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# Integration of local participatory and regional planning: A GIS data aggregation procedure

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**Abstract**

This paper presents an approach for GIS integrating local participatory land management information used for regional planning, and contributing to a bottom-up approach to land use planning. In participatory planning, the integration between local and regional levels should facilitate the communication and co-operation among the parties at both levels, for an efficient use of available resources. For coherently linking these two levels it is necessary to transform the data produced at one level, in order to be usable by the other. This transformation consists of a spatial procedure, which allows scaling-up the local participatory rural appraisal (PRA) information for regional purposes and scaling down the regional information for local use, using a GIS. Such an integration procedure is presented and discussed using data from a case study in south-western Burkina Faso.

## Introduction

### *The challenge of integrating different levels in land use planning*

The intent of this paper is to present an approach for integrating local participatory land management in regional planning using GIS, and contributing to a bottom-up approach to land use planning. Integration issues are highly critical in regional planning and including local information from participatory planning was highlighted as a condition for sustainable resource management (UNCED, 1992; FAO, 1995). Integration in regional planning aims at linking the micro level of management (i.e., farm, community land) and the level of policy making (sub-national to national). In land use planning, the problem has more often been approached by studying the interactions between the biophysical and socio-economical elements of a land use system (Fresco *et al.* 1990; v. Duivenbooden, 1995; Mohamed, 2000). For this, multidisciplinary procedures, tools and techniques have been developed for analysing and evaluating the impact of socio-economic activities on the eco-system as well as the relevant effects of the state of the eco-system on socio-economic activities (Mohamed, 2000).

However in a participatory context, the data integration should rather facilitate the communication and co-operation among the parties at both levels (Luning, 1986). It should also contribute to promote a state of democracy of information, allowing genuine negotiations between local and regional stakeholders (Dent, 1997).
For instance, the integration of information representing the two poles should allow to:

- Ascertain the representation of the important local planning issues at regional level;
- Assure the feasibility of proposed local interventions, taking into account regional objectives and constraints (biophysical, socio-economical) as well as local knowledge, incentives and values;
- Provide local planners with decision-making tools for maximizing the potential of regional support (i.e., geodata, financial, organizational, etc.), checking the relevance of regional/national plans to local communities and reducing land use planning conflicts.

A number of studies in the developing countries have indicated that bottom-up procedures are successful for improving the quality of regional planning and resource management (Ramm, 1992; Nurse *et al.*, 1993; Walker and Sarkar, 1996). But despite the increasing interest in establishing conceptual frameworks including anthropogenic factors for analysing local to regional land use planning, examples of models linking local participatory and regional planning are very few (Gottlieb and Reilly, 1994).

Geographic Information System (GIS) can be used for integrating local to regional planning by adequately combining the different spatial levels within a holistic framework. The power of a GIS resides in its capability of handling large amount of spatial data and conducting spatial analysis. This involves (non spatial) attributes querying, spatial queries and generation of new data sets from original databases (Yue-Hong, 1997). As stated by the Economic and Social Commission for Asia and the Pacific of the United Nations (1996) applications of GIS for resource management and decision-making is limited only by the imagination of how to combine the different data sets. O'looney (2000) illustrated this with different GIS applications supporting the local governments to improve the quality of public services, by addressing various questions that can be grouped as:

(1) Efficiency: improvement of public works, transportation, law enforcement, emergency and utility management, economic development;
(2) Equity: sharing resources in tax and budgeting, neighbourhood services, citizen participation and democratic processes, environmental justice;
(3) Community viability: Sound negotiations in land use planning, public health, housing, parks and recreation;
(4) Environmental quality: sustainability of environmental development, resource conservation, and policies.

In a multi-scale planning involving local and regional stakeholders, the GIS should answer specific questions to allow the fluidity of information on both levels: How do we integrate the knowledge, perceptions and needs of all the stakeholders and translate them into feasible plans? How do we facilitate the negotiations between them by providing the relevant information to support decision-making at both levels? The procedure to establish such a system and its feasibility will be analysed in this article, from both a technical as well as a planning point of view.

*The problems of integration in a participatory planning approach*

During the eighties, the planning procedures in Burkina Faso evolved from the bureaucratic top-down to more participatory bottom-up approaches, based on the design and implementation of local land management/land use planning programs. The Structural Adjustment Program (SAP) introduced in nineties has also contributed to reduce the sway of the central governments and regional institutions in the planning process. Local people are part of active land management boards dealing with decision-making in planning, implementing and evaluating activities for sustainable development. In this new context adequate processes and data integration are very essential for a good communication between the two levels (Figure 1).

A convenient aggregation procedure should include local stakeholders' interests representing socio-cultural factors such as the tenure regime, political issues and many other critical local constraints. These local phenomena and situations apparently insignificant from a regional perspective may sometimes determine the success or failure of the planning process.

The classical aggregation methods used in regional planning are often confronted with the difficulties of scaling-up from the farm to the region level. Despite important efforts to improve the farm classification methods and develop convenient aggregation models (Driessen and Konijn, 1992) satisfactory procedures are still lacking (Fresco *et al.*, 1990; Rabbinge and van Itersum, 1994; Mohamed, 2000). Besides the technical problems usually invoked (Rabbinge and van Itersum, 1994), many others appear in a participatory planning approach such as:

- The difference in perception and representation of space and spatial phenomena between local people and regional planners;
- The difference in data formats, capturing and modelling techniques: local PRA data and methods are in 'soft systems' formats (Scooness and Thompson, 1994), while 'hard systems' methodologies and data are used at regional level;
- The storage media and processing tools are also different, hence differences in data quality: While at regional level data are stored in modern standard formats (analogue and digital), the local level use more informal ways due to the oral tradition environment (e.g. sketch maps).
- The scale difference, often implying different representations of spatial objects: At local scale, a village territory can be represented as a region (area) while at regional level it can be represented as a point.

Besides, institutional incoherencies and bureaucracy still strongly influence the relationship between the regional planners and the local communities. This contributes to the superimposition of different types of planning and management units (Table 1), generating land use conflicts. Operational methods for breaking down the regional implications (e.g. sharing regional constraints, budgetal location, transportation, etc.) are also lacking, affecting the soundness and feasibility the local plans.

The integration herein aims at a mutual support of the planning processes at both sides by supplying the relevant information out-coming from one level of planning as input information for the other. This means that the procedure should allow the best use of local information (mostly PRA data) into regional planning analysis and vice versa. Interest of using PRA approaches to support sustainable local planning processes has increased (Chambers, 1994; Grenier, 1998; v.d. Hoek, 1992; Waters-Bayer and Bayer, 1994). However, research that attempts to integrate local PRA data in systematic regional planning approach is lacking. This could be achieved through a spatial approach combining the different spatial levels in a holistic framework using a GIS.

