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Linking participatory and GIS-based land use planning methods: A case study from Burkina Faso

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ABSTRACT

Sustainable land use planning is crucial for realizing the aim of food security and for combating land degradation in the Sahel. A participatory land use planning workshop was organised in a village in the eastern region of Burkina Faso to investigate land use problems, their causes, effects and possible solutions. Participatory research tools and GIS were combined to get insight into possible conflicts or synergies between different land use options as mapped by different ethnic groups. Pictograms were used to locate alternative land use options on the map, after which they were digitised for analysis with GIS. The workshop confirms the importance of integrating scientific and local knowledge to develop concrete options for sustainable land use that fit to local realities and aspirations. Local people are knowledgeable about the driving forces behind land degradation, they take actions to combat the effects of degradation, and they have concrete ideas about alternative land use options. The use of GIS proved its added value in the participatory process of integrated land use planning. The maps that were produced also facilitate discussions between community members, researchers and government representatives at the regional level, both regarding current land use problems and regarding alternative options as perceived by the local population.

Introduction

Due to several reasons, such as climatic variability, low soil fertility and population growth, food security problems are a major issue in sub-Saharan Africa. The Sahel was hit by disastrous droughts in the 1960s and 1970s, sparking the concept of the Sahara desert advancing into the Sahel region, and bringing the region to the forefront of scientific interest (Hutchinson et al., 2005). Although it has later been shown that these ideas about desertification where not correct (Thomas, 1997; Herrmann and Hutchinson, 2005), that the droughts of the 1970s were part of climatic variability (Tiffen and Mortimore, 2002; Le Houérou, 1996), and that there has been a 'greening' of the Sahel since the 1980s (Hutchinson et al., 2005), these droughts of the 1970s showed the fragility of the region both in ecological and economic terms. Likewise, although claims of soils being depleted cannot always be substantiated with evidence (Vanlauwe and Giller, 2006; Mazzucato and Niemeijer, 2001), Heerink (2005), for example, showed that, because of population growth, per capita food production has decreased despite increased yields. Thus, although it has been shown that degradation in semi-arid areas is not as widespread as is sometimes claimed (e.g. Thomas, 1997), semi-arid areas such as the Sahel are fragile, and food security is not assured.

In attempts to prevent food shortages, considerable effort has been devoted to strategies for increasing agricultural production. This is being achieved by an expansion of cultivated area, as well as by higher productivity per unit area. The need for new agricultural land has been a strong argument for the extensive clearing of natural vegetation. This, however, could result in widespread environmental degradation. As Sidibé (2005) noted, reducing soil degradation is needed to increase agricultural production. There is clearly a need to develop an integrated approach towards sustainable land use planning that involves and balances agricultural production objectives and environmental concerns.

The VINVAL project was motivated by the concern over the current pace of land clearing in West-Africa, driven by the need to

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Table 1
Land use (%) in the three research catchments.

	Agricultural land	Fallow land	Natural land
Sambouali	0	23.3	76.7
Bounou	25.2	28.5	46.4
Diamanga/Tanyelle	57.9	17.4	24.6

exploit land for food production. In Ghana, for example, the forested area decreased from 31% to 8% of the land surface between 1977 and 1987, and currently 2% of the forested area is cleared per year. The deforestation is 90% for agricultural purposes (Asubonteng and Otoo, 2002). In Burkina Faso, natural forested area is reported to have decreased from 52.6% to 16% of the land surface area between 1983 and 1990 (FAO, 1983, 1995; Ouedraogo, 2001). These developments in land cover change have also raised the concern whether the land, be it in natural condition or cultivated, can continue to hold its environmental functions needed to sustain the use by man.

The VINVAL project aimed to contribute to sustainable land use planning, its overall objective being to develop a new method for integrated land use planning at watershed scale that contributes to improved sustainable agricultural production systems in small catchments in West Africa. It is increasingly being recognised that local farmers around the world are usually very well able to manage their lands in a sustainable way (Mazzucato and Niemeijer, 2001; Tiffen and Mortimore, 2002; Altieri, 2002; Muchena et al., 2005; Herrmann and Hutchinson, 2005). A participatory and integrated research approach is advocated that links scientific and local knowledge. This does not mean that local knowledge should be accepted unquestioningly by researchers, but that there is a need to integrate knowledge within and between researchers and local communities (Reed et al., 2007). In this way, both researchers and stakeholders learn (e.g. Hoang Fagerstrőm et al., 2003). Sustainable land use can only be achieved with input from farmers, development workers and researchers (Defour, 2002). The VINVAL project involved these groups as well as policy makers in its research activities. Part of the land use planning method developed by this project consists of GIS-supported participatory land use planning at village level. A workshop was organised in Bounou, a village in the eastern region of Burkina Faso, with participation of residents of three other villages. This workshop aimed to facilitate and enhance the discussions about alternative land use options within these communities. The aim of this paper is to describe the method used for the village workshop, and to evaluate the added value of the use of GIS for participatory land use planning.

Study site

The research villages were located in three small watersheds in southeastern Burkina Faso (Fig. 1). The sites were situated in the Gourma province, in the southern Sudanian Savannah zone. This zone is characterised by 800–1000 mm of annual rainfall, a single rainy season from May till September, a substrate consisting of phyllites and granites, and an undulating relief with remnant laterised shields. The three catchments had similar climate, hydrology, type of vegetation, morphology, etc. but were different with respect to soils, land cover and land use intensity (Table 1). Land use intensity was low in Sambouali, medium in Bounou and high in Diamanga. The vegetation in all three watersheds consists of bushes, cropland, grass and isolated trees. With increasing land use intensity, the more natural vegetation, especially around the villages and in the valley bottom, is replaced by agricultural land.

