P-GIS and disaster risk management: Assessing vulnerability with P-GIS methods- Experiences from Búzi, Mozambique

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P-GIS and disaster risk management: Assessing vulnerability with P-GIS methods – Experiences from Búzi, Mozambique

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Abstract

P-GIS methods and methods addressing vulnerability assessments are currently merging at an interesting focal point. Both terms and fields are under discussion in the scientific world as both concepts ask for clearer definitions, review of its relevance and deeper exploration of methodologies.

Within this paper we present the case study of Búzi, Mozambique where P-GIS 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 minimize vulnerability to natural disasters the need for a package consisting of programs for poverty alleviation, prevention measures and preparedness activities was identified which should be realized through external sources under the participation of communities. As an outcome of the overall project a manual on Participatory Disaster Risk Management was compiled.

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 P-GIS, to "participate", empower and represent indigenous spatial knowledge, a common agreement on objectives, methodologies and a strong legal framework is needed.

We describe the process of P-GIS within a vulnerability assessment and its legal and regulatory framework. Additionally the relevance of such methods has been evaluated and outcomes will be presented within this paper.

Keywords: Participatory GIS, Vulnerability Assessment, Decision Support, Relevance, Mozambique, Natural Hazards

1. Introduction

Participatory-GIS (P-GIS) for Disaster Risk Management is often mentioned in the literature as one of a classical example of P-GIS applications. Surprisingly not much literature is available and examples are also scattered over several years and range from a wide variety from nuclear waste disposal to environmental risk assessments. P-GIS methodologies in general are well suited to include people's knowledge and can be applied to disaggregate the complex coherences in an understandable and adaptive way to less-empowered people.

Suffering from cyclones, floods and droughts Southern Africa is recognized as a highly disaster prone area. In addition lack of knowledge and infrastructure, political instability, extreme poverty and HIV increase vulnerability of communities to disasters.

In the District of Búzi and Chibabava, Mozambique, P-GIS methodologies were applied within a development project to assess the vulnerability of communities to natural disasters. As the scientific discussion on P-GIS evolved very freshly to a broader research community the methodologies used in this case rose from the Participatory Rural Appraisal toolbox and were aimed to satisfy lack of data and to acquire more profound information of perceptions and living situations of local people.

The relevance of the applied methodology was reviewed and will be described within this paper. Experiences made will serve as a basis to link the balancing act between vulnerability assessments and P-GIS methodologies and should stimulate the discussion on the role of P-GIS in disaster risk management.

2. The concept of Vulnerability and how it is linked to P-GIS

2.1. What is vulnerability?

Vulnerability research and assessment is one of the major themes under the umbrella of sustainability science. Despite this, the term "vulnerability" has not a universally definition (Downing 2003). Social scientists often have a different understanding than e.g. climate scientists. Broadly speaking, the vulnerability of a system, population or individual to a threat relates to its capacity to be harmed by that threat. Vulnerability varies widely across peoples, sectors and regions. This diversity of the 'real world' is the starting point for a vulnerability assessment. Although assessments are often carried out at a particular scale, there are significant cross-scale interactions, due to the interconnectedness of economic, social and environmental systems (Fig. 1).
Two approaches in vulnerability assessments are distinguished, which are risk-based and vulnerability based. Recent controversially discussed definitions come from the International Panel of Climate Change (IPCC), Kasperson et al. (2001), Downing (2003) and Turner et al (2003). Common findings are, that it is adamant to assess vulnerability as an integral part of the causal chain of risk and to appreciate that changing vulnerability is an effective strategy for risk management (Kasperson et al, 2001).

