A pictorial approach to geodesign: a case study for the Lower Zambezi valley.

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Abtract
This article shows how experiences with geodesign in data rich environments such as the Netherlands and the UK can be used to design an approach for interactive workshops in the Lower Zambezi valley, Mozambique. Instead of a model based application that provides real time response to proposed changes, a tool was developed that facilitated open discussion and relied heavily on visualization. This approach required no calculation steps (the local stakeholders provided the input) and relied heavily on drawing and use of icons. This appealed to the participants and the absence of a quantitative model was not seen as a problem. Despite the simple strategy, the tool served its purpose well. It was interesting to observe that was possible to use the principles of our more sophisticated tools in an approach that was simpler, but also much more graphical in order to promote discussion and understanding.

Introduction
Computers get faster, models more sophisticated and human-computer interaction more flexible. These developments lead to a drive for sophisticated tools that perform calculations in real time to produce detailed quantitative results. This is fine if you have plenty of time and money, know exactly what is required and have lots of data. But even then, having a sophisticated model is frequently at the expense of flexibility, which prevents adaptation to changes in problem definition or unexpected ideas of participants. This is even more the case if problem definition is vague, spatial data are of mixed quality and skills of participants are unknown.

Combining expert knowledge with local knowledge in collaborative workshops is becoming common in land use planning. In the past, planners presented their information on large hard copies of maps and used sheets of tracing paper to add stakeholder information to the map (Burrough et al., 2015). The arrival of Geographical Information Systems (GIS) replaced the transparent maps by map layers presented within a GIS on a computer screen (Longley et al., 2010). In recent years involvement of stakeholders has increased. In the early years, the emphasis was on communication; in later years this shifted to participation where active

involvement of stakeholders was required (Sieber, 2006). At present, the focus is on collaboration: stakeholders actively working together to reach the best result. Support systems such as participatory GIS (PGIS) and public participation GIS (PPGIS) evolved along with this development (Balram et al 2004; Dragicevic and Balram 2006; Geertman and Stillwell 2009; Alexander et al 2012; Dias et al 2015). This typically involved map-based tools to support group work and collaborative tasks (Alexander et al 2012; Arciniegas and Janssen 2012; Carver 2003; Jankowski 2009; Zellner et al 2012). Parallel to this process has been a movement to combine the sketching approach common in landscape architecture with numerical analysis available in GIS (Bishop 2013; Dias et al 2013). This combination has recently been labelled "Geodesign" and is defined as follows:

"Geodesign is a design and planning method which tightly couples the creation of design proposals with impact simulations informed by geographic contexts, systems thinking and digital technology "(Steinitz 2012, p.12).

This article demonstrates how experiences with geodesign in data rich environments such as the Netherlands (Janssen et al 2014) and the UK (Alexander et al 2012) can be used to design an approach for interactive workshops in the Lower Zambezi valley, Mozambique. Instead of a model based application that provides real time response to proposed changes, a pictorial geodesign tool was developed adopted that relied on a combination of drawing, use of icons and visualization to facilitate interaction with the participants. The approach required no calculation steps and relied heavily on input provided by the local stakeholders. Interactive tools, such as "greenmap" (http://www.greenmap.org/) use icons to identify issues on a map, are relatively common. Similar approaches to support valuation and evaluation are a new development in this field.

Stakeholder workshops were conducted in Tete, Songo and Caia ; three regions considered representative for the whole Lower Zambezi Valley ((Figure 1). The workshops focussed on collecting local knowledge and spatial preferences within the framework of the ongoing regional authoritative land use planning. This planning initiative was commissioned by Ministry of Environment and is coordinated by the *Agência de Desenvolvimento do Zambezi* (Zambezi Development Agency) in order to develop the Special Spatial Plan for Tete Province (PEOT), this plan will be embedded in the Mozambique law that will constrain and potentiate future spatial developments. The objective of these workshops was to collect local knowledge, to identify if and where conflicts between sectors may occur and find ways to address these conflicts. As the program required travel from the Cahora Bassa in the North East to Caia in the South West, it was decided to leave the heavy (60 kg) Samsung Sur40 touch table at home and to use the more portable Lenovo Horizon (27'').

Figure 1 Lower Zambezi Valley

The next section describes our geodesign tool. The results of our workshops are described in section 3 and conclusions are presented in Section 4.

2. Geodesign Methods

Value maps

Geodesign tools provide the interface between stakeholders and spatial information (Eikelboom and Janssen, 2015a; 2015b). The tool is based on the concept of a value map. Valuation consists of transforming an attribute map layer into a standardised value map. A value map is a combination of the attributes of the region with a value function representing the value judgements of the stakeholders. A value map also requires clear spatial units to represent the values on the map. Figure 2 shows an example of a value map. The map shows the value for agriculture for each parcel in a region in the South West of Friesland, The Netherlands. For each parcel (the spatial unit) the underlying attributes, ground water level and soil type, are translated to a value for agriculture using a value function combining these attributes.

Figure 2 Value map agriculture, south east section Grote Veenpolder, The Netherlands

The figure below shows how multiple value maps can be presented as symbols on top of any background map (See also Janssen et al 2014).