Soils in the area classify as Lixisols, Cambisols and Vertisols according to the WRB (World Reference Base) classification (FAO, 1998). Due to the absence of tectonic activity the areas have not been rejuvenated and soils have been strongly weathered and leached, and are poor in plant nutrients. The different degrees in land use intensity in the three watersheds influence some soil physical and chemical properties which are relevant to crop growth and to the natural vegetation. Soils in the study areas have high acidity, low fertility and locally sandy textures, which makes their suitability for agriculture problematic. The soil structure deteriorates with increasing land use intensity, resulting in increased bulk density and in lower porosity for high intensity use. This in turn affects, e.g. absorption of water and infiltration rate.

Water resources include – in order of importance – boreholes and wells, the Kompienga reservoir (lower part of Fig. 1), and rivers and streams. Water is used for domestic purposes, drinking water, and irrigation. In the dry period, water sources are not available in the research villages and villagers must get their water from neighbouring villages. An analysis of the annual water balance for the three watersheds showed that the main components of the water balance are rainfall (862 mm on average per year) and actual evapotranspiration by vegetation and crops (715–768 mm per year), and that water extraction and surface runoff are small compared to these components. The analysis also showed that there is a water balance surplus in all three watersheds, ranging from 94 to 136 mm/year, indicating that during years with average rainfall, there is enough water to grow a crop.

There was one village in the Sambouali and Bounou catchments, but there were two villages in the Diamanga catchment, namely Diamanga and Tanyelle. According to a census held in 1996 (INSD, 2000), the number of inhabitants of the different villages was as follows: Sambouali 330, Bounou 706 and Diamanga/Tanyelle 765.

The main ethnic groups represented in the southern part of the eastern region of Burkina Faso are the Gourmantché, Yamaa, Mossi and Fulbe. The eastern region is the traditional territory of the Gourmantché ethnic group, and the Gourmantché still form the largest group in the area (Mazzucato and Niemeijer, 2000). Mossi from the Central Plateau and Fulbe from the Sahel have joined them mainly through in-migration. Their in-migration sped up when drought struck the country in the mid 1980s. Agriculture is the main means of subsistence of the Gourmantché, Yamaa and Mossi, whereas Fulbe are agro-pastoralists. The Fulbe form the smallest minority. Main crops grown in the area are millet, maize, sorghum (red and white), groundnuts, cowpea and to a lesser extent rice and soya (Van den Berg, 2003). Cow peas and groundnuts are mainly produced for the market and represent a very important source of revenue for both men and women. Mossi migrants have recently introduced the production of cotton in the area. All ethnic groups collect forest products for a wide range of purposes. Independently of land use intensity, the cultivated area per farm is on average 1.9 ha and small compared to the average farm area (5.1 ha). Fallow periods range from shorter than 10 years to longer than 20 years.

Method

The participatory land use planning method used in the framework of the VINVAL project is based upon the socio-economic and gender analysis approach (SEAGA) developed by FAO (FAO, 2001) and consisted of two major phases: (i) diagnosis; and (ii) participatory land use planning. The diagnostic phase was conducted in the period June–August 2002 and aimed to analyse the socio-economic living conditions in the research villages and to assess their dependency on natural resources in the watersheds. To this end, a series of two rapid participatory diagnostic appraisals (RDA) was implemented (Van den Berg, 2003). The first appraisal was exploratory in nature and the second intended to get a deeper understanding of current land use and management. During and after the diag-

