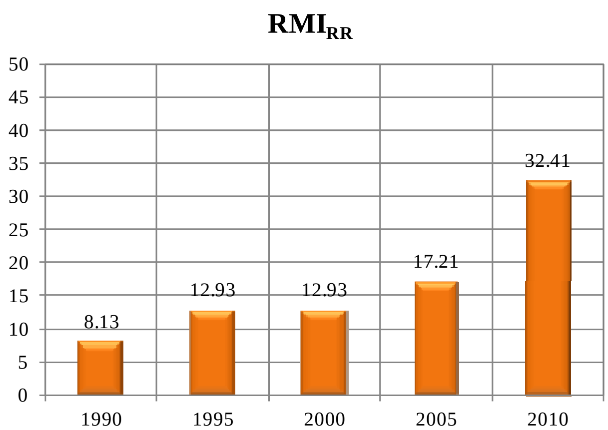
[12] The numbers in the tables mean: 1: *low*, 2: *incipient*, 3: *significant*, 4: *outstanding* and 5: *optimal*.



Ind.	1990	1995	2000	2005	2010	Weight
RI,1	2	2	2	3	3	13.56
RI,2	1	2	2	3	3	18.14
RI,3	1	1	1	2	2	15.06
RI,4	1	1	2	2	3	20.95
RI,5	1	1	2	2	2	15.13
RI,6	1	1	1	2	2	17.16

Figure 14. RMI_{RI}

Figure 15 shows sub-indicator qualifications that composed the RMI_{RR} and their respective weights, obtained using the Analytic Hierarchy Process (AHP).

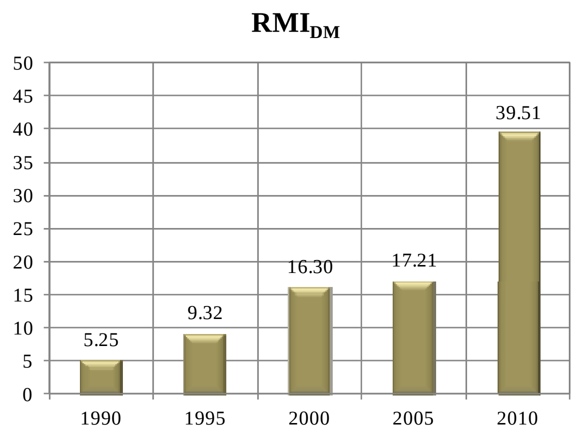


Ind.	1990	1995	2000	2005	2010	Weight
RR,1	1	1	1	2	2	27.19
RR,2	1	1	1	2	3	16.44
RR,3	1	2	2	2	2	10.13
RR,4	1	2	2	2	2	13.65
RR,5	2	2	2	2	3	18.58
RR,6	1	2	2	2	2	14.01

Figure 15. RMI_{RR}

Management related to risk reduction indicates that in the country between 2005 and 2010 there was a significant increase in the RMI_{RR} (risk reduction), as seen in the change from the incipient to the significant level in two of the indicators, the hydrological basin intervention and environmental protection (RR2), and the updating and enforcement of safety standards and construction codes (RR5). The other indicators did not change between 2005 and 2010. The implementation of hazard-event control and protection techniques (RR3), the housing improvement and human settlement relocation from prone-areas (RR4) and the reinforcement and retrofitting of public and private assets (RR6) did not change; these had the same incipient level from 1995.

Figure 16 shows sub-indicator qualifications that composed the RMI_{DM} and their respective weights, obtained using the Analytic Hierarchy Process (AHP).



