Citizen Science and Digital Geomedia: Implementing a Biodiversity Information System in Cabo Verde

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Abstract

Digital geomedia has an enormous potential for the activation of citizens and organizations in the area of ecological and spatial awareness. By means of the new spatial media, the civil society is given the opportunity to acquire information and knowledge on environmental aspects. At the same time, they can collect new georeferenced data independently, and contribute this data to the scientific community. The purpose of this paper is to contribute a practical approach to promote a sustainable biodiversity management and monitoring system in combination with an education system in Cabo Verde. The underlying theoretical framework for the design of the participatory Biodiversity Information System (BIS) is set by the critical GIS-debate. The project is based on educational approaches of environmental citizenship and spatial citizenship, which explicitly take into account aspects of participation, empowerment, and capacity building. The result of this paper aims at implementing a cooperation between citizens and scientists in the area of biodiversity in Cabo Verde.

1 Science Communication and the Role of Digital Geomedia

Scientists of all research disciplines are being confronted with the phenomenon that within the last decades, successful research explaining the functional relationships of complex ecosystems has been conducted, but at the same time many natural ecosystems are being threatened by destruction through human activities. The explanation of this observation is complex and multi-layered. However, in this context the communication between scientists and society plays a crucial role, as BICKFORD et al. (2012) have also acknowledged: "The time has come for conservation biologists to embrace our roles working for society. (...) Explaining and communicating our science to non-scientists should be one of our most important jobs and the manner by which we go about this communication is vitally important" (p. 75). This quotation shows that the communication between the scientific community and the civil society is characterized by obvious deficits and is in need of improvement. A more ecologically educated society, coming to informed decisions about the management of the environment on the basis of scientific evidence and the needs of the population, has to be developed in the context of spatial planning processes, methods and concepts, located at the interface of science and civil society.

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Nowadays digital geomedia, also described as new spatial media (ELWOOD & LESCZYNSKI 2013), such as public participatory geographic information systems (PPGIS) and digital globes combined with web 2.0-technology, have an enormous potential to make science communication more efficient and to link science with civic engagement of citizens and organizations, as both academia and civil society groups, policy makers and individual citizens have recognized the potential of digital geomedia in the context of citizen science (SUI et al. 2013, CONNORS et al. 2012, GOODCHILD 2007). Citizen science is defined "as scientific activities in which non-professional scientists voluntarily participate in data collection, analysis and dissemination of a scientific project" (HAKLEY 2013, p. 106).

Citizen Science is not a new phenomenon. Since the beginning of science itself, citizens have collected data and given it to the sciences, especially in the disciplines of archeology, natural sciences and ecology. Currently, there is a globally observable increase in the development of digital geographic applications for citizen science activities, such as the German internet portal "www.artenfinder.de". The portal allows committed citizens, via an online-entry, to capture their visual and geo-referenced observations of species, which are judged by scientifically trained experts, and then released for the official nature conservation as well as for scientific analysis (JACOBS & RESCH 2013). Besides this example, there is a variety of other citizen science activities on environmental issues at local, regional, national, international, and global levels in areas such as biodiversity, air pollution, or in the recording of the changing shapes of cities (ALAGAN & ALADUWAKA 2013, CORRIGAN & HAY-EDIE 2013, DAVIS et al. 2011).

Regarding citizen science activities in the context of Volunteered Geographic Information (VGI), HAKLEY (2013) points out two problem areas which have to be taken into account: "First and foremost, there is a need to consider which scientific questions can be answered by citizen science according to the patterns of data collection, the ability to recruit and train volunteers, the suitable participation level and other aspects of VGI. Second, there is a need to overcome the cultural issues and to develop an understanding and acceptance of citizen science within the scientific community" (p. 120). During the course of our contribution, we will not be able to discuss all of the aspects mentioned by HAKLEY.

Our research question is: How can citizen science be involved in scientific biodiversity research, by presenting a concrete project that has been developed as a co-operation between German universities and the University of Cabo Verde? In addition, we would like to discuss aspects regarding the participation of citizens in scientific projects. Hereby, we will first introduce some of the conditions under which biodiversity, science, and civil society policies exist in Cabo Verde before we will present the specific project, including the educational framework of the training of the citizen scientists, and aspects of networking activities between citizens and scientists. Based on this, we will continue with a discussion of the involvement of citizens, whereby criteria for a successful integration of citizens will be introduced. Finally we will give an outlook on future research activities which seem to be important for the project.

