Developing Environmental Education Tools Based on Geodata to Create Awareness for the Kakamega-Nandi Forests Ecosystem

Die Entwicklung von auf Geodaten beruhenden Umweltbildungsmaterialien zur Sensibilisierung für das Kakamega-Nandi-Waldökosystem

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Over the last 100 years the Kakamega-Nandi forests area, western Kenya, experienced a loss of about 60 % in natural forest cover due to human interferences. In order to create awareness for sustainable forest use among the local population, tools for environmental education have been developed. The tools, here among others a jigsaw puzzle and a card game, aim at making use of geospatial data because map reading literacy is considered a prerequisite in any natural resource management and planning. The tools are introduced as well as the chosen participatory approach, which allowed enhancement of prototypes in an iterative manner.

■ Keywords: non-formal environmental education, geospatial data, cartography, developing country

Das Kakamega-Nandi-Waldgebiet in Westkenia hat über die vergangenen 100 Jahre 60 % an Fläche naturnaher Waldbedeckung verloren, dies durch menschlichen Eingriff. Um bei der lokalen Bevölkerung ein stärkeres Bewusstsein für die nachhaltige Nutzung des Waldes zu schaffen, wurden Umweltbildungsmaterialien entwickelt. Die Materialien, u. a. ein Puzzle und ein Kartenspiel, sollten raumbezogene Daten mit einsetzen, da Verständnis, wie man und was man aus Karten lesen kann, als Voraussetzung in der Naturschutzplanung betrachtet wird. Es werden die unterschiedlichen Materialien vorgestellt sowie der partizipative Ansatz zu deren Entwicklung, welcher eine iterative Verbesserung der Prototypen ermöglichte.

■ *Schlüsselwörter: Informelle Umweltbildung, raumbezogene Daten, Kartographie, Entwicklungsland*

1 Background and aim

Kakamega Forest, placed in western Kenya about 30 km north of Kisumu, is known for its high biodiversity and represents the only relic of Guineo-Congolean rainforest type within the country. However, the forest is found in one of the most densely populated rural areas of Kenya with a poverty rate above 50 % and therefore experiences severe pressure (Mitchell et al. 2009). Research results of processing old 1:250.000-scale topographic maps, historical aerial photography and Landsat satellite time series imagery revealed that the today existing three separate forests of Kakamega Forest and the two Nandi Forests (Figure 1) once formed one continuous forest block (Mitchell et al. 2006). Natural forest cover in the Kakamega-Nandi forests area decreased from 78,124 ha in 1912/13 to 29,882 ha in 2003. This loss of 60 % mainly relates to human influence (Schaab et al. 2010). Forest loss changes biodiversity and other essential ecosystem services (e. g. water, fuel wood, food, medicinal plants). The forests are regularly visited by the adjacent population for such forest products and services (Mitchell et al. 2009). The forests have already a long management history (ibid.), however, with further increasing pressure due to population growth and climate change, efforts in sensitizing the local population for the need of forest conservation are urgently required.

About 300 geodata sets for the area (http://www.biota-africa.org/East_GIS-Web1 _ba.php?Page_ID=L600_04) resulted from more than nine years of funded project work within the integrated biodiversity research framework of BIOTA East Africa (2001–2010). The data is available on the ground, i. e. in the Biodiversity Information Centre. It was set-up in Kakamega Town towards the project's end to empower the many stakeholders of the area. Handling of geodata, however, requires experts. A wider audience was tackled with the BIOTA East Africa Atlas. Rainforest Change over Time (Schaab et al. 2010). It was widely disseminated throughout Kenya but asks for map reading abilities which seem to be lacking among the local people (Schaab et al. 2009a). Wide attention is drawn with visually stimulating playful tools like the BIOTA-East multimedia presentation (Zimmer at al. 2008). It points to other forms for successful communication of scientific findings to also less-educated people. Here the combination of playful approaches with mapped information appears promising for creating the needed map reading literacy, as geodata is considered a prerequisite in any, ideally participatory natural resource management and planning (cp. GISIG 2002, ESSC 1998).

Increased environmental knowledge, stronger awareness of problem solving strategies, and higher motivation levels for actions are the cornerstones of a successful, so-called environmental education (Stapp 1969). The aim for Kakamega Forest became to develop environmental education tools which support stakeholder institutions in their work with the local people for reaching the long-term goal: a change in attitude towards real forest protection among the local population. For successfully educating and informing local people, the development of effective tools has to follow an iterative participatory process, which engages the multipliers of the tools with their insights into the needs of the end-users. It is further expanded by empirically pilot-testing the jointly developed prototypes in respective user groups. We thus aim at contributing to ways how scientific geodata can be effectively turned into playful tools (here among others a jigsaw puzzle and a card game) which allow environmental education of people of any age and level of education in a developing country.