*The proposed solution: A geo-information approach*

The proposed approach uses a geo-data data abstraction procedure developed in spatial data handling theory (Molenaar, 1998). It is based on the use of the spatial distribution of specific information issued at one planning level, as a means of communication with the other. Considering the mutual support between the two levels, the integration is a bi-directional procedure (Figure2) consisting of:

(a) A bottom-up procedure for a regional planning using a spatial abstraction method. It is based on the definition of the local land management units relevant to all stakeholders using local driving factors (derived from PRA and household surveys data), to derive the regional planning units (Loader and Amartya, 1999; Sedogo and Groten, 2000).
(b) A regional feedback to support the lower planning levels, using regional information during the local planning process. In this instance, the local planning units are

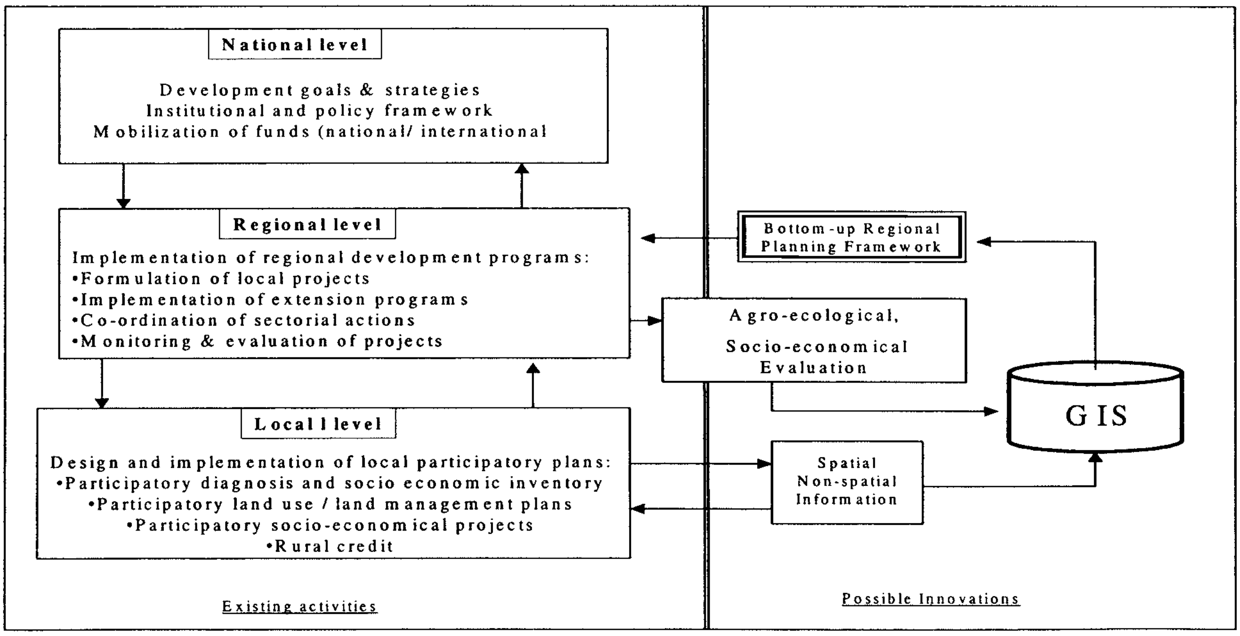


*Figure 1.* The planning context in Burkina Faso and the potential innovations in a GIS planning support system.

*Table 1.* Regional planning units with their possible impact on local management units.

| Regional Units | Local units | Nature of impact | Relative importance | Planning action |
|---|---|---|---|---|
| Roads | Local forests | Deforestation | Low | Buffering |
| | Local plantation | | Very high | Reallocation |
| Transhumance | Local reserves | Deforestation | High | Buffer corridors |
| roads | Pastoral lands | Overgrazing | Very high | Reallocation |
| Dams | Cultural sites | Flooding | Very high | |
| | Local plantations | Flooding | Very high | Reallocation |
| Reserve areas | Agriculture | | | |
| | Pastoral lands | Encroachement | Low to high | Reallocation |
| Pastoral lands | Agriculture | | | |

defined during participatory surveys, using georeferencing tools such as topographic maps, global positioning system (GPS) or aerial photographs, together with local knowledge.

Because of the differences between the two systems, a transformation is necessary to convert the data generated on one side (e.g., sketch maps), into a compatible usable format on the other. In order to do so, we represent the planning units at a particular level (i.e., local level) as spatial features in a GIS (points, lines or polygons), with their attributes pertaining to the different dimension of land management system (biophysical, economical and social-cultural). According to the nature of the attributes data of these spatial objects, their scale and type of measurement, specific GIS transformation functions can be used to perform the spatial conversion, for scaling-up or down the information. Such a procedure enables the determination of the spatial impact of any planning information on one level, over the (planning) units on the other level. The principle of encapsulation and other properties of the object-oriented data model (Molenaar, 1993; Tang *et al.*, 1996) allow flagging the information for an easy retrieval and use in the procedure. This spatial approach to integration was implemented and tested for linking local participatory and regional planning in a case study in Burkina Faso.

## Case study in western Burkina Faso

### *Presentation of the study area and the cases*

#### *The study area*

The study area is the province of Houet located in the south west of Burkina Faso (Figure 3). The annual rainfall ranges between 800 and 1,200 mm and the main cropping systems are rainfed cultivation (extensive cereals and semi-intensive cotton), irrigated rice, fruit trees and small-scale market gardening. Extensive livestock farming is increasing due to clearance of the tsetse fly, the contribution of cotton revenues and the impact of migration from the arid northern areas. Despite the area being relatively wealthy in terms of

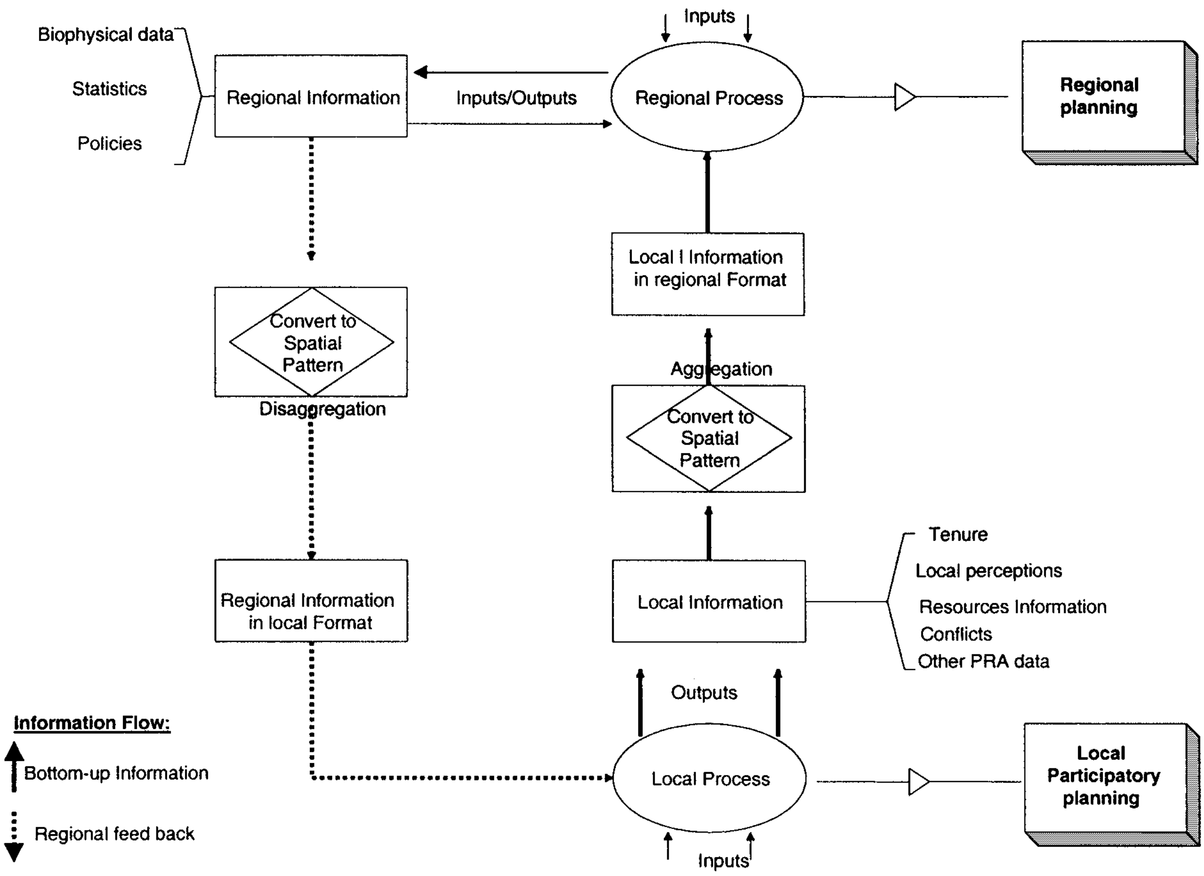


*Figure 2.* Data transformation procedure for integrating local and regional planning processes.

natural resources as compared to the rest of the country, it is severely degrading due to a combination of factors. These factors indicate a high population growth, an increasing livestock number, an important immigration, an important impact of traditional tenure systems, archaic farming systems and inappropriate land use strategies. For that reason, the province was chosen as a pilot to start implementing a community-based land management approach. A participatory land management program financed by the World Bank was initiated in 1992 with the objective of conducting a sustainable land management based on a participatory planning, while improving the local social conditions by increasing the household revenues. Based on the remarkable results of this experience the government started at regional scale a sustainable land management program for the period 2001–2005. Two cases were used for studying the local to regional integration.