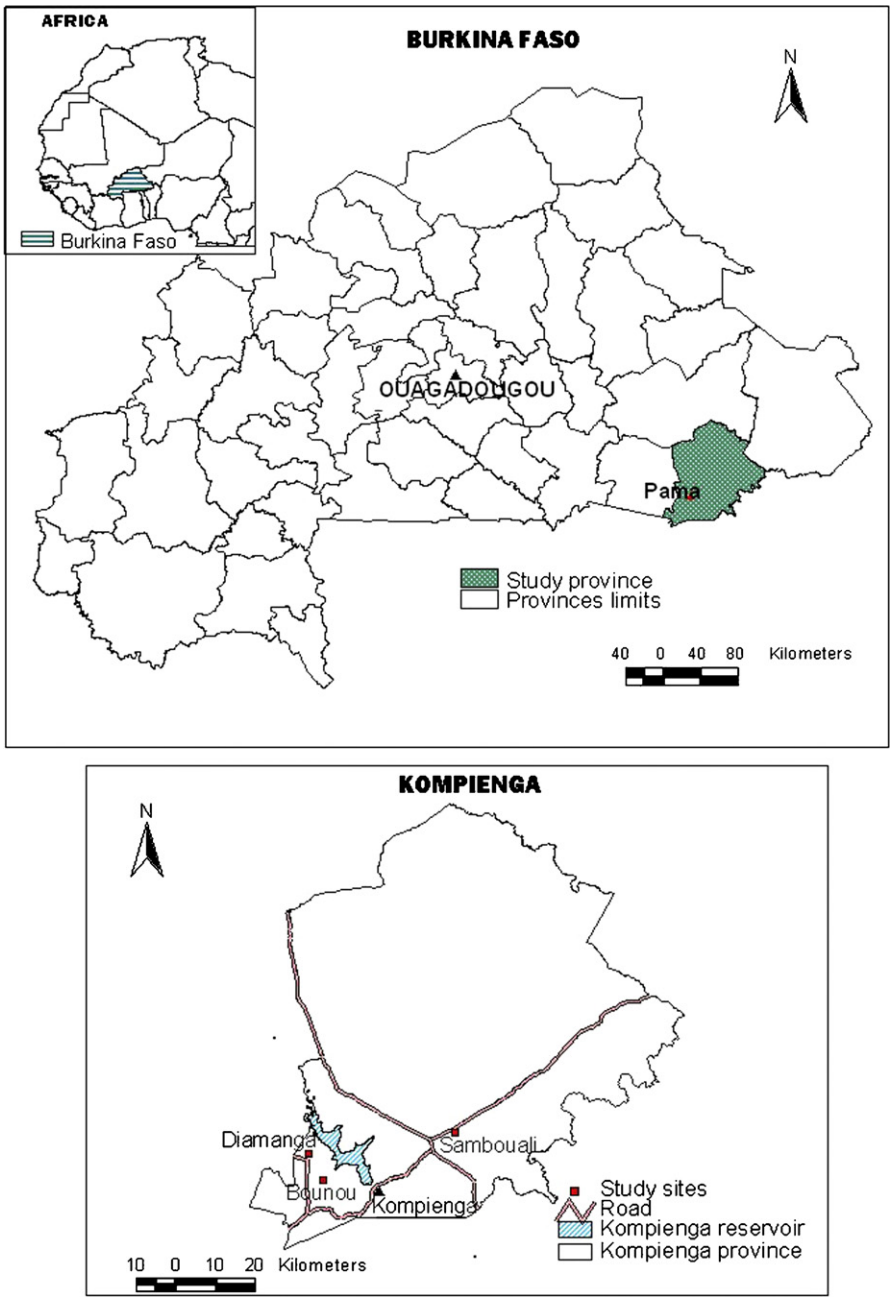

Fig. 1. Location of study villages.

nostic phase, relevant data on physical aspects were also collected, albeit not with participatory methods. A number of methods, ranging from obtaining and digitizing existing land use maps to the description of soil profiles and vegetation types were used.

The diagnostic phase was followed in September 2005 by participatory land use planning in Bounou with participation of representatives of the other three research villages with the aim to develop alternative land use options to address priority land use problems as perceived by the village inhabitants. The participatory land use planning phase consisted of the following five stages.

1. Sensitisation of community members

To prepare the workshop, several meetings were organised. These meetings were to inform inhabitants of the villages about the workshop and to explain why the workshop was organised. Also, in Sambouali, Bounou, and Diamanga, populations were sensitised to stimulate their participation to the participatory land use planning.

2. Training of field staff

To initiate the process of participatory land use planning, a training workshop was organised to introduce the researchers, community leaders and community workers to the basic concepts of participatory land use planning and different participatory planning stages and to explain the planning tools. A total of 20 persons participated in the training among which were four representatives of the pilot communities.

3. Identification of alternative land use options

In a two day village land use planning workshop in the village of Bounou, attended by community members, community leaders, community organizers and researchers, alternative land use options were identified to address priority land use problems. A total of 80 persons participated in the workshop, among which 15 women. To ensure active participation of all participants, the discussions were organised in separate focus groups according to age, gender and ethnic background (day 1) and according to interests and needs in the three watersheds (day 2). The workshop method consisted of four steps. The first focused on learning about the causes and effects of current land use problems, while the last two focused on planning for the future.

Step 3.1: To assess the existing situation

The first step focused on identification of the most important land use problems of different community members and aimed to learn about people's understanding of the causes and effects of land use related problems, as well as what they currently do to cope with such problems. This assessment of the current situation was done in separate groups according to ethnicity and gender. For joint problem analysis in these groups the following tools were used: pair wise ranking matrix and flow diagram (FAO, 2001). Discussions were facilitated by researchers, with the assistance of a local interpreter. Documentation sheets were completed for all group discussions by a note-taker. These documentation sheets allowed us to evaluate afterwards what went well, and what was difficult. Particular attention was paid to the level of participation of the different participants. These group discussions were followed by a discussion with all workshop participants on the priority land use problems, showing where different people's priorities overlap and where they differ. Particular attention was given to efforts to address a particular problem. These coping strategies represented the basis for identification of alternative land use options in step 3.2.

Step 3.2: To identify alternative land use options

This step built directly upon the joint problem analysis in step 3.1. Alternative land use options were developed with all workshop participants by building upon the solutions identified in the flow diagrams and coping strategies in a plenary session with all workshop participants.

Step 3.3: To identify synergy or competition between alternative land use options

This step was used to learn about synergy and competition between alternative land use options. A synergy–competition matrix was developed to define for each combination of two land use options whether these options could be combined (synergy), or whether they conflicted with each other (competition).

Step 3.4: To map alternative land use options

This step intended to stimulate discussions on spatial implications of alternative land use options developed by the workshop participants. Participatory mapping sessions were organised in focus groups composed according to the interests and needs of the participants in the three watersheds: Bounou, Sambouali and Tanyelle/Diamanga. The aim was to discuss the locations where specific actions could be carried out and to produce an integrated alternative land use map that represents the shared vision of all participants. Each focus group worked with a large print of a topographic map of the study site, and received a number of different pictograms representing land use options, to put on the map where they would like to employ that option. The land use options were based on the results of the diagnostic participatory appraisals in the villages (Van den Berg, 2003) and complemented with new options identified in step 3.2. These new options were written on pieces of paper, which were put on the map just like the pictograms. Some of the options mentioned by the participants were not mapped, as some could be combined with others that were identified and listed already.

Each of the pictograms placed on the map represented essentially a point. To convert this point into an area to which the focus group wanted to apply the land use option represented by the pictogram, each pictogram was assumed to represent a circle with a radius that depended on the option. This was deemed the easiest way to convert the point data from the focus groups into maps in which the different land use options covered different areas. The location of all pictograms was digitised using ArcView, for each focus group separately. The maps of the different focus groups were then overlayed two by two to identify areas in which both focus groups wanted to employ certain options. From the synergy–competition matrix (step 3.3), it was then determined for each combination of land use options whether they represented conflict or synergy.