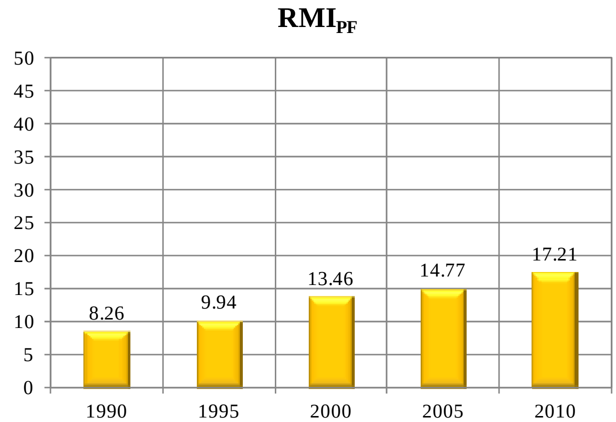
Ind.	1990	1995	2000	2005	2010	Weights
DM,1	1	1	2	2	3	20.93
DM,2	1	1	2	2	2	25.30
DM,3	1	2	2	2	3	11.57
DM,4	1	2	2	2	3	15.52
DM,5	1	1	2	2	3	16.44
DM,6	1	1	1	2	2	10.24

Figure 16. RMI_{DM}

Management related to disaster management indicates a progressive advance from 1990 to 2010. All the indicators started in 1990 with a low level. The incipient level was reached by the endowment of equipment, tools and infrastructure (DM3), and the simulation, updating and testing of interinstitutional response (DM4) in 1995. The other indicators reached this level just in 2000, with the exception of rehabilitation and reconstruction planning (DM6) which reached it in 2005. In 2010, organization and co-ordination of emergency operation (DM1), endowment of equipment, tools and infrastructure (DM3), simulation, updating and testing of interinstitutional response (DM4), and community preparedness and training (DM5) reached the significant level, up from the incipient level.

Figure 17 shows sub-indicator qualifications that composed the RMI_{FP} and their respective weights, obtained using the Analytic Hierarchy Process (AHP).

Management related to financial protection and governance for risk management indicates that the country has lightly increased its performance. In 1990, all the indicators with the exception of housing and private sector insurance and reinsurance coverage (FP6) were at a low level of performance. In 1995, the reserve funds for institutional strengthening (FP2) passed to the incipient level. Also, in 2000, budget allocation and mobilization (FP3) and implementation of social safety nets and funds response (FP4) reached the incipient level. In 2005, the insurance coverage and loss transfer strategies of public assets (FP5) passed also to the incipient level. Finally, in 2010, the performance of interinstitutional, multisectoral and decentralizing organization (FP1) was improved also to the incipient level. This gradual improvement is reflected by the RMI_{FP}.



Ind.	1990	1995	2000	2005	2010	Weights
FP,1	1	1	1	1	2	26.23
FP,2	1	2	2	2	2	12.20
FP,3	1	1	2	2	2	16.77
FP,4	1	1	2	2	2	12.72
FP,5	1	1	1	2	2	12.53
FP,6	2	2	2	2	2	19.54

Figure 17. RMI $_{FP}$

Figure 18 shows the total RMI value obtained from the average of the component indicators and the aggregated version which illustrates the contribution of each indicator.

