Sustainable Hazards Mitigation in Kigali City (Rwanda)

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1. Introduction

In many places of the world, human activities have to face hazards (G. Berz and al., 2001; N. McGuire and al., 2004) which are generally recorded in mountain areas (T. Glade, 1998; A.S. Dhakal and al., 1999; B. Temesgen and al., 2001; V.Vanacker and al., 2003; A. Knapen and al., 2006) and also in hilly regions (J. Schmidt &R. Dikau, 2004). Land use and its impacts on the environment have been one of the increasing concentrations during on-going global changes (T.N. Chase and al. 1999; E.F. Lambin and al. 2001).The expansion of human settlements and accompanying activities, especially the rapid urbanization occurring in the developing countries, play an important role in global land use (J.G. Masek and al., 2000), causing changes to ecological processes on a local and global scale. The causes of hazards are closely related to topographical, climatic, biological, hydrological and human-made factors. Indeed, as witnessed by hazards worldwide, land use and cover change associated with human activities may change the hydrological processes and increase hazards (A. Brath and al., 2006; X. Zhang and al., 2007).

In the search for appropriate instruments for mitigating hazards, research in recent decades has called for a shift in focus from hazards response and recovery to proactive measures to mitigate the effects of natural hazards on humans. Hazards mitigation has traditionally referred to measures that can be taken to minimize the destructive and disruptive effects of hazards and thus lessen the magnitude of a disaster (A. Maskrey, 1989). Mitigation measures can take a variety of forms, ranging from physical or structural measures such as dams or levees to control flooding, to controlling development in hazardous areas through land use planning and policy-making. Efforts during recent decades have largely been focused on physical or structural mitigation measures. Experience has proven time and again that these types of measures alone are inadequate (P. Blaikie *et al.*, 1994; I. Burton *et al.*, 1993; D.R. Godschalk and al., 1998; A. Maskrey, 1989; D.S. Mileti, 1999; G.F. White & J.E. Haas, 1975).

The concept of sustainable hazard mitigation has then evolved and been refined over the last half-century. Beginning with the pioneering work of eminent geographer F. Gilbert White (1945), who first studied the control of land use in floodplains as a means of reducing flood loss rather than the reliance on structural flood mitigation (such as dams and levees), the concept has matured due to the contributions of several key authors (G.F. White, 1974; G.F. White & J.E.Haas, 1975; I. Burton, 1978, 1993; D.R. Godschalk, 1989; D.S. Mileti, 1999). Consistent in these works is the conviction that the integration of hazard mitigation as an integral part of participatory process, environmental quality improvement and disaster resiliency is considered essential to achieving sustainable hazards mitigation. Hence, the purpose of this paper is to apply the literature relevant to sustainable hazards mitigation into the context of Kigali city (Rwanda).

2. Framework of Sustainable Hazards Mitigation

Incorporating the principles of sustainability as well as those of hazards mitigation creates a sustainability framework to guide community planning and development (A. Houlihan, 2007). This framework consists of six basic components that establish six corresponding principles of sustainable hazards mitigation (Fig.1).These components include: environmental quality, quality of life, disaster resiliency, economic vitality, inter- and intra-generational equity and a participatory process (D.S. Mileti, 1999).

