# The Economic Impacts of Natural Hazards: Lessons Learnt from the PDNA International Damage Assessment Project Implemented in Haiti After the Earthquake of 2010

**Giulia Pesaro**

**Abstract** On January 12, 2010, an earthquake of magnitude 7.3 on the Richter scale shook Haiti for 35s. It was the most powerful earthquake to hit the country in 200 years and one of the most severe at the world level. Such earthquake caused an unprecedented situation in Haiti, with enormous repercussions affecting all sectors of society, well beyond the areas directly affected by the catastrophe. The essay, after introducing the issue of the economic impact of natural catastrophes, offers the example of the Post-Disaster Needs and Assessment Report for Haiti as an innovative reference instrument for damage reporting and reconstruction organization. The Report, developed with the assistance of many international organization, from the UN to the European Community, has been designed not only to assess the whole of the territorial values destroyed or damaged referring to direct, indirect, and systemic damage, but also to enlighten the most important impacts and the reconstruction needs for different economic sectors and territorial resources. It therefore offers a complete list of elements to take care of together with the timing and organization of the reconstruction phase.

## 1 Introduction

A country is a territorial system. Territorial systems are aggregates formed by combining several territorial components, subjects and objects, functions, and/or systems of interests, which represent a specific territorial capital. Such elements represent the system of resources the country or the territorial system may rely on to function and continuously evolve. This is based on specific and different dynamics and referring to different territorial components, which interact with each other over

G. Pesaro (✉)
Department of Architecture and Urban Studies, Politecnico di Milano, Milan, Italy
e-mail: giulia.pesaro@polimi.it



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time producing new components. Such elements and capital resources are the values exposed to natural hazards.

The shapes, characteristics, local specificities, and availability of the whole of the territorial resources in an observed territorial system is the result of a complex system of actions/reactions/non-actions which are, at their turn, the results of combinations and interactions of elements and their dynamics. Combinations and interactions which are stratified over time and integrated in the territorial "objects," activities and resources and produce territorial capital as the result of a variety of decisions and decision processes developed over time by a huge variety of different territorial subjects/stakeholders, with defined systems of interests, needs, goals. The territorial capital which characterizes a country has different roles, potentials, and values, according to its availability, renewability, sustainability and, of course, direct economic, and financial values. Moreover, territorial capital not only sustains the usual, everyday, functioning of a country or a region but also have potential functions and roles for future developments, often not completely exploited or visible.

As a consequence, following an economic perspective and looking at the conditions of a developing country, the damage produced by a natural disaster always means a loss of resources/territorial capital which will affect the territorial system to a certain degree over time (Pesaro 2007). The greater are the vulnerability, or fragility, of the territorial components exposed to hazards and their values and the lower are their substitutability, renewability, or recoverability, the greater will be the total value of the losses. The application of the economic approaches and assessment tools can therefore offer an effective support to explain to what extent and how a disaster will affect the capital of local resources. This in terms of direct and indirect values of the whole amount of resources involved in the disaster, looking to the capability of the system to continue producing over time goods and services, values, and revenues for final consumers and production means and to reproduce (if possible) the lost resources.

An increasing number of official/scientific-based Reports are available at the international level concerning ex-post damage assessment methodologies and practice and knowledge building on damage from an economic perspective but still the variability of the damage lists and of the methodologies is very high. Moreover, there is an increasing evidence about the importance to better understand the specificities of the damage models in developing countries. This is for two main reasons. The first is the need for improving the assessment activities in countries where the available data are often poor, and the direct accounting of damages is often made difficult by the lack of information and hard access to the hit areas. The second is the importance to learn from past events, in order to improve mitigation and prevention measures and the related investments benefit/costs ratios.

