WEB-BASED PARTICIPATORY INFORMATION SYSTEM FOR VULNERABILITY MAPPING IN CENTRAL PROVINCES OF VIET NAM

Bui Quang Thanh[1], Nguyen Quoc Huy[2], Nguyen Trung Kien[1], Pham Van Cu[1], Pham Minh Hai[3]

[1]VNU University of Science, 334 Nguyen Trai, Hanoi, Vietnam
[2]FIMO Center, VNU University of Engineering and Technology, 144 Xuan Thuy, Cau Giay, Hanoi, Vietnam
[3]Viet Nam Institute of Geodesy and Cartography, 479 Hoang Quoc Viet, Hanoi, Vietnam
Email: thanhbq@vnu.edu.vn; huyquoc2311@gmail.com; kien.nguyen@hus.edu.vn; cu.phamvan@gmail.com; haialas@yahoo.com

ABSTRACT

Vulnerability index mapping seeks to understand the multidimensional (economic, social, political) and multi-level (individual, household, community or group) issues over a given area under impacts of climate change. In combination with GIS, we created a technical framework, based on Open-source technology, for participation of grassroots groups in calculating area index that are ex-ante prediction of the vulnerable magnitude under impacts of climate change induced water disasters. The Information System provides three main functions: (i) storage of various data viewer; (ii) Web-based analyst tool; and (iii) Information communication. The result is a Web-based GIS, through which stakeholders interactively mapping vulnerability, exchange dialogue and contribute to managers and decision makers. We found that although there is still limitation in having access to internet, the local communities become more active and are willing to involve in the decision making processes.

Keywords: Vulnerability, Web-based GIS, Participatory

1. INTRODUCTION

Climate change, especially through extreme climate events (ECEs) is currently a major threat to Vietnam's socio-economic development (Chaudhry 2007), with potentially heavy impact on particularly the livelihood of communities that are vulnerable to the impact. Vulnerability is understood as the degree to which a household/group/country is susceptible to, or unable to cope with, adverse effects of the disasters (IPCC 2007). It is multi-dimensional (economic, social and political) and multi-level (individual, household, community, or group) (Adger 2006). Existing literature indicates that the adverse impacts of climate change are likely to be unevenly distributed across different socio-economic groups, with the poor and (socially and politically) marginalized groups being particularly vulnerable (WorldBank 2009). Specifically with respect to Vietnam, (Fortier 2010) notes how poorer people are often the most exposed and sensitive to climate change.

Climate change research and adaptation programs in Vietnam are facing serious challenges such as: the lack of a scientifically well-argued background for understanding the complex interaction between nature and society under the context of climate change; qualified human resources; inter-sector collaboration; and especially, the lack of spatial data infrastructures (SDI) and efficient tools to be applied in the local policy making processes like Participatory Geographical Information System.

Internationally, the concepts of "Participatory Information System" (PIS) are recently developed in environment and risk management (Admire 2009, Dagmar 2011) but are still almost new in Vietnam. In addition, the issues related to the assessment of Climate change (Tan 2010) and its impact on water disasters and the comprehensive assessment of vulnerability (Viet Trinh 2010, Nguyen Mai Dang 2011) are not fully investigated in Vietnam, especially in the central provinces. We presented an approach that creates an integrative working model for the local authority, scientist and community to share knowledge for vulnerability reduction (Figure 1). In this study, we focused on a number of issues when combining GIS, Vulnerability mapping, and community participation in ext-an simulating impacts of climate change by calculating the vulnerability index that is a function of exposure, sensitivity and adaptability. This ext-an index might provide useful information for policy makers.