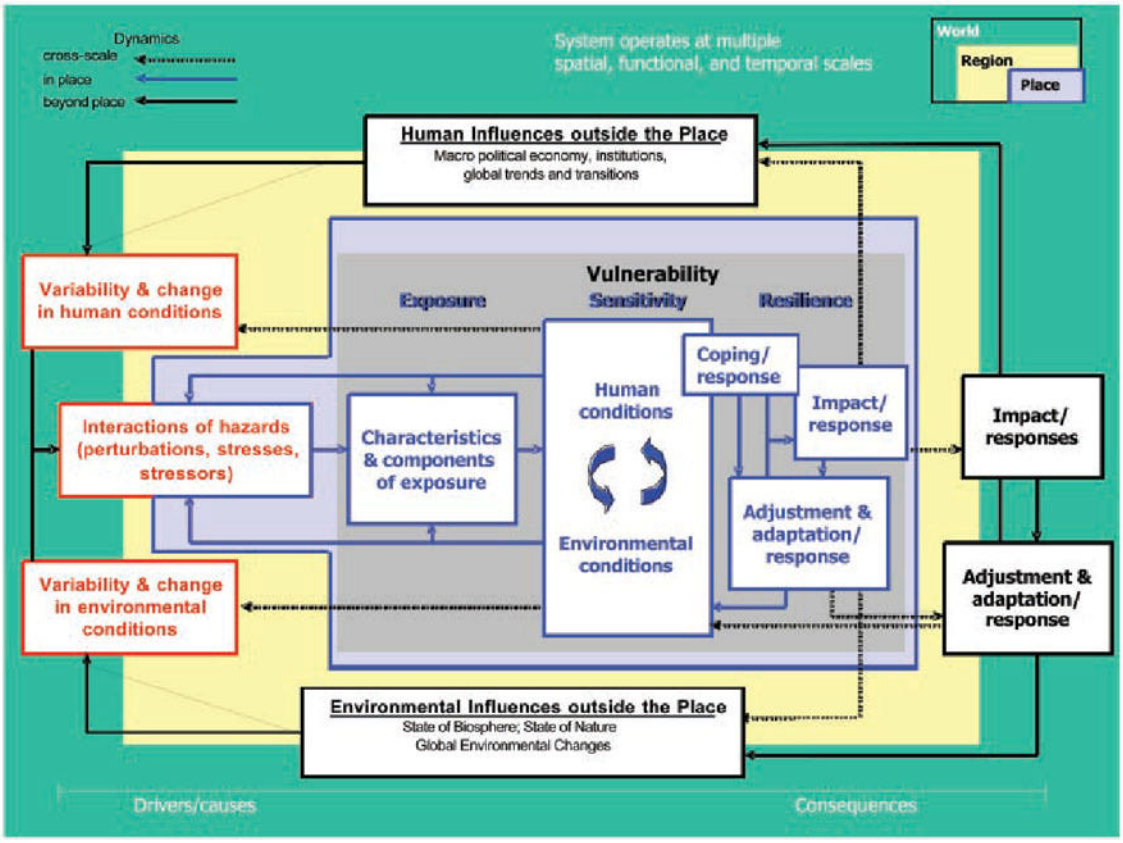

Fig. 1: Vulnerability framework. Components of vulnerability identified and linked to factors beyond the system of study and operating at various scales (Turner 2003)

All evolves around the answers to the following questions:

- Who is vulnerable?
- To what are they vulnerable?
- What are the specific reasons for their vulnerability?
- Where are the vulnerable?
- How have they come to be vulnerable (or under what circumstances will they become vulnerable)?

Turner et al (2003) identified the following elements for inclusion in any vulnerability analysis, particularly those aimed at advancing sustainability:

- Multiple interacting perturbations and stressors/stresses and the sequencing of them;
- Exposure beyond the presence of a perturbation and stressor/stress, including the manner in which the coupled system experiences hazards;
- Sensitivity of the coupled system to the exposure;
- The system's capacities to cope or respond (resilience), including the consequences and attendant risks of slow (or poor) recovery;
- The system's restructuring after the responses taken (i.e., adjustments or adaptations); and
- Nested scales and scalar dynamics of hazards, coupled systems, and their responses.

The methodological challenge is to develop a reporting framework or system on vulnerability that can include both qualitative, quantitative as well as even visual data (photographs, sketches, maps) to flesh out a sophisticated appraisal of vulnerability that is at all times context-specific and linked to data on adaptive capacity. Ideally, vulnerability assessments should be continuously up-dated (e.g. FEWS for Southern Africa).
Additionally a set of vulnerability indicators has to be developed. The vulnerability indicators should be used to evaluate adaptive strategies and measures as well should serve as the baseline for monitoring development processes.
Bogardi (2004) sees "vulnerability" as the "key" to human security. He argues that the occurrence of extreme events, their superposition with the creeping environmental deteriorations is usually a local or regional phenomenon, while the expected consequences are global ones. For this reason, disasters may be better defined within the context of human (in)security. Bogardi defines the concept of human security as focusing on threats that endanger the lives and livelihoods of individuals and communities.
Different methodologies have been developed to assess the vulnerability of a system at different scales (e.g. FAO, WFP, IFRC etc). Continuous scientific discussions exist about general concepts of vulnerability sciences and the development of indicators, which are suitable for the different scales and conditions.

