ASSESSING THE VULNERABILITY TO NATURAL HAZARDS ON THE PROVINCIAL/COMMUNITY LEVEL IN MOZAMBIQUE: THE CONTRIBUTION OF GISCIENCE AND REMOTE SENSING

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ABSTRACT

The assessment of vulnerability at the community level is currently strongly evolving. Also participatory methods are seen as the way forward to act successfully at the local/community level. In order to carry out effective measures for risk reduction, information has to be available about the hazards that threaten a certain area, the elements at risk (population, buildings, infrastructure, economic activities) that are exposed to these hazards, the vulnerability of these elements at risk and an estimation on the expected losses.
The concept of vulnerability has not been finally defined yet and indicators and agreements on how to measure the "unmeasurable" are still on its way. Parallel to this, also the field of participatory practices is moving forward and new concepts such as "Participatory GIS" (PGIS) are emerging.
Within this paper the current application fields of PGIS and the use of GIScience and methodologies for Disaster Risk Management are reviewed and summarised. From a general evaluation focusing on available and suitable data and constraints within data distribution experiences will also be drawn from on-site experiences in Búzi, Mozambique where PGIS methods were applied to assess the vulnerability of communities to hazards (focus on cyclones, floods and droughts; Project PRODER-GTZ (2000-present)). Primary data was gathered through participatory approaches applying techniques of semi-structured interviews, transect walks and community mapping.
To integrate the broad and interlinked concept of vulnerability, including social and natural issues from the global to the local, and to successfully address the main objectives of PGIS, to "participate", empower and represent indigenous spatial knowledge, a common agreement on objectives, methodologies and a strong legal framework are needed. The relevance of PGIS practices has been evaluated within the Mozambican case study and will be presented in this paper. A certain attention lies on the requirements for developing countries and the role of GIScience from a technological perspective, but also from its data availability and potential to communicate information to involved stakeholders.

Key Words: Vulnerability Assessment, Community-based disaster risk management, Multi-scale representation, meaningful units, PGIS, Remote Sensing

1. INTRODUCTION

Recently, Mozambique has been affected severely by different types of hazards. Triggered by the influence and activity of the El Niño-Southern Oscillation (ENSO) Mozambique is alternately struck by droughts or floods/cyclones. The past years have been characterised through severe droughts whereas the last rainy season (November 2006 – March 2007) has shown sever flooding at the Zambezi and Búzi river systems. Additionally, the devastating cyclone Favio, which hit the town of Vilankulu, led to high losses among the local population. The most affected by these hazards are rural and poor people living close to river banks but are also widely distributed across rural Mozambique.
Since the last major floods in the year 2000 and 2001, which have undergone wide media coverage, different efforts have been initiated to make people less vulnerable and more disaster prone. Efforts are targeting different levels, such as the strengthening of national institutions but also focusing on the local/community level.
Additionally, new terms and concepts have entered into the debate about effective disaster risk reduction. The concept of vulnerability often gains high attention and is currently discussed strongly among different

scientific disciplines, whereas practitioners try to develop and implement suitable methodologies. Participatory approaches are also evolving as a result of the failure of different top-down development approaches in the last decades.
This paper tries to bundle this discussion together and focuses on a case study in Mozambique. The possibilities and constraints of GIScience to assess vulnerability at different scales under the specific conditions of the case study are the central topics of this paper.