Although the mapping of land use options was performed for all three watersheds, the analysis of synergy and conflict could only be performed for Bounou. The reason is that the workshop was held in Bounou, so that the number of participants was much higher for Bounou than for the other villages. For Bounou, there were 3 focus groups: A Fulbe ethnic group, a group of Village Elders (Gourmantché), and a group of Mixed ethnicity (Mossi and Gourmantché).

4. Feedback meeting

The results of the workshop in Bounou were presented to a larger audience at a subsequent feedback meeting. In this workshop, government officials and organizations working in the area participated, as well as the leaders of the four research villages. During this meeting, the method was explained, and the results were shown, including the results of the conflict/synergy mapping. The aim of this meeting was to inform organizations and government about the results of the VINVAL project, and about the results of the participatory workshop in particular.

5. Revisiting

A follow-up mission was organised in November 2007, to learn about the ways the inhabitants of Bounou, governmental representatives and other organizations working in the area have responded to the priority land use problems and alternative land use options as identified during the village participatory land use planning workshop. Activities focused on soil degradation (both erosion and soil fertility degradation) and uncontrolled grazing. For these two priority problems, what had happened since 2005 was assessed, why and with what impact. During the return visit, people from several organisations working in the study area were interviewed. Furthermore, a group discussion was held in Bounou village. Two village elders, two women, and representatives of the Mossi, Gourmantche and Fulbe took part in this discussion.

Results

Diagnosis

The diagnosis of the three catchments provided the following data.

Use of agricultural land

Millet, maize and sorghum are the major food crops grown in terms of quantities, while groundnut, cotton and cowpea are the

major cash crops. Land use intensity does not seem to influence crop types grown between the three watersheds; the only difference being the main cash crop (groundnut in Bounou and Diamanga, cotton in Sambouali). In all watersheds, the financial value of the most important food crops maize and millet is small compared to that of the other main crops grown. The use of fertilizer, biocides and ploughs is limited.

Use of natural and fallow land

Natural and fallow land is used for the collection of numerous products. Products are collected from natural land for construction, food, medicinal and/or socio-cultural purposes, and include herbs, fruits, wood, snails and mushrooms. Grazing and hunting also occur on natural and fallow land. The types of non-timber forest products collected in the sites are not related to the land use intensity in the three watersheds, with the exception that the watershed with medium land use intensity shows the largest variation in product types. Fuel wood and almonds are the most commonly gathered non-timber forest products in all three watersheds. The floristic biodiversity in the study watersheds was found to decrease with increasing land use intensity.

Socio-economic conditions

In all research villages, Gourmantché and Mossi live, while Fulbe live mainly in Bounou and Yamaa live in Tanyelle. Land tenure follows the system of 'primi occupanis' (the first settler owns the land) and heritage. In Tanyelle the first settlers were Yamaa, while in the other three villages they were Gourmantché. However, all villages are open to in-migration by other ethnic groups, although descendents of the original settlers have the most powerful position as they decide about the use of the land, and of the available water. Generally, agriculture is practiced by Mossi, Gourmantché and Yamaa as their principal activity, although they may have other secondary activities too (e.g. livestock farming), while the Fulbe are mainly pastoralists although they do grow some crops too. Of the ethnic groups, Fulbe have the least powerful position. Women also have fewer rights than men, irrespective of ethnicity. Differences in socio-economic conditions between the watersheds were found with respect to the occupation of household members, hired labour, the value of agricultural activities and income. In the watershed with low intensity land use (Sambouali), the involvement in farming, either on family fields or as hired labour, is largest. The average net farm income increases with land use intensity and the importance of livestock farming. Livestock farming appears to be more profitable than cropping.

Village workshop

The village workshop held in Bounou resulted in the identification of priority problems and the causes and effects of these problems. Coping strategies for the different problems were also listed. Table 2 presents an overview of the priority land use problems, their causes, coping strategies and land use options to address problems. Coping strategies refer to what local people currently do to cope with their land use problems, while land use options refer to possible future actions based on coping strategies.

The major problems for agricultural production systems were (Table 2): soil degradation (soil nutrient depletion, limited possibility to buy fertilisers and other inputs, land shortage), bush fires, overexploitation of wood, insecurity of land rights, overgrazing and weed infestation. Other problems that were mentioned included labour shortage, limited access to markets, and for Sambouali village also water shortage. Insecure rights on agricultural land were an important problem for women and Fulbe pastoralists. Women have user rights only on agricultural land, but cannot own land as all land is inherited from father to son and daughters are excluded from any land inheritance. Fulbe pastoralists must negotiate access to land with farmers to obtain permission to herd their livestock on farmland or to obtain access to grazing land. This negotiation process is complicated by the damage which the livestock may cause to fields and crops. Women and Fulbe pastoralists, due to their weak property rights, suffer most from the increasing pressure on the available land due to the in-migration of Mossi farmers. The major constraints to natural production systems include the clearing of trees for fire wood collection and agricultural purposes and bush fires.

From the list of options (Table 2), the following were seen as the main ones, which were discussed in more detail.

Intensification of agricultural production

Options for intensifying agricultural production in the watersheds include the regulation of crop rotation, mechanised farm operations, improved crop management, the cultivation of smaller fields, increased use of fertilisers, the planting of fertilizer tree species and the training of farmers in the use of appropriate farming techniques. The regulation of crop rotation refers to the adaptation of cropping systems to the (unreliable) rainy season, intercropping and the adaptation of crop rotations to the temporal distribution of labour availability over the year.