The essay will be developed in two parts. The first will very briefly introduce to post-event damage assessment from an economic perspective, paying particular attention to some main elements and conditions for its operational implementation. The second will propose the case study of the Haiti Earthquake Post-Disaster Needs Assessment project (from now on PDNA 2010), related to the event of January

12th, 2010. An event listed as one of the strongest earthquakes ever recorded worldwide, with a number of deaths amounting to between 200,000 and 250,000, and damages amounting to between 7.2 and 8.1 billion dollars, 1 billion more than the entire Haiti's annual GDP (Carvallo et al. 2010). The catastrophe resulted particularly heavy compared to the population exposed (between 20,000 and 25,000 killed per million inhabitants, as in Carvallo et al. 2010) and because of the very bad average quality of the built environment in the country (InsideDisaster 2010). The impacts were enormous from all viewpoints, causing an unprecedented situation in Haiti, with huge repercussions affecting all sectors of society, well beyond the areas directly affected by the catastrophe (PDNA 2010).

## 2 Recognize and Measure the Impacts of Natural Catastrophes from an Economic Perspective

As already stated above, the damage provoked by a natural extreme to a country means a loss of developmental resources for the territorial system as a whole, and damage impact can affect such areas for long periods, contributing to slow down development (Pesaro 2007). This of course results in an additional burden in countries where the development level is still very low, like in Haiti, whose position in the Human Development Index list in 2016 was 163 on 188 listed countries (UNDP 2016). The presence of major natural or na-tech hazards should therefore be regarded and accounted for as an additional weakness the country is exposed to, as hazards mean potential losses of tangible and intangible resources, producing "obvious" negative externalities, that is *losses of values*. In an economic perspective, vulnerability means to what extent and how a disaster will affect:

- the capital of local resources—that is direct and indirect values of the whole amount of resources;
- the capability of the system to continue producing goods and services—that is values and revenues produced for final consumers or as production means;
- the capability of the system to reproduce the lost resources and in how much time—that is direct and indirect values related to reproducible and non-reproducible resources.

The greater the vulnerability of the territorial components exposed to hazards and their values are, and the lower their substitutability, renewability, or recoverability, the greater will be the total value of the losses. The application of the economic approaches and assessment tools can therefore offer an effective support to explain to what extent and how a disaster will affect the capital of local resources. This particularly considering the direct and indirect values of the whole of the resources involved in the disaster, looking at the capability of the system to continue producing over time goods and services, values, and revenues for final consumers and production means and to reproduce (if possible) the lost resources. The

economic dimensions of damage will not therefore only depend on the lost values expressed in money but also, and mainly if developing countries are involved, on the impact of such damage on the socio-economic systems and the related capabilities and resources to face the events. The economic vulnerability assessment will therefore depend on:

- the type of hazard/disaster and its "local characteristics" (droughts, seismic, earthquakes, hurricanes, etc);
- the characteristics and values of the exposed system of resources: which resources, for which uses and with which availability, renewability, and reproducibility profiles;
- the territorial system as a system of monetary and non-monetary values, as in the social model, in the economic model, and in the built environment, made of settlements, buildings, and infrastructure systems;
- the over-local role of the territorial system and the interdependence with other territories;
- the existing development conditions and the fragility of the local communities and activities facing unexpected events and shocks.

An increasing number of official/scientific-based Reports have been made available at the international level from the late 1990s concerning ex-post damage assessment methodologies and practice [see, as an example, the Report from the USA Committee on Assessing the Costs of Natural Disasters (1999), and Van der Veen et al. (2003) for the EU]. Different evaluation methods have been object of discussion and testing activities over time at the international level (see, among other early studies, Hubert and Ledoux 1999; Cochrane 2003), and some literature reviews are now available (for instance Shreve and Kelman 2014; Mechler 2016). Monetization models have also been developed over the last 15 years but still, monetary evaluation remains very difficult (see, among others, Meyer et al. 2013). This is why, again, the availability of damage assessment experiences like the Haiti one are even more important, apart from the image itself of the impacts a catastrophic earthquake like the 2010 (one of the most disruptive in the human history) may produce in a vulnerable and exposed developing country. In economic sectors, for instance, indirect and systemic damage may be huge (Cochrane 2004) and the time needed for restoration or reconstruction may become crucial factors for the capability of the whole territorial system to start again with its "everyday life." These factors should be better recognized and deepened, the costs being related to the cascade of impacts coming from business interruptions (direct or because of the interruption of lifelines and other territorial infrastructures and services; see Rose and Huyck 2016), rebuilding and reconstruction investments and time needed, substitution of machineries and production materials, injuries to workers. This may result in a deep loss of competitiveness and reduction of market shares. So high, sometimes, to pull economic subjects to stop their activities. It is therefore easy to understand how indirect and systemic losses might weight in terms of future development of the territories hit by natural disasters.