2.2. Participation and P-GIS

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.
Abbot et al., (1998) refer to P-GIS 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).
McCall (2004) finally 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. The core question always is what do we mean by 'participation'?
Participation in Mozambique is generally defined as the right of individuals and communities to obtain information and to contribute opinions in public consultations. Participation, as part of decentralization from national organs to local communities, is foreseen in the form of self-decisions regarding community concerns, however through licensed associations or

committees. Decisions are generally made at higher institutional level, because of the lack of institutionalized mechanism to channel interactions and decisions within communities. However, committees for water, natural resources management, land use and disaster emergency as well as professional associations are increasingly created through the support of NGOs, which empower participation of communities in planning and decision.
From the P-GIS perspective it is necessary to find a definition, which incorporates the local understanding of participation as well as legal aspects.

2.3. Merging "Vulnerability" and P-GIS

Vulnerability science helps to understand the circumstances, which put people and places at risk. It also tries to understand the conditions, which reduce the ability to respond to environmental threats. A vulnerability assessment is fundamental for the definition of effective risk, hazard, and disaster impact reduction measures and policies which directly affect individuals and communities.
As most of data inherit a spatial reference, GIS is the appropriate tool to visualize, analyse and model the "real world" turning data into valuable information (Fig. 2). The objective to empower and secure information flows is the link to "participation".
In practice and especially from a GIS perspective one has to define the rights to participate, to object or to collaboratively decide.

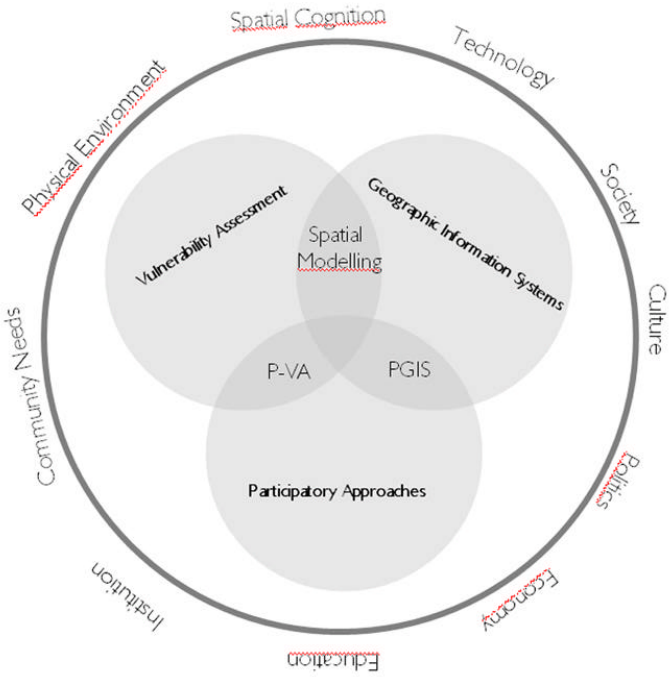

Fig. 2: Overlaps between Vulnerability Assessment, GIS and participatory approaches, and the location of methodologies including triggering factors

Presently, next to "vulnerability", also in the field of P-GIS conceptual and methodological discussions are ongoing and evaluations in regard to usability of these approaches are still underway. Terms and concepts are not always used the same way and standardized methodologies are not asserted. Various terms for similar or related techniques are circulating such as Participatory GIS (P-GIS), Public Participation GIS (PP-GIS), Community-Integrated GIS (CiGIS; Weiner & Harris 1999), Community Mapping or Participatory 3-Dimensional Planning (P3DM).

3. The Case of Búzi, Mozambique

3.1. General Overview of the study area

Mozambique's socio-economic development is characterised by the aftermath of its long civil war which ended in 1992 and a gradually growing economy 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. In addition, environmental disasters and its modification through the Global Climate Change bear heavily on the development. The floods in the year 2000 and 2001, and the current drought are strongly clogging improvements.

The District of Búzi (Fig. 3) 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. 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.