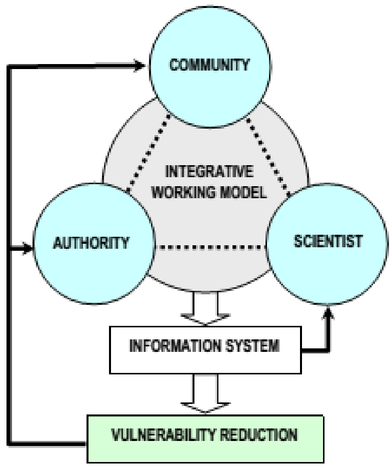

Figure 1: Conceptual framework

2. PARTICIPATORY GIS

Technology is one of the most important tools for transformation. It can improve the life chances of socially excluded people by increasing opportunities to intervene and tackle emerging problems ((DCLG) 2006). Although, there are many definitions or understandings of PGIS, but all pertain to the integration of Web-based GIS and levels of local participations. (Tulloch 2003) refers PP-GIS refers to the uses and applications of geospatial information and GIS technology used by members of the public, individually or grassroots groups, for participation in public processes that affect their lives (and so, encompasses data collection, mapping, analysis, &/or decision-making). As (Craig 1999) describes the Public Participation GIS principles as accessibility, understand ability, and accountability, Web GIS continues to draw attention as a public participation tool (Sakamoto et al 2004). Besides, (McCall 2003) discussed the question of where "participation" in PGIS was. The research described the participation as a governance criteria and supporting governance imperatives of equity and respect for people´s right that depending on intensities and purposes of participation, local communities will be involved in the processing with significantly different roles. However, several points should also be taken into consideration when one developing a PGIS project. Some were discussed by (Jordan 1999) as shown in **Table 1**

Table 1: Advantages and Disadvantages of PGIS *Adapted from (Jordan 1999)*

Advantages	Disadvantages
Viewed as a participatory process it can empower the community by involving them in the decision making process	If the participatory process is not well structured, the community will not feel to be a part of the decision-making process
It can be used to effectively combine quantitative and qualitative approaches to community development	There is a potential risk of the focus getting shifted mainly towards extractive data collection
Spatial data in the form of maps and other resource information can be utilized by	There is a likelihood of sensitive spatial information like cadastral maps being

community in their decision making process rather than having access to GIS	subject to unintended misuse if held centrally
Natural resource information can be easily put together, analyzed and returned to community for use	Excluding disadvantaged groups from the mapping process can have a disempowering effect on them
Useful information can be returned to the stakeholders for informed decision making	Availability and knowledge of the technology itself encourages a centralized approach

Enabled by the rapid development of Internet, Web-based geospatial data provision is now an integral part of a nation spatial data policies by taking advances of internet technologies that has fundamentally changed the ways spatial information is provided and used. Web-based GIS integrates spatial data and its components and end-users to support local authorities in decision making process and provide platforms for local communities to visualize and participate. Functionally, users can employ a GIS application to visualize spatial data or to develop an analytical model for natural resource monitoring or emergency response or to provide understanding of spatially distributed phenomena in many areas of decision making and evaluating problems (Sakamoto A. & Fukui 2004).

Technically, Web-based GIS is not simply an extension of data inventory, rather it is a growing means for data sharing and stakeholder interactions, implementing the systems via Internet. Although typically Internet users focus on simple display and query tasks (Goodchild 2005), burgeoning efforts have been made to develop more active and dynamic systems and to make Web-based GIS more interesting for end users. Legally, however, how deep or levels of details/intensity of spatial data that local users access, are decision of system creator and depend upon national/local strategies for public involvement. The participation simply includes provision of data, data layering, spatial queries and spatial processing in more complex systems. (McCall 2004) refers Participatory mapping (P-mapping) and Participatory GIS (P-GIS) to be cost-effective, notwithstanding that their lower costs may be offset by lower standards of precision and maybe accuracy, than for full-blown GIS. This limitation, however, has overcome by new surveying technology.

Worldwide, with a realization that country that seeks to sustainably manage its natural resources and implement spatial services requires a Spatial Data Infrastructure (SDI) to ensure the achievement of spatial interoperability among various government organizations and communities. A SDI aims at providing standardized information base to assist decision making processes and underlining technical and social bases for spatially built-on applications. The growing effort from international / national communities has been made to streamline the sharing of spatial data, decentralized management of data to local administrative bodies and implement Web-based natural resource management systems in the Internet environment. A SDI has many components but three main elements include: (1) Technology – Hardware, Software, Networks, Database, Technical implementation plans; (2) Policies and Institutional Arrangements – Governance, Data privacy and Security Data sharing, Cost recovery; (3) People – Training, Professional Development, Cooperation and Outreach (Williamson 2003) .A SDI allow building data once and use many times for many applications and integrate distributed providers of data usage of GIS functionalities. PPGIS and SDI integration help increase the participation of community and the quality of vulnerability assessment.

