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Sustainable resource management in Benin embedded in the process of decentralisation

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Abstract

This article gives an overview on an integrated socio-economic approach to meet the complexity of resource use in a representative catchment area in Benin, West Africa. Main objective of the studies is to analyse interdependencies between resource availability and socio-economic, respectively, demographic development, incorporated in the process of institutional reorganisation. The ongoing decentralisation in Benin encounters obstacles, as responsibility is shifted from a national to a local level without being embedded in a framework of constitutional security.

In this article we focus on crucial problems and highlight significant though preliminary results with reference to the decentralisation process, regarding basically the resources water and land. Results of field surveys are presented together with a modelling tool to integrate these data in an agricultural sector model.

Water will become scarcer due to growing population and changing water consumption patterns. Migration flows aggravate the competition over land and water. The detailed knowledge on these shortly outlined processes allows to identify sustainable strategies in order to mitigate the impending crises. Resource management approaches like CBNRM ("Community Based Natural Resource Management") form a conceptual basis, which must be accompanied by a long-term planning of state institutions to steer resource use and by the introduction of locally adapted land use systems (like Cashew-plantations in the catchment). The decision support system BenIMPACT supports the quantitative assessment of different development paths.

The dominant basic needs strategies of all national and international development agencies operating in Benin have to recognise the process of the shortening of the basic natural resources water and land to ensure their sustainability in the future.

Keywords: West Africa; Water supply; Water demand; Decentralisation; Land use; Modelling

1. Introduction

Low per capita income, an economy that is dominated by a subsistence-oriented agricultural sector, and high population growth provoke scarcity and overexploitation of resources in several regions of Benin, West Africa. Compared to other factors limiting development such as land and capital, water is not the most important one, but one of growing importance in an economic and ecological dimension.

On the one hand, the total amount of renewable water resources in Benin reaches up to 4000 m^3 per capita and year (UNESCO, 2003), which is considered to be a sufficient amount (Falkenmark and Widstrand, 1992). On the other hand, the Water Poverty Index of the Centre of Ecology and Hydrology classifies Benin in 137th position out of 144 countries (Centre for Ecology and Hydrology, 2003). This example demonstrates that the availability of resources depends on different factors. Developing solutions for these complex problems

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requires an integrated approach, focusing on both local and regional scales.

In this article we refer to the socio-economic part within IMPETUS, an interdisciplinary project which is located in the northern part of the Ouémé-catchment in Benin. The main objective is to analyse the interdependences between resource availability and socio-economic or demographic development, which is embedded in the process of institutional reorganisation. The ongoing decentralisation in Benin encounters obstacles as responsibility is shifted from a national to a local level without being incorporated in a framework of constitutional security.

The catchment area is an example reflecting the situation of several regions in Benin and other countries in West Africa. It already faces land scarcity for not land-owning social groups, provoking water and land conflicts between different user groups. The approaches to mitigate or to even prevent these consequences like CBNRM ("Community Based Natural Resource Management") should be accompanied by a long-term planning of state institutions and donors.

In this paper we focus on the following crucial problems and highlight significant results with reference to the decentralisation process: water, land use systems, policy analysis, and a modelling tool for resource management.

2. Main problems of resource management on a local/regional scale

2.1. Water demand and supply

The following chapter describes the situation of water demand (domestic, agricultural and industrial) and of water availability, which shows the effects of population growth and the impact on the decentralisation process. The rising water demand is particularly determined by the high population growth of 3% at present (World Bank, 2003). In the year 2025 Benin's population will grow up to 11.1 million people (UNFPA, 2003). At the same time high immigration rates intensify the pressure on natural resources. The population growth in the Ouémé-catchment reaches up to 5% because of high immigration rates in this traditionally sparsely populated area. Migrants from neighbouring countries and the northern parts of Benin find there the last vacant cultivable area.