2. Vulnerability – A concept under construction

Since the 1970s, but with increasing emphasis in the 1980s and 1990s, researchers from the social sciences and humanities have argued that the impact of natural hazards depends not only on the physical resistance of structure, but on the capacity of people to absorb the impact and recover from loss or damage. The focus of attention moved to social and economic vulnerability, with mounting evidence that natural hazards had widely varying impacts on different social groups and on different countries. The causal factors of disaster thus shifted from the natural event towards the development processes that generated different levels of vulnerability. Vulnerability reduction began to be advanced as a key strategy for reducing disaster impact, though this proved elusive to implement.
The definition formulated by the International Strategy for Disaster Reduction (UN/ISDR) is one of the best-known and defines vulnerability as:
"The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards." (UN/ISDR 2004)
One major issue of vulnerability is the view of a forward-looking and policy-supporting variable. Cannon, Twigg and Rowell (2003) characterised it, *"vulnerability (in contrast to poverty, which is a measure of current status) should involve a predictive quality: it is supposedly a way of conceptualising what my happen to an identifiable population under conditions of particular risk and hazards."*
A current definition of vulnerability is put forward by UNU-EHS: *"Vulnerability is the intrinsic and dynamic feature of an element at risk (community, region, state, infrastructure, environment etc.) that determines the expected damage/harm resulting from a given hazardous event and is often even affected by the harmful event itself. Vulnerability changes continuously over time and is driven by physical, social, economic and environmental factors"*.
The UNU-EHS definition is further conceptualised through the BBC concept (Bogardi, Birkmann, Cardona), which sees vulnerability embedded in the hazard-vulnerability chain (Fig.1).
At the moment there has not been any consensus achieved yet and debates are vital but still isolated among different scientific disciplines (disaster studies, climate change community, ecologists, social scientists,…). However, different initiatives take currently place such as the Expert Working Group on Vulnerability led by the United Nations University – Institute for Environmental and Human Security. This led also to the publication of different synthesis reports which compile different approaches and findings (Adger 2006, Birkmann 2006, Gallopín 2006, Thywissen 2006, Villagran 2006).
Despite the agreement on a conceptual basis the difference to traditional methods is the interdisciplinary approach of vulnerability, which sees the manifestation of a disaster not only by the increase of hazards through physical factors, but also takes into account the social and political conditions which lead to an higher degree of vulnerability and to losses. To integrate and connect these different factors among different sectors, disciplines, dimensions and spatial scales makes the assessment of a system in regard to its vulnerability a difficult and often complex task.
The methodological challenge is to develop a reporting framework or system on vulnerability that can include qualitative and quantitative data, and allows the communication and visualisation of vulnerable places and dimensions to relevant decision makers and stakeholders. Also the integral view of natural and social dimensions is still an open research question.
A major challenge is the identification and definition of a set of vulnerability indicators. The vulnerability indicators should be used to evaluate adaptive strategies and measures as well should serve as the baseline for monitoring development processes.

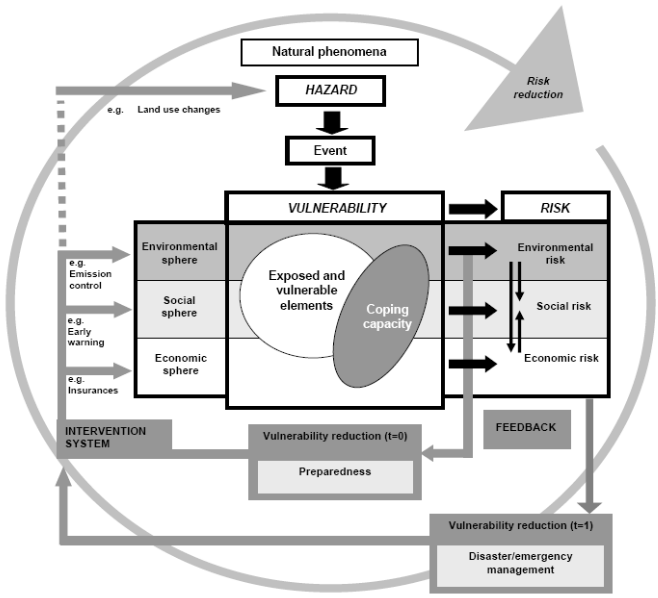

Fig. 1: The BBC conceptual framework

A critical task is the definition of the appropriate scales. In general also the typical scale dependency as for natural phenomena can be applied (micro-, meso-, macro-,…etc), but also includes the difficulty to integrate scale independent phenomena originating from the social science perspective. Additionally, as the main target group for a vulnerability assessment are decision- and policy makers, their scale, the scale of policies, has to be considered. A central question, as for common decision support systems to be answered is: If XY changes, WHAT happens WHERE?

2.1 GIScience and the assessment of vulnerability

Despite the conceptual discussion and the difficulty to define and create appropriate indicators to map vulnerability the identification and monitoring of places with a certain degree of vulnerability remains still a challenge considering to multifaceted way of vulnerability.
Traditionally GIS and Remote Sensing methodologies have been applied to assess the risk to certain type of hazards linked with its vulnerability in a close relationship to the physical dimension (e.g. assessment of the built environment, hydrological modelling, etc.) and critical infrastructures and sector vulnerability.
Cutter (2003) has summarised major research needs in GIScience in regard to disasters and emergency management. Needs targeting the topic of vulnerability are the better integration of physical processes and social models to enhance the prediction of hazard impacts and the needs for better representations of risk and vulnerability, visual images that capture the spatial and temporal shifts in the risk and local vulnerability, but also the uncertainty inherent in the information being presented. Additionally an open question is the daily and diurnal occupation of certain areas within cities. Cutter places emphasis also on closer collaboration with the user community and proposes a bottom-up-approach. This research needs are still valid, also viewing it from the perspective of conducting a vulnerability assessment.
An overlaying issue and an evergreen in many cases, is the lack of interconnected spatial data infrastructures and the availability of sufficient data (with different characteristics between the developed and developing world).
As the discussion is still ongoing about concepts and definitions in regard to vulnerability, assumptions have been made to facilitate the application of Earth Observation and GIScience within this paper:

- Vulnerability differs spatially
- Vulnerability changes within time
- Vulnerability has different dimensions (environmental, physical, economical, social,…)

- Vulnerability assessments are policy oriented with the overall objective to mitigate/avoid the negative impacts of disasters
- Vulnerability is currently measured indirectly and is described through specific indicators which allow representing and monitoring the different dimensions of vulnerability.

To bring the main three components/characteristics or dimensions of vulnerability together three axis can be defined within a "vulnerability cube" (Fig 2.):

- Time – Revealing event or process (e.g. daily, monthly, yearly decadal)
- Space – Scale of vulnerability (can be defined in absolute terms such as macro-, meso- etc,…or "policy scales" e.g. individual, household, community, municipal, etc)
- Organisational Level – Dimension of vulnerability (natural and human system)

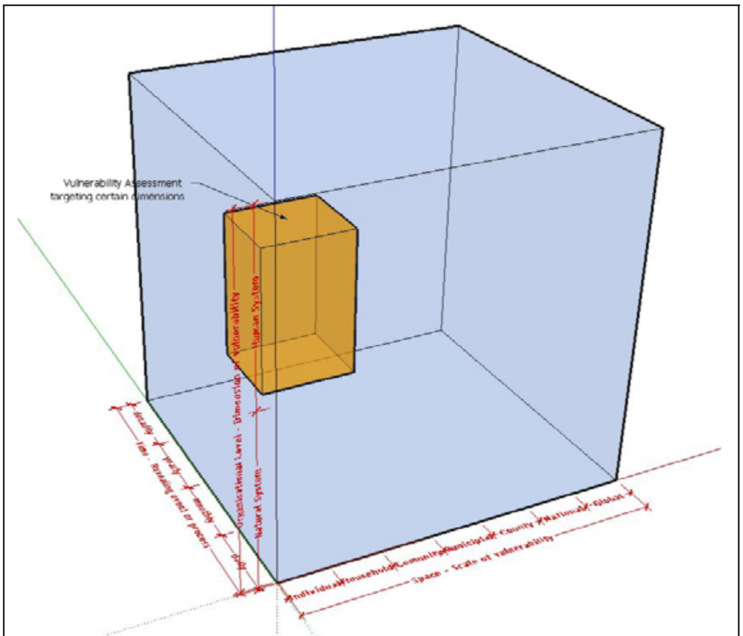

Fig. 2: Vulnerability Cube: The cube allows the positioning of a certain phenomena within the view of vulnerability

This concept strongly links to the topic of "scale" and "scaling" which is outlined and currently further conceptualised by Wu (2006). Drawing on this, a strong relationship to object-based image analysis (OBIA) exists, which aims to generate image objects not only making use of spectral reflectance values but also includes shape, texture, neighbourhood relationships and scale hierarchy. According to this, a system under observation can be separated into its components according to the scale and can be ordered hierarchically (different scale levels).
These approaches are also currently applied and research is undertaken within different application fields such as landscape ecology (Burnett & Blaschke 2003), damage assessment (Schöpfer et al. 2007) or population monitoring for humanitarian aid (Lang et al. 2006).
A current need for such approaches arises from the increase in resolution of satellite imagery in the recent years. As a consequence the complexity increases and new methodologies are necessary to derive also the necessary information from satellite data.
Meaningful units, derived from image objects, reflecting the vulnerability at a certain level can be seen as a desired outcome. In this regard the scale dimensions of different phenomena should be integrated in a hierarchical way (Fig. 3). Critical are the interrelations and feedback loops between e.g. social and natural phenomena. To integrate this, methodologies should be developed to assess vulnerability (with its interdisciplinary focus) with a certain spatial view, and to provide stakeholders with sound decision supporting tools.