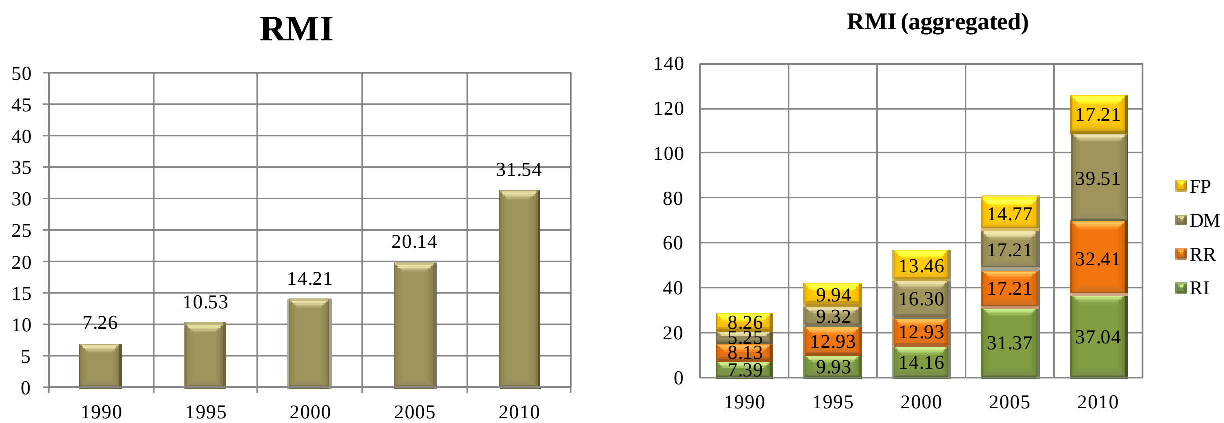


Figure 18. Total RMI

In the RMI graphics one can observe a gradual advance in disaster risk management, in general, between 1990 and 2010. The most notable growth was between 2005 and 2010. Indicators which vary more considerably have been the RMI_{DM} of disaster management and RMI_{RI} of risk identification. Progressive variation in RMI illustrates a general advance of the country in risk management. Nevertheless, although the country's RMI average represents a current significant level of performance, as can be deducted from the value of 31 in Figure 18, this figure still implies there is much work to do in order to achieve better performance levels in risk management.

Table 10 presents, in a more illustrative form, the changes in the performance levels of the indicators that composed the aspects of the four policies related to risk management, between the first and the last evaluated period. In summary, the Table below shows that during the period 1995-2010 there was a significant progress in terms of disaster management (RMI_{DM}) and risk identification (RMI_{RI}) in Guyana. The indicators that presented a more notable positive change (40 marks) were the organization and co-ordination of emergency operations (DM1), community preparedness and training (DM5), the vulnerability and risk assessment (RI4), and the hydrological basin intervention and environmental protection (RR2). Other indicators with a significant change, but at a lower degree, were the endowment of equipment, tools and infrastructure (DM3), the simulation, updating and testing of inter-institutional response (DM4), the systematic disaster and loss inventory (RI1), the hazard monitoring and forecasting (RI2), and the updating and enforcement of safety standards and construction codes (RR5). Some activities had any advance; these are mostly related to the risk reduction public policy.

Table 10. Differences between first and last evaluated period for RMI sub-indicator function performance

Values of the performance functions of sub-indicators

1995	**RI.1**	17	**RR.1**	5	**DM.1**	5	**FP.1**	5
	RI.2	17	**RR.2**	5	**DM.2**	5	**FP.2**	17
	RI.3	5	**RR.3**	17	**DM.3**	17	**FP.3**	5
	RI.4	5	**RR.4**	17	**DM.4**	17	**FP.4**	5
	RI.5	5	**RR.5**	17	**DM.5**	5	**FP.5**	5
	RI.6	5	**RR.6**	17	**DM.6**	5	**FP.6**	17
	RMI_{RI}	9.93	**RMI_{RR}**	12.93	**RMI_{DM}**	9.32	**RMI_{FP}**	9.94
	RMI	10.53						
2010	**RI.1**	45	**RR.1**	17	**DM.1**	45	**FP.1**	17
	RI.2	45	**RR.2**	45	**DM.2**	17	**FP.2**	17
	RI.3	17	**RR.3**	17	**DM.3**	45	**FP.3**	17
	RI.4	45	**RR.4**	17	**DM.4**	45	**FP.4**	17
	RI.5	17	**RR.5**	45	**DM.5**	45	**FP.5**	17
	RI.6	17	**RR.6**	17	**DM.6**	17	**FP.6**	17
	RMI_{RI}	37.04	**RMI_{RR}**	32.41	**RMI_{DM}**	39.51	**RMI_{FP}**	17.21
	RMI	31.54						
Change	**RI.1**	28	**RR.1**	12	**DM.1**	40	**FP.1**	12
	RI.2	28	**RR.2**	40	**DM.2**	12	**FP.2**	0
	RI.3	12	**RR.3**	0	**DM.3**	28	**FP.3**	12
	RI.4	40	**RR.4**	0	**DM.4**	28	**FP.4**	12
	RI.5	12	**RR.5**	28	**DM.5**	40	**FP.5**	12
	RI.6	12	**RR.6**	0	**DM.6**	12	**FP.6**	0
	RMI_{RI}	27.10	**RMI_{RR}**	19.48	**RMI_{DM}**	30.19	**RMI_{FP}**	7.27
	RMI	21.01						

With relation to the governance and financial protection the advance was low. These activities had a very slight progress from low to incipient level, with the exception of the reserve funds for institutional strengthening (FP2) and the housing and private sector insurance and reinsurance coverage (FP6), which just maintained the incipient level along the years.