2 Biodiversity, Science, and Civil Society in Cabo Verde

2.1 Biodiversity Research

The archipelago of Cabo Verde is a biodiversity hotspot, and besides the climate change-related changes (sea level rise, etc.), increasingly threatened by an agricultural and urban land use change (DUARTE et al. 2008). The Cabo Verdean government has responded early to this situation and has ratified the "Rio Convention on Biological Diversity" in 1992, under which small island states have been identified as regions where protection measures have to be implemented with priority (UNITED NATIONS 1992). However, a major problem in Cabo Verde is the lack of a biodiversity monitoring system for the spatiotemporal observation of the development of land use and biodiversity (MORENO 2009). Scientific deficits in the area of Cabo Verde may be explained by the late foundation of the public university (2006), resulting in the fact that a domestically developed body of knowledge, as well as a civil society debate in terms of functions and sustainable use of biodiversity is still in its infancy.

2.2 Socioeconomic Factors

In the social and economic area, Cabo Verde has undergone a rapid development in recent years, with the result that The World Bank has upgraded Cabo Verde from a "Least Developed Country" to a "Middle Income Country" in 2008. This progress is also reflected in the HDI, where Cabo Verde no longer appears in the lowest category (THE WORLD BANK 2012). The basis of this success is the efforts made to strengthen good governance, which are borne on the existing integrated e-governance model that is praised worldwide as a best-practice model (HAFKIN 2009). A crucial component of the e-governance strategy is the internet access of civil society. In this regard, the government has provided on the one hand, free internet access in front of each municipal town hall and at major public places, and, on the other hand, has made available stationary internet access at City Halls as well as mobile internet access on buses, which stop in remote areas at programmed times for citizens without digital terminals (NOSI 2005).

2.3 The Role of Information and Communication Technology

The strong role of information and communication technology (ICT) in politics and business is also reflected in the education system. At the university level, e.g., each teacher is obligated to map his/her courses on the moodle learning platform. In the area of primary and secondary schools, the government has applied the Mundu Novu-program in 2009, which aims to develop a new concept of interactive education through the use of ICT (MINISTÉRIO DAS FINANÇAS 2009). Through the integration of ICT, teaching methods are modernized not only technically, but also didactically. The program seeks to promote social justice and to reduce the digital divide, and, consequently, social inequalities. Initiatives carried out by the program are, for example, the introduction of ICT as a subject on various levels of education, the creation of a knowledge portal (moodle), access to libraries and databases, and the introduction of new interactive teaching and learning methods. In the area of infrastructural facilities and the training of teachers, Mundu Novu has made reasonable progress in recent years. However, massive deficits still exist in the area of content creation for learning modules.

3 Background, Objectives and Work Packages Regarding the Design of the Biodiversity Information System

At this point, we would like to mention that the German Academic Exchange Service funded a fact-finding mission in the spring of 2013, for the initiation of a Quality Network Biodiversity Program, with the aim of determining potential cooperation partners. During the journey a total of five departments of the University of Cabo Verde, the private University Jean Piaget, four municipal facilities, seven non-governmental organizations (NGO), five ministries, seven protection areas, four reserve administrations, two schools and five private sector organizations were visited on five islands. Discussions were held with a total of 66 people. The key issues that emerged in the discussions with the co-operation partners can be described with these keywords: biodiversity, digital geomedia, and education.

From this preliminary work, different deficits arise: a lack of a sustainable biodiversity management and monitoring system. Shortcomings remain in the area of environmental literacy and spatial literacy within the education system. The main reason in both cases is the tremendous need for the recently founded university to catch up. At the same time, through its initiatives in education and e-government, Cabo Verde offers an excellent basis for a scientific and civil society biodiversity-monitoring program.

With colleagues from the University of Cabo Verde, we found that for effective bio-diversity monitoring, detailed ecological mapping is essential, but that an area-wide, spatially explicit capturing of biodiversity patterns is not possible due to the workload involved. A possible solution is a remote sensing-supported biodiversity information system that integrates satellite and terrain data, and provides a consistent set of data for assessing biodiversity. In addition, a web-based information system opens up the possibility to use the system both for scientific purposes and for civil society formation processes. The overall objective of this partnership is to develop a participatory Biodiversity Information System (BIS) as a body of knowledge for the detection and management of biodiversity information in Cabo Verde for science and civil society (see Fig. 1).