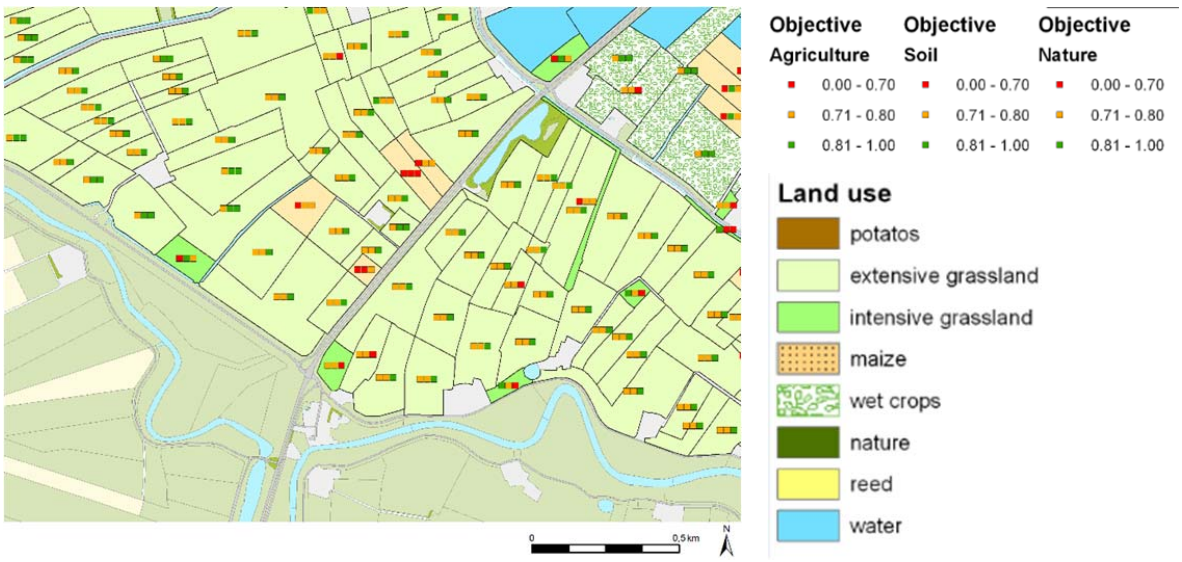


Figure 3 Values agriculture, soil and nature, south east section Grote Veenpolder, The Netherlands

The pictorial value maps

The pictorial value map tool uses the same principles as the value maps described above. The tool does not require a predefined spatial unit such as the land parcel in the example above. This is important in studies where no clear spatial unit can be linked to the underlying attributes and the categories to be valued as is the case in our study of the Zambezi valley. At the basis of our tool is an extensive collection of map layers available from the project's WebGIS (Figure 4). A standard drawing tool is used to allow participants to draw the spatial units to be valued. In the

Zambezi case these units represent the areas considered relevant for the developments of the various sectors.

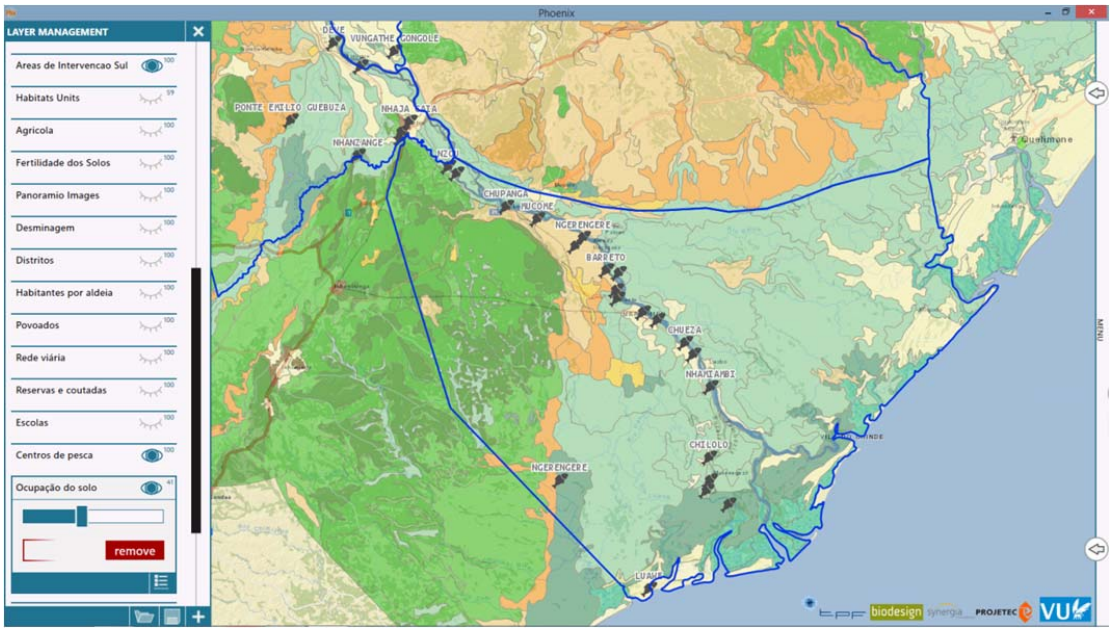


Figure 4 Sectors and map layers.

Next step is linking a value to each sector. As in a standard value maps this value is derived from the underlying map layers. However, instead of calculating these values, an expert assessment is made of these values. Participants, using the same underlying map layers, can accept or change these values. The tool developed includes a library of icons representing all the sectors (Table 1). Participants can add or delete an icon or move them around on the map. Participants can assign a value by selecting green (high) yellow (medium) or low (red).

Table 1. Sector icons

	Farming (Commercial or subsistence)
	Community development
	Conservation
	Energy
	Fishing (Commercial or artisanal)
	Forestry
	Maritime transport
	Mining
	Tourism
	Wildcard
	High, Medium, Low

