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Analysis and evaluation of the agro-potential of inland valleys in the Upper Ouémé catchment (Benin, West Africa)

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Abstract

Using a multi-level approach, this study aims to analyse the current and future agro-potential of the inland valleys in the Upper Ouémé catchment of central Benin. As no sufficient inland valley database was previously available for Benin, a detailed field survey of physical and socio-economic properties of inland valleys was carried out. This was done in cooperation with the *Cellule bas-fond*, the governmental structure for inland valley management in Benin. In addition, remote sensing data were analysed in order to locate inland valleys in remote areas. The catchment properties of the inland valleys were determined using GIS-data of soils, geology and topography. For selected inland valleys, detailed field studies of soil properties (physical and chemical) were conducted. The results attained here will be used as input for a future integrated modelling approach to assess the agro-potential of the inland valleys in the Upper Ouémé catchment. Based on the results of the survey, the GIS-analysis, and the modelling approach, a decision support tool will be developed in cooperation with stakeholders. The tool will aid the *Cellule bas-fond* and the Communes to decide the inland valleys where agricultural exploitation is feasible, and where to best install water management infrastructure.

1. Background and aim of the study

The rapidly growing population in sub-Saharan Africa necessitates an increase of food production. In some regions, arable land has already become scarce and the degradation of soils continues due to the shortening fallow period. Inland valleys offer extensive, relatively unexploited potential for agricultural production due to their higher water availability, lower soil fragility and higher fertility compared to the upland areas.

The scarcely populated Upper Ouémé catchment in central Benin has been subject to high population growth in the last decade, due to high fertility and high immigration rates. This has caused an expansion of agricultural areas, and led to both deforestation, and shortages of immediately available land for agricultural production. Therefore, the exploitation of inland valleys will only become more important to this region's future.

The aim of this study is to analyse the current and future agro-potential of inland valleys in the Upper Ouémé catchment, considering aspects of global change.

This study forms part of the IMPETUS project. This programme looks at the impact of global change on water resources and food security in two catchments in West Africa: the Wadi Drâa, and the Ouémé catchment in Benin. A major focus of the project is to transfer the results of research to decision makers in the target countries. Another is to develop decision support tools based on the research results, with the participation of stakeholders.

The governmental department responsible for the planning and management of inland valleys in Benin is the *Cellule bas-fond*, a part of the *Direction de Genie Rural (DGR)* in the Ministry of Agriculture. As the main decision maker in terms of inland valley management, the *Cellule bas-fond* is the logical main stakeholder integrated in this study. Communal authorities are also involved in the planning process.

In order to efficiently plan and manage the exploitation of inland valleys, the *Cellule bas-fond* and the communes both need a database with information about physical and socio-economic properties of these areas. The results from the study 'Inventaire, Etude et Aménagement des Bas-Fonds', carried out between 1986 and 1992 by the FAO, are not available in a database format. Further, these inland valleys were not georeferenced, or surveyed for their physical or socio-economic properties. In this original FAO investigation, about 180 inland valleys were identified in the entire Benin (Assigbé & Mama, 1993).

Benin is also a member of the Inland Valley Consortium (IVC), a platform for regional cooperation to promote the sustainable development of inland valleys. However, the past activities of the IVC in Benin mainly focused on detailed investigation of three inland valleys in the commune of Dassa-Zoumé (Assigbé & Mama, 1993).

Overall, no satisfactory database for the analysis of the agro-potential and the efficient planning of inland valley management has been available for the decision makers of Benin. Therefore, the development of an adequate inland valley database was integrated as part of this investigation in cooperation with the *Cellule bas-fond*. This database, and an integrated modelling approach, will be used to develop a future decision support tool in cooperation with the *Cellule bas-fond* and the IVC.

2. The multi-level approach

The approach to evaluate the agro-potential of the inland valleys in the target region consists of four steps. These involve: a detailed survey of the inland valleys, a GIS and remote sensing analysis, detailed soil property investigations of 13 inland valleys, and a multidisciplinary modelling approach.

2.1. Survey of inland valleys in the Upper Ouémé catchment

As no sufficient database was available for inland valleys, a survey to determine physical and socio-economic properties of those located in the communes of the Upper Ouémé catchment was carried out, in Cooperation with the *Cellule bas-fond*. While the communes N'Dali, Djougou, Parakou, Bassila and Tchaourou were surveyed completely, only the parts lying within the Upper Ouémé catchment were taken into account for the communes of Copargo, Sinende and Bembéréké. The subject inland valleys were identified by the staff of *Cellule bas-fond* through personal interviews with local authorities (*chef de village, délégué*) in each village of the target region. With the assistance of local farmers, the extent of each inland valley was mapped using GPS. For each inland valley, a detailed questionnaire was completed to determine aspects of geomorphology, soils, hydrology, ethnic affiliation of the farmer, exploitation of the inland valleys, management structures, selling of products on the markets, etc.