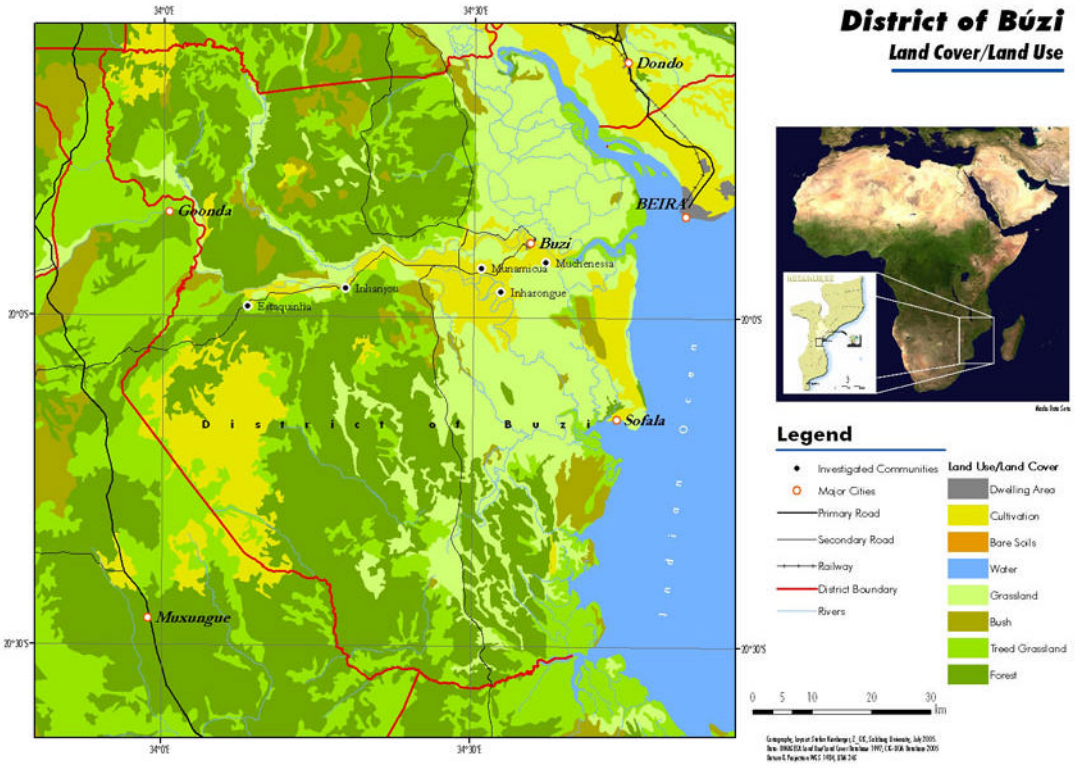

Fig. 3: Land Cover/Land Use Map of the District of Búzi and the location of the investigated areas

In early 2000 Búzi was hit with the worst floods in over 50 years affecting most parts in south and central Mozambique. The enormous amount of rainfall, dumped by three consecutive cyclones, affected around 4,5 million people, which is one-quarter of the country's population. The floods displaced 400.000 people, and caused at least 700 fatalities. Buzi was one of the most affected districts due to its downstream and low-altitude location.

The floods 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).

3.2. The Participatory Vulnerability Assessment in Búzi

In the year 2002 a hazard risk and vulnerability assessment (Steinbruch 2003) was conducted in nine communities of the Búzi district and eight communities of Chibabava district in the province of Sofala/Central Mozambique. The assessment was part of a GTZ project establishing and improving Disaster Risk Management at the local and district level. The analysis itself was conducted together with staff of the Centre for Geoinformation at the Catholic University of Mozambique, Beira (CIG-UCM).
Focus was drawn on floods, droughts, cyclones, uncontrolled fire and erosion. Earthquakes, pests and epidemics were included as these also occur with some frequency in the investigated areas.
The method of participatory data acquisition was applied for this specific study. The PRA toolbox served as a basis whereas it has not been specifically developed for hazard risk analysis, but has been used widely in development projects and for rural development planning.