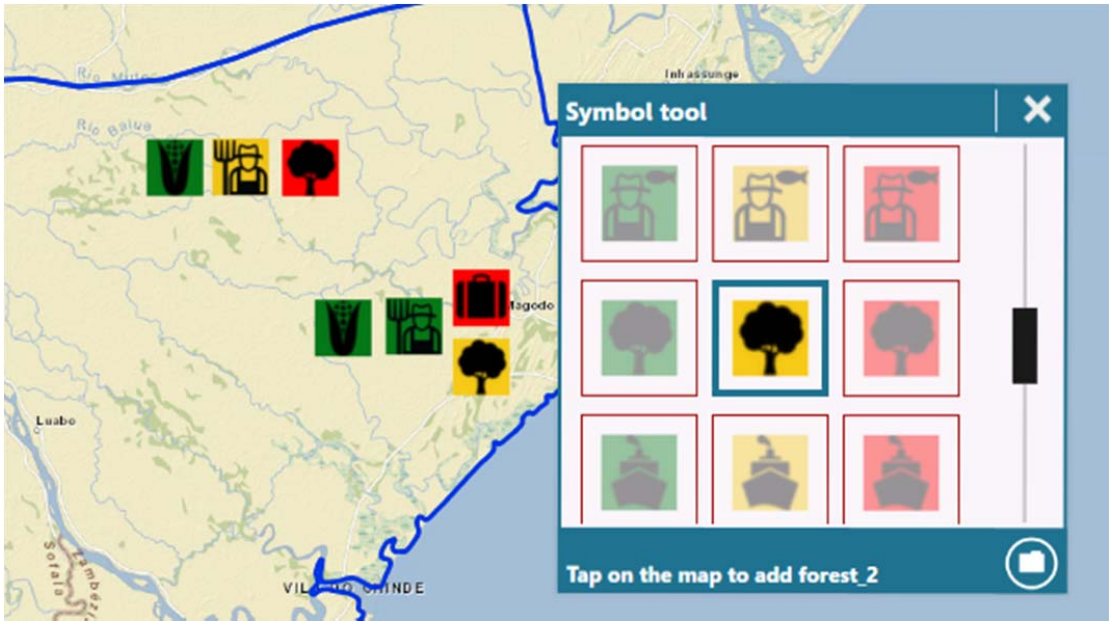


Figure 5 Use of sector icons for valuation and ranking.

Participants can also ranking the sectors by moving the icons around on the screen. Figure 5 shows that on both locations Commercial agriculture has a high claim (green) and has priority over the other claims. The claim of forestry is considered low (red). In the southern location the forestry claim ranks equal with the tourist claim.

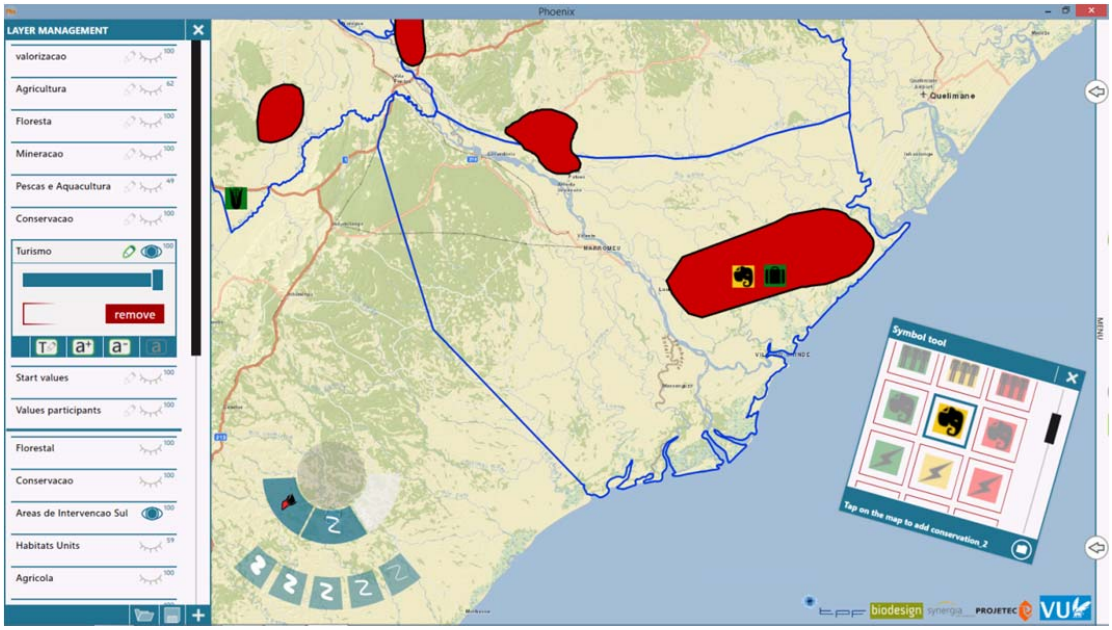


Figure 6 The interface of the geodesign tool

The tool requires use of a touch screen. For our study we used the Lenovo Horizon (27'') . The tools are implemented in Phoenix, a software package developed by GEODAN to support visualization (http://www.geodan.com/products/phoenix/ last accessed 01-10-2015). Figure 6

shows the various elements of the interface used. Access to all map layers on the left. The icons tool on the top right and the drawing tool at the mid-right. Selection of background map, drawing, selecting and moving icons are all touch operated.

3. Interactive Workshops for the Zambezi valley

The workshop design and implementations described in this paper were carried out within the scope of the public participation activities of an ongoing planning process in the lower Zambezi. This work, commissioned by the Agency of development of the Zambezi valley (ADVZ) and the Mozambique Ministry for Land, Environment and Rural Development (MTADR, formerly known as MICOA), will deliver new (spatial) regulations in the form of a legal framework and spatial plan that should enable the sustainable development of the economic sector, protect the environmental aspects and overall social well-being of the inhabitants. This planning process will deliver the instruments Multisectorial Plan (PM), Spatial Plan for the region (PEOT) and Digital Model tools (MD). For all the components, there is a public participation process that includes institutional consultations, open hearings and the core of this research interactive spatial planning workshops to uncover local spatial issues and solutions in the region. The Lower Zambezi Valley, is located in the centre of Mozambique and occupies an area around 150 thousand km^2. It extends through the whole province of Tete and partially through the provinces of Manica, Sofala and Zambezia. The Zambezi is the largest river in Mozambique and the fourth largest in Africa. It runs through distinct landscapes within Mozambique, from mountainous regions in the north-west to low altitude plains and Zambezi delta close to the coast. The extent of the region involves different landscapes and climates that condition the occurrence of different vegetation, soil types and land cover. This means that the different regions face different challenges and opportunities such as biodiversity and ecosystem protection in the delta and agriculture suitability at the flooding plains. The region is inhabited by 3,5 million residents from diverse socio-cultural backgrounds with a large rural population performing subsistence agriculture. In the north is the Cahora Bassa hydroelectric facility which delivers a substantial share of the Tete regional GDP, while in the Zambezia province the largest economic contribution is from commercial agriculture. Especially the north is rich in mineral resources. The development of megaprojects for coal exploration in the Tete province and additional hydro resources exploration may deliver an additional economic boost, depending on the alternative scenarios implemented for the regional development within the framework of this study. The megaprojects include large-scale coal mining in the Tete region (expected to increase from the current yearly 4 million tons to 20 million tons per year before 2018); the expansion of hydropower generation, and irrigation projects following irrigation demand within a changing climate (World Bank, 2010). These intense economic activities attract job seekers and accelerate urbanization. Additional challenges include threatening the already vulnerable ecology of the lower Zambezi delta, a RAMSAR site (Hoekstra, 2003), and its associated prawn fisheries (Hoguane and Armando, 2015). These developments call for an integrated and collaborative planning environment where local knowledge of sectorial stakeholders may play a crucial role in understanding the developments, trends and opportunities, but also potential local impacts of the different choices of future land uses.