Despite the increase in research and operational applications, still, the variability of the *damage lists* and of the data collection and elaboration methodologies is very high. Moreover, there is an increasing evidence about the importance of better understanding the impact of extremes, through satisfactory damage and losses assessment models, better taking into account the specificities of the damage profiles in developing countries. The goal is to improve information and knowledge about the *numbers of damage*, to better evaluate the damage in the aftermath of an event in a less developed region. Damage assessment should be designed not only to define the direct economic impacts of an extreme and assign a *dimension* to what has been lost (and is therefore needed for reconstruction) but also to:

- control the reimbursement amounts due to local territorial subjects;
- identify the elements and values more exposed to the disaster and the dimension of damage (exposure and vulnerability);
- understand the resistance of the territorial system facing disasters (coping capacity and adaptation);

A second important element is to design the damage assessment model so to improve the capability to learn from the past events, organizing data collection and analysis and enlighten the needs for further knowledge to enhance the reliability of future ex-ante damage scenarios. This in a preparedness perspective, looking at improving mitigation and prevention measures and better address decision-making and benefit/costs ratios of investments.

This is why it is so important to treasure on-the-field experiences, especially when the damage information collection and the related assessment has been developed in the best possible way even if facing a critical situation and in countries where "normal information" activities can be difficult. This is the case of the damage assessment activities developed in the aftermath of the Haiti earthquake 2010, as clearly explained in the document "Haiti Earthquake PDNA: Assessment of damage, losses, general and sectoral needs" (PDNA 2010).

## 3 The PDNA International Damage Assessment Project After the Haiti Earthquake in 2010

The Post-Disaster Needs Assessment Report (PDNA) has been conducted in Haiti in February and March 2010, at the request of and under the direction of the Government of the Republic of Haiti. The technical support has been provided by the United Nations, the Inter-American Development Bank, the Economic Commission for Latin America and the Caribbean, the World Bank, and the European Commission (European Commission DG DEVCO 2015). The PDNA has been designed in order to respond to such a highly severe event going further than traditional post-disaster assessments (PDNAs 2010). The objective has been not only to better understand the whole of the damages and losses and the related system of chain effects, but also to lay the foundations for reconstructing the

damaged areas and to contribute to a long-term national strategic development plan, in order to begin rebuilding Haiti.

The approach used to develop the PDNA was quite unusual compared to similar Reports, as it goes far beyond a damage and loss assessment as a list of deaths and injured individuals and of the number and typology of lost buildings and physical infrastructures on whose basis to calculate the economic damages and losses. The Report distinguishes short-term rehabilitation needs and offers an estimate of the medium and long-term needed interventions to rebuild the country. These have produced a quite complete image of the economic values at stake. Damages and losses from the one hand and the rehabilitation and reconstruction costs or, better, investment needs to sustain the country's development.

The two main assessment goals have been based on two different, here integrated, assessment models. One is the DALA (Damage Assessment and Loss Assessment), developed by the United Nations Economic Commission for Latin America and the Caribbean (UN ECLAC) and introduced in the early 1970s (of course enriched by integrations and research developments over time). The second is the HRNA (Human Recovery Needs Assessment), a United Nations method for assessing recovery needs at community level. Taken together, the HRNA and the DALA make up the Post-Disaster Needs Assessment (PDNA) in which the two assessments come together to identify the disaster characteristics and impact and how to intervene, in the reconstruction phase, so to reduce future disaster risks and to accompany the affected communities on the path to recovery.