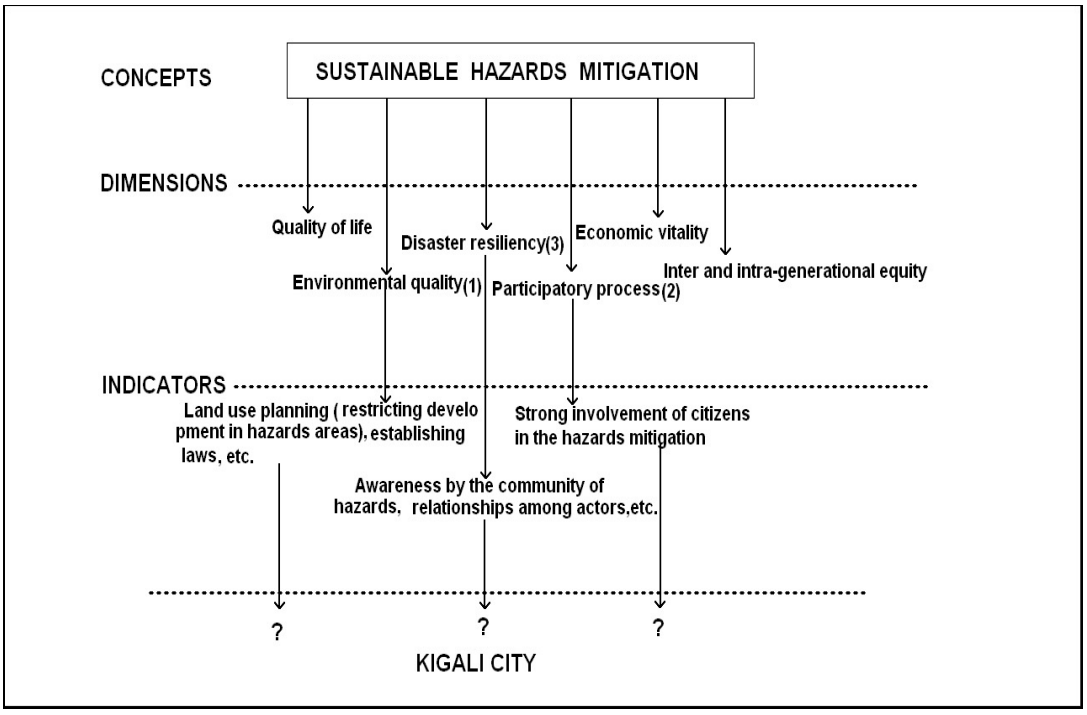

Fig.1. Conceptual and operational framework of sustainable hazard mitigation
Source: Authors, 2010

In this paper, we are mainly concerned with only three dimensions (environmental quality, participatory process and disaster resiliency).This was due to the availability of information. With regards to environmental quality, it seeks to preserve and maintain the environmental quality and to improve it whenever possible. Specific examples include restricting development in hazard-prone areas through land-use planning, and minimizing the exposure to hazards and environmental degradation due to urban sprawl by developing less vulnerable and less destructive transportation systems.

Establishing a sense of community responsibility for and resiliency to natural hazards is another important principle of sustainable hazards mitigation. A certain degree of self-sufficiency is required if a locality is to endure a natural disaster with minimum loss and damage. This requires a conscious effort by all community residents to be aware of environmental problems, common natural hazards, and environmental sustainability issues specific to their areas. A viable local economy is another component of resiliency

that demands a degree of self-sufficiency. A strong, diversified local economy is less likely to be thrown into upheaval by an extreme disaster than one dependent on a specialized industry whose productivity could be severely diminished by a natural hazard.

Local, regional, national, and international cooperation and coordination are necessary aspects of ensuring environmental quality. While a certain degree of self-sufficiency and responsibility is important, the resiliency of local communities is also dependent on their relationships with other places. Therefore, a consensus building approach, initiated at a grass-roots level but ultimately bridging the global community, is an important principle of sustainable hazards mitigation. It should be noted that full consensus is not the objective; rather, it is a process where wide participation is sought among all stakeholders, generating ideas and information, and creating a sense of ownership and community are the goals (D.S. Mileti, 1999).

3. Methodology

In order to apply the literature related to sustainable hazards mitigation, a case study of a city experiencing hazards, namely Kigali (Rwanda) was thought to be the most appropriate research strategy. Yin (2003) states that case studies are the preferred strategy when “how” or “why” questions are being asked, when the researcher has little control over events, and when the focus is on a recent issue within a practical context.

The case study’s unique strength is its ability to deal with a variety of evidence, including existing documents, archival records, semi-interviews, direct observation, and physical artifacts (Yin, 2003). For the purposes of this case study research, existing documents such as aerial photographs, satellite images, maps, legal texts like laws, decrees and policy texts; semi-directed interviews, and direct observation were most heavily relied upon.

3.1. Documents and tools

As part of an inventory of natural hazards in the city of Kigali, several documents were used. These include topographic maps (scale of 1/50000), geological maps (scale of 1 / 100000), aerial photographs, satellite images obtained from Google Earth (2007) and different documents like reports, plans and laws. As regards to tools, ArcGIS 9.2 has been used. It is important to mention that tracking hazard sites only by means of the documents (topographical maps, aerial images) is a problematic task. In most cases, field observations were necessary in order to recognize the sites at risks. After having selected potential hazard sites on the topographical maps, aerial photographs and satellite images, these sites were checked in the field. Not only the potential hazard sites were checked, photos were taken as well. The sites interpreted as affected by hazards were mapped. This resulted in multihazards map (Fig.2).