Workshop objectives

Three sectorial workshops were conducted in the Zambezi valley in May 2015. As the whole of the region is far too big to get local people involved these workshops were on a regional scale. This makes it possible for the participants to use their local knowledge to provide input. Objectives of the workshops were to : 1. communicate sectorial claims; 2. identify matching and conflicting claims; 3. find ways to match claims and 4. prioritize claims if matching is not possible. To cover the full range of sectorial claims three intervention areas were selected for the workshops: 1. Songo (north) with sectorial claims of conservation, rural development and tourism. 2. Tete/Moatize (centre) with sectorial claims of the mining sector, agriculture and hydropower and 3. Caia (south) with claims of fisheries, conservation navigation and agriculture. The three workshops covered the full range of sectorial conflicts. In this article only the third workshop is described. The map below (Figure 7) shows the intervention area of the third workshop.

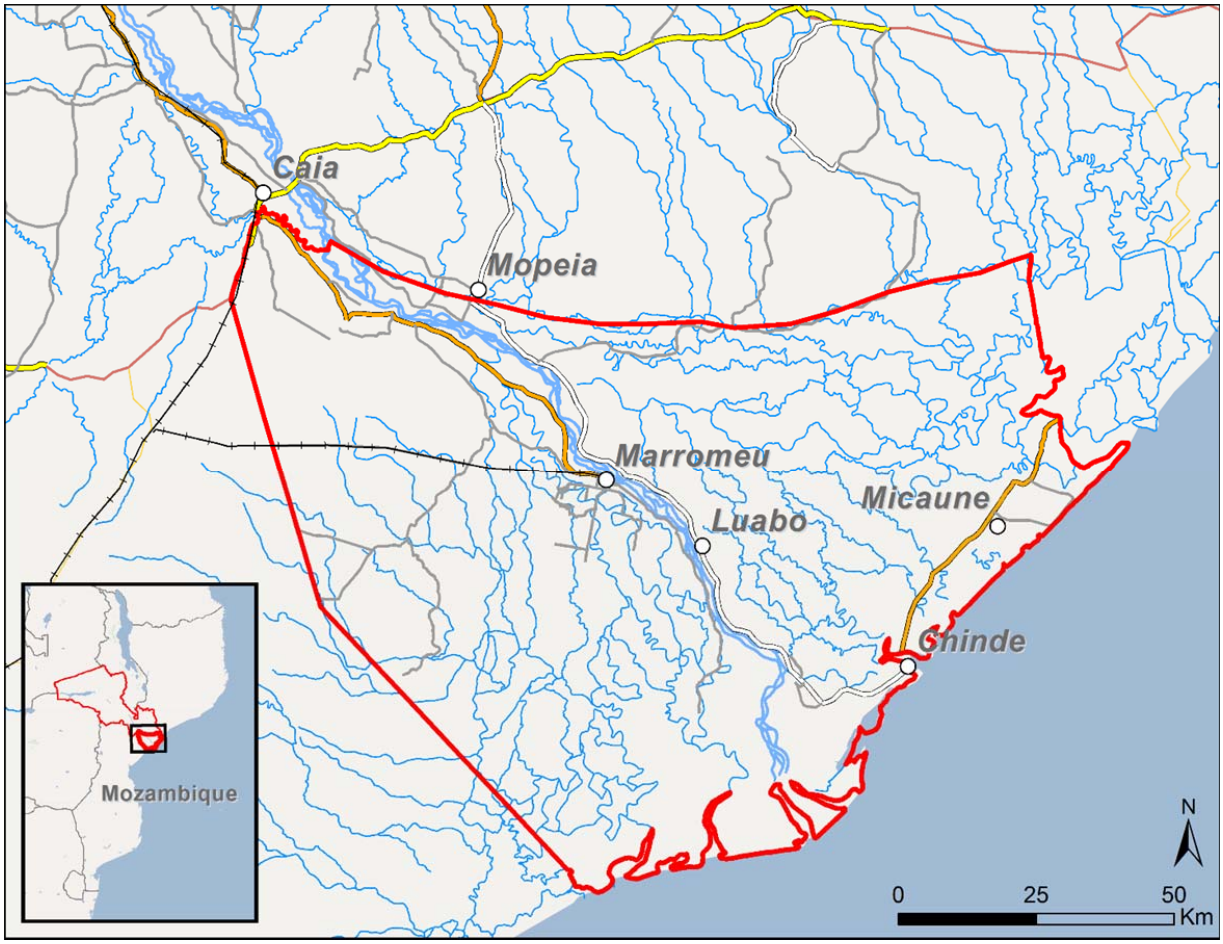


Figure 7 Map of the Caia workshop intervention area

Workshop set up

The local partner invited relevant participants to contribute local knowledge on the sectorial claims. It was important that the participants were sector stakeholders and experts from the region in order to give insight into claims strengths and solutions. Although this need was communicated and agreed with the partner, the invitations were (unexpectedly) mainly addressed to the planning sections of the local districts. While some sector representatives were indeed present, the list of participants for all workshops does suffer a bias from the sector expertise to local planning expertise. This can be assumed a limitation in this study where in such participatory approaches the quality and completeness of the outputs is always limited by the knowledge of the participants. Still the planning professionals who participated did reveal intrinsic knowledge from their region and acted as surrogates for the sector expertise as they are the ones dealing with sector implementation in the districts and showed understanding of the claims, potentials and conflict between sectors. As the participants did have local sectorial knowledge of all sectors the composition of the group participants seemed no problem to the testing of the methodology.

