UNISDR
The United Nations Office for Disaster Risk Reduction

GAR
Global Assessment Report
on Disaster Risk Reduction

INPUT PAPER

Prepared for the Global Assessment Report on Disaster Risk Reduction 2015

# PEOPLE-CENTRED EARLY WARNING SYSTEMS AND DISASTER RISK REDUCTION

A Scoping Study of Public Participatory Geographical Information Systems (PPGIS) in India

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27-Dec-2013

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# 1.0 Introduction

Nations across the globe have long been concerned about the huge impacts that disasters have on society. With a rise in population, change in climatic conditions and more people living in risky places there has been a severe increase in the vulnerability of coastal communities to disasters. Nearly a million people have been killed over the last decade by disasters caused by storms, cyclones, tidal waves, tsunami and floods. While some loss of property seems to be inevitable, especially in the case of very large and sporadic events, in some cases the loss of human lives could have been avoided if there were proper precautionary measures. This would have been the case for the December 26, 2004 Indian Ocean tsunami, which aggravated the fatalities surpassing a quarter of a million people. The lack of early warning system and awareness regarding coastal hazards and the absence of training to respond to a warning prevented the authorities and the local population from executing proper precautionary measures; which would have significantly reduced the loss of lives.

Today, formal early warning systems for a range of hazards are in place. A frequent problem, however, is the weak linkage between the technical capacity to issue the warning and the local communities' capacity to respond effectively to the formal systems of warning. Despite the increasing accessibility of data, information, knowledge and expertise, such information has not yet effectively reached those who need it the most – the vulnerable sections of the population. On the other hand, experiences and narratives from disaster sites have demonstrated that local and indigenous knowledge prevalent among the local fishing communities has helped many such communities to avoid large-scale casualties. This paper envisages the significant role of Participatory Public Geographic Information Systems (PPGIS) in integrating local knowledge systems with the scientific institutions of early warning.This paper is the primary outcome and work in progress of a larger project, which began as a committed effort to study traditional knowledge systems that coastal communities use in hazard forecasting across different parts of India.

Early warning systems are still considered as a probabilistic science. The usage of the term 'early warning' denotes 'the provision of information on an emerging dangerous circumstance where that information can enable action in advance to reduce the risks involved' (Basher, 2006). Researchers have identified certain crucial components of early warning system. These include (i) risk knowledge; (ii) monitoring and warning service; (iii) dissemination and communication; and (iv) response capability (ISDR-PPEW, 2005). Moreover, for early warning systems to be useful to the local communities, they must meet their needs and must provide accurate and reliable information as well as sufficient lead time to allow them to take suitable action (Havidan et.al, 2004).

For enhancing effectiveness, early warning systems need to be sensitive to how communities respond to warnings and what type of information has been provided to enable meaningful risk preparedness (Dash, 2002; Escobar-Wolf, 2008). Past warning experiences could provide insights on how communities responded to warnings and how it was able to avoid loss of life and property (Handmer, 2002). Warning systems need to be simple and user friendly (Washington and Downing, 1999; Ronan and Johnston, 2005). However, this requires the integration of technological systems with social knowledge or a balance between the formal and local (Washington and Downing, 1999; Dash, 2002). Communication and participation of communities at risk are thus, essential determinants of effective early warning systems (Howell, 2003).

Effective early warning systems thus require reliable forecasts with warning messages that serve to communicate threat, enabling communities at risk to take meaningful action within a stipulated time (Betts, 2003; Havidan et.al, 2004; Trainor and McNeil, 2008). Authorities responsible for issuing warnings should cast out a warning plan, which consists of unambiguous messages and clearly spell out whom and how to notify the emerging threat (Ronan and Johnston 2005). Warnings need to be issued through 'credible' sources (Ronan and Johnston 2005). And there should be sufficient clarity on whom the ultimate responsibility of issuing warning is vested with (Betts 2003). The time of issuing warning and its continuous updation(of message) also determines the effectiveness of early warning systems. There should be sufficient lead time to take appropriate action (O'Neil, 1997; Betts, 2003; Havidan et.al, 2004).