3.2.1. Methodology and Criteria

As a precondition an agreement was achieved on the investigated communities. Communities of the districts of Chibabava and Búzi most vulnerable to natural disasters were identified through a participatory process through local authorities. A request was sent to the district administrator asking to call for a meeting with local representatives and activists of the Mozambican Red Cross with the objective to identify vulnerable communities. This resulted in agreements on the selection of communities to be worked with. After a pilot and evaluation phase the participatory assessment was carried out.
The following procedure was applied for each investigated community:

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

The community participation included semi-structured interviews, whereas women were divided from men to avoid conflicts due to given social structures as well as due to gender specific working tasks; transect walks, guided by community representatives; community mapping and agricultural cycle.

3.2.2. Outcomes

To be able to set priorities for a community plan as well as for disaster preparedness activities and the development of policy options a list of vulnerability indicators suitable for this specific Mozambican case was developed. The indicators were divided into physical, socio-cultural, economical, and institutional vulnerability which lead to an overall vulnerability of the communities. The outcomes serve as a basis for identifying programme focuses and needs for each community (Fig. 4).
Additionally community maps were produced. The main objective was to acquire spatial data of the communities through GPS surveys, to visualise the community in an understandable

way to help the people, and the Disaster Risk committees, to identify secure locations in the case of floods. These maps were also a central part within the undertaken evaluation.

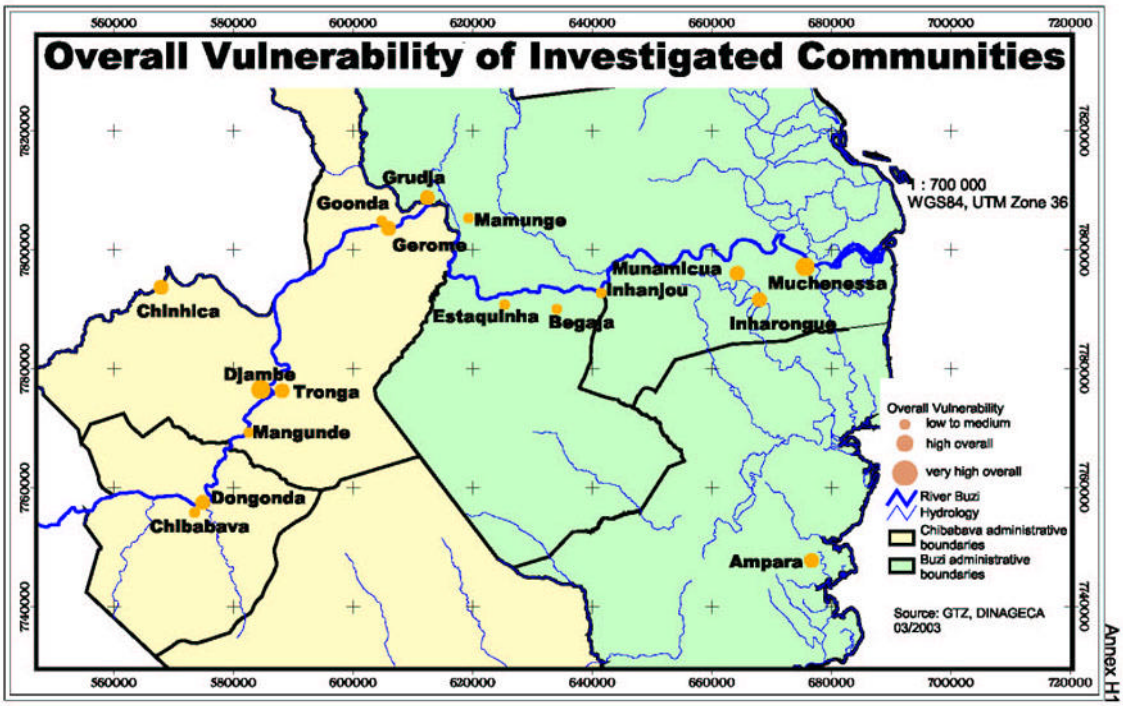

Fig. 4: Result of the vulnerability assessment, showing the overall vulnerability of the investigated communities

4. Assessing the relevance of P-GIS for vulnerability assessment in Búzi

In June 2005, three years after the assessment, the relevance of the applied participatory methods was evaluated on a scientific basis (empirical results still to be published). The views and opinions of community members were investigated. Due to time limitations five communities were selected in the district of Buzi: Muchenessa, Inharongue, Munamicua, Inhanjou and Estaquinha.