2 The use of geodata in environmental education

2.1 Types of environmental education

The concept behind environmental education is that increased knowledge leads to awareness, and both together stimulate action (Hungerford and Volk, 1990). Since the Intergovernmental Conference on Environmental Education in Tiblissi (Georgia) 1977, major efforts have been put in providing a clear structure to the wide field (UNESCO and UNEP, 1978): From learning about the physical environment (in the 1960s), awareness creation via outdoor facilities (1970s), to action research (1980s) and participatory approaches (1990s) (Palmer 1998). Nowadays the focus is on educating citizens to become both knowledgeable and skilled for making responsible decisions (Hungerford, 2010). It applies to all people and is, therefore, integrated in the formal education sector (where learners have to learn) or outside of it (non-formal, where learners choose to learn) or happens even unintended (informal, where learners happen to learn) (e. g. Pandey 2006).

2.2 Environmental education materials

Otiende and Ezaza (1997) point to the availability of good material being a prerequisite and that it should be ideally prepared locally. It requires a clear illustration of the purpose, instructions meeting user needs, up-dated content, and a locally relevant topic (Otiende, 1997). The NPEEE (2004) states six key characteristics of environmental education materials: fairness and accuracy, depth, emphasis on skills building, action orientation, instructional soundness, and usability. As examples of environmental education means for the non-formal sector EECO (2000) lists next to print and media products, role plays and other kinds of active stimulations. Games in particular are named in Mueller and Bentley (2009) and highlighted by Hewitt (1997), in both cases for the formal sector. For Kakamega Forest, besides those visualization tools which resulted from BIOTA activities and revealed value for educating the locals (cp. section 1), only a recently published animated cartoon musical (The Rainforest Musical Kakamega by Shirley Choi, 2014) and some teaching units having been developed for secondary schools (Mali Asili ya Msitu by Marc Lung, 2004) are known to the authors.

2.3 Maps in non-formal environmental education material

The potential of geodata or maps is not acknowledged in the reviewed literature on materials in environmental education (section 2.2). Geodata, as depicted in maps, has a potential to inform as well as to support communication and decision-making. For example, Hauck et al. (2013) point to the case of ecosystem services, where maps are able to show complex issues and are a useful instrument for biodiversity conservation. Integration of geodata into an environmental education tool allows the tool to become an aid for building map reading literacy which is important in the context of spatial citizenship. According to Gryl et al. (2011), the capability to read, interpret and ideally create maps and therefore also to work with geodata enhances one's ability to take part in decisions which are spatially related. Map reading literacy can therefore contribute to a balanced participatory forest management where all participants understand geodata- or map-based decision aids. Based on on-site tests with local people and forest (security) guards/rangers from Kakamega Forest, Schaab (2009) concluded that tools targeting environmental education in a game-like and playful manner have a great potential in non-formal environmental education, however, challenges occur when these tools involve skills of map reading. This challenge is particularly occurring when at the same time being newly introduced to a digital device. Therefore, further efforts should be undertaken in developing environmental education tools that emphasize on geospatial information.

2.4 The envisaged environmental education tools

Effective environmental education needs quality material to help inform the audience (section 2.2). Due to many years of research in the area, a thorough database has been achieved (section 1). One