Factors such as power, access to resources, cultural specificities etc. influence the effectiveness and outcome of early warning systems (Balluz et.al, 2000; Aguirre, 1998). A culture of 'shared understanding' between various stakeholders involved in the formal and local platforms of early warning is an essential pre-requisite for effective warning (Handmer, 2001; Betts, 2003). It should also ensure that the populations at risk who receive the warnings should have the authority and capability to use and apply the knowledge they have acquired (Dixon, 2005). However, the most obvious criticism of present-day formal warning systems is that they are more techno-centred rather than people-centred (Basher, 2006). Today, scientists and technologists control the production and sharing of geophysical and technical knowledge, which only propagates linear models of early warning. Such linear models are top-down and expert-driven. They neglect the likely impact of the hazard and how warnings are communicated and responded to (ibid). There is an absence of shared meaning and cooperation among various stakeholders involved in the early warning system (Handmer, 2002). This is because of the predominant belief among the scientific community that the populations at risk are not experts, but mere receivers of warning (Betts, 2003). Yet another assumption is that the populations at risk are disinterested in planning the warning processes (ibid). There is little or no engagement with those populations who are vulnerable and at risk. In due course, local communities also tend to lose faith in their own capacities and begin to consider disaster risk reduction as a mere state responsibility or that of the experts (ibid). This, itself has been pointed out as the cause of failure in existing early warning systems (EWC II, 2004). In many developing countries, poor people living in hazard prone areas have least access to scientific warnings or understand the meaning of different warning signals. They are left to feel alienated from a 'scientific' system (Howell, 2003). Too much of scientific information, which are often difficult to be interpreted by the population at risk affects the warning's credibility (Dash, 2002).

People may ignore the warnings due to economic reasons, ambiguity in the message and also due to presumptions that officials’ warnings are not infallible. Early warnings, today, are affected by the 'crying wolf syndrome' whereby people discount low frequency risks and distrust or disown formal warning systems (Dash, 2002; Ronan and Johnston, 2005; Basher, 2006). 'Accuracy' and 'ease of use' are supposed to be the most important elements of a good early warning system which is often lacking these days (Reed et.al, 2008). People at risk require specific, accurate information such as- a) whether they are individually at risk; b) whether the hazard will reach their place of residence; and even c) whether their houses will be affected or not; and d) if evacuated how far and where should they go (Dash, 2002). On many occasions, there is very little time to review and receive warnings (Basher, 2006). In many developing countries, it is a challenge to deliver effective warnings to smaller scale hazards in the shortest lead time (O'Neil, 1997).

Today, scientists and technologists are typically the core stakeholders in early warning systems as they are the custodians of the geophysical and technical knowledge base upon which the warning system relies (Basher, 2006). However, this has largely shaped early warning systems as hazard-focused, linear, top-down, expert driven systems, with little or no engagement of end-users or their representatives (ibid). Such an end-to-end linear paradigm provides less emphasis on the vulnerabilities, risks and response capacities of the local population. In this context, Mitchell (2003) points out that a disaster risk reduction framework must be flexible enough to be modified through a participatory process and specific benchmarks that are locally derived. Such a participatory process will help to generate political will and a sense of ownership, which are seen as crucial in achieving disaster risk reduction gains.

Though studies have highlighted the significance of people-centeredness in early warning systems; studies and field level implementation practices have seldom taken into account the role of local knowledge in predicting natural hazards. Knowledge is information combined with experience, context, interpretation, and reflection (Davenport et.al, 1998). Though the creation of a people-centric knowledge management system is not a simple task, it has been envisaged that such a system will enhance communities' understanding of where to go to find a particular knowledge stream, saving their time and effort (Offsey, 1997). This is relevant specifically with respect to early warning systems and disaster risk reduction processes. The need to develop a comprehensive understanding of knowledge processes for the creation, transfer and deployment of this strategic resource therefore becomes critical.