3.2. Semi-directed interviews

The most important element of this research was interviews (n=26). Yin (2003) states that key informant interviews are one of the most important sources of information in a

case study, and often critical to its success. We conducted in-person, semi-directed interviews with twenty-six (26) key informants. These individuals were chosen because of their involvement in hazards management. Semi-directed interviews conducted with the thirty key informants are divided into two categories as follows: 1. National institutions like Disaster Management Centre and Rwanda Environment Management Agency (n=2); 2. Local structures (n=24) including "*grass root communities of interests*".

To analyze the case study data, we relied largely on comparison to the analytical framework in existing literature, namely the chosen three dimensions of sustainable hazards mitigation. According to Yin (2003), this is the most preferred strategy of analyzing data because the objectives and design of this case study are based on propositions that reflect the theory and knowledge gaps found in the existing literature. These types of questions were relied upon and were most common in key informant interviews during the case study.

4. Case of study: state of hazards in Kigali city

Kigali city has experienced rapid expansion and urbanization over the last five decades. In this region, hazards have become, recently, one of the centered problems (Fig.3). In different parts of Kigali city, several hazards are associated (Fig.2) and thus, cause damage to buildings and other infrastructure and recently much attention was paid on them through public participation, technical and institutional innovations.

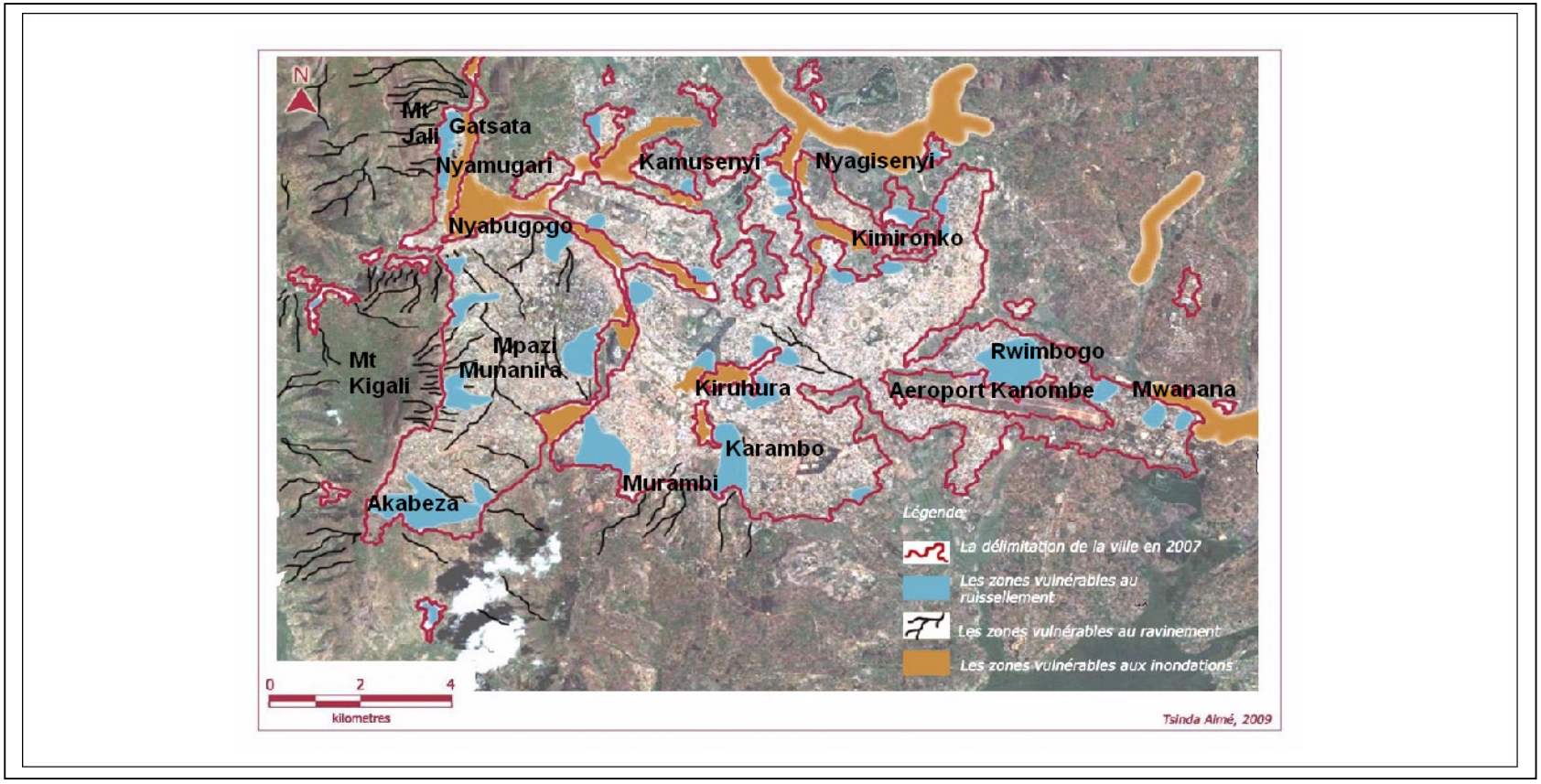

Fig.2. Inventory of multi-hazards in Kigali city (Rwanda)

Source: Authors, 2009

Historically, within Kigali's territory, most of built-up land was located in the lower floodplains. The strong demand for protecting the populous settlements has accelerated construction of the water facilities and flood control systems. Since 2004, Urban Infrastructure and City Management Project (UICMP) spent much money on infrastructure. However, in order to meet the demand of urban development, intensive human activities, including excavating sand, building bridges, dams, were encouraged. Also, the uncontrolled development of industries (Gikondo marshland) was permitted along the rivers. Until recently, some households had settled in the flooding zone. On large scale, natural factors such as extreme rainfall storm, overflow of river banks, and change in hydrological conditions of the rivers should be dominantly responsible for runoff, abnormal floods and ravines. On local scale, rapid urban sprawl has caused an increase in the magnitude of impervious land and subsequent runoff. It was noted that approximately 80 % of the water facilities must be reinforced to defend from floods (Kigali Master Plan, 2008). Therefore, given the compound effects of natural and anthropogenic factors, especially the rapidly urbanized area of Kigali city will be more subject to the disastrous floods in the case of extreme events (Fig.3.1).