Figure 8 Participants at work in the Caia workshop

The workshop took place in the local government (district of Caia) conference room (Figure 8). It included 18 participants from various backgrounds (Figure 9). The workshops lasted half a day and had the following program: 1. Warming up; 2. Introduction to the area; 3. Drawing sectorial claims; 4. Valuing overlapping claims; 5. Ranking overlapping claims and 6.Wrap up

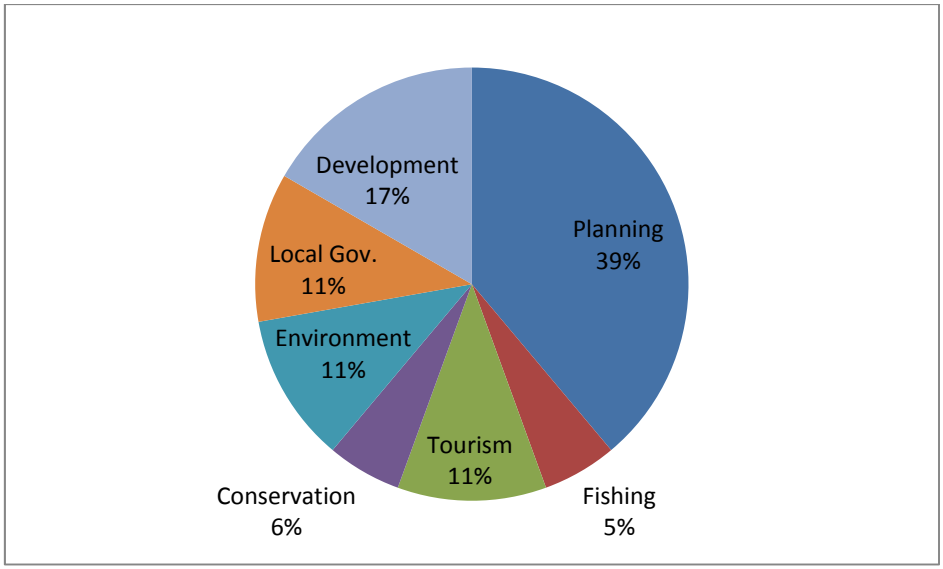


Figure 9 Stakeholders (N = 18) segmentation per sector

Warming up

As a warming up exercise, participants were invited to imagine the area in ten years' time, to write down their dreams and nightmares ("*Sonhos e Pesadelos*") for the region on post its and stick the post its on the wall. This generated a lively discussion on the region. The dreams and nightmares were clustered around three main topics. From the discussion in Caia, the topics that emerged were infrastructure, environment (with food production) and civil protection (with legal framework). It was interesting to note that most of the dreams were linked to infrastructure development of the region, while most nightmares concerned the loss of ecosystems and nature values. So the participants are very aware that they desire the economic development of the region but within constraints set by the environment. As runners-up. sustainable and secure food production was also mentioned as a dream while the nightmare was the inefficacy of legal planning instruments leading to unsustainable growth.

Introduction to the area

Photographs representing the area were presented in order to stimulate discussion about the needs and perceptions of the local participants. These photographs were geo-referenced and presented in a 3D interactive map that allowed to situate each photograph in its geographic context. After a short introduction to the area the moderator flies to the first photograph location and opens it. The photographs illustrated potential issues, needs or daily life that stimulated discussion around topics such as accessibility (boat transport), wildlife-human conflicts (crocodile attacks), road constructions, water supply and food security. The photographs supported that the story of the area was told by the participants.