2.2. GIS and remote sensing analysis

In addition to the personal surveys, GIS and remote sensing analyses were performed. Using GIS-analysis, geology, soils, topography and land use were carried out using a geological map of the

catchment area (Office Béninois des Mines, 1984), a soil map (Faure, 1977), the SRTM digital elevation model, and the land use classification of Judex (2002).

The personal survey only identified inland valleys known by the local population. Consequently those inland valleys situated in remote areas were not located. In order to locate remote inland valleys, aerial photographs (available for a small band of the catchment) were analysed. Landsat images for the whole catchment were available, but past investigations by the IMPETUS-project have shown that the identification of inland valleys using Landsat scenes is very difficult. Using the database generated through the personal surveys, numerous training areas were available which made a classification of less known inland valleys easier.

Using the database of the survey and the analyses of remote sensing will facilitate the identification of most of the inland valleys in the target region.

2.3. Detailed investigation of selected inland valleys

Based on a GIS-analysis of topography, geology and climate, different zones were classified. In each zone, the geomorphologic and hydrologic properties of the inland valleys determined by the survey were analysed in order to select typical inland valleys of each zone. In the 13 selected inland valleys, detailed soil investigations of physical and chemical properties were carried out. The results of this work formed important input for the modelling approach described in the next section.

2.4. Interdisciplinary modelling approach

In order to evaluate the agro-potential of the inland valleys, an interdisciplinary modelling approach will be applied. The hydrological model determines the extent of the saturated area and the length of the period with sufficient water availability for cultivation in the inland valleys. The results are used in the crop models EPIC and ORYZA, which calculates the potential yield of different crops cultivated in the inland valleys (e.g. rice, yams etc.).

The total agro-potential will be assessed using the modelling results, in combination with the exploitable inland valley area (determined by the survey and the remote sensing analysis).

As input data for the modelling approach, the results from the survey and the detailed soil investigation are used. In addition, data concerning climate, crop parameters and information about the tillage system were taken from former investigations of the IMPETUS-project.

The modelling approach is shown in Figure 1.

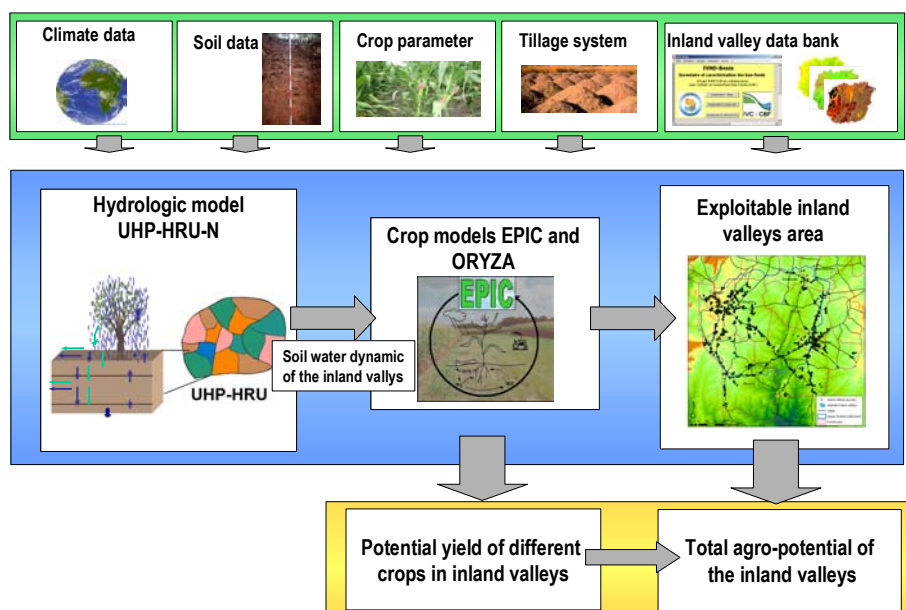


Fig. 1: Modelling approach to evaluate the agro-potential of inland valleys

Using this approach, the evaluation of current and future agro-potential of inland valleys is feasible. Climate and land use scenarios are provided from climate and land use models from the IMPETUS-project (Paeth, 2004; Thamm et al., 2005).

3. Initial results

Based on the survey data, and the GIS-analysis, a user friendly Access database was set up in cooperation with the IVC.