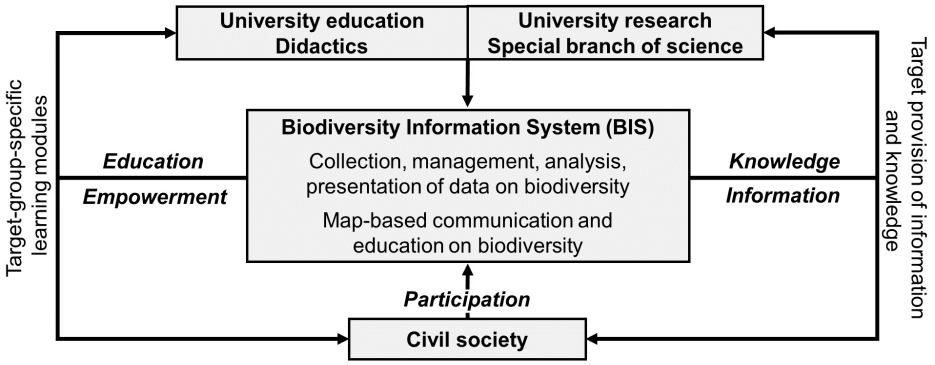

Fig. 1: A Biodiversity Information System (BIS) as a web-based platform for the management and monitoring of biodiversity for science and civil society

Research area: As the study area for the creation of a prototypical BIS, we opted for the national park Chã das Caldeiras on the island of Fogo. Due to its endemic flora and fauna, and its geological and cultural landscape formation, the national park is one of the most interesting areas of Cabo Verde. For the same reason, it has been set up as the first conservation area in Cabo Verde. The German Kreditanstalt für Wiederaufbau (KfW), a development bank, supported the establishment of the protection area at the end of 2004. The park management is also working in the education sector. They collect biodiversity data with students, which are not used for scientific purposes, but only for one-time educational activities. Currently, the KfW supports the construction of an information and education centre in the park.

Networking of subject area and teaching methods: The implementation of the overall objective requires the interdisciplinary combination of closely coordinated multiple academic and educational work packages. The work of the German and Cabo Verdean scientists and students is summarized as follows: the subject areas geography, ecology and computer science are combined under the heading "ecosystem computer science" and the disciplines geography didactics and psychology/evaluation under the heading "didactics". The scheduled implementation takes place in clearly defined work packages, which are built on one another but are self-contained. In each case a partial objective in the field of ecosystem computer science and didactics is pursued in parallel (see Fig. 2).

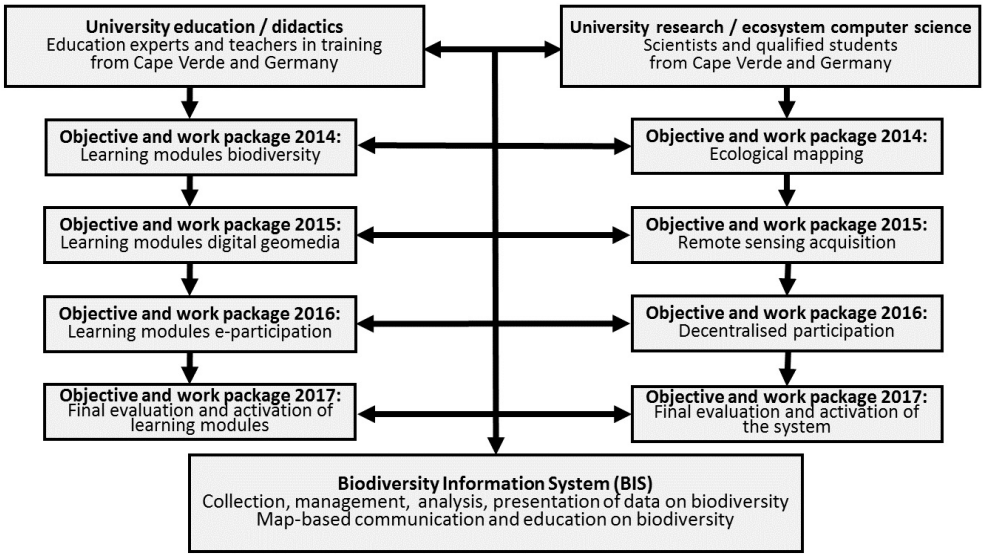

Fig. 2: Objectives and work packages for the development of a Biodiversity Information System in Cabo Verde