*Case 1: Integrated land use planning at semi-regional level*

The Forest of Maro and the Hippopotamus conservation lake are two protected areas located in the north of the province. During the pilot phase of the project (1992–1996), an integrated land use plan was initiated in that area, with the following components:

- A participatory management of the Maro forest by an inter-village committee representing 17 villages surrounding the forest with multiple objectives of income raising for the local people, supplying fuel wood to the province capital, and the conservation of the forest;
- The delineation of a local pastoral zone to secure the pastoralists living in the area while avoiding the increasing pressure of cattle on the reserve areas;
- The protection of riverbanks against soil erosion and sedimentation;
- The definition of local conservation areas to protect the village cultural sites.

*Case 2: Bottom-up regional planning based on local participatory planning information*

In preparation for the actual phase of the program (2001–2005), the regional office of PNGT implemented a participatory diagnosis in 12 test villages during the year 2000. This step provided the regional planners with relevant information that should serve as basis for an implementation at provincial scale by:

- Efficiently supporting the local planning procedure at regional scale;
- Efficiently articulating the local plans with regional formal planning activities;
- Allowing scenario building at regional level in order to orient sectoral strategies based on the most relevant local planning information.

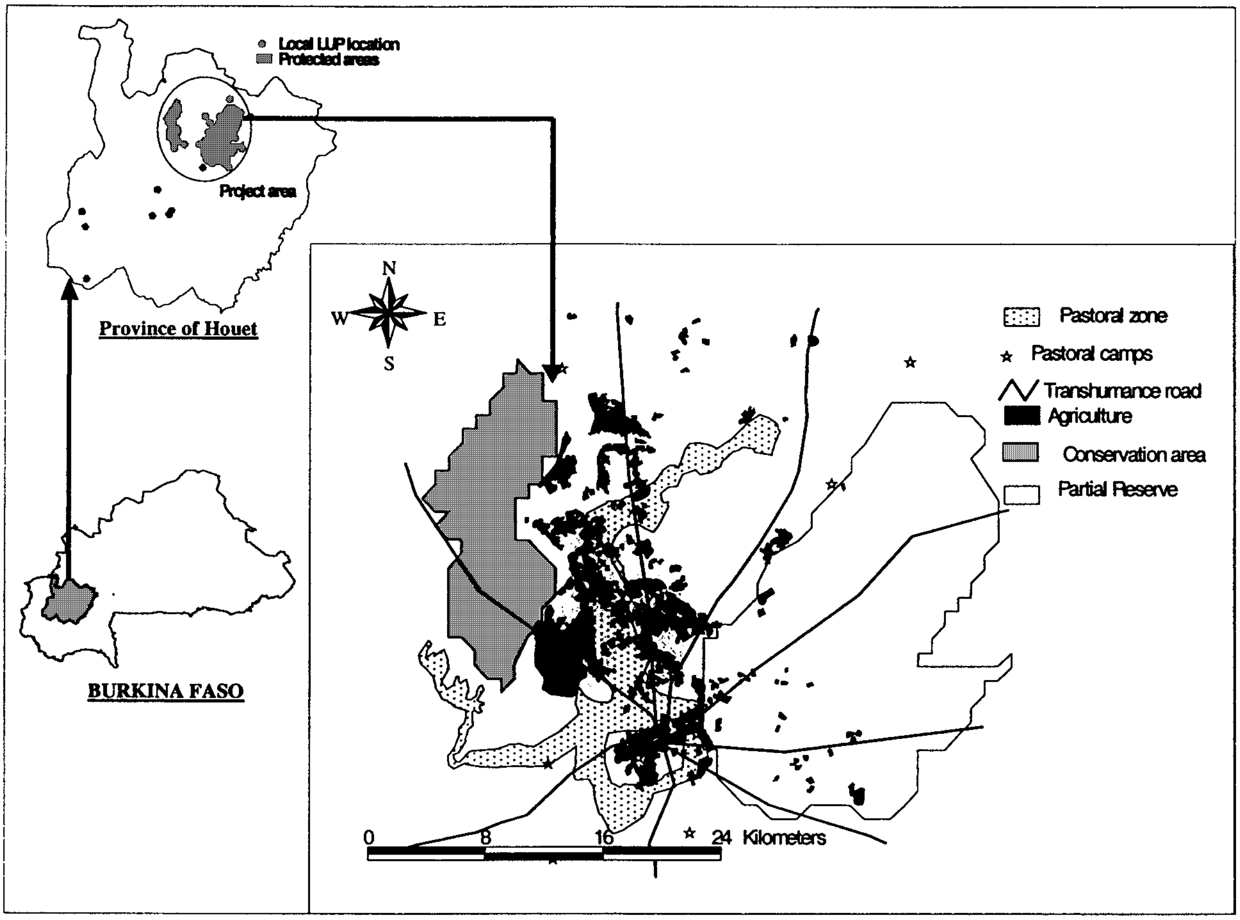


*Figure 3.* The study area: Location of local use plans (LUP) and the land use map in the project area.

## Methods

### *Local PRA surveys and data*

PRA surveys were conducted in three sample villages in the neighbourhood of the Maro forest, aiming to understand the biophysical, socio-cultural and economical factors related to the management of the natural resources in the area. The land use zones agreed between the villages in the project area were delineated from a photo-interpretation. They were geo-referenced during participatory field-check, using topographic maps and hand GPS. In addition, secondary PRA data were compiled from surveys carried out by the project in 12 villages. Ancillary data were also collected near the regional services. They included biophysical and socio economical data at provincial level, and a village level socio-economic database of the province. A land cover map of the project area was derived from the interpretation of a 1:25,000 scale air photograph. Digital elevation model and a slope map were generated by interpolation using contour lines digitised from a topographic map at scale of 1:200,000.

### *System development and data modelling for multi scale land use planning*

To support a multi scale land use planning model, an information system (Davis and Olson, 1985) was developed in order to get a holistic framework of the land management system from both local and regional perspective. It combined a 'soft system methodology' (Checkland and Scholes, 1990) with a structured system approach enabling the technical integration of the local knowledge collected from PRA into the system design. The information needs for the system were obtained by analysing the land use planning problems at both levels. PRA methods were used to determine the boundary and the components of the local land management information system (biophysical, social-cultural, economical sub-systems), their interrelations and input/output data. Interviews were also conducted with regional planners to define the upper boundary (regional level) of the system. A Business System Planning (BSP) technique (IBM, 1984; Davis and Olson, 1985) was implemented to define the architecture of the integrated planning system.

Conceptual modelling was used for structuring the system, according to the users' perceptions, based on the terrain-object approach (Molenaar, 1993, 1998). Different spatial layers were created, including local as well regional planning information (biophysical and socio-economical data, regional planning units such as reserve forests, transhumance roads, cotton gathering network, settlements etc.).