It is in the above-mentioned context that this paper explores the possibility of developing a GIS platform that could be integrated with the local knowledge systems of coastal fishing communities in Kerala, India. Typically, the aim is to build a geographic database that is in tune with the cultural notions of risk and hazards, while at the same time providing information to diverse stakeholders with early warning. We understand that a major challenge for us scientists as outsiders is to integrate the particular community's requirements in a GIS. As this paper is an outcome of a work in progress, we are not yet sure about the constraints and design capabilities of GIS that could be easily used by communities in planning and implementing hazard forecasting services.

## 2.0 Participatory GIS and Disaster Risk Reduction

GIS can be defined as 'a computing application capable of creating, storing, manipulating,visualizing, and analyzing geographic information' (Goodchild, 2000). GIS has been applied in a wide range of context such as urban planning, conflict management, natural resource management and environmental conservation. GIS is also considered as a powerful mediator of spatial knowledge, social and political power (Elwood, 2006). Nevertheless, there has been a lacking of what Dunn (2007) calls a 'socially aware GIS' in mainstream GIS initiatives. Public Participatory GIS has its origins from social theories and methods applied in the fields of planning and participatory action research, anthropology, geography, social work and other social sciences. A significant feature of the Public Participatory GIS is that facilitates a stream of interactive approaches ranging from direct face-to-face situations to web-based interfaces.

Public Participatory GIS(PPGIS) is relatively a context and issuebased approach and emphasises on community involvement in the production and application of geographical information (Dunn, 2007). It enables itself as an interactive platform that could integrate local knowledge with 'expert' data (ibid). Functionally, it also ensures local community participation in the creation and storing of information in a GIS platform and subsequently used in spatial decision-making (ibid). Though PPGIS is very helpful for policy makers and guarantees access to timely information by all stakeholders, the resulting output mainly in the form of maps can persuasively convey ideas and inform people on the importance of those ideas (Sieber, 2006). With respect to present PGIS project, we have in our mind the following intended outcomes. Appreciating the fact that local communities and state authorities are the primary stakeholders in hazard forecasting and early warning, we envisage that the PGIS would enable both the community and state agencies to understand and mutually describe the spatial distribution of risk, vulnerability and hazards. Secondly, we presume that the concerned stakeholders will recognise and assess the risk of coastal hazards on people, environment and their livelihoods; and demonstrate diverse ways, in which populations at risk could prepare, mitigate or respond to these hazards. This would also mean that there is a common platform to share the respective actors' vocabulary of risk and hazards, and arriving at mutually understandable forms of knowledge.

The authors are aware of the criticism that PPGIS has invited. True to say, it is still a critical question whether participatory mapping can empower the vulnerable and provide them a greater stake in negotiating with the structures of power or the government. Tools like participatory mapping and spatial technologies like GIS are criticized as inherently political and likely to reinforce or re-create the status quo of power relations. (Ferguson, 1994; Kosek, 1998; Hodgson and Schroeder, 2002).It is often argued that participatory mapping is of limited political utility as it always does not help to address the root causes of vulnerability such as lack of access to resources and decision making structures. Yet another critique of participatory mapping and GIS is that local knowledge systems are highlyincompatible to western cartographic knowledge systems (Bauer, 2009; Rundstrom, 1995).Nevertheless, with all its limitations PPGIS as a spatial tool in participatory planning can provide new insights on how risks can be addressed. It also has the potential to translate the lived experiences and knowledge of marginalised and indigenous communities in hazard forecasting and early warning (Harris et.al, 1995). It can also help in strengthening the legitimacy claims of traditional communities over their common property resources (Gonzalez et.al, 1995; Chapin et.al, 2005).It is with theseassumptions; that this paper presents the PPGIS model that is being developed with respect to coastal hazards in India.Creation of a PPGIS is not a simple task, although it has been acknowledged that such a system will enhance communities' understanding of where to go to find a particular knowledge stream, saving their time and effort (Offsey,1997). This paper is an effort in this direction to build, apply and share knowledge for the support of pioneering and valuable knowledge-intensive work towards the enhancement of capacities of local communities and authorities to monitor, adapt and respond to natural hazards.