4.1. Methodology and Criteria

The criteria for choosing the communities were, in contrary with the focus in 2002, based on accessibility, willingness to cooperate and a difference between them in regard to their vulnerability and geographical location. Semi-structured interviews served as core methodology of the survey. Key-informants, such as the district administrator, the president of the Mozambican Red Cross and program leaders were consulted before the field trip. In each community 6-8 people (mainly farmers, gender-balanced) were identified, who participated in the community mapping exercises in 2002. Each of them was interviewed with the help of a translator, as the local language in these rural areas is Ndau besides the official language Portuguese.
The criteria to evaluate the participatory process, with the main focus on the community mapping exercises, were derived from McCall (2003 & 2004).
The research aimed to answer the following questions:

- Why? The purpose and intentions of promoting participation in the context of disaster risk management
- Who? Stakeholders, Partners, and Power
- What? Qualities and values of Geoinformation
- When? Phases in participatory spatial planning and management
- How? Manageability at local level by local people

4.2. Results

Participative decisions and consensus finding are deeply rooted in the investigated communities in Central Mozambique. This implies the need for a participative process in anything concerning the entire community and defines success or failure of an outside-imposed initiative, such as a vulnerability assessment.
The population of the investigated communities in the Buzi district have experienced a number of participative assessments, which all used participative mapping as a central methodological element. One of the first was the assessment of the socio-economic potential of the Buzi district in 2001 (Roque & Tengler, 2001). This was followed by a participative disaster risk inventory of the Mozambican Red Cross, Sofala in 2001 and 2002 (CVM, 2002). The Organization for Rural Assistance in Mozambique (ORAM) has been conducting in individual communities of the Buzi district participative land delimitation and exercises in empowerment of natural resources management since shortly after the floods in 2000 (especially, Guaraguara, Bandua, Grudja).
Therefore the communities have undergone several learning phases in participative mapping and the use of maps. Out of this some of them have developed their own set of symbols for mapped objects. It was further noted, that participative maps, although produced in different circumstances only slightly varied from each other.
In the case of the participatory disaster risk assessment of Steinbruch (2003) it is concluded, that the participatory approach was mainly one-directional, with the main objective to aggregate information with the help and participation of the local people.

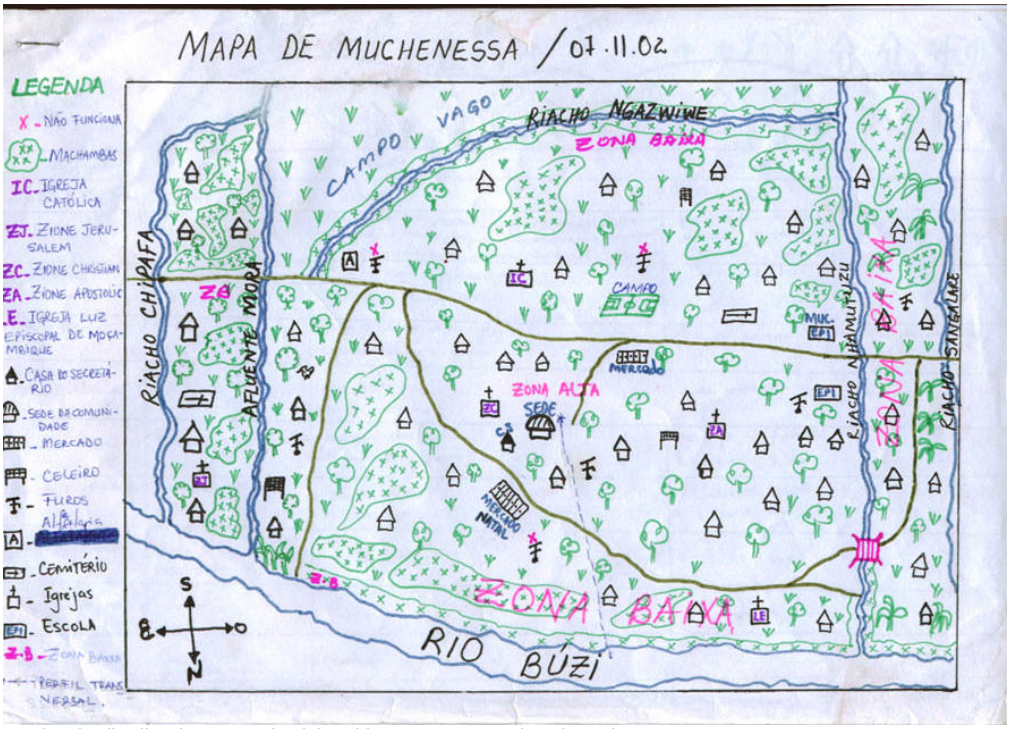

Fig. 5: Example of a finalised community (sketch) map, Community of Muchenessa

The feedback loop consisting of the intentional use of the maps for disaster preventive planning was not followed up. The reasons are twofold: 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 the 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.
In a later stage, 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. Interestingly, a momentum developed in some communities without any donor