4 CONCLUSIONS

The Disaster Deficit Index (DDI) illustrates the economic implications of a catastrophic event. The Local Disaster Index (LDI) points out the incidence and uniformity of the effects among all municipalities of the country, caused by small and moderate disasters. The Prevalent Vulnerability Index (PVI) accounts for the susceptibility and aggravation factors of the direct effects of the disasters due to deficiencies in development; and the Risk Management Index (RMI) points out what has been achieved and what is intended to be done for improving risk management.

From these results it is possible to have as conclusions that in Guyana there was a decrease in the DDI since 2000 for the different return periods evaluated (50, 100 and 500). The prevalent vulnerability maintained similar levels since 1990. In the case of the RMI, the country has not presented notable progress, especially in activities related to disaster management and risk identification. The estimation of the indicators of disaster risk management for Guyana shows that the country has improved its performance in all the topics related to risk management. Nonetheless, it is still necessary to maintain constant work and effort in the country to achieve sustainability.

In making a comparison of the trends in the indicators, it is possible to conclude that the system of indicators presents results generally consistent or appropriate to the reality of the country. It is in any case important to disaggregate these indicators and identify areas where improvements can be made through actions, projects, and specific activities, in order to achieve further progress and greater sustainability. These activities can be done by the central government with the participation of different sectoral agencies, municipalities, and communities. Decision-makers and stakeholders, besides identifying indicators of weaknesses, must take into account other characteristics that are not revealed or expressed by the evaluation obtained. Indicators provide a situational analysis from which it is possible to extract a set of actions that must be done and, therefore, formulated in a strategic and integrated disaster risk management plan, which should be the next step. The aim of the indicator system is to help to formulate general recommendations for planning.

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NASA images courtesy MODIS Rapid Response Team at NASA GSFC. Caption by Michon Scott.

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APPENDIX I

NATURAL HAZARDS OF THE COUNTRY

Guyana is consistently identified as a country at high risk from the effects of coastal and rainfall flooding and from the emerging and likely future consequences of climate change. Climate change will have many indirect impacts on the global economy that will affect Guyana, but will also have more direct impacts on Guyana's agricultural economy through increasing variability and severity in precipitation, leading to increased flood risk and also sea-level rise, thus increasing pressure on Guyana's coastal defences and land drainage and irrigation infrastructure, including that of Georgetown, which continues to rely in large part on gravity drainage at low-tide. Despite interior exploitation of forestry, minerals, and cattle, around 75% of the activities contributing to national GDP, a considerable majority of built heritage, accumulated and valuable infrastructure and buildings, and 90% of the nation's population are located on the low-lying coastal plain within 15 km of the high-tide line on land at or below sea-level –all are at risk to flooding.

On the coast of Regions 1-6, physical assets, lifeline infrastructure and population centres (including Georgetown) follow a common pattern. They are most concentrated between the sea-wall and coast road, with the latter sometimes acting as a dam to trap surface water. Behind the coast road additional settlement gives way to active or abandoned agricultural land under rice or sugar plantations or local vegetable production. Plantation agriculture is supported by irrigated water collected in water conservancies further inland. The result of this land-use pattern is a highly vulnerable residential core including administrative functions, health and education services. This core is at risk from breaches and over-topping of the sea-wall, accumulation of surface water from heavy rain when drainage is not possible, and the movement of water through the irrigation system, including the possibility that the conservancy dam might be breached or water released to prevent this. This produces a cocktail of flood hazards and human vulnerability. In Georgetown, hazard has been increased through the concretization of land and through the infilling or poor maintenance of drainage canals.