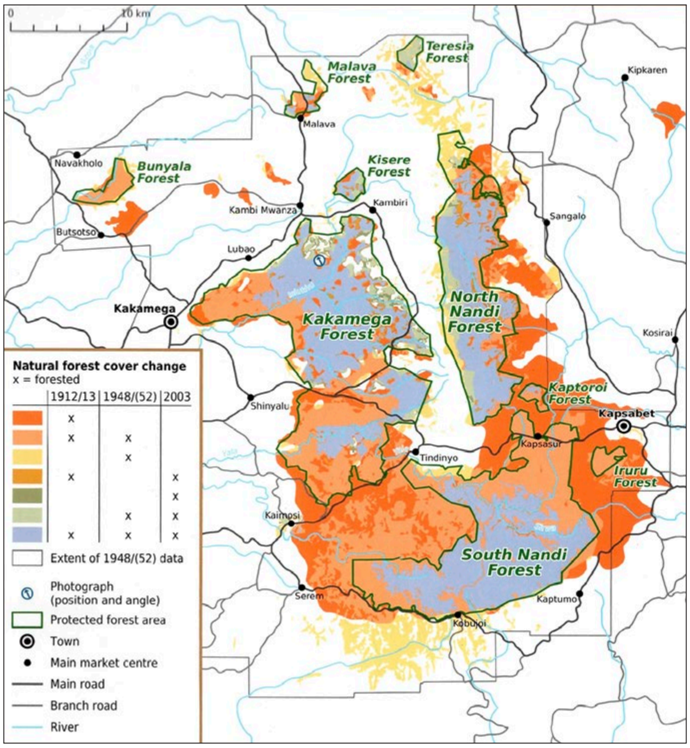

Fig. 1: Natural forest cover change in the Kakamega-Nandi forests area, western Kenya (Schaab et al. 2010, p. 21, original scale: 1:370.000)

major outcome of BIOTA-East is The BIOTA East Africa Atlas which among many other maps depicts change in natural forest cover for the Kakamega-Nandi forests area between 1912/13 and 2003 by assigning colours to the intersected geometries based on a matrix legend (Figure 1). It is making use of three time steps: 1912/13 presenting the earliest available time step and this before the official demarcation (gazettement) of the forests, 1948/(52) as a middle time step still revealing a small link of Kakamega and South Nandi Forests along Yala River, and 2003 as the latest time step available when conducting geodata analysis (Schaab et al. 2010). Although understanding the cartographic representation method normally requires explanation, this map is well known as it covers, in a much bigger version, also a wall in the Biodiversity Information Centre (section 1). Its local appreciation led to the idea to turn the differently colour-shaded forest parts into a jigsaw puzzle in order to help the local population as well as local decision-makers to better understand the extent and history of natural forest and cover loss since 1912/13.

The multimedia presentation on BIOTA-East (section 1) includes a game on 23 local uses of Kakamega Forest, where a photograph per use has to be dragged and dropped onto the according board, one labelled "Permitted with limitations", the other "Forbidden". If placed correctly, a map highlights the areas where the local forest use is permitted or forbidden. The game showed a big potential when tested among local people, but with concerns regarding the usefulness of the map in particular for children (Schaab 2009). In the meanwhile more local forest uses had been identified plus that such a game directly demands clarification on the rules under which circumstances certain uses are permitted (ibid.). Thus the task was to develop an improved and more complete game, which includes all relevant information on the forest use rules.

The project work this article is based on (Paul 2014) also covered the development of touristic tour leaflets for promoting ecotourism in the area as well as of flipbooks for sensitizing on the four major forest threats and sustainable alternatives, the latter without making use of geodata.

The aim for all four education tools was to target a most broad potential user group as well as to be locally applicable in environments with or without electricity and technical devices. Therefore, analogue as well as digital versions had to be elaborated (cp. Schaab et al. 2009a). The analogue versions were to be produced first due to the so-called Digital Divide.

3 Tool development

3.1 A participatory approach

Athman and Monroe (2001) specify participation of stakeholders in the development process among their requirements for successful environmental education programms. A participatory development process actively involves people whose life is subject of the study (Bergold and Thomas 2012). However, the participation level can vary (see Clayton et al. 1997). The higher the level of participation, the more difficult is an exact planning of the project (Bergold and Thomas 2012). Therefore, Participation by Consultation was considered the most suitable strategy for this study due to the pre-existing ideas for tools. Depending on feasibility and quality of the stakeholders' input, it can be considered or not and thus allows for control over the process. In software engineering, development models provide frameworks for the development of a product in cooperation with a customer (Sommerville 2007). This framework was adopted for integrating input of local stakeholders in the development process. This way the environmental education tools can be enhanced prototype by prototype, until reaching the stage of a concept for a final version. Because the requirements for the final environmental education tools are not known in the beginning but developed together with the local stakeholders, more specifically Boehm's Spiral Model for software engineering (Sommerville, 2007) served as inspiration for guiding through four iterations (Figure 2). Here, each iteration enhances the prototype of the former iteration in order to continuously reduce the risk of unsuccessful environmental education tools.