Adaptation of cropping systems to unreliable rainfall. Lack of rainfall was identified as a priority problem, which results in poor crop growth and in soil degradation. Under average rainfall conditions, there is sufficient water to grow a crop, but if the rain fails, crops fail and famine can result. As there is no telling when the next drought will strike, land management should be such that it is able to cope with drought as best as possible. Intercropping was identified as an option to enhance sustainable agricultural production. Mazzucato and Niemeijer (2001) confirm that intercropping is a wide spread practice in villages in Burkina Faso. Intercropping makes better use of the rainy season and of the available water, increases plant cover and thus improves soil conservation, especially if one of the crops is a fast growing leguminous species (Zougmore et al., 2000). Moreover, nitrogen can be fixed if one of the intercrops is leguminous (e.g. cowpea, soybean), which benefits other crops such as maize, millet or sorghum and reduces nutrient depletion (Mazzucato & Niemeijer, 2001). Higher yields for the field as a whole can be expected (although the yield for the individual crops would be lower), and risk of total crop failure is reduced as some crops require more water than others.

Adaptation of crop rotations to the temporal distribution of labour availability. Labour availability, especially in the months with the largest labour requirement, is the limiting factor for the area of crops that can be grown. Selecting crops with a better spread of labour requirement over the year would enable a household to crop a larger area, but would of course only be sensible if there is demand for the selected crops on the market.

Anti-erosion and soil fertility measures

The construction of manure pits, stone bunds and the delineation and management of grazing areas were mentioned by community members as possible measures that could be taken to control soil erosion and reduce soil nutrient depletion. Planting of trees was mentioned as an option to combat the clearing of trees for fuel wood and as a way to prevent the extension of cultivated area. Thus, the focus groups showed understanding of their environment, and had various concrete ideas about actions to be taken to overcome current land use problems.

Table 2
Overview of priority land use problems, their causes, coping strategies and land use options. The options that farmers thought most important are shaded.

Priority problem	Causes	Coping strategies	Land use options
Soil degradation	• Non-respect of rain making ceremonies	• Individual ceremonies for rain making	• Agricultural intensification
	• Population increase	• Individual training (agricultural extension officers)	• Agricultural activities in the low season
	• Lack of fertilizers	• Local fire brigades	• Stone bunds
	• Unsustainable agricultural techniques	• Creation of livestock paths	• Manure pits
	• Bush fires	• Discussions between farmers and pastoralists	• Sensitisation in relation to suitable agricultural techniques
	• Overexploitation of (grazing) lands	• Crop rotation	• Increased crop rotation
	• Uncontrolled/overexploitation of wood	• Tree planting	• Agro-forestry activities, such as planting fertilizer species
	• Irregular and lack of rainfall	• Stone bunds	• Enforcement of customary land use rules
	• Lack of arable lands	• Ridging	• Cultivation of smaller fields
	• Water erosion	• Decrease of total area of individual fallow lands	• Increased control of transhumance by governmental authorities
	• Increase of parasite plant species (Striga a.o.)	• Protection of certain tree species when clearing land	
	• Uncontrolled grazing		
	• Disappearance of fertilizer plant species		
Bush fires	• Hunting	• Local fire brigades	• Awareness building in relation to bush fires
	• Land clearing	• Discussions between farmers and pastoralists	
	• Protection of homesteads		
	• Production of energy sources		
	• Blacksmiths' activities		
Uncontrolled/over-exploitation of wood	• Clearing trees and shrubs for agricultural aims	• Protection of fruit trees	• Awareness building in relation to uncontrolled wood exploitation
	• Activities of pastoralists	• Discussions between farmers and pastoralists	
	• Fire wood collection		
	• Production of medicines		
Insecurity of land rights	• Conflicts between farmers and pastoralists	• Negotiations between farmers and pastoralists	• Increased acceptance of customary land tenure among local people
	• Lack of arable lands	• Search for other/new arable lands	• Delimitation and management of grazing areas
	• Decrease of total area of fallow lands	• Sedentarisation of pastoralists	• Security of land rights
	• Transhumance		
Uncontrolled/over-exploitation of grazing lands	• Lack of grazing and arable lands	• Periodically other locations for grazing livestock	• Search for other/new grazing lands
	• Lack of fodder	• No bush fires	• Awareness building among pastoralists
	• Food needs of humans	• Search for other/new grazing lands	• Security of land rights
Increase of parasite plant species (Striga a.o.)	• Decreasing soil fertility	• Cutting parasite plant species	• Increased use of fertilizers
	• Livestock dung	• Organic fertilizers	
	• Time and labour constraints for cutting parasite plant species.	• Intercropping with groundnuts	

Management of grazing zones

Overgrazing due to uncontrolled grazing on fallow and arable land was mentioned as a key priority land use problem for both farmers and pastoralists and as a source of conflicts between these population groups. The causes are lack of arable and grazing land, lack of fodder and food for both people and cattle and insecurity of land use rights, especially among pastoralists. Options to address the negative impacts of uncontrolled grazing include establishment and management (control, rotation) of grazing areas through negotiation between farmers and pastoralists and increased control of transhumance by governmental authorities.

Spatial analysis of land use options

During step 3.2, some land use options, such as those that had to do with land use rights, collecting of water and gravel, and hunting & fishing, which were listed by Van den Berg (2003) were discussed, but participants felt that these did not need to be mapped. Some of the options mentioned by the participants (Table 2) were also not mapped, as some could be combined with others that were identified and listed already, at least for mapping purposes, while others did not have a spatial dimension (e.g. extension service, enforcement of current regulations) or were of small size (e.g. stone bunds and manure pits). The list of options that were mapped is given in Table 3.

Maps drawn by the different focus groups were compared and discussed in a plenary session in which all workshop participants participated. Below, the results of the community mapping for the Bounou watershed are presented.

Community maps for Bounou watershed were drawn by three groups composed of respectively: Fulbe pastoralists, village elders (Fig. 2A) and a people with mixed ethnic backgrounds (Fig. 2B).

Table 3
Pictograms used to represent land use options.