Both richer and poorer households are exposed to flood hazard. Lack of adequate maintenance in urban drainage systems is a major contributing factor to exposure. There is some evidence that small scale events can be mitigated by successful local collective action to clean drains, but such actions are limited. Guyana's demographic profile and economic development challenges mean there are high numbers of children and old people with limited resources who are at risk. The practice of filling in bottom houses and more recently of building on ground level (including some public housing stock in Georgetown) has also generated exposure to flood risk with low-income families (often including the elderly or young couples with small children) disproportionately residing in such dwellings in both the formal and informal housing sectors. Growth in the informal housing sector and limited administrative capacity make regulation of land-use and building standards a considerable challenge.

Research into the physical drivers of flood risk has concentrated on coastal geomorphology. Macro-ripples in the non-consolidating, near-shore sediments that process in a westerly direction help explain some breach events and erosion of the sea-wall and the remaining mangroves and shell cheniers, which provide local natural protection. Even without climate change related sea-level rise, the empoldered coast has been in retreat, as can be observed by abandoned kokers at sea. Coastal erosion events are then closely associated with sea-water flooding, including on the coast and major rivers. Guyana's rainfall regime has been unstable over the last decade with two seasonal wet seasons being less easy to define. The tropical climate is impacted by El Niño cycles. There is no hurricane hazard.

Flood risk management on the coast is built around the drainage and irrigation infrastructure described above. Some elements have been maintained for over 200 years. The coastal defence infrastructure is also of mixed quality, with some extensive and recent investments. Hard defence has served Georgetown well with rip-rap being predominant along the developed coast, and some residual mangrove and chenier systems providing additional protection, especially in Regions 1 and 2. Responsibility for the maintenance of this infrastructure is split between Ministries and some private sector actors engaged in agriculture.

Flood Hazard and Risk

Guyana lies 1.2 m below sea-level and has extensive but variable rainfall, which makes the country prone to natural disasters such as floods and droughts. The country's susceptibility to natural disasters is further increased by the high level of poverty, and the lack of flood-protection infrastructure adds further severe contours to the risk landscape. No recent changes in annual rainfall patterns have been observed, and this increase has therefore largely been associated with a range of human processes. Impervious areas within Georgetown increased by 50 per cent between 1963 and 1993, raising the volume of runoff channelled through Georgetown's drainage system. At the same time, drainage capacity has been reduced due to the infilling of drains, inadequate maintenance of existing drainage, the use of drains for informal refuse disposal, and the use of drainage reserves for informal housing and petty-agriculture. Since 1989, uncontrolled urban expansion into unserviced areas has similarly increased city vulnerability to flooding from high rainfall events (Pelling 1997). Almost 90% of the population lives along the coast of the Atlantic Ocean where flooding is more likely to occur.

In January 2005, floods devastated coastal areas, killing 34 people and affecting more than 37% of the population. As a result, the total loss in terms of economic activity was equivalent to $465 million US dollars. Figure A.1 shows the Multi-Satellite Precipitation Analysis, MPA, rainfall totals for Guyana and the surrounding region of north-eastern South America between 24 December 2004, and 20 January 2005. The highest rainfall totals on the order of 20 inches of rain (red areas) occurred just offshore and right along the coastline of Guyana near the mouth of the Essequibo River and Georgetown.

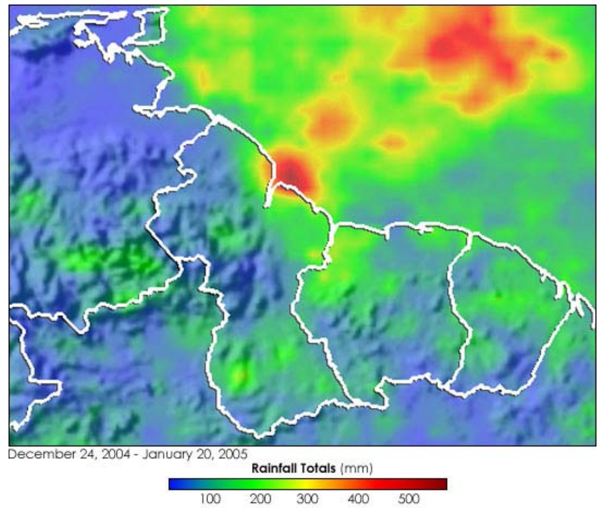

Figure A.1. Rainfall totals for Guyana between 24 December 2004 and 20 January 2005.[13]