The Haiti earthquake has been one of the first experience in the use of the HRNA, whose development started with an agreement among the UN, the European Commission and the World Bank, together with other international partners, signed as a Joint Declaration in 2008 (GFDRR 2013). The HRNA is the most innovative part of the PDNA, as it reflects the concerns and priorities of disaster-affected individuals and stakeholders to recover their full potential and to lead productive, creative lives according to their needs, rights, and interests (GFDRR 2013). Based on these perspectives, the HRNA estimates the requirements for each sector, assigning particular importance to restoration of governance and social service systems, post-disaster capacity building, measures to ensure the fulfillment of rights as well as access to reconstructed infrastructure, approaches to fully restore livelihood systems, and strategies to enhance resiliency against future disaster risks. This includes measures required, for example, to restore gender equity in school enrolments, reversing disaster-induced destitution, protection, and regeneration of natural resources affected not only by disasters but also by reconstruction programs, etc.

The PDNA, as the integration of the two assessment methodologies, mainly follows a people-centered approach, but in the Haiti case also, the built environments and infrastructures have been attentively considered, together with the macroeconomic impacts and the needs to make the economic system begin to work again, taking into consideration that it was already very weak before the event. The main assessment elements of the PDNA are summarized in Fig. 1.

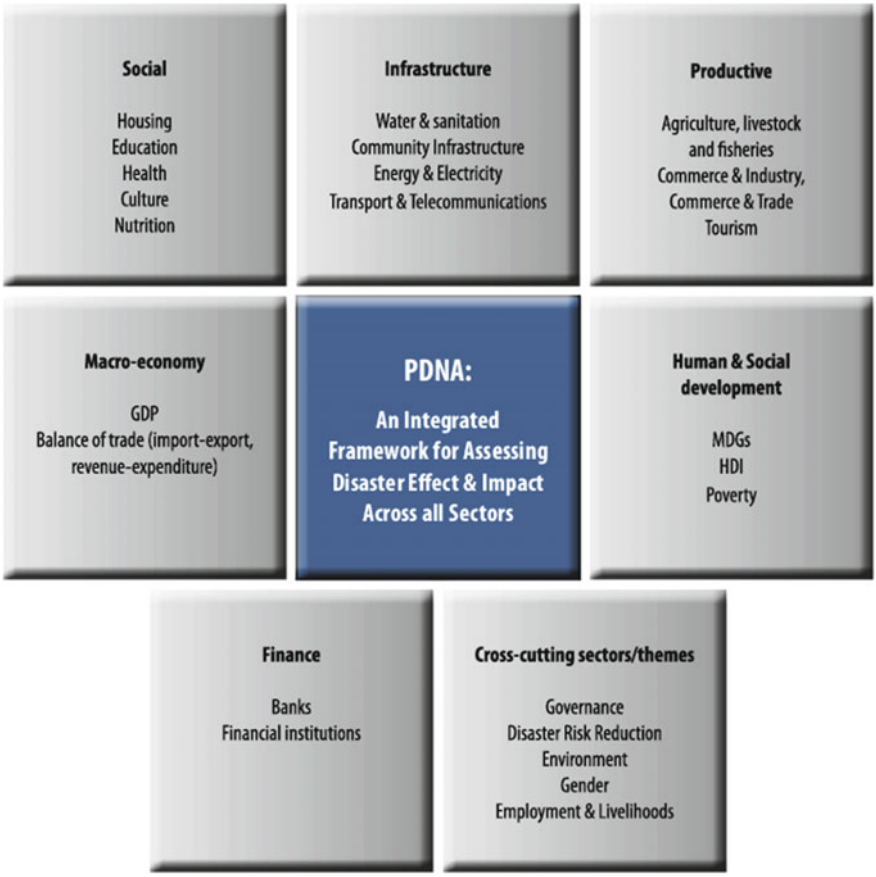


**Fig. 1** Sectors assessed in the PDNA (Reproduced from GFDRR 2013)

In the Haiti case, eight essential sectors have been identified, looking at impact, urgency and feasibility criteria, time (from short to medium and long-term) and the availability of economic means: governance, the environment, disaster risk management, social sectors, infrastructure-related sectors, the production sector, a macroeconomic analysis, and cross-cutting sectors (youth, gender, vulnerable persons, employment). These have been integrated and connected with each other as the results of the cross impacts produced by the event on the human, infrastructure, and environmental systems. Based on this, socio-economic impacts have been finally highlighted (see Fig. 2).