Fig.3. 1) Floods in the La Palisse, 2) Runoff at Kinamba and 3) Ravine of Mpazi
Source: DMC, 2010

5. Research results

Analytical framework	**Results from application of analytical framework in the context of Kigali city**
Environmental quality	• Duplication of responsibilities (For example, 1. Disaster Management Centre covers a combination of all hazards while Rwanda Environmental Management Agency is mandated to carry out all environmental issues including hazards; 2. Disaster Management Centre and Rwanda Environmental Management Centre are responsible to the Government for hazards and environmental management but it is not clear whether or not they have power on local structures whereby these (local structures) are under the Ministry of Local Government and Community Development); • Focus purely on technical issues like channels construction and little attention of an adequate conceptual framework for hazards management; • A great effort in legislative and policy framework. For example: 1. Ministerial Decree No. 003/2008 (15/08/2008) determining the requirements and process to follow for the environmental impact assessment;

	2. Ministerial Decree No. 004/2008 (15/08/2008) determining the lists of work to be done, activities and projects being subject to environment impact assessment; 3. Ministerial Decree No. 005/2008 (15/08/2008) laying down detailed inspection of companies (industries) or activities which generate environmental pollution; 4. Ministerial Decree No. 006/2008 (15/08/2008) regulating imports and exports of substances that deplete the ozone layer and products and equipment containing such substances;
Participation process	• Little involvement of citizens in hazards mitigation even if there are community works once a month; • Strong involvement of "*grass root communities of interests*" in hazards mitigation (construction of channels for runoff drainage, plantation of trees on the top of Kigali mount, collection of waste twice a week);
Disaster resiliency	• Lack of human resources and equipment specialized in hazards mitigation; • Several channels have been constructed by Urban Infrastructure and City Management Project (UICMP) and offer some control over rivers but in some cases they have created a false sense of safety to the people living nearby and have actually increased losses when an extreme event surpasses design specifications;

Table1. The main findings of the study
Source: Compiled by authors with data from interviews and documents, 2009

The main question from the results above is the following: How can these mentioned dimensions be adjusted within the reality of Kigali city? In the following section, this paper analyzes and discusses at which points the current hazards mitigation might be enforced to ensure its sustainability.