3. DATA AND SYSTEM DESIGN

The Information System provides three main functions: (i) Storage of various data and viewer. It provides background information on the climate change-induced problems being addressed and references for further reading. This section essentially comprises of a single page introducing the initiative, objectives of the system, web structure / sitemap, registration page if needed. Topics covered within this section include climate change-induced disasters (drought, salinity intrusion, heavy rainfall, flood inundation) and related documents. This section also serves as a repository of downloadable spatial data. (ii) Web-based analyst tool. Users can interactively calculate vulnerability index via spatially processing data and altering exposure, sensitivity and adaptability parameters. (iii) Information communication. Here, the index map is displayed. The communication component enables sharing of local/scientific knowledge and guidance of decision makers. Data analysis by scientists, information verification and feedbacks from the users), the information system will be getting more and more enriched. (Figure 2)

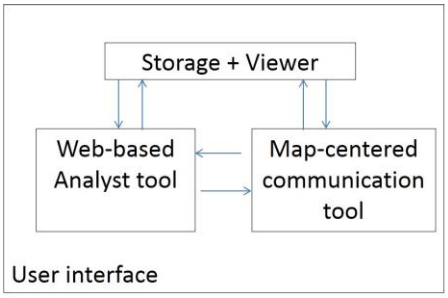

Figure 2. PIS Framework

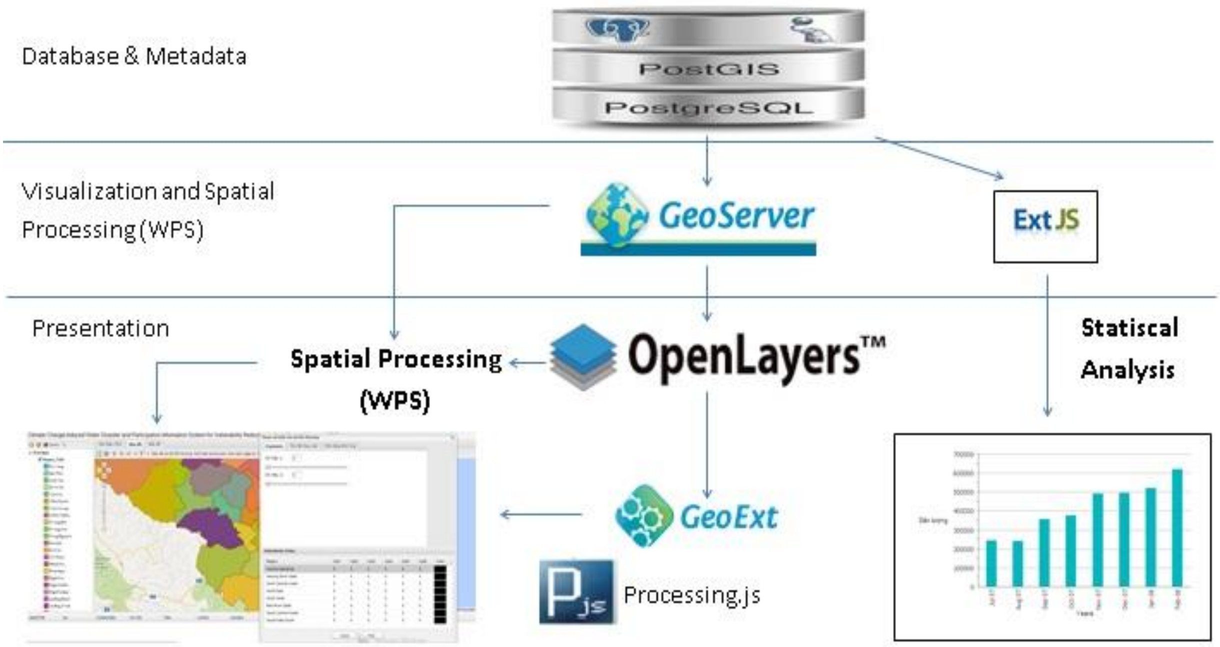

Figure 3. Architectural framework

The system also provides a mechanism for multi stakeholders to participate in the creation and refinement of the information. The input data can be of various formats, such as quantitative data or "indigenous knowledge" data obtained from the communities. It can be in the format of photos, videos, drawings, satellite images, documents, forecasts among others. This large amount of data is then digitalized, standardized, specialized and integrated into GIS-based Knowledge Base. The knowledge base can be accessed by web browsers via Internet.

4. RESULTS

The criteria for selection of systems embrace many aspects, such as Free and Open source software (FOSS), leverage open standards, hierarchical layering, spatial functionality, query layout, documentation and loading time. Among two most popular open-source mapping servers UMN MapServer and GeoServer, GeoServer was selected because of its extension that serves Web Processing Service. From client side, there are many available frameworks that are sophisticated enough to compare with each other. We employed GXP library, Openlayers Extjs and GeoExt. The platform design is shown in (Figure 3). It started by installing Suite package that includes GeoServer. PostGIS and Quantum GIS were installed separately and spatial data in shapefiles format were converted to PosGIS. SLD files were built in Quantum GIS. The server was setup to serve WFS, WMS services and javascripts were added for spatial processing and communication functions. The WebGIS system was developed as a tool in promoting an end-user centric approach in vulnerability assessment in the central provinces of Viet Nam.