The specific elements assessed in the Report have been summarized as in Tables 1 and 2, which follow.

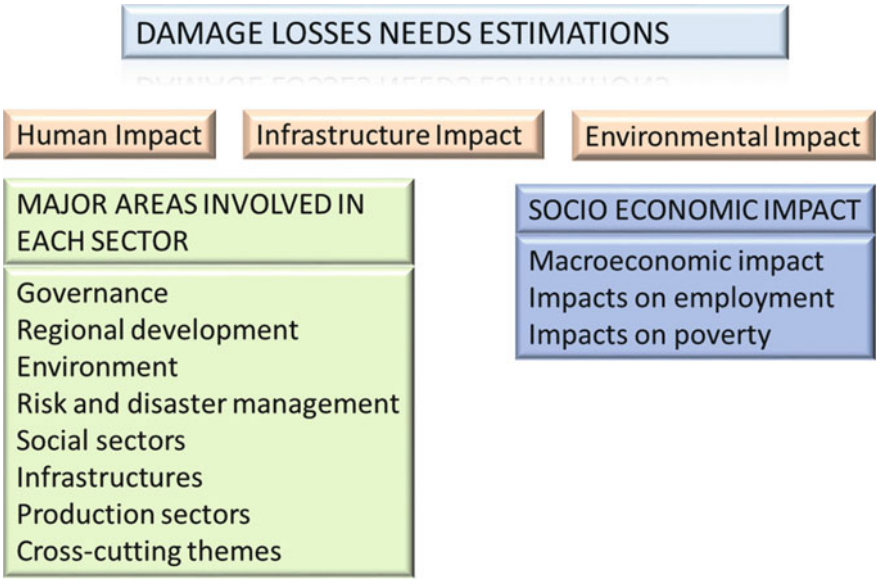


**Fig. 2** System of the impacts of the Haiti 2010 earthquake as in the Haiti PDNA (Author's elaboration after the Haiti PDNA Report, Haiti Government 2010)

## 4 Conclusions

The Haiti experience has made the effectiveness of the PDNA model and strategy clear. The model developed for Haiti has been object of further studies to fine-tune the scheme to collect and organize data about damage and losses, together with the assessment of the recovery and reconstruction needs. This in order to obtain a tool able to address the decision-making system and to enlighten the whole of the amounts needed to allow developing countries to bounce back after an extreme. Elements which are also needed to better organize the international intervention and support. The lessons learned have then been treasured by the more important international bodies and gave birth to the 2013 Global Facility for Disaster Reduction and Recovery Report (GFDRR 2013) in which schemes and lists of elements are made available to facilitate the needed assessment actions. This particularly when facing a huge variety of local conditions influencing the impacts of natural events on territorial subjects and objects, with reference to exposure and vulnerability.

The socio-economic-based evaluation has to be applied to a variety of physical territorial elements and their characteristics and interactions, whose dynamics depend on the development stages of a country and the ways in which local communities take advantage of their territorial capital. These also according to the different characteristics of the built environments, of the related use functions and the different profiles and features of the communities of users and stakeholders.