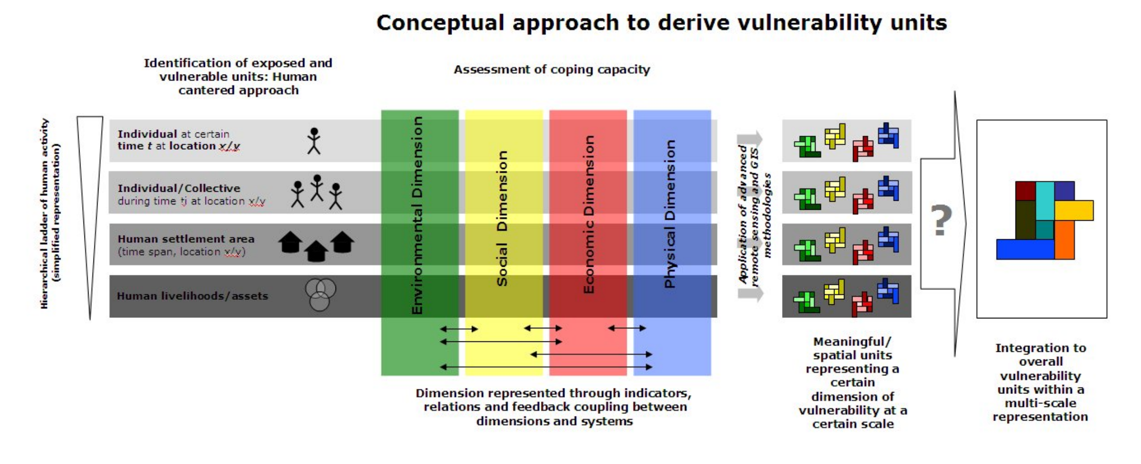

Fig. 3: Conceptual approach to derive vulnerability units through the application of GIScience and advanced remote sensing methodologies within a hierarchical and multidimensional framework

3. Participatory GIS approaches and vulnerability assessment

In the mid 1980s the development community recognized that four decades of development cooperation did not lead to sustained improvement. Infrastructure was mainly “imposed on” the countries of the South without taking the cultural and social environment into consideration. This finally led to the cognition that active participation of stakeholders is a core condition for successful and sustainable development. Since the 1990s “Participation” is a central issue within the field of development cooperation. Different methodologies such as the Participatory Rural Appraisal toolbox (PRA) are widely used by NGOs and governmental development agencies.

Participatory development is defined as a partnership which is built upon the basis of dialogue among the various actors, during which the agenda is jointly set, and local views and indigenous knowledge are deliberately sought and respected. This implies negotiation rather than the dominance of an externally set project agenda. Thus people become actors instead of being beneficiaries (UNDP 1998).

What is still criticised is that there are different interpretations of the term of “participation” even within organisations. Participation may be just used as a “buzzword”, handled as an instrument or targeted as a goal. Despite this, Participatory Geographic Information Systems (PGIS) have developed out of the debate between pro-technology GIS scientists and social science critics of GIS (Carver 2001, Craig et al. 2002, Obermeyer 1998). As GIS gained popularity as a mainstream tool for the organisation, analysis and representation of geographic information for decision-making, social scientists criticised it for being top-down, complex and inaccessible as a tool designed to facilitate decision-making. GIS thus had to respond to the demands of a society where democracy, good governance and public participation were key to planning and decision-making.

Abbot et al. (1998) refer to PGIS in regard to developing countries as “an attempt to utilise GIS technology in the context of the needs and capabilities of communities that will be involved with, and affected by development projects and programmes”. Other probing ideas of the subject include incorporating community participation into a GIS, the social-behavioural implications of GIS and broadly the inter-relationship between GIS and society (Craig et al. 2002, Nyerges et al. 2002, Obermeyer 1998).

In the recent years terms, have become clearer and more defined (Rambaldi et al. 2006). There is a certain distinction between the use and objectives of participatory approaches in the developed and developing world. PPGIS (Public Participation GIS) is seen as the connection of spatial planning and GIScience applying sophisticated methodologies and visualization techniques. Whereas in the South PGIS (Participatory GIS) is more seen as the crossing of participatory progressive development and GIScience integrating low and high tech spatial management applications. In this context PGIS is also seen as a practice which should facilitate empowerment (possessing own spatial information), communication among stakeholders and as learning process.

McCall (2004) argues that strict definitions may have little value, as they might be interpreted differently anyway. He notes that participation is the essence and the key to P-mapping and P-GIS. The participation is more fundamental than the map or the GIS product. The spotlight always falls back on the participation and the participatory processes, rather than the GIS.

3.1. Review of existing PGIS applications in disaster risk reduction

There is growing evidence to show that most top-down disaster risk management and response programs fail to address specific local needs of vulnerable communities, ignore the potential of local resources and capacities, and may in some cases even increase people's vulnerability. As a result, a broad consensus has been reached among disaster risk management practitioners to put more emphasis on community-based disaster risk management programs. This means the vulnerable people themselves will be involved in planning and implementing disaster risk management measures along with local, provincial, and national entities through partnership.