How could future demand on water be prognosticated? An analysis of water demand requires reliable data, but calculations of international organisations do not correspond to the newest conditions. Own fields research is necessary in order to choose and develop solution strategies. The following remarks are the results of interviews with experts (88 experts during the first round and 43 experts in the last round) after the Delphi method (Pepels, 1995; Akker, 2000). Based on the use of a structured questionnaire, these interviews were conducted in three interdependent series and among rural and urban peoples.

Concerning water demand, the current allocation is divided into 28% for domestic, 58% for agricultural and 14% for industrial use (FAO, 2002). Many experts estimate that the percentage on the domestic level will rise up to 30% by 2025 because of population growth, progressive urbanisation and waste of water. The industry will also expand their need up to 20%. This is explained by the development of new industries. In contrast to the domestic and industrial sectors, agriculture will not proportionally expand its need (50%). A more rational use and a reduction of the population of farmers due to the migration is expected.

The results of focus group discussions with experts at the beginning of this study reveal three different conditions of water consumption: people who are living in rural (Sérou) and in urban areas (Djougou), with and without access to water (tap).

The results of the water consumption analysis on household level show that inhabitants of rural areas use about 17 l per person and day. The absence of own water sources, the long distance from the habitation to a well, and limited resources in the dry season characterise consumption in rural Benin. A similar situation was found in the outskirts of the town areas. People without access to water have the same problems like people from the villages. So the water consumption level reaches with 20 l a similar amount. In contrast, the water consumption of the city inhabitants, who have their own water sources, is clearly higher with 29 l. The water demand will rise as the living standard increases. Now, a progressive urbanisation can be observed. This process will lead to an increase of water consumption. Water poverty is seen as the most important problem by 85% of the women in the selected area (multiple answers were possible). Although water poverty presents an important issue, 95% of the families are not willing to migrate. This is due to strong family ties, land and house ownership. If people prefer to stay in the region of their origin, even if there are limited water resources, pricing of water might be a solution to control the consumption of this scarce resource. This aspect was also discussed in the investigation area. About 95% of the persons asked would accept to pay, but only in the dry season.

Up to now, irrigation has just been of marginal importance in Benin. Apart from actively watered fields at the river courses, expansion of crop fields is dominating in order to satisfy basic needs. It was stated that the proportional part of the quantity of water for agricultural use will decrease in the future. However, irrigation, which is promoted by many projects, will become more important. At present, the industrial production is of little importance in Benin. The main part of industrial water consumption is attributed to wood, beverage and textile industry. Due to the high population pressure, food-processing industries have to be developed.

The expansion and intensification of these facilities are mainly obstructed by missing financial and technical means. Anyhow, there are also problems of water supply at the administration and organisation of supplying strategies. The national water authority, which is responsible for the supply of rural areas, was divided into 12 regional units in the course of decentralisation. The present national water supply strategy has followed a bottom–up principle since 1992. This means that service supplies are done only in a demand-driven way. That includes the verification of certain conditions of organisations or institutions within the village as well as the transfer of a certain amount of money on a special account. Two principles are used in order to strengthen the national supply strategy: the decentralisation of the decision-making process down to the level of the villages on the one hand, and cost recovery (the community of the demanding village has to pay a part of the costs) on the other hand. The principle may work well providing that there are reliable rules, time frames and equipment. In fact, the following problems show up: the decentralisation faces problems in terms of organisation, as the strategies of the regional units of the national water authority (SRH) are not carried out uniformly. The rules given to the villagers are not examined by the SRH and sanctions are arbitrarily determined. The population cannot adjust to a uniform and reliable system. The waiting period can reach up to 3 years before a well or a pump has been installed (after the community has paid the amount for self-participation) so that there is a growing lack of confidence in state institutions. As a consequence, the villages ignore the rules of the SRH. Long-term losses of damaged supply installations become thus inevitable. Maladjusted structures or missing sensitisation can both be possible causes. To ensure work on community level, resource management has to be embedded in a framework of reliability and constitutional legality.