**Table 1** Summary of the damage and losses, US million dollars

| Theme/Sub-theme: | Damage | | | Losses | | |
|---|---|---|---|---|---|---|
| | Public | Private | Total | Public | Private | Total |
| Environment and disaster risk management | 3.00 | 0.00 | 3.00 | 321.40 | 1750.00 | 496.40 |
| Social sectors | 153.80 | 805.40 | 959.40 | 197.80 | 355.60 | 553.30 |
| Water and sanitation | 20.90 | 13.10 | 34.00 | 8.40 | 193.00 | 201.40 |
| Health | 94.70 | 101.70 | 196.40 | 187.70 | 86.10 | 273.70 |
| Education | 38.20 | 395.60 | 434.00 | 1.70 | 41.50 | 43.20 |
| Food safety and nutrition | 0.00 | 295.00 | 295.00 | 0.00 | 35.00 | 35.00 |
| Infrastructure | 628.1 | 2 538.60 | 3 166.7 | 774.2 | 520.60 | 1294.8 |
| Housing | 0.00 | 2333.2 | 2333.20 | 459.40 | 279.30 | 738.70 |
| Transport | 188.50 | 118.6 | 307.10 | 91.60 | 197.50 | 289.10 |
| Telecommunications | 66.00 | 28.00 | 94.00 | 24.00 | 22.00 | 46.00 |
| Energy | 20.80 | 0.00 | 20.80 | 37.23 | 0.00 | 37.23 |
| Urban and community infrastructure | 352.80 | 58.80 | 411.60 | 162.00 | 21.80 | 183.80 |
| Production sectors | 3.10 | 394.00 | 397.10 | 0.00 | 933.30 | 933.30 |
| Agriculture | 3.10 | 49.90 | 53.00 | 0.00 | 96.00 | 96.00 |
| Industry | 0.00 | 74.60 | 74.6 | 0.00 | 267.70 | 267.70 |
| Retail | 0.00 | 148.70 | 148.7 | 0.00 | 490.60 | 490.60 |
| Finance and banking | 0000 | 98.20 | 98.2 | 0.00 | 0.00 | 0.00 |
| Tourism | 0.00 | 22.60 | 22.6 | 0.00 | 79.00 | 79.00 |
| Total | 781.80 | 3738.00 | 4526.2 | 1293.4 | 1984.50 | 3277.8 |

Reproduced from Haiti PDNA Report, Haiti Government (2010)

Finally, as the involved territories are systems of interconnected resources and values, a systemic perspective should be applied, to make the assessment processes more accurate and able to mirror reality.

The Haiti PDNA Report also offers evidence of an important element, which till that moment was quite underestimate in developing countries. In the aftermath of an event like this one, the main attention is often paid to the emergency and recovery phases. In this case, emergency and damage accounting were immediately complemented, with a great evidence for the reconstruction needs and the related timing and phases, according to urgency and importance of the different sectors for coming back to everyday life. This is how *a damage and losses assessment Report* has become a *Post-Disaster Needs Assessment Report* as a comprehensive policy instrument, to support public action in the aftermath of disasters. This has been useful not only to better understand the economic and social impacts and the financial needs related to a certain natural catastrophe during and after the event but also to offer a reference for the building of a strong and well-recognized governance system for the recovery process and the reconstruction phases. Initially, the economic approaches were meant to enhance the capabilities to identify all damage