*Spatial analysis*

The spatial analysis aimed to identify and overcome (or at least reduce the effects of) the main bottlenecks to the implementation of the local management plans. It was based on a spatial abstraction procedure (object classification and aggregation). Based on the concept of terrain-object representation (Molenaar, 1993), we used the entity ‘village’ (represented on the regional map by point features) as the lowest elementary object. Attribute data were used to create different GIS attribute maps.

For analysing the socio-economic data, knowledge of village boundaries was required (political/administrative). In absence of an existing map we simulated temporary artificial boundaries using ‘Thiesssen polygons’. The PRA data were analysed to determine their relevance and possible contribution to a GIS based planning system. We identified three main factors with spatial impact as being able to create conflicts between local and regional planning activities:
(1) Activities at regional level threatening the sustainability of local planning units: The sustainability of the pastoral zone near the Maro forest was analysed with regard to the spatial impact of local constraints and the seasonal cattle migration (transhumance).
(2) Specific socio-economical constraints to the implementation of the local land use plans at regional scale: For instance, the implementation of several labour intensive or profitable activities during the same period at local level may face multiple constraints: time, labour availability, weak coordination among regional partners, etc.)
(3) Access to the land by the different groups of stakeholders: Access to land was used as a limiting factor for the sustainable management of the local natural resources at a regional scale. We classified the tenure regimes by combining different variables included in the village level database (Table 2), as following:

a. Village status: (1) the administrative villages with legal land rights; (2) cultivation hamlets (3) pastoral camps having illegal status
b. Traditional land rights. These are based on the land rights conferred to the most important ethnical group in each settlement according to its’ social origin, established as follows: (1) the natives having full rights, (2) the migrants agriculturalists having some limitations and (3) the pastoralists facing high land insecurity (Sedogo and Groten, 2000).
c. Conservation areas (state properties forbidden for local population): (1) yes; (0) no.
d. Irrigation schemes and reserve forests are state properties on which local population (or co-operatives) may have legal use: (1) yes; (0) no.

We used the biophysical data to test the validity of some local agricultural and land management strategies at regional level, based on local perceptions and knowledge on the biophysical environment. Sedogo and Groten (2000) have determined that the farmers in the study area define their preferences for land management units according to topography (essentially in view of flood risk), slope and soil texture. This information was used to derive different terrain units using the DEM as the following: (1) the lowlands (height ranging from 299 to 320 m); (2) undulating glacis plains; (3) the upper plateaus and hills (above 360 m). The slope map was also classified as following (slope ranging between 0 and 23% in the area): (1) the flat areas with less than 2% (flooding zone); (2) gentle slopes (from 2 to 7%); (3) the steeper slopes above 7%.

By overlaying the different layers with the village base map in a GIS, each entity (village) inherited the related information as attributes from which the spatial abstraction procedure was performed.

## Results and discussion

*Evaluation of Information from PRA for GIS input*

*Format and relevance of the PRA data for regional planning*

The local planners showed a high ability in using PRA methods. Table 3 gives a synthesis of the different types of information collected at local level from PRA and their possible use in local and regional planning processes. As compared to other methods used in rural surveys, PRA is distinguished by the use of local graphic representations created by the community, which legitimise local knowledge (Grenier, 1998). The analysis of the PRA information in different formats (sketch maps, scoring matrices, diagrams and models) in terms of spatial, thematic and temporal relevance for a GIS-based planning system is shown in Table 3.

*The thematic content: a reliable base for participatory modelling*

As pointed out by Mascarenhas and Kumar (1991) quoted by Chambers (1994), participatory modelling and mapping have been a striking finding of PRA. Local people for designing comprehensible models of land management systems use different flow diagrams and models. In the present case different PRA tools were mainly used to: (a) define the local system boundaries and their external links using Venn diagrams; (b) identify the input output data using the exchange flow diagrams and (c) identify the local land management processes and their interaction using the diagrams of systems. This allowed structuring the land management system around the Maro forest as follows.

- The forestry management sub-system: The local forest is a reservoir resources for the villages and the city (fuel wood, medicinal plants, fruits, etc.) and an important source of income for the farmers.
- The of agricultural management sub-system, Agricultural lands symbolize food security and economic wealth for the farmers. The inputs from the villagers represent labour, seedlings, equipment and land management activities (soil conservation manure fertilising, and ploughing).
- The pastoral management sub-system: The definition of pastoral units symbolises not only the stability and security for livestock farming, but also the improvement of agricultural systems through fertilisation.

*Table 2.* Types of tenure regime derived from local information.

| Tenure regime Type | Status of settlement | Legal status | Land owners | Dominant population | Legal and traditional land rights |
|---|---|---|---|---|---|
| 1 | | | | Native population | Legal, full access |
| 2 | Village | Administrative | | Migrant farmers | Legal with Limitations in land management |
| 3 | | | Native population | Pastoralists | Non secured access |
| 4 | Cultivation hamlet | | | Native population | Full access |
| 5 | | | | Migrant farmers | Illegal and limitations in land management |
| 6 | Pastoral camp | Illegal occupation | | Pastoralists | Illegal, non secured access |

*Table 3.* Type, relevance and potential use of PRA data in the study area.

| Information type | PRA Tools | Data | Use in local panning | Use in regional planning |
|---|---|---|---|---|
| Thematic | Matrices Diagrams Semi structured Interviews | Ranking Main processes; relationships; system components; thematic attributes, | System analysis and design; application models; conflicts; socio-economic driving factors | Planning objectives; weight maps; information requirement; application models; databases; |
| Temporal | Calendars Historical profiles | Land use dynamic; time planning | Land use changes; conflicting activities | Land allocation; planning alternatives; resource allocation models |
| Spatial | Sketch maps; transect | Management units; land use zones; biophysical data | Mapping; land use planning; | Spatial database |

- The surface water management sub-system: The water reservoir is an essential complement for livestock farming (watering), but yet has no interaction with agricultural activities (the dam was recently built in 1998).

*The spatial quality*

Participatory mapping was used for (a) inventorying the natural resources available in the village territories; (b) mapping the main management units; (c) referencing the landmarks limiting the villages (Figure 4). As in conventional mapping, different features are used for representing the spatial information. Their geometric quality is generally low and georeferencing by means of a GPS or topographic maps is a prerequisite for GIS input. For instance, landmarks are highly reliable and should be used to complete conventional local mapping (e.g. delineation of boundaries, identification of infrastructure). Despite their high thematic quality, lines and areas are very poor for localising spatial phenomena. Geo-referencing requires crosschecking by different groups of resource persons (elders generally). The combination of sketch maps with enlarged air photographs at scale 1:5,000 by the local people as recommended in Groten (1997), proved to be useful for defining of local land management units.

*The temporal aspects*

Two main temporal information types were extracted from the PRA data: (a) long-term trends shown by historical profiles (land use dynamics, resource degradation) and (b) short-term information generated from activity-planning calendars (crop calendars, land management activities, etc). As shown by the activity-planning calendar in Figure 5, the implementation of agricultural production, as the unique activity in half of the year indicates its importance for local people. The number of activities implemented during the dry season (November–April) is an indicator of a potential time constraint.