Category	Land use option	Pictogram	Buffer radius (m)
Cultivation	• Cultivation of food crops mainly (millet, white sorghum, maize)		100
	• Cultivation of cash crops mainly (cowpea, groundnut and cotton)		100 (70 for most, 150 for cotton)
	• Cultivation of irrigated rice		200
Livestock	• Herding of livestock		1000
Agroforestry	• Harvesting tree food products from cultivated fields		30
	• Harvesting tree food products from natural land		500
	• Collection of fuel wood		1000
Cultural values	• Sacred places		100 (20 for trees, 200 for hills)
Reforestation	• Reforestation		100

General observations from the maps are:

- Food cropping is indicated by all groups, but mostly by the group of village elders. The locations of food cropping appear not to be related to soil types for the Fulbe pastoralists and the mixed ethnic groups.
- Cash cropping is indicated by the mixed ethnic group only.
- Grazing is indicated by all three groups, but was mentioned more often in the Fulbe pastoralist and village elders groups. The Fulbe pastoralists and the mixed ethnic groups locate grazing in zones close to settlements, while the group of village elders located grazing in a linear zone across the catchment. This seems to reflect a strategy to avoid conflicts between livestock grazing and cropping, by assigning pathways along which herdsmen can walk and livestock can graze.
- Activities regarding natural land indicated on the maps are few. They include agro forestry, reforestation, fuel wood collection and sacred places.
- Activities were mentioned that aim to protect natural resources: soil conservation activities (stone bunds, manure pits) and protection against forest fires by fire alleys. These options, however, were not mapped as they were of insufficient size to allow mapping.

A conflict/synergy matrix was developed to show which activities of ethnic groups could be combined, and which would result in potential conflict between groups (Table 4). This table is based upon the results of workshop and follow-up discussions that were analysed by researchers. Conflicts between activities of the groups occur among others in overlapping zones with grazing and food cropping, and with reforestation activities and food cropping. Synergies occur among others in zones where grazing areas of more groups overlap (herders can take care of cattle from other groups), and in zones where agroforestry overlaps with reforestation or grazing.

Using this conflict/synergy table, estimations of conflicts and synergies between priority land use activities of Fulbe pastoralists, village elders and mixed ethnic groups were made by overlaying the option maps that were made by these groups. Fig. 2C shows conflict and synergy between the village elders and the mixed ethnic group. Note that although the option maps only contained circles, the resulting conflict/synergy map contains other shapes if circles in the original map overlapped partly. As can be seen from the figure, some areas with conflict, neutrality and synergy are identified. Conflict mainly resulted from a combination of grazing and cropping, neutrality from a combination of grazing and fuel wood collection, and synergy from a combination of grazing and grazing.

Return visit

From the interviews and discussions held during the return visit, it became apparent that there have been significant positive changes in the area since 2005. Agriculture has intensified by using a larger range of farm equipment as well as more fertilisers (both manure and chemical fertilisers), which has resulted in a decrease of cropped area. Agroforestry has increased; trees have been planted in the fields, and a tree nursery has been established. A grazing area was also been established, thus improving the access to land for Fulbe pastoralists. On the downside, the land use rights of woman have not changed, and growing crops in the dry season (which is possible due to availability of irrigation water from Kompienga reservoir) has so far not been successful because this activity is considered to increase siltation of the reservoir.

Table 4
Conflict and synergies between land use activities according to different focus groups.

Village elders	Fulbe pastoralists					
	Cultivation food crops		Herding livestock		Agroforestry	
Cultivation food crops	C	No security in land use right for Fulbe	C	Risk to damage crops	S	Agroforestry can be realized in fields used for cultivation
Herding livestock	C	Risk to damage crops	S	Collaboration in livestock activities	S	Agro forestry is not threatened by livestock
Reforestation	C	No space for crops in reforestation area	S	Reforestation could improve livestock food	S	Reforestation and agroforestry do not exclude each other

Fulbe	Mixed ethnic group									
	Cultivation food crops		Cultivation cash crop		Herding livestock		Collection fuel wood		Sacred place	
Cultivation food crops	C	No security in land use right for Fulbe	C	Cultivation of food crop is More and more abandoned for cash crop	C	Risk to damage Crops	N	Collection of fuel wood mainly outside area used for food crops	C	Sacred place can only be preserved if not cultivated
Herding livestock	C	Risk to damage crops	C	Risk to damage crops	S	Collaboration in livestock activities	N	No relation between collection fuel wood and herding livestock	C	Sacred place can only be preserved if not cultivated
Agroforestry	S	Agroforestry can be realized in fields used for cultivation	S	Agroforestry can be realized in fields used for cultivation	S	Agro forestry is not threatened by livestock	C	Risk to use trees in agroforestry area as fuel wood	C	Sacred place can only be preserved if not cultivated

Village elders	Mixed ethnic group									
	Cultivation food crops		Cultivation cash crop		Herding livestock		Collection fuel wood		Sacred place	
Cultivation food crops	C	No security in land use right for Fulbe	C	Cultivation of food crop is more and more abandoned for cash crop	C	Risk to damage Crops	N	Collection of fuel wood mainly outside area used for food crops	C	Sacred place can only be preserved if not cultivated
Herding livestock	C	Risk to damage crops	C	Risk to damage crops	S	Collaboration with livestock activities	N	No relation between collection fuel wood and herding livestock	C	Sacred place can only be preserved if not cultivated
Reforestation	C	No space for crops in reforestation area	C	No space for crops in reforestation area	S	Reforestation could improve livestock food	C	Risk to use trees in reforestation area as fuel wood	C	Sacred place can only be preserved if not cultivated

C = conflict; N = neutral; S = synergy.