Networking of the work packages: The work packages are both disciplinary and temporally cross-linked. For example, in the work package "Ecological Mapping" (year 1), the requirements of machine learning methods when determining the study design have to be taken into account. Similarly, the technical development of the BIS, in particular the

targeted visualization component, has to be accompanied didactically because when building multi-thematic content, there are unfavourable-comprehension and understanding-effective sequences of representation (HORZ & SCHNOTZ 2010). Contrary to that lies the development of learning modules, which are each implemented in cooperation with the academic experts.

Development of the Biodiversity Information System: The Biodiversity Information System is not implemented in a large work package towards the end of the partnership, but implemented gradually, with the complexity and capability of the system increasing with every year. A formative evaluation process that takes into account user-specific workflows will accompany the implementation. The basis of the system is a modular, analytical database system XXL (https://code.google.com/p/xxl/).

The educational framework of the citizen scientist training activities: The respective learning modules, developed in the didactic work packages, are based on the pedagogical approach that is pursued by the Cabo Verdean Ministry of Education in the Mundu Novu program, and includes the following didactic principles: student orientation, promoting critical thinking, collaboration and use of ICT. In the area of curriculum development, a pragmatic situational approach is chosen, which is determined by the contents of the subject-based work packages, but also aligned with the curricular content of school and university in Cabo Verde. The arrangement of the learning material is, on the one hand, based on the didactic concept of the spiral curriculum, i.e. that individual issues are worked out for different cognitive levels, which is, on the other hand, combined with a multipath curriculum. A multipath curriculum consists of single units and topics and/or modules which are grouped against different aspects of the certain domain. However, there is no 'fixed' or uniform learning process, which means that knowledge and skills are acquired to achieve particular outcomes, e.g. different learners with individual foreknowledge, different professional backgrounds etc. (FOOTE 2012, PAINHO & CURVELO 2012). Hereby, the heterogeneous educational level of the citizens is taken into account. The learning modules are developed as flexible, web-based tutorials for self-organised learning, based on the moodle learning management system that is already established in schools and university across the country. Formative evaluation takes place in collaboration with university, schools, and national park administration.

The proposed project structure shows that the communication and cooperation between scientists and citizens in this project will be taken seriously. This paves the way for an understanding and acceptance of citizen science within the scientific community. Which forms of interaction will be finally realized between citizens and scientists, depends on the form in which citizens participate in the BIS. Concerning this crucial point, some aspects need to be considered which we will discuss in the following section.

4 Citizen Science, GIS and Aspects of Participation

According to the context of science and civil society, the theoretical framework of critical GIS is essential, because it contains upcoming new digital geotechnologies as new forms of spatial media and new knowledge politics combining social and political impacts (ELWOOD et al. 2011, ELWOOD & LESZCYNSKI 2013). Eric Sheppard's discussion of genealogy and prospects of critical GIS leads to a revision of the familiar definitions of geographic

information science (GIS) and geographical social theory (SHEPPARD 2005). The revision contains an extension of the definitions through new technologies, which provide an insight into gathering, sharing and administration of user generated spatial data. These innovations offer new forms of connectivity and interactivity between users themselves in the 'web 2.0' (ELWOOD et al. 2011). More and more geographers acquire information about these new forms in the research of 'new spatial media' (CRAMPTON 2009) 'geo@web' (GRYL et al. 2013) and in particular within Volunteered Geographic Information (VGI) (SUI et. al. 2013, GOODCHILD 2007).

Representatives for VGI initiatives are Flikr or Open Street Map. These services allow users to contribute geo-referenced data of their observations for an empowerment of themselves. LIN (2013) summarized, that "these VGI practices create new participatory spaces but also new exclusions" (p. 99). In other words, spatial data in the digital representation of places and people is an implement for ex- or inclusion and for dis- and empowerment (ELWOOD et al. 2011). If the framework cannot enclose the knowledge claims, experiences, and identities of places or social groups, spatial data is under-represented. The underrepresentation has a kind of political and social inference and must be a part of the investigation for the development of a PPGIS.