Different methodologies (such as de Dios 2002 (Oxfam), ADPC 2004, Action Aid 2005) are used today through different agencies. However, if one looks into the literature and focuses on the application of PGIS practices in this context only a few publications are available. This is also contrary to the fact that one of the typical application fields of PGIS often mentioned is the field of disaster risk management (Moctezuma 2001, Touré 2004, Kienberger et al 2005, Knud 2005, McCall 2005).

There is still lacking evidence of the efficiency and effectiveness of PGIS practice in regard to disaster risk reduction.

4. Case Study – Mozambique: District of Búzi – The application of PGIS practices at the community level

Mozambique has been suffering from war of independence followed by a civil war for almost 16 years. With the peace accord in 1992 and the first democratic elections in 1994 social life is shifting to normality and economic activities are slowly growing, however with strong disparities between the capital and the provinces. Lack of infrastructure and qualified people, political discrepancies, political and economical changes in the region (Zimbabwe) and not-to-forget the HIV pandemic, are factors which slow down the development of the central region.

Additionally to this Mozambique is regularly affected through natural hazards such as droughts, cyclones and floods. The last major disasters have been floods and cyclones in the year 2000 (400.000 displaced, 700 fatalities) and 2007 (~ 140.000 displaced). The events in 2000 affected almost entire Southern and Central Mozambique and have been the largest floods ever seen in this area. As a result, a number of processes were initiated by the Mozambican government as well as several non-governmental organizations with the common goal of being better prepared for future disasters. In 2007 major flooding affected the Zambezi river and a sever cyclone hit the town of Vilankulu in Central Mozambique. The recent events also have shown despite the devastating impacts, improvements in regard to disaster management have been made, as the Mozambican authority INGC (Instituto Nacional de Gestao de Calamidades) has decided not to appeal for international aid and recent observers, such as national and foreign, have praised the preparation and organisation which ensured that a major flood did not turn into a disaster.

However, not only floods and cyclones put pressure on the affected communities, influenced by the El Nino phenomena the years in between were characterized through severe droughts. This fact makes it also difficult for donors and practioners to target their efforts but also the people who have to adapt to these "contrary" hazards.

4. 1 Case study overview

The case study was conducted in the District of Búzi which is located along the river Búzi in the southern part of the province of Sofala (Central Mozambique) and shares coastline with the Indian Ocean. The district has a population of about 1,5 million (1999) and covers an area of ~7000 km². People rely on subsistence farming such as sorghum, rice and sweet potatoes as well as fishing and livestock.

Common natural disasters in Búzi are droughts, floods and cyclones but also earthquakes can be identified but usually do not lead to disasters and are therefore not really remembered by the people. Erosion and uncontrolled fire are human-triggered or through mankind accelerated disasters that are increasingly

becoming a problem in the region. Epidemics occur almost annually leading to an accumulation of socio-economic problems and increasing vulnerability to disasters in either triggering disasters or turning small events into disastrous dimensions.
The floods in the year 2000 triggered a number of policy changes in Mozambique (Law on Disaster Management in 2002). Donors and foreign technical co-operations changed their policies from reaction to prevention measures (African Regional Consultation 2004). Matsimbe (2003) summarised the lessons learnt as follows and put forward different recommendations:

- lack of institutional coordination to respond situations of extreme need
- weak mechanisms of communication between different levels of the administration
- lack of efficient channels and mechanisms to disseminate information on natural hazard management to communities that really need that information
- centralisation of decision-making at national level and nonflexible mechanisms for information flow from bottom-up. As result, most of the decisions taken do not reflect the needs and expectations of the people on the ground
- fragile and incompatible links between the different powers created in a context of new democratisation. At the local level there is no clear definition of roles between the traditional and administrative authorities; this sometimes results in conflict, which can have a negative effect on institutional coordination in disaster management

Gall (2004) also summarized that the effectiveness of information depends on the will and motivation of decision makers to incorporate and utilize information. As long as decision-making rests upon political implications rather than on "objective" information, the advantage and benefits of GIS will be withheld.
Furthermore Wiles et al (2005) expressed *"the lack of transparency and sharing of information created a culture of passive acceptance and a climate of misinformation. During the 2000 floods this did not result in major conflicts, but could become an explosive situation in the future. Agencies involved in post-emergency interventions should explicitly recognize the need for improved communication with beneficiaries and take measure to promote a culture of openness"* and recommends that "*there should be an increased emphasis by government, donors, and agencies on building capacity for disaster management at the district level. This will involve more sharing of information on budgets and planning"*.
The present constitution of the Republic of Mozambique (2004) defines and encourages community participation. The forms of participation that the law establishes are public hearings, consultation and the channelling of problems and/or suggestions of solutions of problems to the municipalities (Nguenha & Massangaia 2005). However it has to be noted that there is a strong interest especially by donors who put the issue of participation forward. Parallel to this, the identification and creation of committees for different issues (water, disaster management,…) etc. can be observed. One critical point in rural Mozambique is still the existence of parallel structures of traditional and official administrative units, which is still an ongoing issue to be clarified and underlies frequent changes, especially within the traditional systems.