Another problem is the fact that the national water supply depends to a considerable degree on project funds that means on money from foreign countries. This has the effect that comprehensive long-term planning is not possible, or only possible for a maximum of 1–2 years.

The daily problems of the domestic water supply are clarified in the accompanying illustration. Apart from the waiting periods at the water points, the time for walking to the water points and back must also be taken into consideration for the time requirement. As a result, we can observe an average of 6 h per household in the rainy season. In the dry season the time requirement is of course even higher and reaches a daily average of 10 h per household in Kaki-Koka (a small village in the catchment).

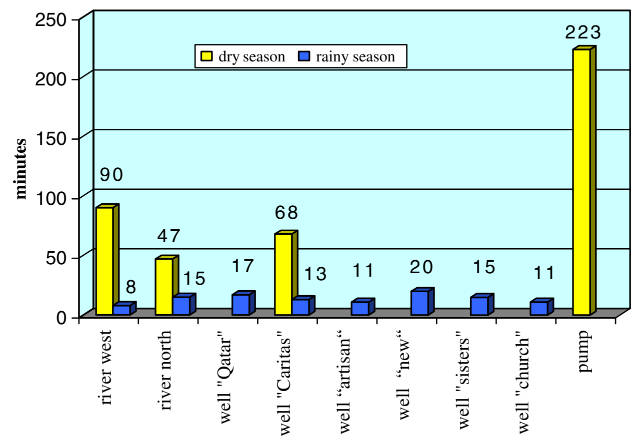

Fig. 1. Waiting time at water points in Kaki-Koka (in minutes), own calculations.

The following illustration refers to two time analyses that were accomplished in April and September 2002 in Kaki-Koka (see Fig. 1).

The example shows that the only way of having access to safe water all year round is to construct a deep pump or a deep well. The deep pump in Kaki-Koka, however, is totally overcrowded in the dry season. The organisational aspects of an additional pump cause large problems to the villagers due to the reasons specified above. This is why there is no safe domestic water supply at present. Besides the improvement of organisational constraints, the domestic water supply in the villages could be risen by saving water in agriculture.

2.2. Land use systems under demographic pressure on land and climate change

Sustainable land use systems can improve the domestic water supply for example "if we managed to improve the [water] efficiency by 1% in one hectare, this will provide drinking water for 150 people for a whole year" (Florin, 2003). Wallace (2000) confirmed that there is great potential for improving agricultural water use efficiency. Land use systems in the upper Ouémé-catchment can be classified in natural vegetation, fallow and agricultural areas that are not yet accompanied by any strategies to improve agricultural productivity. Thamm and Menz (2002) found out that the forest area diminished from 11% to 6% between 1986 and 2000. The shifting cultivation system (Ruthenberg's coefficient > 66; Ruthenberg (1976)), through land clear, is mainly responsible for the decrease of natural vegetation and biomass burning which has lead to soil degradation and carbon release in this area. The carbon sequestration (as stored in soil, litter, aboveground and underground biomass) reaches 135.0 t/ha in closed forest and 70.9 t/ha in savannah forest but only 32.3 t/ha in cultivated areas.

The current immigration process in the area of research is an agricultural colonisation without any intervention of the state and an almost complete absence of other development agencies. Migrants and autochthonous farmers extend their cropland every year for subsistence and market production. For example, around 10,000 migrants, who have settled in the southern part of our research area within the last five years, clear 1500 ha of dry and savannah forests for yam production every year. A growing number of autochthonous farmers in our research villages have also increased their land property up to 70 ha. The appropriation of common land through individuals planting trees on ancestral lands was identified as one social indicator for the shortening of available croplands. Another one was the worsening of land use conditions for not land-owning groups such as the growing number of herders and migrants. The access to land of the latter was sometimes limited to subsistence level in villages without enough land to clear any more. Use restrictions such as formal and informal taxes have also worsened for these groups. A third indicator was the emergence of a land market in semi-urban areas. All three trends, together with a growing number of different users, tend to include a high conflict potential for the future (Akpaki, 2002).