*Integrated land use planning around the forest of Maro*

Different classes of spatial management units were identified in the area and characterized as follows:

- Individual/farm level management units (such as soil and water control, fertilising and agro forestry) are defined on the agricultural lands. Because of their relative small size at semi-regional scale they were merged with the cultivable lands that can be mapped from photo interpretation.
- Village-communal management units are composed of new forest plantations, local cultural sites (converted into local reserves), protected riverbanks (plantation of trees, shrubs and herbaceous species) and small irriga-

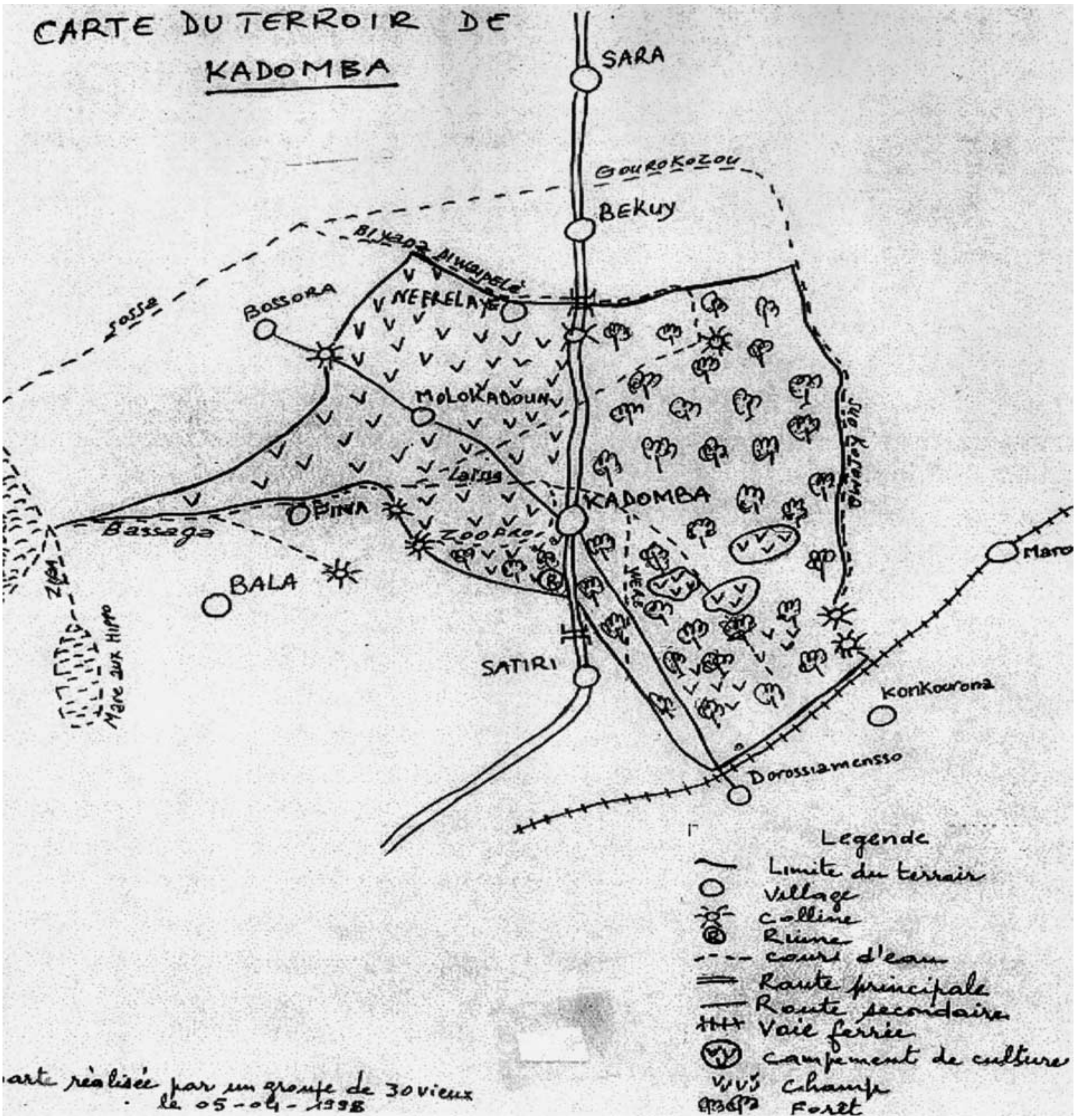


*Figure 4.* Sketch map of resources distribution drawn by a group of elders in one village of the study area. NB: Note that there was no scale.

tion schemes. Even though they are difficult to represent on a semi-regional scale, the principle of encapsulation offered by the spatial database makes them easy to be retrieved.

- Inter-village management units represent mainly the pastoral zones, forests surface water bodies and reclamation of flooding lowland areas.

The spatial analysis in the GIS by overlaying the new pastoral coverage with the terrain units map, the slope map and the land cover map allowed to determine the biophysical constraints on the planning process as presented in Figure 6. The Figures 6a, 6b and 6c show the spatial distribution of the different land/cover land use types and the terrain units in the project area.

As shown in Figure 6b, agriculture is encroaching on the new pastoral zone (15%). This suggests an ongoing negotiation process for reallocating new lands to the people who used to cultivate in that area. Figure 6c shows that nearly 80% of the pastoral zone corresponds to lands for which the farmers have little interest for agricultural purpose. This indicates that somehow, the planning process has generated a clear physical boundary between these two conflicting systems and gives more security to the pastoralists. Thus, a bottom-up procedure contributed to define the new pastoral zone, by integrating the local perceptions, knowledge and objectives in the planning process. This shows that the spatial aggregation procedure can be reliably used for linking the two levels of planning.

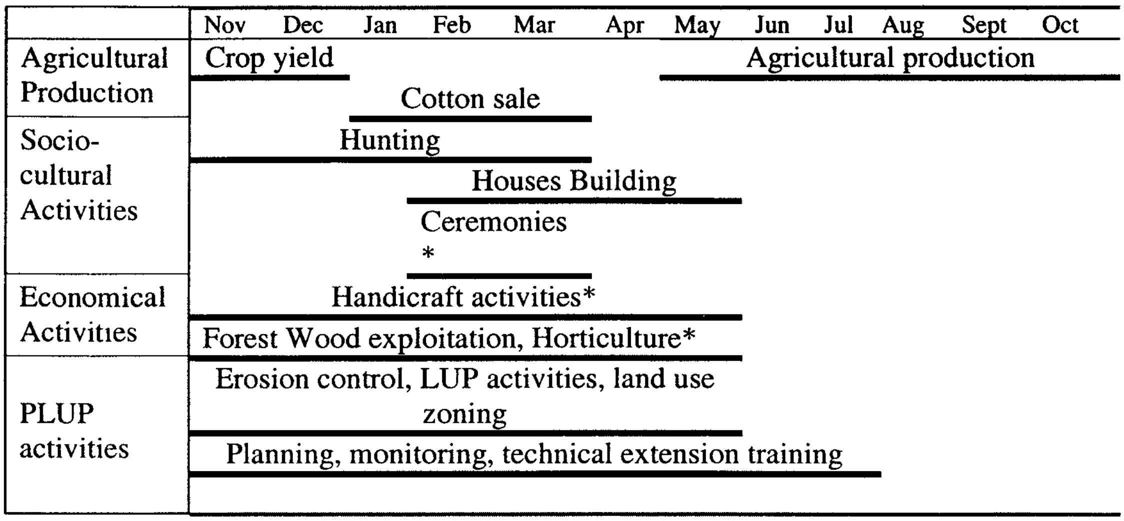


*Figure 5.* Synthesis of activities implemented yearly in the different villages as obtained by PRA. (*): Activities with no significant spatial impact.

From a sustainable management perspective, the analysis gave the following picture: Given a cattle number of 13,300 Tropical Livestock Units (TLU) for all the villages involved in the local planning (source Projet RESO, 1998) the carrying load was estimated nearly at 87 TLU/km$^2$ in the new pastoral zone. According to the regional statistics, the average rangeland load is nearly 31 TLU/km$^2$ for the province. However, based on of the potential biomass production for this agro-ecological zone estimated from ground surveys (Boudet, 1991) we can expect a theoretical sustainable carrying capacity of nearly 100 TLU/km$^2$. This shows that the bottom-up procedure can be reliably used for defining sustainable planning units at semi-regional level.