The environmental education tools have to match the local requirements in design and content when aiming at successful education and informing of local people and visitors. Each iteration except the first starts with a participatory development activity. This activity is used to determine the requirements of the proposed tool together with local stakeholders (i. e. the target users). Thus, each activity influences the iteration's goals and actions: The analysis of the activity results in a concept for enhancing the respective tool

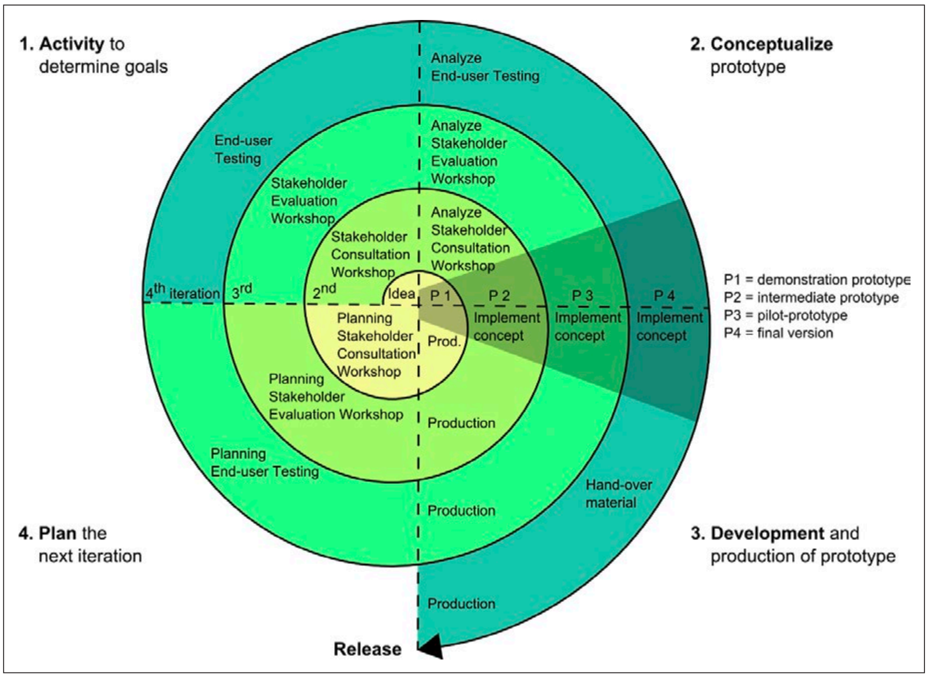

Fig. 2: Boehm's Spiral Model for software engineering (Sommerville 2007) adapted for the participatory development of tools for environmental education in four iterations

prototype (P), the implementation of the concept leads to the production of an enhanced prototype and, finally, the next iteration is planned. The iterative passing through these three steps is also implicit in the user-centered design process (Roth et al. 2015). The eventual overall result is a concept for a final version (P4) of the proposed environmental education tool, based on the analysis of the end-user testing in the fourth iteration. This way, the process comprised two stakeholder workshops, on the first one working with focus groups, on the second (aiming for the same participants) mainly working with focus groups and questionnaires. Data collection during end-user testing was based on observations and semi-structured interviews. Focus groups and semi-structured interviews are pointed out by Bergold and Thomas (2012) as the most common for collecting input in participatory research. As we worked with one focus group per tool and due to the analysis of the results by one researcher only, no further measures prior to the actual content analysis was required.

3.2 Cartographic work

Preparing the jigsaw puzzle involved most cartographic work. Here the game board represents the base map of the Kakamega-Nandi forests area. The manual contains beside the instruction also solution maps for the changes which have taken place. While an additional matrix legend is required to remind the users on the meaning of the colours. Most challenging was the design of the jigsaw puzzle pieces. Because the available geodata on natural forest cover had been derived in very high level of detail (1:30.000 to 1:250.000; section 1), it was necessary to change to a much lower level of detail. Thus big enough jigsaw puzzle pieces were produced which nevertheless preserve the highly fragmented character of the forested landscape. The chosen process was a manual generalization in GIS, following the purely graphic generalization rules 'simplification', 'enlargement' and 'displacement' and the conceptual generalization rules with graphic effects of 'merging', 'selection' (Kraak and Ormeling 2010), 'classification' and 'exaggeration' (Hake et al. 2002). The geodata has been generalized for a target scale of 1:75 000 which results in a jigsaw puzzle with a game board of 72 cm by 80 cm. This size is needed to be able to represent also small but typical forest parts by jigsaw puzzle pieces of a sufficient size. Otherwise, the tool would tamper with the real situation of natural forest cover. Examples of applying the generalization rules to the forest cover change geodata for deriving the jigsaw puzzle pieces are provided in Figure 3. The initial total number of 2012 pieces after geometrically intersecting the three original vector geodata sets representing a time step each reduced thus to finally 91 jigsaw puzzle pieces.