influence, in which maps were also used in community meetings to discuss spatial-relevant issues. In one community the map is even used for teaching pupils about their community environment.
Since a map contains and transmits information one would regard a map as an instrument of power. Yet, 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,
People found it quite easy to orientate themselves on the sketch maps, in which simple symbols defined by the community members were used. Additionally to the sketch maps (Fig 5), the maps were digitized in a GIS (ArcView 3.x) and later handed-over to the district administration. Some of these maps were also given to the communities. Community members identified them as not very useful as the cartography was too complex.

5. Conclusion

Participatory methods and especially P-GIS methods are well suited to be implemented in a vulnerability assessment and are also crucial for the success of it.
As the case showed, participation is often seen from the funding agency's perspective and its pre-defined objectives. Participation does not go beyond the level of public consultation. Vulnerability assessments before a disaster event should have the objective to prepare the ground for the establishment of preventive measures. It should therefore involve participation up to the level of public decision-making. To meet this vision P-GIS can be a highly useful instrument.
However to successfully integrate P-GIS applications and to address the various scales of vulnerability assessments more prerequisites are necessary:

- Policies or social environments permitting participation must be in place
- Maintaining an information flow

  Institutional requirements have to be set that the information flow is guaranteed. An important condition in this case is the political will. A network which is based on trust and good practice is necessary.
- Strengthening of local GIS focal points for data processing

  As the modelling of different data involves GIS skills, local resource centres are necessary which can provide data and also information. Such centres could also serve as data warehouse, however access of data and the need for Spatial Data Infrastructures is evident.
- Involvement of local people

  Local people, who understand the complexity of their environment, are crucial for the success of participatory methods. Most important on the community level, trustworthy and motivated facilitators are needed to implement such concepts. Also these concepts have to be adapted through lessons learnt and should always focus on a self-sustainability.

Challenges are that both concepts, P-GIS and vulnerability, are not established as a definitive methodology. Both are adopted and interpreted for a specific situation. Finally P-GIS and the objectives of vulnerability assessments are often not linked up with practitioners, as the discussions are mainly discussed in a scientific circle. Practitioners, without any emphasis on research, should be more strongly involved in the scientific elaboration of vulnerability and P-GIS on the local level.

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Biographies

Stefan Kienberger is presently working as a researcher and PhD candidate at the Centre for GeoInformatics (Z_GIS), Salzburg University (Austria). He is involved in a capacity building project in Mozambique, which aims to set up a GIS Centre at the Catholic University of Mozambique in Beira. Main tasks include training and technical activities, project development and capacity building. Besides this his research interests lie in Participatory-GIS in developing countries, disaster risk management and security with a special focus on vulnerability science. Stefan Kienberger is also focusing on these topics within his PhD thesis, which tries to define a framework for P-GIS within a vulnerability assessment (Case Study: Communities in the district of Búzi, Mozambique). He obtained his Master of Science in Environmental System Sciences – Geography from the University of Graz (Austria) and Macquarie University Sydney (Australia).

Franziska Steinbruch has obtained her degree as Master of Geology from the Technical University of Mining and Technology in Freiberg/Germany and is currently enrolled as a PhD student in the fields of hydrogeology at the Department of Hydrogeology at the same university. She is working as the Technical Coordinator of the Center for Geographic Information at the Catholic University of Mozambique in Beira/Mozambique. In total she has been working with the Center for Geographic Information for almost six years. Main tasks are project and market development, technical formation of staff, supervision of students working on their final theses and technical organization and advisory. Fields of interest and specific involvement are disaster risk management, hydrogeology and water quality. All of these are embedded in the context of the use of GIS (Geographic Information Systems), remote sensing technologies as well as methodology development.