**Table 2** Summary of the needs for recovery and reconstruction, US million dollars

| | 6 months Sep, 2010 | 18 months Sep. 2011 | 3 years | Total 0–3 years |
|---|---|---|---|---|
| Total | 1477.5 | 3086.1 | 7627.2 | 12,190.9 |
| Governance | 329.3 | 374.3 | 215.0 | 918.6 |
| Rule of law, justice, security | 44.0 | 215.5 | 200.0 | 455.5 |
| Democratic process | 40.3 | 35.2 | 0.0 | 75.5 |
| Administrative governance and public services | 249.0 | 123.6 | 15.0 | 387.6 |
| Regional development | 0.0 | 182.0 | 533.0 | 725.0 |
| Regional development | 0.0 | 46.0 | 118.0 | 164.4 |
| Land tenure management | 0.0 | 54.0 | 100.0 | 154.4 |
| Decentralisation and decencentration | 0.0 | 92.0 | 315.0 | 447.4 |
| Environment—disaster risk management | 60.1 | 345A | 992.7 | 1398.2 |
| Environmental governance | 3.0 | 15.0 | 12.5 | 30.5 |
| Land and resource management | 10.0 | 58.5 | 380.8 | 449.3 |
| Pollution and nuisance | 43.1 | 221.9 | 472.9 | 737.9 |
| Disaster risk management | 4.0 | 50.0 | 126.5 | 130.5 |
| Soda sectors | 900.4 | 1547.0 | 3928.9 | 6376.3 |
| Health | 283.0 | 500.0 | 708.0 | 1491.0 |
| Education | 449.3 | 465.4 | 1685.1 | 2599.8 |
| Food safety and nutrition | 21.0 | 299.1 | 399.5 | 719.6 |
| Water and sanitation | 95.4 | 199..2 | 776.9 | 1071.5 |
| Sport and leisure | 11.4 | 22.8 | 258.5 | 292.7 |
| Culture | 40.3 | 60.5 | 100.9 | 201.7 |
| Infrastructure | 124.9 | 417.4 | 1295.1 | 1837.5 |
| Housing | 5.2 | 149.8 | 505.0 | 660.0 |
| Urban and community infrastructures | 0.7 | 68.0 | 96.6 | 165.3 |
| Transport | 29.7 | 118.8 | 448.0 | 546.5 |
| Energy | 83.3 | 71.8 | 192.2 | 3473 |
| Telecoms | 6.0 | 9.0 | 53.3 | 6873 |
| Production smears | 29.6 | 108A | 204.5 | 342.4 |
| Agriculture and fishing | 6.9 | 13.7 | 20.5 | 41.1 |
| Tourism | 1.7 | 16.2 | 25.7 | 43.6 |
| Trade and industry | 6.1 | 75.8 | 151.7 | 233.6 |
| Employment | 14.9 | 2.6 | 6.6 | 24.1 |
| Transversal | 48.1 | 101.7 | 458.0 | 607.8 |
| Youth | 45.0 | 93.0 | 440.5 | 578.5 |
| Sender | 2.8 | 8.4 | 16.9 | 28.1 |
| Vulnerable persons and social welfare | 0.2 | 0.3 | 0.6 | 1.1 |
| Information management | 0.1 | 0.0 | 0.0 | 0.1 |

Reproduced from Haiti PDNA Report, Haiti Government (2010)

typologies—direct, indirect, and systemic—involving a specific territorial area both in physical terms (number and typologies of territorial subjects and objects exposed to hazards and their vulnerability) and value terms (using money as the measure unit). After the Haiti PDNA experience, the immediate integration of these with the following needs for reconstruction and sustain of the development became more clear and important.

Finally, a careful evaluation of the past events and the related impacts has also been more and more recognized as a prevention tool itself for future events. Complete images of past damage and needs dimensions and characteristics are one of the mainstays of hazard management and disaster risk reduction over time and the basis for choosing among many possible tools and intervention options. Damage is the benchmark for analyzing past predictions and key element to build better correlations between exposition and vulnerability evaluations. Needs are the element needed to better prepare the system for future events. It is however clear that, to obtain these goals, damage and needs estimation must exist as a concrete, precise, and stable practice and the results be recorded and easily accessible for users. According to this logic, damaged elements recognized and evaluated after a disaster become precious information sources to assess the future potential impacts of hazard, while the needs emerging in the aftermath of events should be carefully considered and forecasted because it will represent the resources for future development.

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