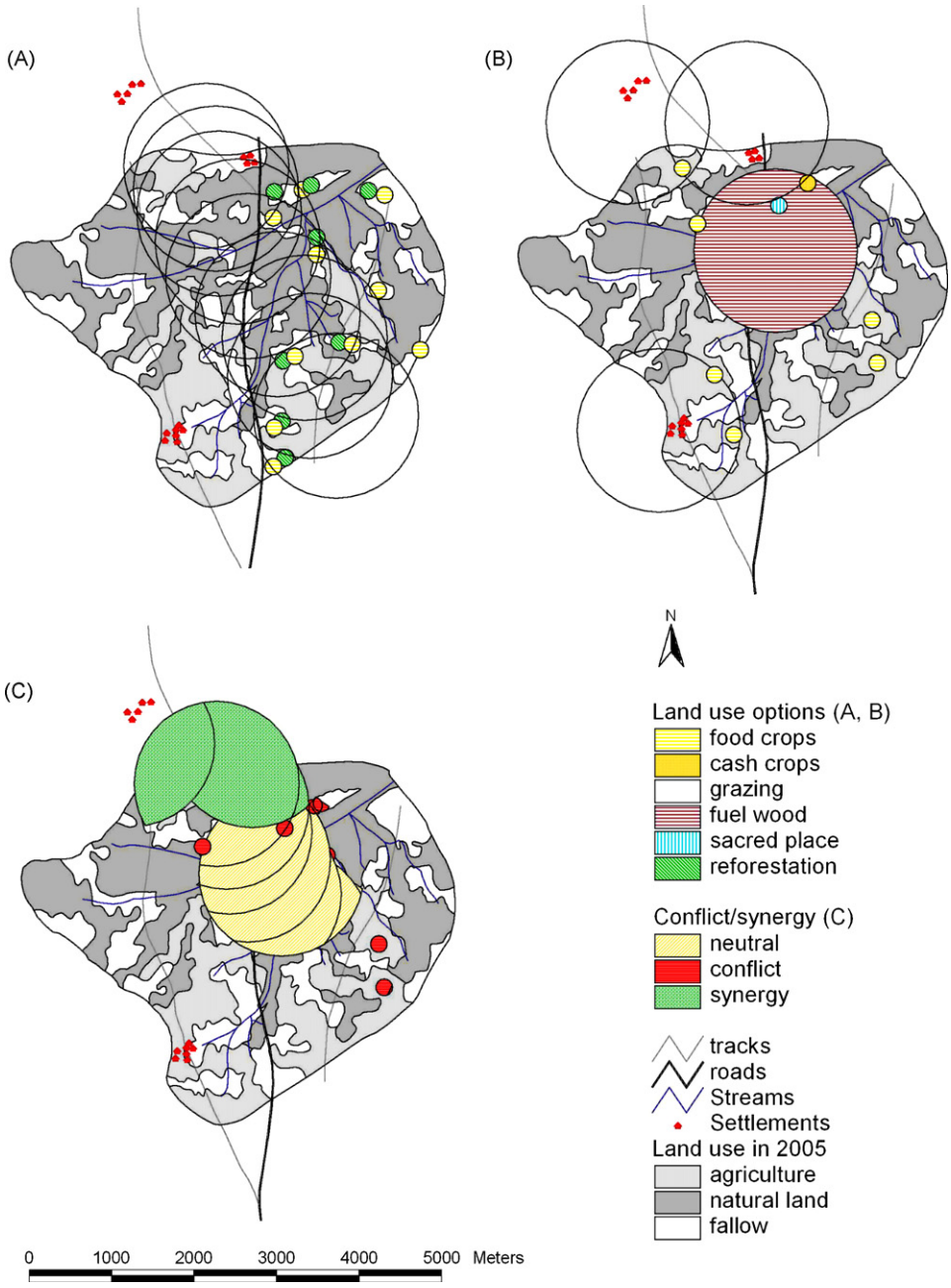

Fig. 2. Land use aspirations of village elders (A), mixed ethnic group (B) and conflict/synergy map of the village elders and mixed ethnic groups.

Discussion and conclusion

Participatory approach

Numerous studies on issues such as land use planning, soil fertility management and natural resource management, have been conducted in close collaboration with local stakeholders. To name but a few relevant to the Sahel, Defour (2002), for example, used a participatory planning method for soil fertility management in Mali and Kenya. Tschakert (2007) investigated farmers' ideas and coping strategies for climate change in Senegal. Brown (2006) summarized the results of 100 PRA studies on natural resource management in Senegal and The Gambia. Lescuyer and Emerit (2005) dealt with sustainable management in tropical forests in Cameroun. Warren et al. (2003) studied indigenous views on soil erosion in Niger. Finally, Sidibé (2005) studied adoption of conservation measures in northern Burkina Faso.

The use of participatory methods has become commonplace. Mapping is also increasingly used in participatory approaches. For example, Lescuyer and Emerit (2005) used GIS as a tool in sustainable management in tropical forest in Cameroun. Defour (2002) used maps drawn by farmers in Kenya. The method developed in the VINVAL project involves the use of topographic maps, but at the same time uses a simple approach to mapping land use options. It was found that the method is easy to apply, because farmers and pastoralists proved capable of reading and interpreting maps. Thus, the mapping showed the potential of GIS as a tool to be used in participatory planning workshops, confirming results obtained by, e.g. Lescuyer and Emerit (2005). The method as it was used in our study is further discussed in Section 'Community land use mapping'.

Results of village workshop

Participation in the village workshop was high, with around 80 participants from the four villages, the majority of which were from Bounou, as the workshop was held there. However, the village workshop was preceded by a long period of preparation that included, e.g. description of soil profiles, analysis of soil samples, measurement of soil erosion and Rapid Diagnostic Appraisals. It was found that stakeholders partially lost interest in the project during this long period, even if they received some compensation for their participation. However, being the final project activity in the village, the village workshop did attract a sufficient number of people for useful discussions. Nevertheless, to reduce the risk of losing people's interest, the time interval between diagnostic and land use planning phases should not be too long.