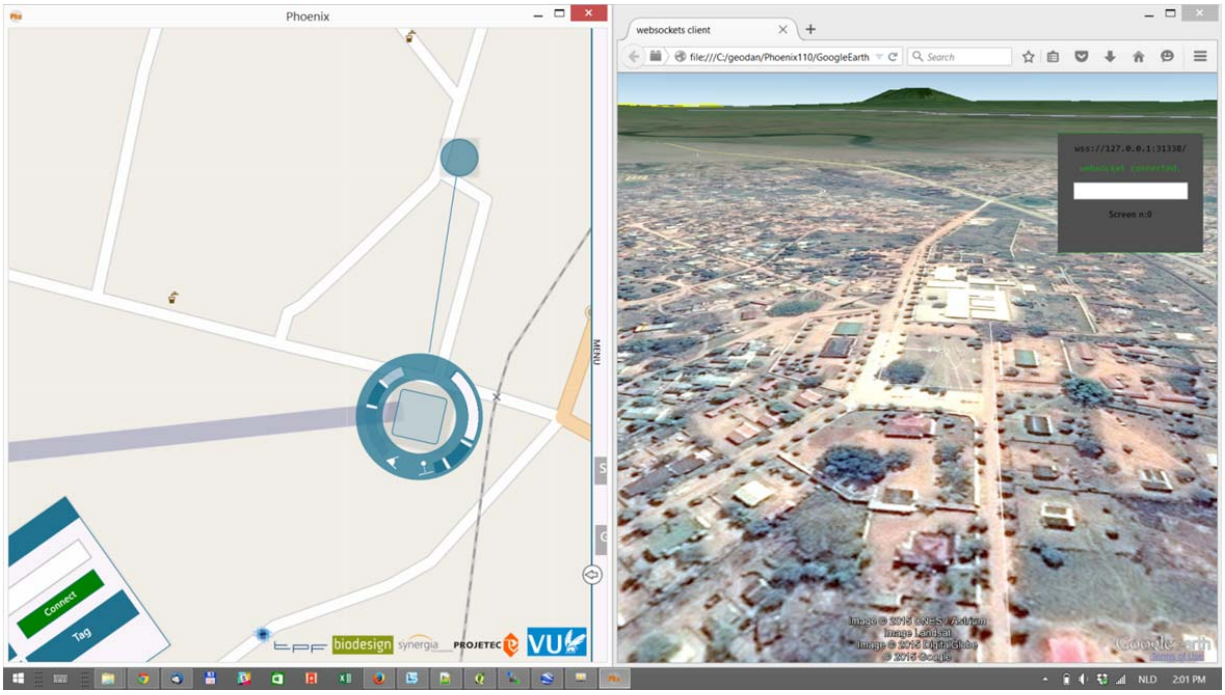


Figure 10 Use of the 3D map viewer

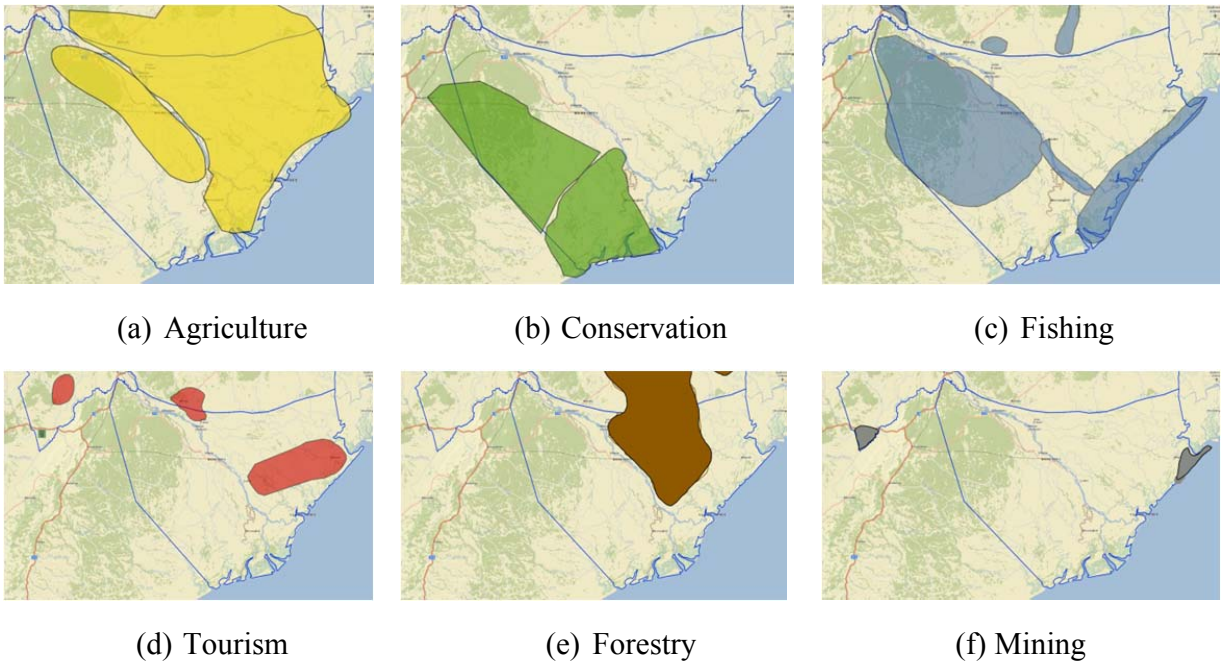
Table 2. Photographs presented in the workshops, summary of comments by participants

1		Participants commented that this is the type of road they desire for the region to increase accessibility.
2		This photograph started a discussion on illegal hunting and the lack of awareness of the laws and restrictions. The participants mentioned that illegal hunters endanger themselves and the animals (they actually suggested creative initiatives to raise awareness among local populations). It also lead to a discussion about animal rights, where the Mabeco is an endangered species in the region and they proposed to revise the law to secure Mabeco conservation.
3		The river photograph with hippos is another example of man-wildlife conflict. It was mentioned that hippos invading the "machambas" (family vegetable gardens) in the river banks is a serious issue. The hippos go as far as 200 m into the farmed area. Projects are set up with local government to keep hippos away from family farms.
4		Participants saw the flamingos as a symbol for birdwatching in the region and discussed if tourism in the river banks can actually be sustainable and if law can be improved to secure conservation. Ideas were discussed.
5		The water pump was a reminder that there are still challenges in the access to water for the population. And that basic needs need to be met.
6		A destroyed and abandoned sugar factory where 10,000 people lost jobs due to its closing.

This simple step of presenting photographs was an effective way to continue the warming up and inciting the participants to think in terms of needs from the sector and its relation to the liveability of the area. Full account of the discussions and ideas generated are available in the project public participation report (http://zambeze.pt/)

Drawing sectorial claims

As a first step participants from each sector were asked to identify the regions of importance for the development of their sector. This was done by drawing on the map Some participants used the background layers as reference to locate the important areas for their sector. Map layers used were soil suitability combining soil type, fertility and irrigation potential, current national parks and reserves, land use, infrastructure, population density and villages. The important regions were drawn one by one by the different participants using a different colour for each. Using different drawing layers allowed to hide each sector results so that the participant were free to choose the areas they really found important independently of the areas of the other sectors.