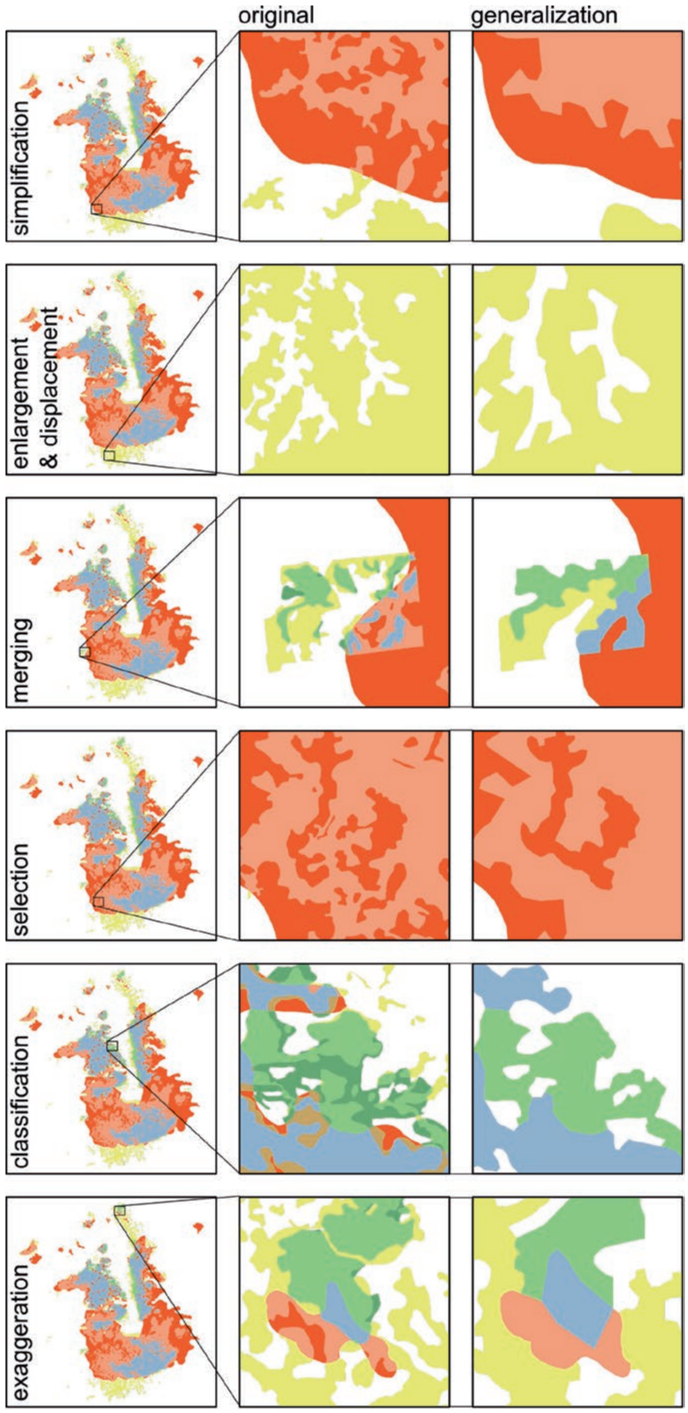

Fig. 3: Examples of cartographic generalization for the intermediate prototype of the forest cover change jigsaw puzzle

The local forest use card game consists of pairs of cards representing the various uses and a manual. Here, cartographic work was more limited. It required to include a small map on one of the cards of the pair. It highlights by the colours red and yellow where the local use is forbidden or is in parts permitted respectively. According to the management rules in place, six different versions of the most simply kept map in 1:600.000-scale are required. To nevertheless allow for proper