January 2006 marks the second year running that Guyanese coastal cities have faced severe floods. During the latter half of January 2006, heavy rain fell over Guyana, bringing flooding to the coastal regions of the South American country. The floods threatened the loss of thousands of acres of rice, the Red Cross reported. Figure A.2. (bottom) shows the area on 1 January 2006, and the figure above shows the wetlands near the coast (expanded) by January 22 (top).

The South American nation of Guyana has two rainy seasons: May to August, and November to January. February typically experiences much drier conditions. In late February 2011, however, the country received roughly 10 inches (25 centimetres) of rain in a 24-hour period (Bloomberg, 2011). This was more than what Guyana usually receives in the entire month, and rice farmers worried that their crops might be lost. Figures A.3 show an area along the Guyana coast on 26 February 2011 (top), and 5 February 5 2011 (bottom).

[13] http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=15995

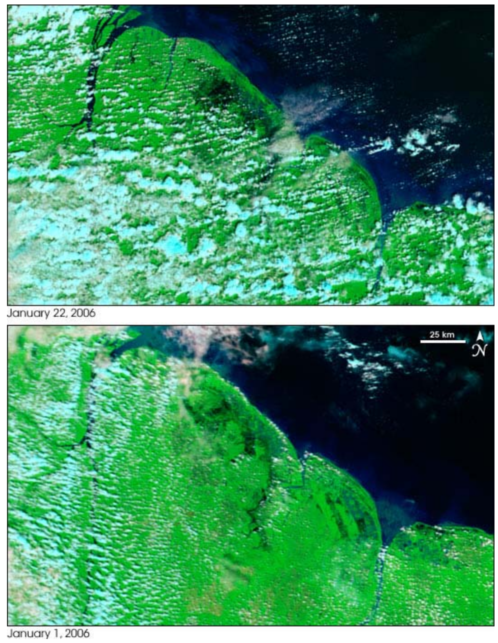

Figure A.2. Area along the Guyana coast on January 22 and January 1, 2006.[14]

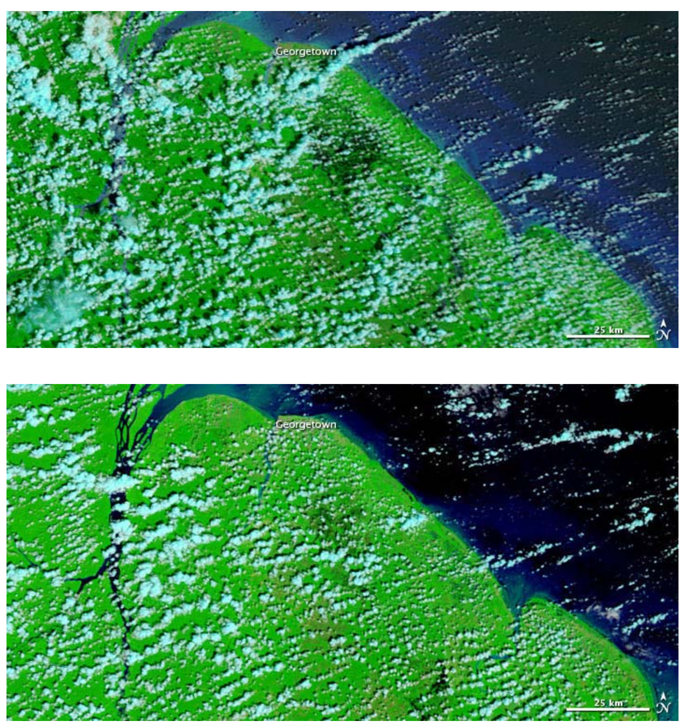

Figure A.3. Area along the Guyana coast on February 26 and February 5, 2006.[15]

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[14] http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=15995
[15] http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=15995