## 3.0 Process of Creating the PPGIS Framework

Local knowledge can be a valuable resource in adapting to natural hazards. Based on our earlier study among the traditional fisher-folk of Kerala and Maharashtra, it has become obvious that there is already a vast store of information at the community level involving the forecast of natural hazards. To develop an appropriate PPGIS platform, our first step will be to create a repository of local knowledge collected from fishing communities along the coast of Kerala and Maharastra, India. Different types of local knowledge exist amongst the fishing communities to predict kolu (cyclone), storm surge, sea surge and monsoon rain. These include knowledge pertaining to the (i) oceanic and (ii) atmospheric and celestial spheres. The oceanic sphere refers to knowledge related to behaviour of oceanic creatures such as fish, crabs and varieties of fish. The oceanic sphere refers to the knowledge embedded with fisher-folk's observation and inferences related to changes in the nature of the marine environment such as bubbles, colour of the sea, foams, smell, sand in the shore, water-flow and waves. The atmospheric and celestial spheres include clouds, lightning, moon, rainbows, stars and wind. Nevertheless, when it comes to the application of knowledge, it is an integrated and comparative understanding of these knowledge spheres that add to the forecast, prediction and early warning of coastal hazards.

As a preliminary step, we are in the processes of creating a knowledge portal to capture, store, retrieve and reuse the knowledge to EWS. A 'portal' is a service provided to access information from different websites or databases to any user. Further, a knowledge portal is a service provided by an organization to disseminate knowledge. Here, the knowledge (tacit and explicit) is converted in to digital formats and is stored in a database thereby making preservation, reuse and sharing possible. 'Database' is a collection of related information, which is arranged or organized in the form of tables, fields and records in a traditional manner. In the hypertext database; text, pictures or any other objects are linked to other objects. Here the backend of the portal consist of hypertext database. Figure 1 describes the process of development of the PPGIS in early warning system, with respect to community-based hazards prediction and its response.Theknowledge portal will be created on anappropriate platform with relevant information as the database. Followed by which, a parent or master table with *Communities* (*Knowledge Spheres*) will be collected and the fields such as characteristics of oceanic and atmospheric indicators etc. The option to update the portal as per requirements will also be provided.