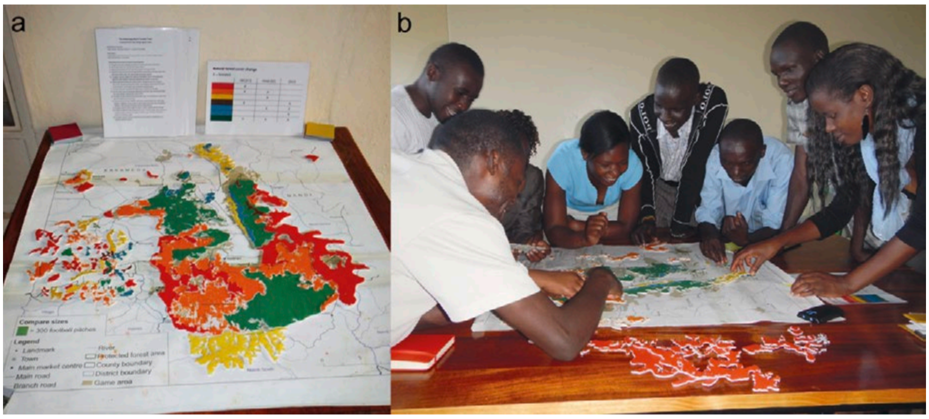

Fig. 4: a) Intermediate and at the same time pilot-prototype of the jigsaw puzzle on natural forest cover change in the Kakamega-Nandi forests area. b) The jigsaw puzzle being tested by a group of university students of MMUST, Kakamega (Photo by R. Joseph)

localization of areas and thus discussion between users, an additional reference map in 1:150.000-scale of Kakamega Forest and the two associated forest patches Kisere and Malava is provided.

3.3 Empirical testing

After conducting the Stakeholder Consultation and Evaluation Workshops with people having been selected via a stakeholder analysis (Slocum 2003), the pilot-prototypes were tested among potential end-user groups (Figure 2). The questionnaires for the end-user groups had had been already used in slightly modified versions at the second stakeholder workshop (Table 1). By then the understanding of the questions in regard to triggering the desired input (cp. respondent debriefing, Scheuren 2004) was mainly pre-tested. Besides learning how best to plan the end-user testing, also additional input from those representing the multipliers was gained. The jigsaw puzzle was independently tested six times with in total 50 participants, each tested only once, of the potential end-user groups: secondary school pupils (15), university students (20), forest guides (3), forest guards/rangers (11). Unintentionally one community member also took part. Afterwards 34 semi-structured interviews (representing a subset of the convenience sample) plus two detailed observations of end-users making use of the tool could be analyzed in regard to still required changes for the final version (P4) of the tool. The questionnaire included two questions on environmental knowledge gained during taking part in the activity, two to check the understanding of the tool, and eight to find out about further required enhancements. The card game was independently tested eight times with in total 43 participants. These represented the potential end-user groups: primary school pupils (15), secondary school pupils (10), forest guides (7) and community members (11). The output for the analysis was answers from 18 semi-structured interviews plus observations noted during five games. Here, the questionnaire included checking of pre- versus post-knowledge and one question on knowledge gain, three to check the understanding of the tool, followed by four for finding out about further enhancements. Overall, the end-user testing for the analogue versions of all four environmental education tools plus also digital prototypes for the flipbook covered 156 participants (none having participated in the workshops) and led to 123 filled-in questionnaires.

4 Results

4.1 The forest cover change puzzle

The many feedback from stakeholder consultation and the end-user testing led to final concepts (P4) for all tools, i. e. their analogue and digital versions. The final jigsaw puzzle (analogue version) is to consist of a game board with a 1:75.000-scale base map including the features: rivers, roads, settlements, land-marking hills, and administrative boundaries. Additionally, a colour tint represents the area which would be covered if all puzzle pieces are put in their correct positions (which differs from the largest forest extent in 1912/13). The legend on the game board includes a square for forest size comparison. The 91 puzzle pieces are to be coloured by six distinctive shades following more closely an associative scheme (areas of forest throughout all three time steps have to be coloured in green, cp. Figure 4a and Figure 1). The effect of generalization can be seen by comparing Figure 4a with the map on the left hand side of Figure 3. The pieces need to show the protected forest area boundaries, which is also included in the game board map, as it helps in locating them as well as facilitates assessing forest loss or gain during the game. Updating the latest time step from 2003 to 2013 (via visual interpretation of satellite imagery of 2013) was of crucial importance, although it asked for minor changes only. The manual encompasses instructions on how to employ the tool, a legend explaining the colours of the jigsaw puzzle pieces' categories, solution maps for each time step and the correct placement of all jigsaw puzzle pieces, and a narrative on natural forest cover change in the area. The legend on the colours is also needed separately and in large size to offer the users a confirmation on the puzzle piece colours at all time during the game. The story of forest cover change (based on Mitchell 2011) will be narrated by the instructor when having completed a time step. It provides the users with reasons for natural forest cover loss and gain and relates via numbers to the respective puzzle pieces (found on the pieces' backside) as an additional help to the instructor besides the solution maps. The end-user testing confirmed the earlier feedback by the stakeholders that the jigsaw puzzle is a challenging but inspiring task and widely usable, but surely not suitable for primary school pupils and other less-educated people (Table 1). Figure 4b provides an impression from students making use of the tool.