In this context the participation of citizen scientists in the BIS in Cabo Verde is determined by socio-institutional and group participants, in addition to PPGIS influences, in combination with tasks and social outcomes that interact with the general process structures (JANKOWSKI 2012). The socio-institutional influence contains the convener, rules and norms of a possible participation and the subject of investigation. The group participants' influence involves a preoccupation with their beliefs, expectations, knowledge, confidence, and values. The BIS represents a channel of communication with all participants as well as a body of knowledge. Participation is encouraged, as a response to local and global environmental problems as well as the interest of the people to join the environmental and education process.

In this sense, the BIS allows the participation of everyone to use scientific information for their lives. Therefore, it is important to anticipate participants' information needs, in order to determine the concerns of potential participants based on a relationship with fundamental economic, environmental, religious or moral values of society (JANKOWSKI 2012). The opportunity to transfer their local knowledge into official knowledge serves as motivation for the participation of local scientists. This official knowledge will be integrated in local and national laws, institutional policies, and culturally bounded information to represent the people in the body of knowledge. This leads to a sustainable and forward-looking inclusion of people and their places in decision making processes. Spatial data is used as resource to be traded upon for influence or political power, so that participation may have an effect on socio-political mechanisms and structures by the means of production, sharing and administration of geospatial data.

In addition to these policy implications, there are further strategies to recruit citizens: setting clear goals to help research to expand data about biodiversity in Cabo Verde and associating clear tasks with them. Existing interests and activities based on the flora and fauna of Cabo Verde can be activated and used to achieve participation. Furthermore, through the activation of local multipliers such as NGOs, universities and schools, more and more scientists are being recruited from the civil society. The motivation of the parties

may be induced by an interest for nature, or the preservation of natural resources as a personal enrichment. Citizen science helps people to understand that they can be a part of science and have an influence.

Especially in the context of development policy cooperation, the management and monitoring of biodiversity is essential to initiate a civil society communication process on the management of natural resources. With a view towards Cabo Verde, this project has a special significance, because the civic awareness of this issue is still in its infancy. The strong use of ICT in this project has to take into account different levels such as the access of civil society to technical solutions and institutional support. The basic philosophy of this project integrates an information and knowledge-based approach. Civil society is given the opportunity to acquire information and knowledge about biodiversity, to collect new information independently, and to make it available in turn. At the same time, new knowledge is generated and communicated across spatial distances using the web-based BIS. This is also guaranteed through the underlying education approaches of the project like environmental citizenship (DOBSEN & BELL 2006) and spatial citizenship (GRYL & JEKEL, 2012), which explicitly consider aspects of participation, empowerment, and capacity building. This also means that the access of the civil society to the BIS is ensured through digital devices that are based on regionally appropriate technologies and approaches. For the purpose of this project, Cabo Verde offers a very good institutional and political environment.

5 Conclusion and Outlook

Citizen Science, digital geomedia and participation function as a basis for the development of a BIS in Cabo Verde. In conclusion, it can be noted that the BIS is a kind of prototype for the design of a participative geographic information system for the link of civil society and science, including empowerment and capacity building. The project involves subsequent work packages with partial objectives in the fields of ecosystem computer science and didactics which are networked. Future research should explore “the four main proposed topics for the new GIScience research agenda that will help the understanding of the process of global change [, which involves] modeling, data collection, knowledge discovery and support for policymaking” (DAVIS et al. 2011, p.124). Additional research regarding citizen science should concentrate, for example, on the following questions: How can we merge unstructured data coming from informal and different spatiotemporal sources? How can the reliability and validity of the collected data be guaranteed? How can we create indicators that can be understood by the general public as a sustainable resource management? And how can we build a BIS that advises public policy makers and societal stakeholders? Firstly, standards to build a framework for reliable and valid data recording will be formulated in cooperation with the local multipliers to create a good acceptance for the participation in the BIS. The next step is to form a concept for educational learning modules of biodiversity to build environmental and spatial competence in the society and to design a formative evaluation for the work packages. A more elaborate discussion of the first project findings and results concerning the relationship of citizen science, digital geomedia and biodiversity will be presented in future publications.

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