*Local planning information as input in regional planning*

The analysis of the synthesis of the land management activities foreseen in the different villages for the planning period (Table 4) shows the following scenarios:

On average, each village has to manage nearly 100 ha of soil and water conservation areas and 160 compost pits. According to estimates and the norms recommended by the National Agronomic Research Institute (INERA), the average production of compost in each village covers 300 ha of fields. Based on conclusions of studies on yield estimates using organic fertilizing in Burkina Faso (Maatman, 2000; Dugue, 1989), and given that the average yields of maize and sorghum in the study area are respectively 1.7 t and 1.2 t per ha, we could expect an increase of more than 400 t of cereals in average per village. Based on the national norms of food security this represents food consumption for nearly 2,100 persons per year. Because agricultural production in this part of the country is already self-sufficient, this means that more food can be redistributed in shortage areas (central and northern parts of the country).

The protection of riverbanks against sedimentation and the plantation of new forest plots are relatively modest as compared to agricultural management activities. However, 50% of the villages expressed the need to protect their cultural sites, which are converted into local conservation areas.

The number of artificial lakes needed (50% of the villages) reveals the importance of surface water control for the population and reflects the constraint of water shortage for cattle watering, fishing and small-scale irrigation during the dry season.

For most of the villages (67%) pastoral zoning is a very important activity during the five-year plan. It aims at defining a stable unit for the activity and more importantly, solving the conflicts between farmers and pastoralists.

*Planning constraints in regional Bottom-up procedure*

The essence of the regional planning aims to identify and overcome (or at least reduce the effects of) the main bottlenecks to the implementation of the local management plans. These bottlenecks reflected by the local planning constraints, were identified from the analysis of the PRA data.

*Impact of tenure regimes*

The tenure regimes previously defined were used to create a GIS layer as shown in Figure 7 and used to gauge the feasibility of land management activities at a regional scale. The Figure 7a shows that the portion occupied by a dominant immigrant population represents in total 50% of the land. This points out the importance of immigration in the area, and its impact on sustainable management. The total area occupied by a dominant immigrant-agriculturalist population only represents 42% of the land. The pastoralists control only 8% of the land, which is in proportion negligible as compared to the other groups.

*Impact of economical factors*

From the activity calendar in Figure 5, potential labour shortage was identified as an important constraint in relation to the motivation of local people for land management activities and their involvement in profitable activities. For instance, wood exploitation is highly profitable for the villages

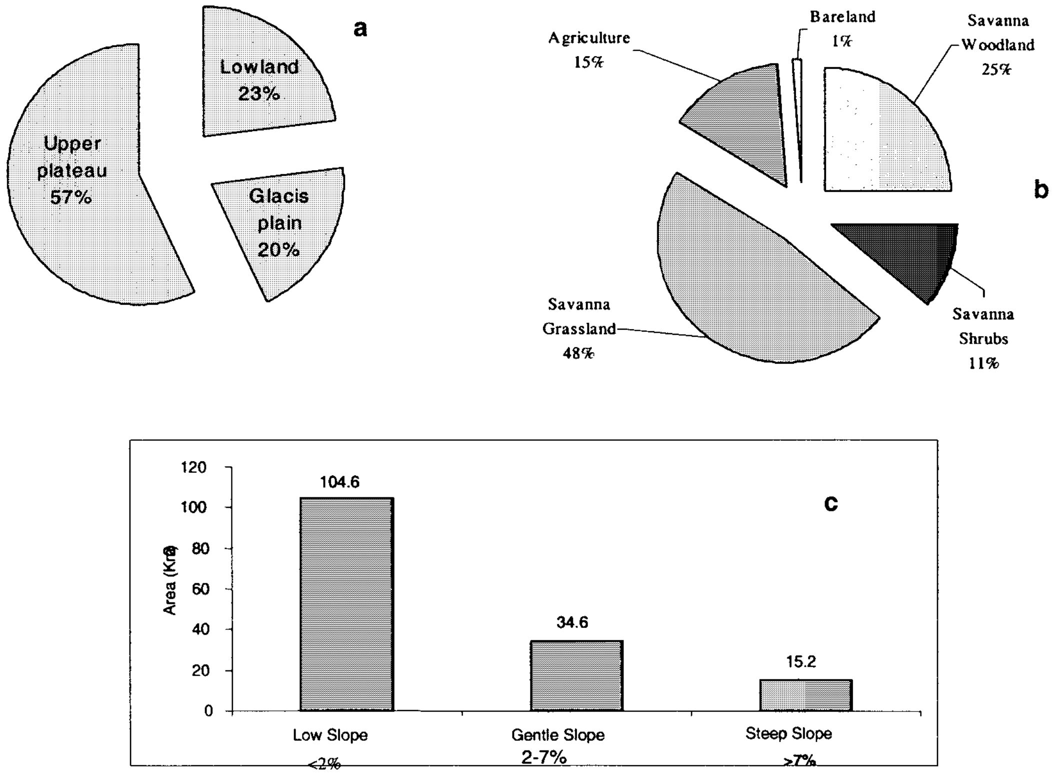


*Figure 6.* Distribution of the pastoral lands according to different terrain units, slope and cover types.

surrounding the Maro Forest. An inter-village committee of forest workers is exploiting 1,200 ha of the forest planted with exotic quick-growth tree species (*Gmelina arborea, Eucaliptus camadulensis and tectona grandis)* according to a plan implemented since 1996. Because of its success, the participatory forest management has become an important component of the regional strategy of firewood supply to the city of Bobo-Dioulasso. The regional forestry service has defined a buffer zone of 80 km in which, villages are authorised to exploit the contiguous national reserve forests. Table 5 gives the statistics for the revenues of the villages, of which a global net benefit was estimated at nearly 150 million CFA.

In comparison, these revenues correspond to the production of more than 1,500 ha of cotton for the same period (the price of cotton was 105 CFA francs per kg for an average yield 915 kg/ha). The time used for wood exploitation overlaps with the implementation of intensive labour requirement activities (erosion control and fertilisation). For instance, the labour requirement for building the small dikes to reduce the speed of water ranges between 50 and 120 men-day/ha (Maatman, 2000, p. 250). Thus in practice, the feasibility of the local plans for potential wood exploitation areas is hampered by this problem of motivation and labour shortage.

Likewise, the information from Venn-diagrams and interviews revealed that the proximity to irrigated cash crop areas (sugar cane, rice) and the industrial centre in Bobo-Dioulasso is also a source of labour shortage and lack of motivation for implementing land management activities. Most young people from the neighbouring villages (5 to 10 km easily covered daily by bicycle) seek seasonal jobs in these areas.

Using this information, we could identify through the GIS analysis the areas where potential labour shortage may occur due to overload of land management activities. It was used as an aggregation factor to identify the areas possibly affected at the province level and where logistic planning is required (checking for the real needs with local committees, coordination of actions between several regional partners, providing additional support to the implementation of the local plans, etc.).

*Impact of regional planning units*

Regional units such as transhumance roads should be considered in local planning procedures. The province is mostly a transit area and this cultural practice can contribute to the failure of rangeland management activities: (overload of watering and rangeland carrying capacity, diseases, conflicts, etc). According to the land reform in Burkina Faso, a buffer zone of 500 m should be created along these roads to protect resources in the transit areas. However in practice, a vast corridor is affected by the grazing, right up to the final destination. From GIS analysis, the areas possibly affected by the transhumance grazing were selected.