4. 2 Participatory Vulnerability Assessment in Búzi

Within the project PRODER-GTZ, which aims to establish and improve disaster risk management at the local and district level, a hazard risk and vulnerability assessment (Steinbruch 2003) was conducted in the year 2002. Nine communities in the district of Búzi and eight communities located in the district of Chibabava in the province of Sofala/Central Mozambique have been chosen as investigation area. The assessment was supported through the local Centre for Geoinformation at the Catholic University of Mozambique, Beira (CIG-UCM). The addressed hazards include cyclones, floods, erosion, drought and uncontrolled fire. Additionally hazards such as earthquakes, pests and epidemics have been considered.
To include also the perception of the local population and to identify and strengthen the local disaster risk committees PGIS practices have been applied. The methods of the PRA toolbox were used and modified to address the specific needs of the hazard risk analysis.

4.2.1 Methodology

The following procedure was applied for each investigated community (Kienberger & Steinbruch 2005):

1. Pre-contact to local authorities mostly via local Mozambican Red Cross representatives
2. Meeting with local leaders and introduction into objectives and expected outcomes of the field work
3. Collection of social and economical base data by means of data revision and interviews
4. Detailed mapping of important infrastructure, i.e. public buildings, drinking water access, roads, bridges with a GPS and topographic base maps
5. Conduction of a 2,5-day participatory workshop, where women and men participated representing their community

4.2.2 Outcomes

A list of vulnerability indicators suitable for the specific Mozambican case was developed to set priorities for community plans as well as for disaster preparedness activities. Physical, socio-cultural, economical, and institutional vulnerability indicators have been developed which have been aggregated to an overall vulnerability. The outcomes serve as a basis for identifying programme focuses and needs for each community (Fig. 4). Additionally community maps were produced. These maps were also a central part within the undertaken assessment as up-to-date spatial data is lacking for Mozambique.

Fig. 4: Result of the vulnerability assessment, showing the overall vulnerability of the investigated communities

4.2.3 Assessment of the relevance of PGIS practices at the community level in Búzi

Three years after the assessment (June 2005), the relevance of the applied methodologies was evaluated. Due to time and resource restrictions five communities (Muchenessa, Inharongue, Munamicua, Inhanjou and Estaquinha) have been chosen to conduct the evaluation. The main methodology was to interview key-informants, such as people who participated in the exercise but also local stakeholders and decision makers through semi-structured interviews.
The following major outcomes can be concluded (Kienberger & Steinbruch 2005):

- Participative decisions and consensus finding are deeply rooted in the investigated communities in Central Mozambique. The success or failure of outside-imposed initiatives depends strongly on the involvement of the community.
- The investigated communities have experienced a number of participative mapping exercises (often independent of each other). Therefore the communities have undergone several learning phases in participative mapping and the use of maps.
- The participatory disaster risk assessment was mainly one-directional, with the main objective to aggregate information with the help and participation of the local people. The objectives of the disaster risk assessment were addressing other issues and the funding agency as the process driving force did not see the potential of maps in their further plans of activities related to disaster

risk management. The participation in this sense is located in the lower end of the “participation ladder”. For the collection of spatial information and to capture the perception of people regarding disasters the participatory approaches was found suitable.

- The potential of the participatory maps for planning of evacuations in the case of floods were discovered and taken up by individuals and local Disaster Risk Committees. A momentum developed in some communities without any donor influence, in which maps were also used in community meetings to discuss spatial-relevant issues.
- It was not found, that any conflicts arose around the ownership or the use/abuse of the map. In many communities more than one map exists due to the disconnected activities of a series of non-governmental institutions. Generally maps are with the head of the community as well as with one responsible member of the Disaster Risk Committees.
- The local population could easily use the generated maps and could orientate themselves on the map. An important issue is that the design of the legend should remain with the local population.