Since the early 70s, West Africa has been confronted with more seasonal variability of rains (IPCC, 2001). The current farming systems, mainly shifting cultivation, are unable to face it in future. The crops are sown principally from May to August. Yam is at the head of crop rotation: tuber (yam)—cereal—cotton or cereal—leguminous, cereal or cotton—cereal—fallow or cashew.

Except for yam, all the other food crops are always intercropped and the number of intercropped crops increases with land scarcity. Farming systems are also characterised by an increasing area for cashew, which can be considered as reforestation system. Due to the abundance of land, the current farming systems ensure food security but the increase of rain variability and land scarcity will cause food insecurity in future. The consequences of seasonal rain variability under the current farming systems have been analysed through data collected on biomass production, which is the ultimate source of food supply for people. The biomass management has also an influence on the climatic changes due to the release of carbon. In the upper Ouémé-catchment, two stereotype villages (regarding farming systems), Dogué (320 km^2, 802 inhabitants) and Sérou (19 km^2, 450 inhabitants) have been selected respectively according to villages with and without land to clear. Based on the assumptions that the rainy season ends in September instead of mid-October, and that the quantity of rain and the farming systems remain unchanged, we obtained the following results. The soil productivity and rain use efficiency will decrease respectively to 17% and 23% in Dogué, and to 14% and 25% in Sérou (Fig. 2). Let us assume that the daily calories needs (2700 kcal/inhabitant) (Falkenmark et al., 1999) are currently met and that 75% of them come from cereals, leguminous and tubers production. Then, the seasonal rain variability in Dogué and Sérou could lead to peoples' migration (5%), deforestation (2–3%), carbon release (77 and 3 t/inhabitant CO_2) and increase of agricultural water consumption (from 1357 to 1756 in Dogue and from 2562 to 3422 m^3/inhabitant-year in Sérou).

Crops groups	**Productivity (10^6 Kcal./ha)**		**Rain use efficiency (Kcal./m^3)**	
Villages	Dogué	Sérou	Dogué	Sérou
Situation without seasonal rain variability				
Tubers	5.6	4.6	611	301
Cereals	5.3	2.8	662	318
Leguminous	1.4	1.2	362	247
Average	**4.1**	**2.9**	**545**	**289**
Situation with seasonal rain variability				
Tubers	5.6	4.6	611	301
Cereals	3.9	2.1	483	232
Leguminous	0.8	0.7	169	115
Average	**3.4**	**2.5**	**421**	**216**
Decrease (%)	**17**	**14**	**23**	**25**

Fig. 2. Productivity and rain use efficiency in Dogué and Sérou, own calculations.

Currently there is no effective intervention of the state or development agencies to face this potentially explosive situation, that is to say to regulate land right, land use and particularly agricultural intensification. The gaps in the rural service systems are partially closed through a large number of self-help initiatives. Deforestation and soil degradation are two problem complexes where future development work could intervene in the context of the ongoing decentralisation process. CBNRM is one approach often mentioned to meet both challenges in such a context.