This system is typically directed toward the widest possible end users (decision makers, managers, local communities) whose contributions may vary considerably. (Figure 4) shows snapshots of the finalized PIS. In reference to index measurement, (Hahn, Riederer, and Foster, 2009), (Pradeep Kurukulasuriya 2010), IPCC defined vulnerability as a function of **(1) Exposure** to climate change, The resulting phenomena might include an increase or decrease in rainfall, an increase in temperature or an increase in the incidence and intensity of extreme climate events, such as droughts and floods. **(2) Sensitivit**y to the impacts of that exposures. Different physical environments will respond in different ways, even if they are exposed to the same manifestation of climate change (whether a hazard or perturbation) **(3) Adaptive capacity** to those impacts and changes. The adaptive capacity of society is correlated with various social factors, including gender, ethnicity, religion, class and age.

Depending on physical and social condition of location, the parameters (α,β,μ) of Vulnerability functions might vary. But in general it should be calculated as: αExposure + βSensitivity - μAdaptability. (Pradeep Kurukulasuriya 2010) proposed: Vulnerability = exposure to climate hazards and perturbations x sensitivity – adaptive capacity. On the other hand, (Rasmus Heltberg 2011) calculated vulnerability as: Vulnerability = 1/3(Exposure + Sensitivity + (1-Adaptive Capacity)). In this study, we created a tool to measure vulnerability through three main above mentioned components and we designed an open platform that users can interactively add or remove sub-criteria and their weights of those main components. The final index we used is a simple linear function of weighted criteria/ sub-criteria.

5. CONCLUSIONS

The system can be used as effective toolbox for inventory, for sharing spatial data among agencies and for collecting information from communities. Current applications have shown the proven benefits of employing Internet and GIS for the delivery of spatial services and WebGIS continues to change the ways how spatial data is used and provided. In broader view, this practice can be applied in climate change-induced disasters where spatial data is at most important and local demands for access to spatial data become more critical. That fits well when decision makers are seeking for good governance that requires a visibility, transparency of governmental open data and decision and accountability mechanism to be a mean for "bottom-up" support of governmental policies.