5. Conclusion

Within this paper different approaches and application fields in the context of GIScience have been presented. A conceptual design to derive spatial vulnerability units has been proposed. Parallel to this a project has been presented where PGIS practices have been applied to assess the vulnerability at the community level in rural Mozambique. To bring this puzzle together the following conclusions and requirements can be drawn:

- Current methodologies to assess risk are available and are currently developed or are under investigation. However, satellite systems operating at a high technological standard alone are not sufficient. To follow a multidisciplinary approach of vulnerability, new approaches have to be developed. Object-based image analysis and spatial analysis can serve as a starting point to model the increased complexity, integrate social and natural dimensions and derive meaningful objects, such as hazard vulnerability units to facilitate improved decision making.
- Out of the experience in Búzi, it can be concluded that institutional requirements have to be set that the information flow is guaranteed. Different levels have different information needs. The challenge is to integrate this in a continuous and interlinked information flow. An important condition in such a case is the political will. A network which is based on trust and good practice is necessary (Fig. 5)

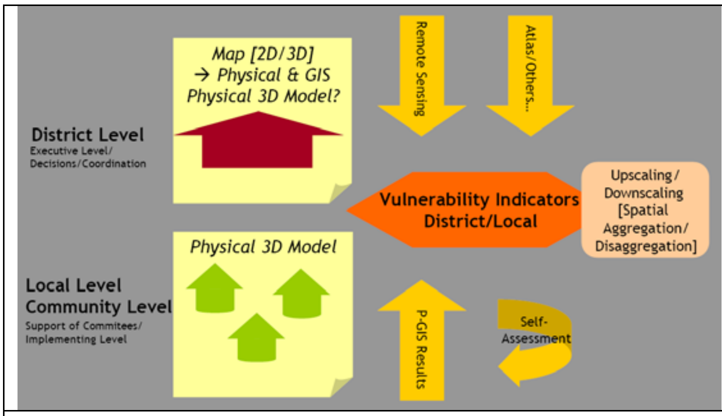

Fig. 5: Contribution of GIScience and remote sensing to contribute to an informed decision making at different levels

- Vulnerability clearly focuses on a policy level and has to address decision makers in different contexts. Following this, the information has to be presented in an understandable format. The identification of hazard vulnerability units and their spatial representation can be suitable to fulfil these requirements.

- Participatory methods and especially P-GIS methods seem to be well suited to be implemented in a vulnerability assessment at the local level under the conditions of a developing country.
- To integrate the broad and interlinked concept of vulnerability, including social and natural issues from the global to the local, and to successfully address the main objectives of PGIS, to "participate", empower and represent indigenous spatial knowledge, a common agreement on objectives, methodologies and a strong legal framework are needed.

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REFERENCES:

Adger WN (2006) Vulnerability. Global Environmental Change 16 (2006) 268–281

Abbot JR, Chambers R, Dunn C, Harris T, de Merode E, Porter G, Townsend J, Weiner D (1998) Participatory GIS: opportunity or oxymoron? PLA Notes International Institute for Environment and Development 33, pp. 24-34.

ActionAid (2005) Participatory Vulnerability Analysis, A Step-by-Step Guide for Field Staff. articipatory Vulnerability Analysis, A Step-by-Step Guide for Field Staff

ADPC (2004) Community-based disaster risk management. Field Practioner's Handbook. Asian Disaster Preparedness Center, Klong Luand, Thailand.

Birkmann J (eds.) (2006) Measuring Vulnerability to Natural Hazards. Towards Disaster Resilient Societies. United Nations University Press. 524 pp.

Burnett C, Blaschke T (2006) A multi-scale segmentation/object relationship modelling methodology for landscape analysis. Ecological Modelling 168 (2003) 233–249.

Cannon T, Twigg J, Roswell J (2003) Social Vulnerability: Sustainable Livelihoods and Disasters, Report to DFID Conflict and Humanitarian Assistance Department and Sustainable Livelihoods Support Office, available at http://www.benfieldhrc.org/disaster_studies/projects/soc_vuln_sust_live.pdf

Carver S (2001) Participation and Geographical Information: a position paper. ESF-ESF Workshop on Access to Geographic Information and Participatory Approaches using Geographic Information. Spoleto.

Craig WJ, Harris T, Weiner D (2002) Community Participation and Geographic Information Systems. Taylor & Francis, New York, 383 p.