4.2 The local forest use memory

The developed concept for the game on local forest as an analogue version (Figure 5b) is a modification of the in the western world widely known Memory game, where users need to find matching pairs of cards from all the cards being laid-out but turned face-down. The difference, however, is that the backsides differ in colour: pointing to the actual uses (green backside) and the categories they fall in, "Forbidden" (red) and "Permitted with limitations" (yellow). The number of identified local forest uses increased to 27 (cp. section 2.4), each represented by a photograph on the card's face. The photo on the matching card is faded to the background and in addition contains now information on rules and their reasoning as well as a very simple map for locating the areas with use restrictions, which does without a legend and labels (Figure 5a). The decision for such simple maps were made based on experiencing locals who readout the annotations on the map as they would be part of the provided textual information. Instead a separate, larger-scaled map is to be provided with all the required features for relating the information of the 'map icons' to the real world situation. The game will also come with an instruction manual. The testing of end-users revealed that the card game is easily steering discussions. As such it is highly suitable and well accepted among the wide range of societal groups (Table 1), providing here an impression from a community group use case (Figure 5c). However, it became apparent that generally map reading skills are poor. Therefore, a knowledgeable instructor is also required for this environmental education tool.

5 Usefulness of the approach taken

The challenge of the work has been the developing of environmental education tools, which are successful in informing a non-scientific audience of a culture being different from that of the researchers and in a developing country. It was clearly not the often acknowledged lack of quality material for developing such tools (e. g. NEMA 2012, cp. section 2.4). The question of this study was how to transform the wealth of information resulting from the BIOTA East Africa project into tools which enable successful communication to the local people. Although the BIOTA project, which ended in 2010, had been particularly successful in feeding science into implementations on the ground (cp. Schaab et al. 2009b), the work described here demonstrates the still not fully tackled potential for add-ons. However, the development can be time-consuming if performed in a participatory way and is also costly.

The approach was based on Participation by Consultation, which proved here to be an adequate participation level, although others might disagree (cp. Bergold and Thomas 2012). Due to the lack of formal map-based education, it is difficult for people in Kenya to imagine such new ideas as presented. A simpler demonstration prototype to start with helped tremendously to start discussions among the stakeholders. It was even more needed as the people generally lack experiences on what can be read from maps (Schaab 2009). By integrating local insights in the needs of the proposed tools, as revealed by stakeholder consultation and end-user testing (Table 1), locally applicable solutions could be developed. By studying local problems, awareness of local environmental problems will be increased. It is demanded by Mueller and Bentley (2009) for formal school education and Pandey (2006) for the non-formal sector involving adults and less-educated people who are nevertheless the important decision-makers in rural areas. The tools thus emphasize on strengthening local decision-making skills in a developing country as postulated by Knamiller (1983). The collection of local knowledge added particularly to the correctness of the information which is provided by the card game (Table 1). The workshops have stimulated interest and desire for the tools among the stakeholder institutions, while the end-user testing has led to excitement for the tools among the locals. Beneficial in this regard has been for sure the playful character of the tools, simply for the same reason which made 'gamification' the new trend in the developed world (Zichermann and Cunningham 2011). The sequence of participatory activities has achieved already the much needed local ownership feeling with a high acceptance among the local stakeholders who are involved in environmental education about Kakamega Forest or the Nandi Forests. A potential pitfall (listed by Otiende 1997) could still be that the tools require a locally well-informed and trained person for successfully using the new environmental education resources.

Both tools meet NPEEE's key characteristics of environmental education materials (2004, see section 2.2). They are particularly strong in 'fairness and accuracy' as they are based on a thorough review of research outcomes and facts. Comparing both, the jigsaw puzzle offers more in regard to 'depth' by fostering awareness and understanding on the natural environment, while the focus of the card game is clearly on 'skill building' and 'action orientation'. Regarding 'instructional soundness' and 'usability' we believe that the tools have benefitted immensely from the chosen approach, although one needs to be aware that the jigsaw puzzle is a tool of a rather advanced learning level.