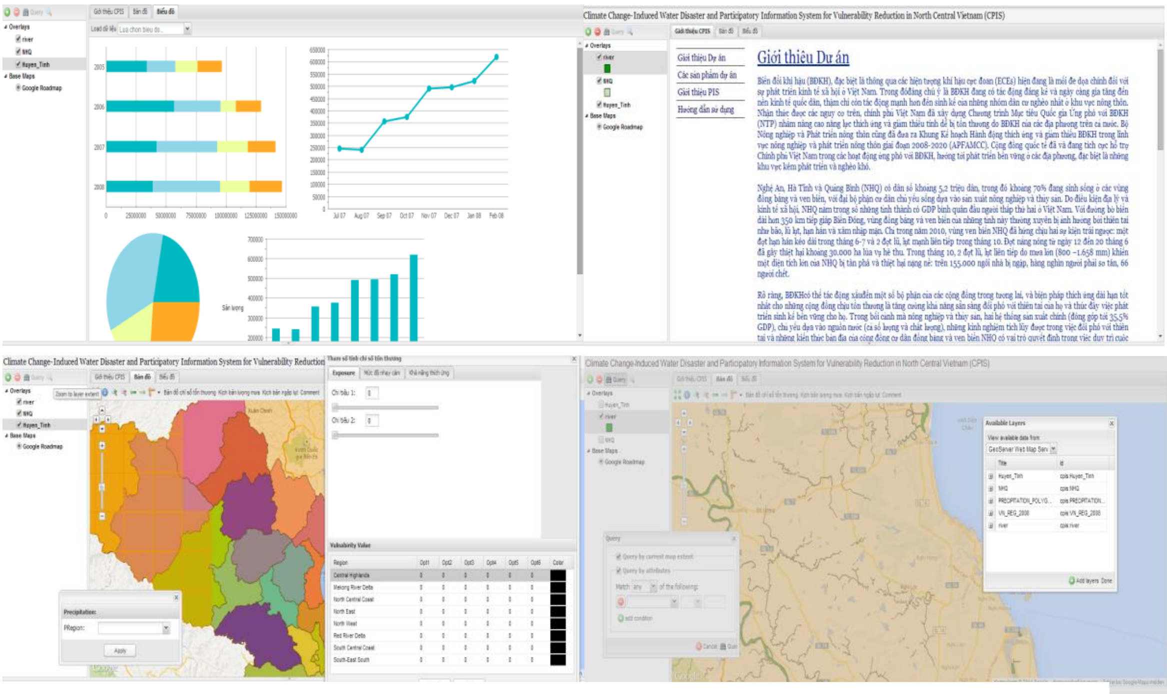

Figure 4. Snapshots of finalized Web-based PIS

6. ACKNOWLEDGEMENTS

The research is part of the project funded by Danida Fellowship Center, grant number: 11.P04.VIE.

7. REFERENCES

(DCLG), D. f. C. a. L. G. (2006). Strong and prosperous communities - the Local Government White Paper**:** 139.

Adger, N. (2006). "Vulnerability." Global Environmental Change **16**: 268-281.

Admire, C. (2009). "Using participatory method and geographic information system (GIS) to prepare for an HIV community-based trial in Vulindlela, South Africa." Journal of Community Psychology **37**(1): 41-57.

Chaudhry, P. a. G., Rousschaert (2007). Climate Change and Human Development in Viet Nam. Human Development Report 2007/2008. UNDP.

Craig, W. H. T. W., D (1999). Empowerment, marginalization and public participation GIS. *Report of Varenius Workshop*. Santa Barbara, NCGIA**:** 22–24.

Dagmar, H. (2011). "Participatory modelling of vulnerability and adaptive capacity in flood risk management." Nat. Hazards.

Fortier, F. (2010). Taking a climate chance: A procedural critique of Vietnam's climate change strategy. Asia Pacific Viewpoint**:** 229-247.

Goodchild, M. F. L., P. A. Maguire, D. J. Rhind Rhind D. W (2005). *Geographical Information Systems and Science*, John Wiley & Sons Ltd, 2 ed**:** pp 291-292.

Jordan, G. a. S., B (1999). "A Participatory GIS for Community Forestry User Groups in Nepal: Putting People Before the Technology." http://www.mtnforum.org/resources/library/jordx99a.htm Accessed (04, April, 2013).

McCall, M. K. (2003). "Seeking good governance in participatory-GIS:a review of processes and governance dimensions in applying GIS to participatory spatial planning." Habitat International **27**: 549–573.

McCall, M. K. (2004). Can Participatory-GIS Strengthen Local-level Spatial Planning? Suggestions for Better Practice. *GISDECO 2004*, Skudai, Johor, Malaysia.

Nguyen Mai Dang, M. S. B., Huynh T. Luong (2011). "Evaluation of flood risk parameters in the Day River Flood Diversion Area, Red River Delta, Vietnam." Nat. Hazards **56**: 168-194.

Pradeep Kurukulasuriya, S. G. e. (2010). Mapping Climate Change Vulnerability and Impact Scenarios/ A Guidebook for Sub-National Planners, UNDP.

Rasmus Heltberg, M. B.-O. (2011). Mapping Vulnerability to Climate Change. USA, Social Development Unit, Sustainable Development Network, World Bank.

Sakamoto A. & Fukui, H. (2004). "Development and application of a livable environment evaluation support system using Web GIS." Journal of Geographical Systems, Springer (Berlin / Heidelberg) **6**(2): 175-195.

Tan, P. V. (2010). Impacts of Global Climate Change on Extreme Climate Events over Vietnam, Predictability and Adaptation Strategies. National Science and Technology Project, Code KC.08.29/06-10 (2009-2010), Ministry Of Science and Technology, Vietnam.

Tulloch, D. L. a. T. S. (2003). "The intersection of data access and public participation: impacting GIS users' success?" Urban & Regional Information Systems Association (URISA) **J. 15**: 55-60.

Viet Trinh, L. R., Jackson Roehrig and Phong Nguyen (2010). Flood risk management for the Thach Han river basin, Quang Tri province, Vietnam. Global change: Facing risks and threats to Water Resource. Sixth World FRIEND conference, Fez, Morocco, IAHS.

Williamson, I., A. Rajabifard and M. E. F. Feeney (2003). Developing Spatial Data Infrastructures: From Concept to Reality. London and New York, Taylor & Francis.

WorldBank (2009). World Development Report 2010: Development and Climate Change. Washington DC., World Bank.

MD. Mosharaf Hossain, 2008. Possibility of spatial data infrastructure (SDI) application. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII, Part B4.