During the survey, 784 inland valleys were located in the target region. A map with the inland valleys located by the survey is shown in Figure 2. Additionally, 8 of the 13 inland valleys selected for the detailed investigation concerning soil properties are displayed. The map demonstrates that most inland valleys were located near roads, which has resulted from the methodology of the survey.

These inland valleys situated close to villages are easy accessible for the population. Therefore, they are more important for the current agro-potential than inland valleys in remote areas. However, for the analysis of future agro-potential, inland valleys in remote areas are also of interest. Consequently, an analysis of remote sensing data is necessary in order to identify remote inland valleys which may actually be located far from any existing village (see Section 2.2).

Of the inland valleys surveyed, 67% are partly used for agriculture by the local population. However, initial remote sensing results showed that a large number of unexploited inland valleys were not identified by the personal survey.

Only 3% of the inland valleys in the region contain infrastructure for water management such as dikes with water control channels, or irrigation support. Most farmers indicated that the major problem of the inland valley exploitation is the lack of water management infrastructure. Water for irrigation is often difficult to obtain during the dry season, and water control mechanisms are missing during the rainy season.

The major crops grown during the rainy season are rice, maize and yam, while during the dry season oca, tomato and onion are often cultivated.

These first interpretations of the survey data show that the survey database contains relevant data for effective inland valley planning and management.

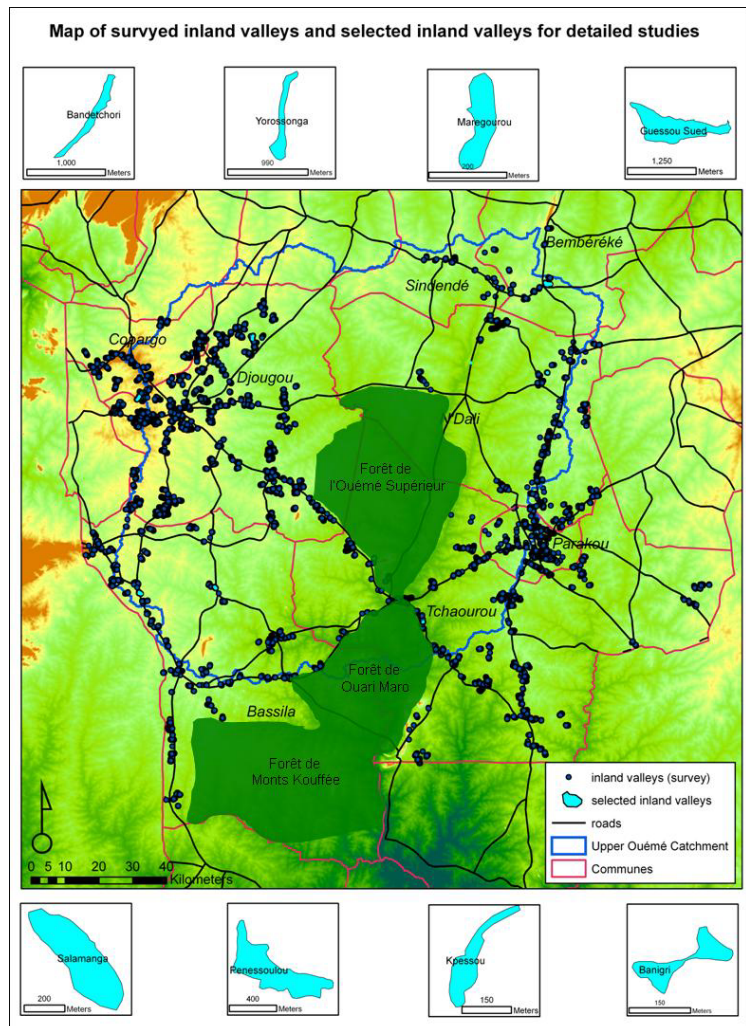


Fig. 2: Map of surveyed inland valleys and selected inland valleys for detailed studies

4. Outlook

Based on the results of the survey, the GIS analysis, and the modelling results, a decision support tool has been developed in cooperation with the main user (*Cellule bas-fond*) and the IVC. A user-friendly inland valley information tool has already been established by the IVC for Togo. Therefore, a similar structure is intended for this Benin decision support tool in order to ensure the sustainable maintenance of the system by the IVC.

Our tool will aid the *Cellule bas-fond* and the communes to decide in which inland valleys the agricultural exploitation is feasible and where to best install water management infrastructure.

An enlargement of the survey for the entire Benin is envisaged by the *Cellule bas-fond*.

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