(a) Agriculture (b) Conservation (c) Fishing

(d) Tourism (e) Forestry (f) Mining

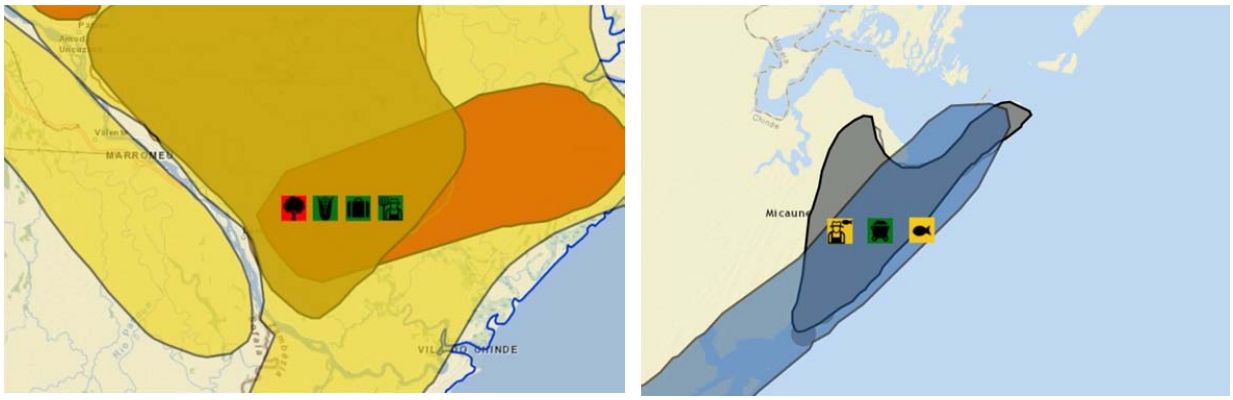
Figure 11 Spatial extent of the sectorial claims.

The participants claimed large areas as important for agriculture (fig 11.a), noteworthy is that they indicated most of the delta region as important for subsistence agriculture (polygon on the right), while in the polygon on the left (Marromeu district) they noted that commercial agriculture is taking place due to the presence of a large agriculture company, *Companhia de Sena*, that provides economic development and jobs in the region. Conservation claims were largely linked to existing reserves. For fishing (fig 11c) a claim was made along the whole coast for both artisanal and commercial fishing and along the Zambezi river and Deda lagoon in Mopeia, for artisanal fishing. For tourism (Fig 11d) the official Wildlife Utilisation Areas

(coutadas), and the reserves of Maimba and reserves in Micaune, Luabo and Chinde were selected. In addition to the existing reserves the participants drew the areas of Sangalanzi and the river Maimba, on the northeast of Mopeia. For forestry (Fig 11e) the areas of *Caocha* and *Magodo* in the districts of *Luabo,* from *Mugurumba* until *Maimba* in the Chinde district and finally on both sides of the National Road 1 *Mopeia* and *Morrumbala* were considered important. Participants also outlined a forest reserve already present in *Nhamitanga*. Finally for mining (Fig 11f) "heavy sands" mining which is already in exploration from the village of *Deia* running along the coast to the area of *Abreus* and the area around *Micaune* were drawn on the map. While discussing the claims maps, an important discussion emerged over the conflicts between tourism and conservation, and more specifically, the conflict between sports hunting and poaching in the area. It was also mentioned that ongoing researches about the availability of hydrocarbon (oil and gas) in this region may undermine conservation efforts.

Value overlapping claims

After identifying the land claims for all sectors the sector layers were overlaid to identify overlapping claims. Overlap between two or more sectors was an indication of a potential conflict or synergism between sectors. Next the participants were asked to value these overlapping areas in terms of its potential for the development of the sector by placing an icon representing the sector with a specific colour that revealed the strength of the claim (I.e. the potential of that land for the development of the sector). This "value of the claim" was discussed and agreed by the participants. It was at this moment also independent of other sectors. Participants only valued the regions with potential conflict. Regions claimed by only one sector were not valued since the goal was to identify regions of conflict/synergism and possible solutions (prioritization).



(a) (b)

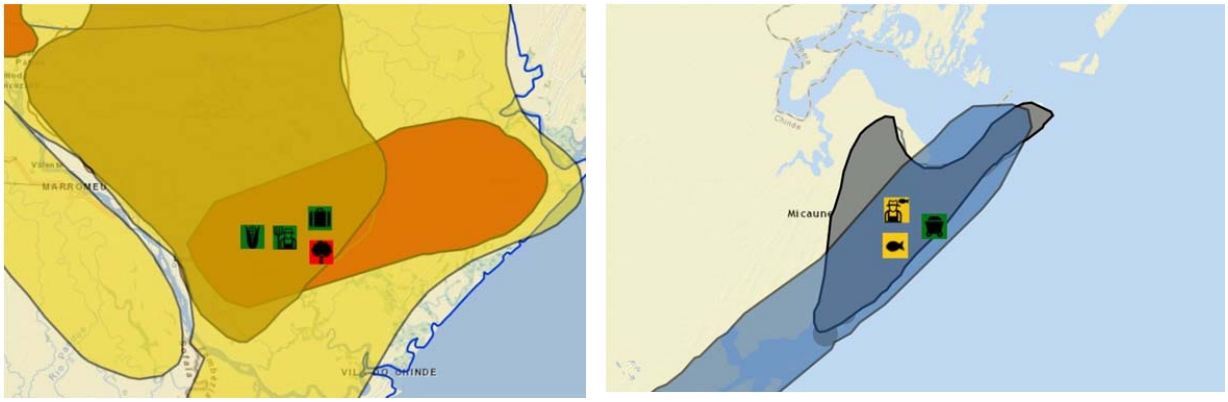
Figure 12 Valuation (a) and ranking (b) of the sectorial claims in the overlapping regions.

The assignment continued on until all the overlapping regions were valued by the participants. As expected most claims in the overlapping area weres valued high (green). The exception is the low value for Forestry in Fig 12(a). Although there is considerable forest in that region (forest

cover classes mainly from 25% to 50% and in part of the area even 50% -75%), participants assigned a low value because they considered the commercial and development potential to be low.

Ranking overlapping claims

In the subsequent step, participants ranked the claims. This identified the land use priorities for future planning. The ranking was an independent step from the valuation. This was done under the assumption that if a region has high potential for a particular sector, it does not necessarily mean that the people of the place want to develop that sector there. It was than possible to identify sectors that have medium or low potential in a region, but still be preferred by the participants. Participants ranked the claims by moving the icons around on the map. The ranking was done under moderated group discussion once the participants agreed on the most important sector, the second most important etc. If two sectors were considered compatible no preference needed to be expressed. The two icons were then placed above each other. This was done for all regions with overlapping claims. .