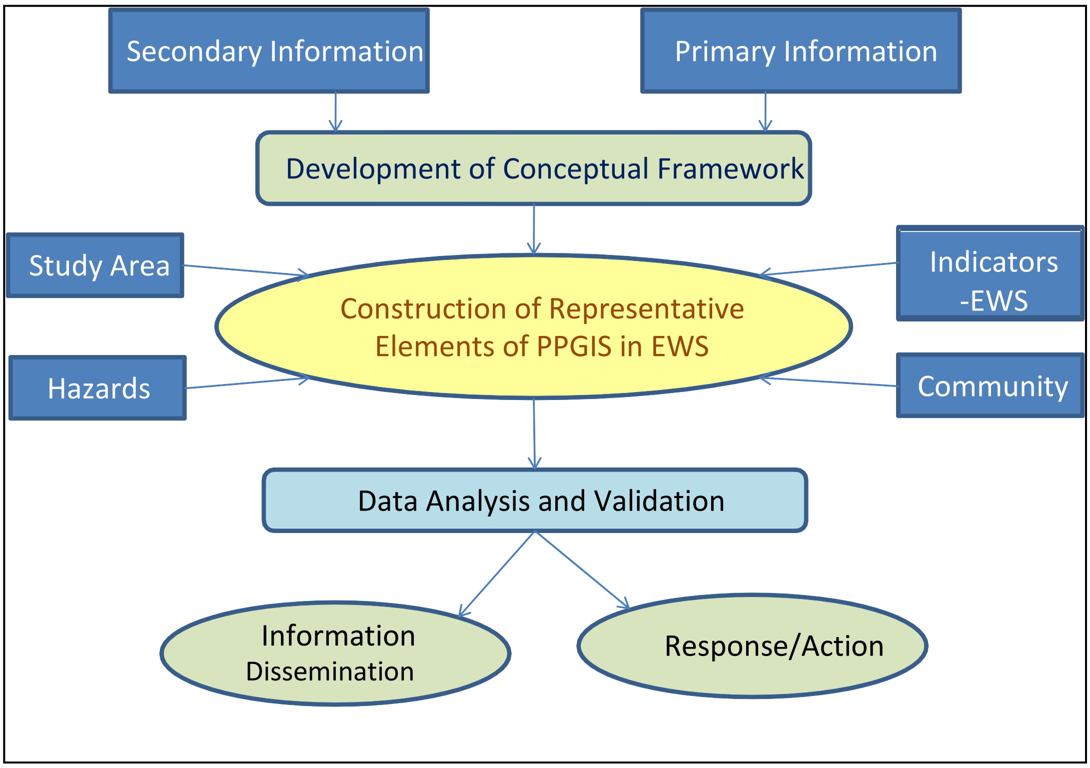

Figure 1: Process and Development of PPGIS in EWS

Upon receiving the coded information from the community about the observations and symptoms of oceanic and atmospheric indicators as part of EWS, the frame work will validate the input from meteorological department before disseminating the information to the local communities. Thus ensuring that no false information is disseminated to the community and proper response or action is taken as per need. Thus, integration and correlation between the formal and local systems of knowledge becomes a crucial function of PPGIS based EWS.

### 3.1 GIS Structure and Organization

As a part of the PPGIS-EWS framework, we prepared the six digital code systems for maximum flexibility, enabling us to encompass the informant observations on landscape and environmental changes. Comprised of three 2-digit fields, each field describes an increasing level of detail. The general category of the feature was assigned the first 2-digit field, the next 2-digit field referred to the sub-category and the third field of two digits incorporated more specific aspects of the feature (Table 1). We were able to append the codes as we encountered a wider variety of information during the study. The hierarchical coding structure allowed geographically specific information to be categorized and ultimately displayed into a GIS database. As an example of the 6-digit scheme: if a location on the map was identified and described as having a potential cyclone in say Kerala with indicators like jellyfish then the given code would be 010104. The 01 in the first field denotes the general category of a cyclone; the second field (02) indicates the location i.e. Kerala, and the last field (04) suggests that the early warning was determined by the presence of Jellyfish. Owing to the nature of the classified phenomena, the second and third 2-digit fields are unique to each topical category, to allow us to capture a variety of both physical and conceptual phenomena. The dataset will be created using Esri's ArcGIS, which allows the user to manage and organize as well as create geographic data. This application is designed specifically to handle data types such as shapefiles, coverages, CAD files, and geo-data bases (ESRI, 2008).

| 1st Field | Type of Hazard | 2nd Field | Location | 3rd Field | Indicators (Oceanic/Atmospheric) |
|---|---|---|---|---|---|
| 01 | Cyclone | 01 | Kerala | 01 | Big fish variety |
| | | 02 | Maharashtra | 02 | Unexpected variety |
| | | | | 03 | Catfish |
| | | | | 04 | Jelly fish |
| | | | | 05 | Crabs on seashore |
| | | | | 06 | Dark clouds with strong winds |
| | | | | 07 | Wind from South West |
| 02 | Storm Surge | 01 | Kerala | 01 | Mathi/Sardines |
| | | 02 | Maharashtra | 02 | Thread fins |
| | | | | 03 | Colour crabs |
| | | | | 04 | Wind from west |
| | | | | 05 | Karu thirachi |
| 03 | Sea Surge | 01 | Kerala | 01 | Yellowish white crab |
| | | 02 | Maharashtra | 02 | Cloud moving towards east |
| | | | | 03 | Full moon position above head |
| | | | | 04 | Wind contains lot of moisture and blowing from west |
| | | | | 05 | Wind from land |
| 04 | Monsoon Rain | 01 | Kerala | 01 | Mullen or Nallakaral |
| | | 02 | Maharashtra | 02 | Ring around the moon |
| | | | | 03 | Rainbow in the east |

Table 1: Example of six digit coding system that will be used in the proposed study

## 4.0 Conclusion

This paper demonstrates that PPGIS displays the potential of a valuable tool for local communities and scientists to work together to monitor and forecast natural hazards as part of early warning system. This tool has the potential to reduce disaster risk by providing local communities and authorities with accurate information at the right time. However it mandates consistent engagement with local communities, their participation and coordination during the process. The process requires validation of information before its dissemination and response.

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