The documentation sheets completed during the group discussions for the different ethnic and gender groups (step 3.1) indicated that the level of participation was generally high. This was also the case for the Fulbe group, and for the women group. However, during the plenary discussions (steps 3.1–3.3.) and during the village group discussions and mapping (step 3.4), participation of women was lower. This might reflect their position in society. On the other hand, women were not afraid to voice their opinion in the group discussions of step 3.1, and Fulbe did their own mapping in step 3.4, and their map did show a different vision than those of the other groups. Thus, power dynamics that exist in the society were visible, but did not seem so strong as to invalidate workshop outcomes.

The analysis of land use related problems, causes and alternative land use options revealed that farmers and pastoralists were well aware of the driving forces behind problems, and that they had clear ideas about what could be done to address these problems. This confirms that local populations should not be seen as passive victims, but that they have the capacity to adapt to changing local circumstances (Tschakert, 2007). However, Tschakert (2007) also showed that farmers' knowledge can be incomplete, so that a role remains for extension workers and researchers. Nevertheless, farmers' knowledge and experience should be the starting point when introducing new options (Defour, 2002). To achieve sustainable use of natural resources, a deep understanding of agroecosystems is needed (Altieri, 2002), and since farmers are better informed about local conditions than researchers can be, neglecting their knowledge is unwise, and could even be counterproductive, for example, if measures are proposed that are not suitable to local conditions and aspirations.

Community land use mapping

As mentioned in Section 'Participatory approach', the mapping method as used in the village workshop proved a success. However, the method as it was applied in the Burkinan villages did have a few shortcomings, which should be improved.

The first is that the conflict matrix was made by researchers, albeit based on information provided by the local populations. It would be better if the table could be made by the focus groups themselves, which requires that the focus groups at least agree on which activities could be combined, and which cannot be combined. Synergy and competition could also be refined by using participatory ranking tools to take into account that some options might conflict more than others. Another complicating factor regarding the use of the conflict matrix is the seasonality of different land use options. For example, during the growing season growing crops and grazing cannot be combined, but if grazing, for example, could be done after the crop has been harvested, there would not be a conflict. To study such aspects a more elaborate approach would be needed.

The second was the use of circles with certain radiuses to represent the area to which a certain land use option would apply. Both the use of circles and the choice of radius can be questioned. Circles were the easiest way to convert point data into areas, and the radius of the circles was estimated by researchers rather than focus groups. A better, though much more time costly and complicated method, would be to delineate the actual boundaries of the land use options as envisioned by the different population groups. Using the circle approach, the entire area in which a certain option is preferred might not be selected in analysis. Putting two or three pictograms on the paper map might be intended to indicate the entire area around those pictograms, but depending on the radius used for that specific option, it might turn out to result in just a few circles.

Thirdly, it was found that the focus groups concentrated on their future aspirations. The focus groups therefore did not map their complete vision of the catchment, but rather some specific locations in which they would like to change current land use practices. These aspirations were also found to be partly governed by current land use practices and rights between different villages, ethnic groups and segments of the population. For example, each of the two villages in the Diamanga watershed only indicated wishes in the vicinity of their own village. Moreover thinking for other groups and conflict avoidance was noticed during the mapping done by the different focus groups.

Finally, the conflict/synergy matrix that was used did not allow the identification of conflict or synergy within one focus group. For example, Fig. 2 showed that circles for growing crop and for reforestation overlapped for the village elders group. This represents a potential conflict. Similarly, conflicts between land use aspirations of focus groups and the current land use situation were not analysed. Although the data would allow this kind of analysis, the question is whether such an analysis would be compatible with the way in which the focus groups performed the mapping. If they mapped their wish for change, it would hardly give new insights if these wishes were found to represent a potential conflict with current land use.

Obviously, identifying possible conflicts is an important step in planning sustainable land use. However, the analysis should not stop at identifying these conflicts, but rather the next step after making the conflict/synergy maps should be that the different focus groups discuss these maps, and finally come up with a joint vision of future land use options. Thus the final result should be an integrated plan for the area.

Return visit

The return visit showed that between 2005 and 2007 there were significant changes in the study area, most of them positive. Of course, it is difficult to say to what extent the VINVAL project has contributed to this, as such changes might have occurred anyway. Nevertheless, the farmers indicated that the project has increased their understanding of the problems, and that they have a better idea about how to deal with such problems. This has also increased their capacity to discuss and collaborate with the different organizations that are working in the area. Some of the options that were identified during the VINVAL project, such as the use of manure pits and composting, are now supported by PICOFA (Programme d'Investissement Communautaire pour la fertilité en Afrique). These results show that results of scientific studies can be used for concrete and real life improvements, if the results address local realities and aspirations. This can only be realized when local knowledge is integrated with scientific knowledge through participatory land use planning approaches. Furthermore, it is imperative that conditions are favourable for farmers to implement, and ben-

efit from, the conservation measures they want (Sidibé, 2005), for example, through appropriate policies (Pretty, 1995; Altieri, 2002; Heerink, 2005) and through support by government branches and organizations. In our study area, such favourable conditions were present, which enabled the positive changes that occurred between 2005 and 2007.

Conclusions

Testing this GIS-based participatory land use planning method confirmed the importance of integrating scientific and local knowledge to develop concrete options for sustainable land use that fit local realities and aspirations. Local people are knowledgeable about the driving forces behind land degradation, they take actions to combat the effects of degradation, and they have concrete ideas about alternative land use options. The use of GIS proved its added value in the participatory process of integrated land use planning, as stakeholders proved able to work with maps. The maps that were produced also facilitated discussions between community members, researchers and government representatives at the regional level, both regarding current land use problems and regarding alternative options as perceived by the local population. Improvements of the method are still possible, and are likely to further increase its usefulness.

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