(a) (b)

Figure 13 Valuation (a) and ranking (b) of the sectorial claims in the overlapping regions.

Figure 13a shows co-existence of commercial farming (coconut plantations) and subsistence farming (family farms in between the coconut trees). This was seen as an example of peaceful and synergetic relation between commercial and subsistence agriculture. Figure 11b shows fisheries ranked before mining. Even with mining as a high potential, the participants reminded that artisanal fishing and subsistence farming are crucial for the local population so should be ranked first. It was mentioned that the co-existence of fishing (industrial or artisanal) with mining (heavy sands) is not possible. Due to the high risk of contaminations raised by the mining activity. The participants also noted that the population in this area survives mainly (and mostly) from artisanal fishing and subsistence agriculture. Therefore, the participants acknowledged the financial benefits of mining for the region, but noted that the development of the mining sector within (or in the vicinity) of the areas needed for the population may generate large impacts in

the local way of life. A similar discussion occurred in relation with the artisanal (subsistence) fishing that occurs mainly very close to the coast, while commercial fishing explores “high-seas” resources enabling in this way also coexistence. Figure 14 shows valuation and rankings for all overlapping regions. This map in combination with the comments made in generating the map is the final product of the workshop.

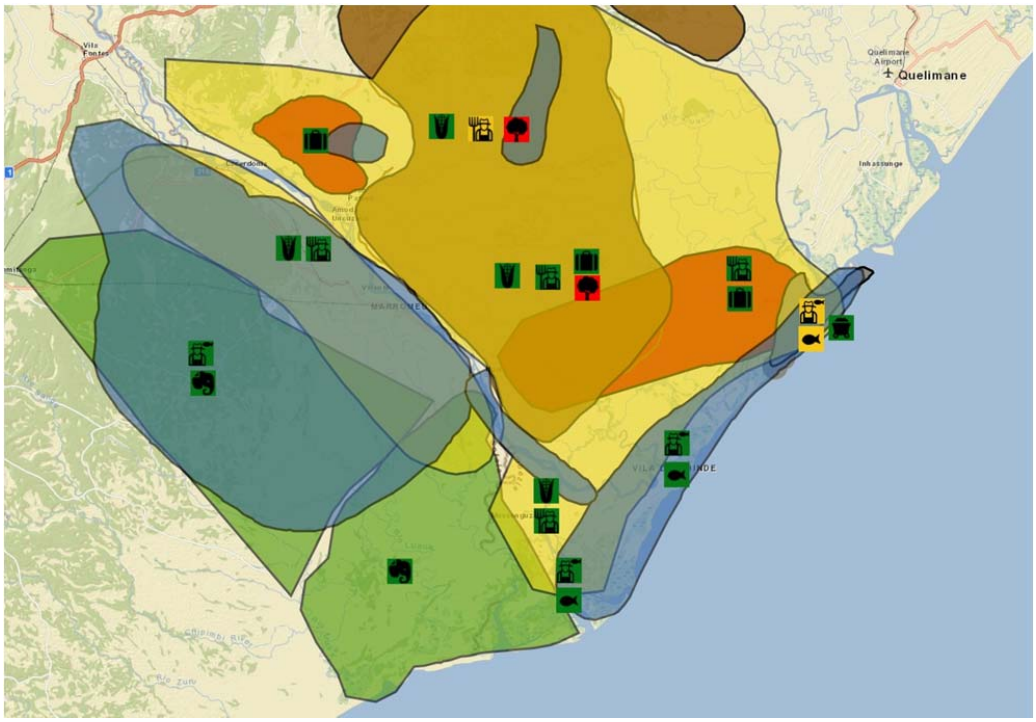


Figure 14 Value and ranking of the sectorial claims

The rankings presented in Figure 13 are also found in Figure 14. In the left of the map the green icons of conservation and artisanal fishery are above each other to indicate that both sectors can co-exist as according to participants local fishermen do not disturb conservation efforts. To the north-east of this example commercial agriculture is ranked higher than subsistence agriculture. This result is in contrast with ranking from the previous workshops where participants mainly place subsistence agriculture and local development as first priority. Here the participants recognize a long standing commercial agriculture activity (carried out by the large company *Companhia de Sena*) that contributes to the economic development of the region. The map also shows that in the south east commercial and subsistence agriculture are expected to co-exist (equally ranked) since it is an area where it is possible commercial coconut plantations which enable subsistence agriculture in between the coconut trees. This assignment facilitated the discussion among the stakeholders in finding ways to match the claims (synergism) and to prioritize claims if matching was not possible.

4.Conclusions

This article described our experiences with a pictorial approach to support planning workshops in the Lower Zambezi valley. Instead of a model based application that provides real time response to proposed changes, a tool was designed that facilitated open discussion and relied heavily on visualization. Direct interaction with the maps worked really well and prompted input from a wide range of participants. Some participants had difficulties navigating in the map. This was solved by adding all village names and a detailed road network to the map. The participants appreciated the innovative aspect of the tool and method, asked to receive the final product and indicated that they would be willing to participate in a follow up workshop. .

This pictorial interface appealed to the participants and the absence of a quantitative model was not seen as a problem. The workshops produced maps for each region representing the groups' assessment of the sectorial claims in combination with all the comments and discussions. The absence of an underlying model provided flexibility in definition of region borders, attributes to be used and sectors to be valued. In this example this flexibility was much needed and outweigh the absence of more precise estimates of the sector values. This was a typical case of "less is more". Despite the simple strategy, the tool served its purpose well. It was interesting to observe that we were able to use the principles of the more quantitative tools in an approach that was simpler, but also much more graphical in order to promote discussion and understanding. A clear limitation is that the results are based on the knowledge of the people present. The limited number of sector representatives is therefore unfortunate. Other participants might have produced different results. Participants were happy to interact with the tool which was supportive in engaging the participants and generating a sense of joint ownership of the results. A clear advantage of the approach that the icon maps provide output that is a shared product of the whole group and can easily be used by the planners.

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