2.3. Institutions for rural development

After the weakening of the state services after 1989 a number of programs and projects have been designed to close the service gaps in rural areas. The main intervention sectors are education, health, micro-financing and infrastructure. At present, there do not exist any surface-covering agricultural programs to promote sustainable land management. As almost all NGOs and private sector organisations do highly depend on external financing through these programs and projects, they lack the budget and the will to participate in foresighted development planning including land management. Also missing are approaches that help to better resolve the basic land-related problems of migrants and herders. Neglecting these important land users as well as the production sphere of agriculture in general contributes to what has been called "agrarian development fatigue" (Mwabu and Thorbecke, 2001). This "fatigue" enhances the negative trends of the shortening of available crop lands and the above mentioned worsening of the access and the use conditions for not land-owning groups. The interests and activities of local development committees and traditional leaders comprise negotiations with all kinds of donor agencies, the management of forest resources and the prevention of a land market. But local institutions, which are dominated by autochthonous farmers, are not interested in resolving land-related development problems. Current CBNRM approaches, which are promoted by some donors who neither play an advocacy role for these groups nor react against the process of land degradation, cannot contribute to sustainable ecological and social development. Our findings on the trumpeted decentralisation process were also rather disillusioning. The new possibilities of political empowerment during the last communal elections were misused as a stage for old power games. The "instrumentalisation of disorder as a political instrument" (Chabal and Daloz, 1999) has reached the local level.

3. BenIMPACT: modelling tool for resource management

To evaluate the impact of changing institutional, economic and resource based conditions quantitative modelling tools are required. The results of the above mentioned and further research activities of natural and social sciences are fed into the Decision Support System *BenIMPACT* (*Ben*in *I*ntegrated *M*odelling System for *P*olicy *A*nalysis, *C*limate and *T*echnology Change). It analyses interdependences between resource availability, water use efficiency, socio-economic, and demographic development, in order to assess different development strategies regarding resource utilisation and food security in Benin until 2020. As carried out in the introduction and in the chapters before, strategies must cover a local or at least a regional level to achieve sustainable development, taking into account the characteristics of each region and the process of decentralisation.

The modelling system operates mainly on community level in the catchment area. In addition, computations for other regions in the country can be accomplished, if data is available. Due to different spatial and temporal scales extrapolation is needed in some cases.

BenIMPACT consists of an agricultural sector model (spatial, synthetic, non-linear), a tool to calculate water balances for each culture and each region and a basic data system, which provides data and results in a mapping tool.

The agricultural sector model (ASM) follows the tradition of spatial programming models with endogenous prices. In opposite to traditional linear programming approaches, the regional aggregate programming models at community level contain a dual variable cost function, allowing for calibration to a base year period and an econometrically estimated supply response. The demand side is based on well-behaved Generalised Leontief demand systems, supporting consistent welfare analysis. Regional markets are linked by transport streams to other regions inside the country and to the rest of the world. The model covers the most important agricultural products (yams, manioc, maize, cotton, peanut, sorghum, niebe, and rice).

Main results are regional crop patterns and water use, demand quantities, prices and transport streams and a welfare analysis (producer surplus, budget for agricultural interventions). The ASM is written in GAMS (General Algebraic Modelling System), a common tool for optimisation models.

The Crop Water Requirements (CWR)-calculator defines effective rainfall (P_{eff}) and reference evapotranspiration (ET_0) per crop and region, depending on climate, crop management and crop varieties, based on a large set of regional climatic and engineering data. It is also possible to measure the impact of changing climate on yield, an important input for the scenarios calculated with the ASM. The CWR-calculator employs mainly the mechanisms of CROPWAT, an international standard in this field, provided by the FAO (see Fig. 3).

Together with parameters relating to plant specific water stress tolerance and soil moisture deficit (or

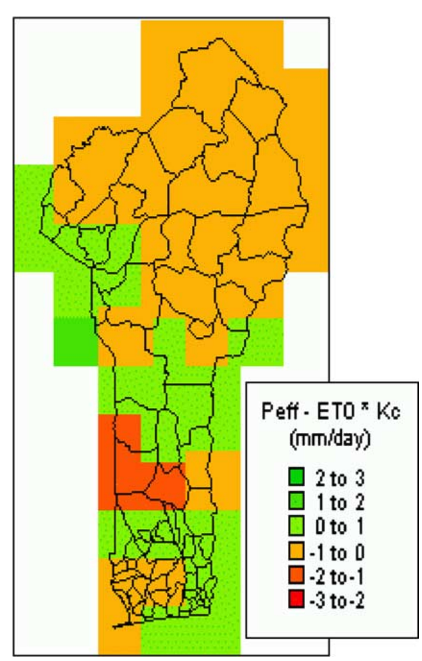

Fig. 3. Crop water balance for maize (average August day).