*Definition of regional planning units by a spatial abstraction procedure*

Figure 8 shows the results of the bottom-up procedure based on a spatial abstraction. The overlay of the village territory coverage with the layers above described generated a new spatial database that was used to perform the aggregation

*Table 4.* Activities to be implemented in 5 years local plans by villages in the study area.

| Villages | Population (1995) | Estimated land (ha) | Soil conservation (ha) | compost pils (number) | Construction water reservoir | Lowland reclamation (ha) | Protection river bank (km) | Plantation forest plots (ha) | Construction vaccination parks | Local roads (km) | Delineation of pastoral zone |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Kadomba | 5,700 | 6,000 | 150 | 125 | 1 | 25 | 20 | 40 | 0 | 0 | 1 |
| Balla | 3,045 | 4,591 | 100 | 100 | 0 | 20 | 0 | 3 | 0 | 0 | 1 |
| Dafinso | 1,200 | 2,716 | 20 | 50 | 0 | 100 | 20 | 13 | 1 | 0 | 0 |
| Banakeledaga | 2,720 | 1,586 | 100 | 150 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diofoloma | 3,200 | 4,356 | 200 | 100 | 0 | 0 | 20 | 23 | 1 | 7 | 0 |
| Sembleni | 400 | 9,855 | 50 | 75 | 1 | 0 | 0 | 3 | 0 | 0 | 1 |
| Gognon | 600 | 6,110 | 75 | 75 | 0 | 0 | 10 | 18 | 0 | 0 | 1 |
| Pala | 1,070 | 6,196 | 20 | 50 | 0 | 0 | 0 | 45 | 0 | 2 | 0 |
| Yegueresso | 1,540 | 1,083 | 50 | 75 | 1 | 0 | 0 | 10 | 0 | 0 | 1 |
| Niamadougou | 1,000 | 1,693 | 50 | 350 | 1 | 0 | 0 | 0 | 0 | 2 | 1 |
| Toussiana | 6,640 | 3,164 | 250 | 650 | 1 | 0 | 0 | 0 | 2 | 32 | 1 |
| Ramatoulaye | 900 | 2,500 | 100 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

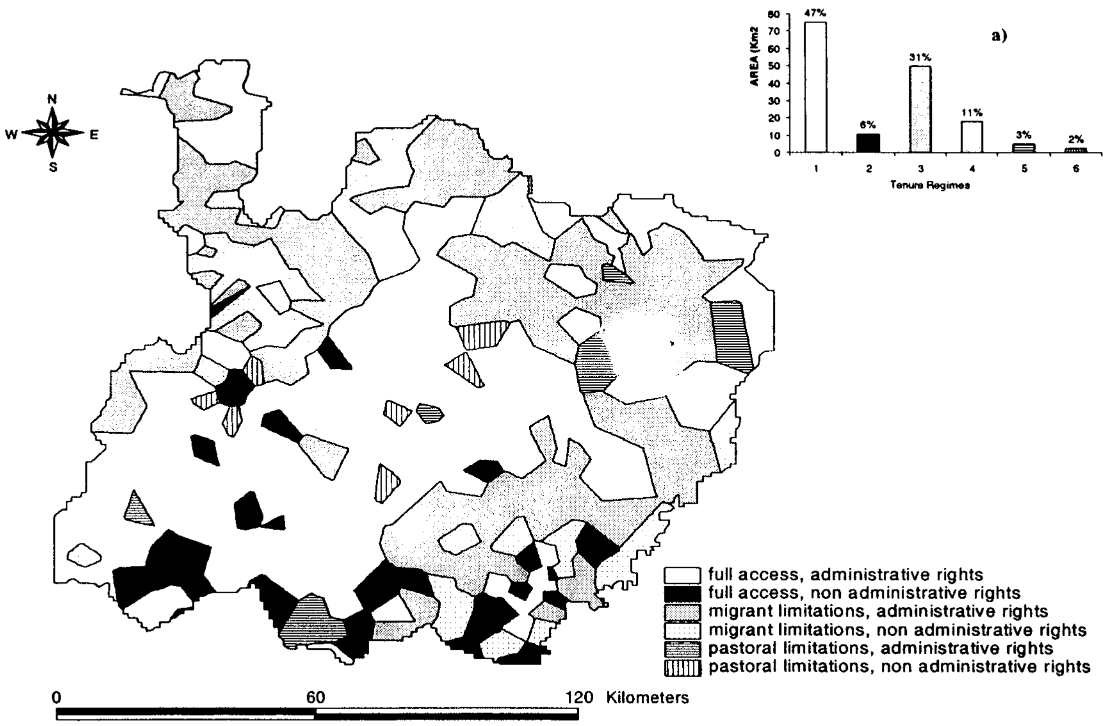


*Figure 7.* Distribution of the different tenure regimes and their importance at regional level.

*Table 5.* Statistics of wood exploitation for the 17 villages around.

| | | Lowest village revenues | Highest village revenue | Average | Total revenues for all the villages |
|---|---|---|---|---|---|
| *Revenues of the wood exploitation (CFA)* | | 183,600 | 2,955,955 | 6,102,273 | 14,735,370 |
| Comparative size of area needed for crop production (ha) | | *Min area* | *Max area* | *Average area* | *Total area* |
| | Cotton | 2 ha | 301 ha | 64 ha | 1,530 ha |
| | Maize | 3 ha | 432 ha | 102 ha | 2,454 ha |
| | Sorghum | 5 ha | 724 ha | 152 ha | 3,681 ha |

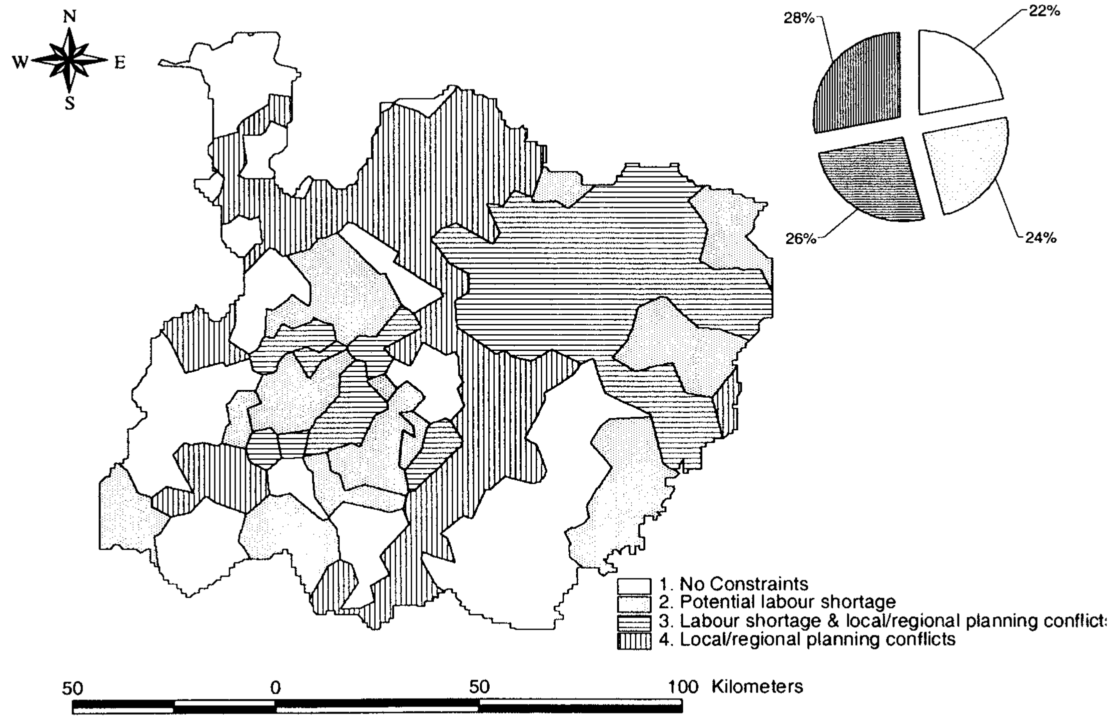


*Figure 8.* Results of a bottom-up spatial abstraction procedure in regional planning.

procedure for regional planning. A spatial database contains data that represent in principle elementary statements, which often refer to the relationships between objects and geometric or thematic data (Molenaar, 1998). In the present situation, the overlay operation added to each village entity a set of attributes representing the different constraints defined above. Queries were performed in this new spatial database, to derive regional objects representing specific regional planning patterns. Class generalisation and object aggregation (Molenaar, 1993, 1998) were done based on Boolean operators ('AND' and 'OR'). This allowed selecting the elementary objects from specific attributes, which were used to recompose (reclassification or aggregation) the regional planning. Thus, based on the local information collected from PRA at local level, different orientations could be given to the regional planning. The results of the aggregation procedure show in Figure 8 that 22% of the province territory is not affected by any of the constraints mentioned above (excluding the issue of access to resources determined by the tenure regimes).