6. Discussions of results

For political and economic reasons, sustainable hazards mitigation should be a very pronounced priority by local and national governments. Thus, much attention should be paid to both technical and institutional innovations as well as "*grass root communities of interests*". Lessons from other developing countries noted that hazards must be managed in proactive and integrated manner rather than hazards response in order to mitigate the effects of natural hazards on humans. Therefore, an integrated and proactive approach is urgently needed. Unfortunately, there was not an integrated early warning system for hazards management in Kigali city yet. It is urgent to produce the flood-risk maps, which will provide valuable information to local and central governments for flood relief. Currently, with wide application of Geographical Information Systems and remote sensing techniques in Rwanda, the goal can be achieved by using key parameters of historical and real-time levels, including precipitation pattern, water levels, tidal levels, flow fluxes, land use patterns, population density, and hazards prone areas. Thus, information on warning levels can be rapidly communicated to the municipalities and local communities for preparedness levels and remedial measures.

Institutionally, the implementation of policies for hazards prevention plays a key role in effective hazards mitigation. Like most developing countries, a "*top-down approach*" has dominated hazards fighting efforts. Usually, responses to past hazards damage prompted increasing construction of water facilities. This required more investment in hazard prevention. In addition, the emphasis on construction of water facilities has fostered an inappropriate idea of land use based on a false sense of security. In pursuing short-term economic benefits, local governments failed to effectively manage land development in the flood-prone areas. In Kigali, due to human activities such as building dams and bridges along the riverside, the ongoing encroachment of flood-prone areas resulted in increasing vulnerability of the existing water facilities. Therefore, on local and regional scales, legislative actions must be taken to strictly control the intensive development in flood-prone areas as it is being conducted by Rwanda Environmental Management Agency nowadays. Moreover, local and central governments should make practicable policies on land use planning.

Planning and management strategies depend on the type of hazards encountered. In any case, the best approach is avoidance whereby affected areas by the hazards are identified and are not developed. A close alternative is relocation. The most common approach however is some form of mitigation to reduce the impact of the hazard by either engineering the construction or the natural system. To control erosion due to surface runoff, there shall be watershed level planning and restrictions on construction, steep-slope development and road building. A watershed management plan identifies sensitive areas, designates acceptable land uses and specifies overall management goals. The protection of pervious surfaces allows precipitation to infiltrate into the ground, resulting in less storm water runoff and erosion potential. Restrictions on steep-slope development and road building also result in less surface erosion, fewer landslides, and minimize land loss. But, this cannot be attained without effective local participation. There can, however, be no question of starting from nothing, since "*grass roots communities of interests*" are already actively involved in hazards mitigation. It is high time that this significant intervention of "*grass root communities of interests*" to be accompanied by complementary actions of public institutions and international agencies as well.

7. Conclusions

Following this study, results show that the city of Kigali is affected by multi-hazards, which cause several damages. Lessons learnt from the Kigali case implied that, sustainable hazards mitigation is hindered by fragmentary policies and dysfunctional stakeholders involved in hazards management. As far as a legislation system is concerned, even though a significant progress has been made in establishing different laws related to environment protection, this system needs to be harmonized with the current administration structure of Rwanda in general and Kigali city in particular. Therefore, an organization of actors is urgently needed and local as well as central governments should make practicable policies on land use planning. This

would discourage encroachment of lands vulnerable to hazards. But this cannot take place if citizens are not empowered with knowledge related to hazards. However, the public participation is sometimes limited in the planning phases, putting people at the "*receiving end*" of plans that were generated and directed by the national institutions and local collectivities. It is highly time to honestly and respectfully gauge the public's willingness and ability to participate in the design and implementation of any hazards in their own communities. Specifically, in Kigali context, "*grass root communities of interests*" should be given a prominent part in the planning process and be completed by joint actions of public institutions (Disaster Management Centre and Rwanda Environment Management Agency).

8. References

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