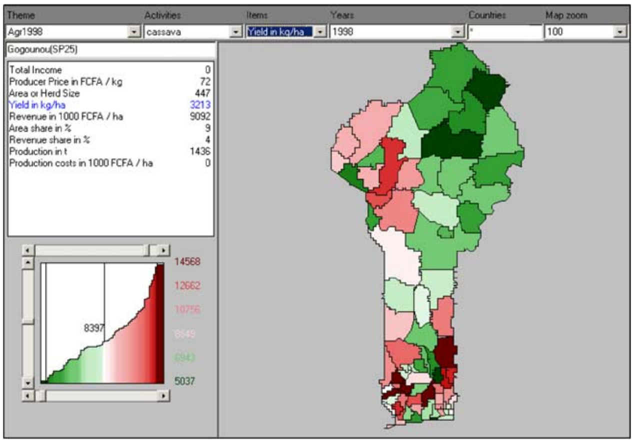

Fig. 4. Benin Mapping Tool.

surplus), the results of the CWR-calculator source restrictions in the ASM, which in turn allows to simulate future agricultural land use.

The results of ASM-simulations are visualised in the interactive "Benin Mapping Tool" (BenMap), based on a Java Applet, so that results can be accessed by stakeholders via Internet. An easy-to-use interface allows to exploit all data in the Basic Data System.

Establishing BenIMPACT as a decision support system in corresponding institutions in Benin is one of the main objectives. Preliminary results indicate that Benin will face severe problems, mainly due to the increasing population, the limited availability of fertile soils, and regional and temporal water scarcity (see Fig. 4).

4. Outlook

The problem areas presented have shown the difficulties that rural population and the development agencies in Benin are facing today. Contrary to the expectations in the sphere of development policy, the unfinished decentralisation process makes the problem management even more difficult. Decentralisation should not be a process ordered by the decision-makers, but a process, which is intended and supported by the population.

The co-management of natural and local resources, too, requires political willingness (against corruption, clientelism) on the part of the state as well as knowledge and procedures considering all social groups of local decision-making. These two basic conditions are not fulfilled in Benin. Projects aiming at the strengthening of local self-help capacities tend to produce fictitious participation due to the lack of a control authority.

As a concept for the future water sector, the idea of CBNRM would lead to a further liberalisation with socially acceptable water prices (determined by the state). Diversification of the offering part would give the local decision-makers the possibility to choose the most efficient supplier, i.e. in the field of well building. The new competitive situation produces an improvement of quality and counteracts corruption.

As described above, most current rural development strategies do not take into account land-related development problems. However, only the introduction of sustainable crop systems, which are promoted by isolated projects, can halt the process of the reduction of land resources. To reverse the negative social effects of this process for not land-owning groups, it would be necessary to embed CBNRM in a legal framework of land entitling, that is accessible for and accepted by all social groups (Leach et al., 1999).

One of the objectives of decentralisation would be to support the farmers' initiatives to improve agricultural intensification, which is the principal way to achieve sustainable food security and resource use. Article 17 of the Kyoto Protocol allows industrialised countries to produce certified emissions reductions and emissions reductions units (Pretty and Ball, 2001) by investing in emission reduction projects in developing countries. Benin can take this advantage to finance projects that will permit sustainable land use.

Designing strategies for future politics requires, beneath a better knowledge of the interactive processes in the observed region or country, modelling tools to assess different development paths. In this regard, the decision support system BenIMPACT can be useful for the decision makers of the corresponding institutions.

The dominant basic needs strategies of all national and international development agencies operating in Benin must notice the process of the shortening of the basic natural resources water and land to ensure the sustainability of their measurements in the future.

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