Almost half of the province is facing either a potential labour shortage for implementing land management activities or potential local to regional planning conflicts. Less than 25% is facing both constraints. Based on these results, different scenarios can be explored by the regional planners to support the local plans. We can conclude that from a land use planning perspective, the spatial aggregation procedure aids real communication between the local and the regional levels.

## Conclusion

The case study has shown that the method of GIS integration was useful for spatially linking the local participatory and the regional levels of planning for sustainable resource management. From the planning perspective, the bi-directional procedure proposed by the study offers an iterative way for providing the relevant information issued from one level, in a spatial format that is usable at the other. The PRA methods provide a holistic way for better describing the local planning units, which are to be aggregated at regional level. The principle of data encapsulation used the in the spatial database enables to flag and retrieve the important specific local information which can be used when necessary.
Technically it was proved that PRA data (often considered marginal) could be reliably handled together with other conventional data in a GIS. However, despite its simplicity and flexibility (which is convenient for regional planning where GIS is often perceived as a sophisticated decision tool) more research is needed for addressing specific issues such as handling conflicts in sustainable resources management using relevant information from both levels.

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## References


Bayer W. and Waters-Bayer A., 1994: *Planning with pastoralists: PRA and more: a review of methods focused on Africa.* Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), Eschborn.

Boudet G., 1991: *Manuels et précis d'élevage: 4. manuel sur les pâturages tropicaux et les cultures fourragères*. IEMVT, La Documentation Française.

Chambers R., 1994: Participatory Rural Appraisal (PRA): Analysis of experience. *World Development* **2** (9): 1253–1268.

Checkland P. and Scholes J., 1990: *Soft Systems Methodology in Action*. John Wiley & Sons, Chichester.

Davis G.B. and Olson M.H., 1985: *Management information systems: conceptual foundations, structure, and development*. McGraw-Hill (McGraw-Hill series in Management Information Systems), New York.

Dent D., 1997: Policy for the management of natural resources. *Land-Chatham*. **1**(1): 3–27.

Driessen P.M. and Konijn N.T., 1992: *Land-use systems analysis*. Wageningen Agricultural University, Dep. Of Soil and Geology. Malang, INRES.

Dugué P., 1989: *Possibilités et limites de l'intensification des systèmes de cultures vivriers en zone Soudano-Sahelienne: Le cas du yatenga* (Burkina Faso). Département Systèmes Agraires du CIRAD, Montpellier.

FAO (ed), 1995: *Planning for a sustainable use of land resources. Towards a new approach*. FAO, Rome.

Fresco L., Huizing H.G.J., Van Keulen H., Luning H.A., 1990: *Land evaluation and farming systems analysis for land use planning: FAO guidelines.* Working document, Rome.

Gottlieb P. and Reilly J.A., 1994: Simulation model for state growth management planning and evaluation: the New Jersey case. *Comp. Environ. Urban Syst.* **18**(1): 43–53.

Groten S.M.E., 1997: Air Photos as means of communication in land Management. *Agricult. Rural Develop.* **4**(1): 11–14.

Grenier L., 1998: *Working with indigenous knowledge: a guide for researchers*. IDRC, Ottawa.

Loader R. and Amartya L., 1999: Participatory Rural Appraisal: Extending the research method base. *Agricult. Syst.* **62**: 73–85.

Luning H.A., 1986: Survey comes of age? : Inaugural address upon his official acceptance of the office op professor of survey integration for development at the International Institute for Aerospace Survey and earth Sciences (ITC), 9 January 1986, Enschede.

Maatman A., 2000: Si le fleuve se tord, que le crocodile se torde: Une analyse des systèmes agraires de la région Nord-Ouest du Burkina Faso a l'aide des modèles de programmation mathématiques. Centre for Development Studies, University of Groningen, Groningen.

Mohamed A.A., 1999: An integrated agro-economic and agro-ecological framework for land use planning and policy analysis: farm type land units, PhD Thesis Wageningen Agricultural University, Wageningen.

Molenaar M., 1993: Objects hierarchies and uncertainty in GIS or why the standardisation is so difficult. *Geo-Inform. Syst.* **6** (3).

Molenaar M., 1998: *An introduction to the theory of spatial object modelling for GIS.* Taylor & Francis, London.

Nurse M.C., Singh H.B., Paudyal B.R., Bonjan S. and Riley J. 1993: Beat-level planning: Development of a management information system for community forestry. *Second National Community Forestry Workshop*. Nepal, Banko-Janakari **4**(1): 91–95.

O'looney J., 2000: *Beyond maps: GIS and decision making in local government*. Environmental Systems Research Institute (ESRI), Redlands.

Rabbinge R. and van Ittersum M.K., 1994: Tensions between aggregation levels. In: Fresco *et al.* (eds), *The future of the land: mobilising and integrating knowledge for land use options*. International interdisciplinary conference, Wageningen. Wiley & Sons, Chichester.

Ramm J.F., 1992: A planning and training approach for local development in Madang Province, Papua New Guinea *UNCRD-Working-Paper*, No. **92**(1).

Scoones I. and Thompson J., 1994: Knowledge, power and agriculture: towards a theoretical understanding. In: Scoones I. and Thompson J. (eds), *Beyond farmer first: rural people's Knowledge, agricultural research and extension practice*. Intermediate Technology, London.

Sedogo L.G. and Groten S.M.E., 2000: Definition of land management units for GIS support to participatory planning: A case study on participatory land management in Burkina Faso. In: Cowie W. (eds), *Special Issue: Participatory Development* Vol. XXI Canadian Journal of Development Studies, University of Ottawa, pp. 523–542.

Tang A.Y., Adams T.M., Usery E.L, 1996: A spatial data model design for feature-based geographical information systems *Intern. J. Geogr. Inform. Syst*. **10**(5): 643–659.

UNCED, 1992: Earth summit: convention on biological diversity. In: U.N. (eds), *United Nations Conference on Environment and Development UNCED*, *Rio de Janeiro, Brazil*. United Nations, New York.

United Nations, 1996: *Manual on GIS for planners and decision makers*. Economic and Social Commission for Asia and the Pacific, New York.

Van den Hoek A.I., 1992: *Planning as a Learning process: a strategy for planning land use programmes at local level with special reference to the uplands of Java*. PhD Thesis. Wageningen Agricultural University, Wageningen.

Van Duivenbooden N., 1997: Land-use system analysis, a multi-scale methodology to explore options for development of sustainable agricultural production system. *International conference on Geo-Information for sustainable land management*. 17–21 August, Enschede, The Netherlands.

Walker M. and Sarkar A.A., 1996: The development of a national agricultural extension policy in Bangladesh. *Europ. J. Agricult. Educ. Extension*. **3**(2): 85–95.

Yue-Hong Chou, 1997: *Exploring spatial analysis in geographic information systems*. OnWord Press, Santa Fe.