Currently, the tools are in the production stage, which will be followed by a dissemination phase ideally including training of instructors. As such we are able to contribute further tools for environmental education in the area of Kakamega

Fig. 5: a) Final-prototype card pair and b) the various components of the card game (pilot-prototype) on local forest uses in Kakamega Forest. c) The card game being tested by a community group in Kisere (Photo by M. Paul)

Tab. 1: Summary on the participants, methods used, and major outcomes of the two stakeholder workshops and the end-user testing

		Jigsaw puzzle	Card game
Stakeholder Consultation Workshop	No. of participants	10 plus moderator and assistant to take notes	9 plus moderator and assistant to take notes
	Institutions involved	Nature Kenya Kakamega & Nandi, Shanda Primary School, Lirhanda Girls Secondary School, Shilolavakhali Youth Polytechnic, MMUST, Karlsruhe University of Applied Sciences, KEFRI, Muileshi CFA, KAFOGA	KWS, Nature Kenya Kakamega & Nandi, Kisaina Primary School, Kakamega Muslim Secondary School, KFS, KAFCOA, Kibiri and Malava CFA
	Empirical methods used	Focus groups	Focus groups
	Major outcomes	– Useful for secondary school and higher education levels; for elementary school and non-formal adult/community education a simpler version would be needed. – Area for size comparison needed on the game board for better understanding. – Key features like settlements, roads and rivers need to be included on the game board. – Include reasons for forest cover change via story. – Use of associative colours for the pieces; avoid using blue (associated with water).	– Usable for all age and education levels. – Should also include a sustainable way of carrying out the activity. – A more detailed map for orientation and discussion is required. – Some uses need to be added, others represent just more general terms and can be left out. – Requires a game instructor. – Cards should be bigger in size.
Stakeholder Evaluation Workshop	No. of participants	8 plus moderator	6 plus moderator
	Institutions involved	Nature Kenya Kakamega & Nandi, Shanda Primary School, Lirhanda Girls Secondary School, Kakamega Muslim Secondary School, MMUST, KEFRI, KWS, KAFOGA, KEEP	Karlsruhe University of Applied Sciences, Kisaina Primary School, KFS, KAFCOA, Kibiri and Malava CFA
	Empirical methods used	Focus groups, questionnaires, observations	Focus groups, questionnaires, observations
	Major outcomes	– Suitable for secondary school and higher educated people, not for community groups. – First to puzzle the time step (starting with latest time step), then to narrate the story. – Digital version is less time-consuming and provides proof for correct placement of a jigsaw puzzle piece.	– Enhances communication while playing. – Some of the information on cards needs to be revised.
End-user Testing	Number of participants	6 test cases with in total 50 participants	8 test cases with in total 43 participants
	End-user groups	Secondary school pupils (15), university students (20), forest guides (3), forest guards/rangers (11), community member (1, unintentionally)	Primary school pupils (15), secondary school pupils (10), forest guides (7), community members (11)
	Empirical methods used	Semi-structured interviews (34), observations (2 games)	Semi-structured interviews (18), observations (5 games)
	Major outcomes	– Useful for all tested end-user groups with a group size of up to about 10 participants. – Difficulties with relating shapes to each other; seems to be a general issue.	– Can be played by anyone who is able to read but for primary school level and some community groups a game version in Kiswahili would be better. – The labels in the small maps on the cards are not understood as such and read out aloud when reading the information on the cards. Do without these labels (shown on the accompanying larger-scaled map).

Forest which emphasize on geospatial information (for the need to foster map reading skills see Schaab et al. 2009a). Thus indirectly the Biodiversity Information Centre is supported as its many geodata will gain appreciation and therefore hopefully a wider use. In the years to come it would be interesting to again perform similar tests with locals who have worked with the tools. It would allow to assess the success of the tools (cp. Leal Filho 2004), i.e. impacts on the people in regard to enhanced map reading literacy, to being better informed and to a changed attitude towards forests. In particular in the case of the jigsaw puzzle, which is heavily making use of scientific results, only with time we will know how beneficial it is for the local people in adding knowledge and understanding. The current testing revealed that the margin for increasing knowledge on the area and sustainable behaviour is still wide. In this context we like to add that we consider enhanced map reading abilities to be a prerequisite for participating self-assured in any forest management planning activity.

6 Conclusion

All in all, environmental education and thus forest conservation in the Kakamega-Nandi forests area can greatly benefit from the developed environmental education tools. The tools can serve as an informal entry into environmental education and enhance and relieve communication between different groups about the forests. The integration of geodata in the tools will also increase the contact of local people with maps and therefore an improved map reading literacy among the locals and stakeholders will become likely.

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