Cutter SL (2003) GI Science, Disasters, and Emergency Management. Transactions in GIS, Vol. 7 (4) , pp. 439– 445.

de Dios HB (2002) Participatory Capacities and Vulnerabilities Assessment: Finding the link between disasters and development. Quezon City: Oxfam Great Britain – Philippines Programme (82p.) http://www.proventionconsortium.org/themes/default/pdfs/CRA/PCVA_2002_meth.pdf

Falk K (ed.) 2005 Preparing for disaster – A community-based approach. Daish Red Cross: http://www.proventionconsortium.org/themes/default/pdfs/CRA/PNRC_CBDP_2005_meth.pdf

Gall M (2004) Where to Go? Strategic Modelling of Access to Emergency Shelters in Mozambique. Disasters 28(1): 82-97

Gallopín GC (2006) Linkages between vulnerability, resilience, and adaptive capacity. Global Environmental Change 16 (2006) 293–303

Kienberger S, Steinbruch F (2005) PGIS and disaster risk management: Assessing vulnerability with PGIS methods – Experiences from Búzi, Mozambique. Mapping for Change, Int. Conference on Participatory Spatial Information Management and Communication, PGIS '05, 7.09. – 10.09.2005, Nairobi, Kenya

Lang S, Tiede D, Santilli G (2006) Varying sensors and algorithms – an information delivery approach for population estimation in African refugee camps. In: 6th African Association of Remote Sensing of the Environment Conference (AARSE), Oct 30 - Nov 2, Cairo, Egypt.

Matsimbe, Z. (2003) The Role of local institutions in reducing vulnerability to recurrent natual disasters and in sustainable livelihoods development. University of Cape Town http://www.fao.org/docrep/007/ae079e/ae079e00.htm#Contents

McCall MK (2004) Can Participatory-GIS strengthen local-level spatial planning? Suggestions for better practice. Paper presented at GISDECO '04, Skudai, Johor, Malaysia, 10-12 May 2004.

McCall MK (2005) Mapping lost homes. GIS@ development (Asian GIS Monthly) 9 (6) 24-27 http://www.gisdevelopment.net/magazine/years/2005/jun/homes.htm

Moctezuma P (2001) Community-based organization and participatory planning in south-east Mexico City. Environment & Urbanization 13 (2) 117-133. http://www.uky.edu/~tmute2/mexico/MexWeb/Mex%20PDFs/moctezuma.pdf

Nguenha E, Massangaia S (2005) Community Municipal Participation in Mozambique: The Case of Cuamba and Pemba. http://www.asaaf.org.zw/archive/research/MDP%20Participatory%20Budgeting%20Mozambique%20First%20Report.doc

Nyerges T, Jankowski P, Drew C (2002) Data-gathering strategies for social-behavioural research about participatory geographical information system use. International Journal of Geographical Information Science 16, pp. 1-22.

Obermeyer NJ (1998) The evolution of public participation GIS. Cartography and GIS 25, pp. 65-66.

Rambaldi G, Kyem PAK, McCall M, Weiner D (2006) Participatory Spatial Information Management and communication in developing countries. Electronic Journal on Information Systems in Developing Countries 25, 1, 1-9 , http://www.ejisdc.org:8011/ojs2/index.php/ejisdc/article/viewFile/237/158

Schöpfer E, Tiede D, Lang S, Zeil P (2007) Damage assessment in townships using VHSR data - The effect of Operation Murambatsvina / Restore Order in Harare, Zimbabwe. Urban Remote Sensing Joint Event. Paris 2007, CD-ROM

Steinbruch F (2003) Hazard risk and vulnerability assessment for the Búzi River Basin/Central Mozambique. GTZ, PRODER-Sofala. Mozambique.

Thywissen K (2006) Components of Risk. A Comparative Glossary. UNU-EHS, Source No.2/2006.

Touré I, Alassane B, D'Aquino P, Issa D (2004) Savoirs experts et savoirs locaux pour la coélaboration d'outils cartographiques d'aide à la decision. (Expert knowledge and local knowledge for the co-elaboration of cartographic decision support tools.) Cahiers d'études et de Recherches Francophones / Agricultures 13 (6) 546-553

UNDP (1998) Empowering people: A guide to participation. http://www.undp.org/csopp/CSO/NewFiles/ docemppeople.html

UN/ISDR (2004) Living with Risk: A Global Review of Disaster Reduction Initatives. Geneva: UN Publications.

Villagrán JCV (2006) Vulnerability: a conceptual and methodological review. UN University - Institute for Environment and Human Security, 4/2006, 64pp.

Wiles P, Selvester K, Fidalgo L (2005) Learning Lessons from Disaster Recovery: The Case of Mozambique. World Bank, Hazard Management Unit Working Paper Series No. 12

Wu J, Jones B, Li H, Loucks O (eds.) (2006) Scaling and Uncertainty Analysis in Ecology: Methods and Applications. Springer, Dordrecht, The Netherlands