Livelihood Characterisation of South Sudan: The use of physiographic and agro-climatic layers.

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The longstanding conflict in South Sudan has led to a heavy reliance on a fragmented knowledge base. Current reconstruction and recovery activities impose the urgent need of a unified and a systematic knowledge base to identify livelihood opportunities and constraints and development priorities. The increased availability of spatially-continuous datasets provides an opportunity to create a spatial database to meet this need. A considerable effort has been dedicated on developing livelihood zones since the 1950s but there are still gaps. In this paper we use ArcGIS to generate a dataset comprising 10 physiographic zones based on five raster datasets: agro-climatology (length of growing period), digital elevation model, USGS land cover, NDVI and FAO Soils of the World. These new zones attempt to bridge the knowledge gap and improve our understanding of the spatial distribution of physiographic characteristics, which are key determinants of livelihoods. In addition, it provides a primary spatial database that can readily be combined with formal surveys to refine livelihoods, conduct vulnerability analysis and identify constraints and opportunities for development programmes. The paper concludes with a discussion of how the map could be used for both contingency and development planning and priority setting.

Keywords: livelihoods, characterization, physiographic zoning, agro-climatic classification**,** vulnerability

1. INTRODUCTION

1.1 Background

Comprehensive mapping of the livelihoods, assets and resources is a fundamental principle in livelihood support in post-war situation (Goovaerts *et al*. 2005). In South Sudan, the longstanding conflict in South Sudan has led to a heavy reliance on a fragmented information system and knowledge base. But the reconstruction and recovery efforts in the post-conflict era present an urgent need of a unified and a systematic knowledge base to identify livelihood opportunities and constraints and development priorities.

This has created a demand for systematic data–derived from detailed case studies, surveys and field investigations–to be used to define a baseline for the post-conflict period. As a result the Sudan Household Health baseline survey was launched in October 2005.

The increased availability of spatially-continuous datasets provide an opportunity to create a spatial database, which can generate a data layer that provides the primary context for interpreting the findings and implications of the formal household and community surveys in terms of natural resources potential or natural capital, agricultural production systems and to identify factors limiting agricultural production.

This study takes a "back-to-basics" approach of combining existing global raster datasets, with expert opinion to derive a spatial database of the physiographic and agro-climatic zones, which will be used as a primary input in livelihood characterisation.

1.2 General description of South Sudan

South Sudan has an estimated population of nearly 10 million people and it covers an area of 640,000 square kilometers. Physiographically, South Sudan is predominated by expansive flood plains and sudd wetlands, associated with the River Nile. The Gross National Income per capita is estimated to be less than $90 US per year (NSCSE, 2004).

Agriculture is the main source of livelihood and there is a tremendous potential to expand to a commercial scale. Sorghum is the main cereal in South Sudan; other crops include maize, cassava, groundnuts and sesame. South Sudan also has a large population of livestock especially in the floodplains and the semi-arid pastoral areas and fish production is also a major source of livelihoods.

1.3 Why physiographic and agro-climatic zoning?

Physiographic (topography, soils and water resources, climate and vegetation cover) characteristics and their interactions define the natural assets (resources) potentially available for livelihood activities. They also delimit the opportunities and constraints for growth and development of primary industries such as agriculture, fisheries and forestry.

Therefore, knowledge of the spatial distribution and people's response to physiographic and agro-climatic elements not only helps to understand the current livelihood activities but also outlines the livelihood options available in different parts of South Sudan.

Because of the primary nature of production (dependent on agriculture, fishing and livestock), the livelihood patterns are highly correlated with the physiographic and agro-climatic zones and therefore, a basic physiographic and agro-climatic layer is a good starting-point for mapping livelihoods since, from a livelihoods perspective, it links endowments (tangible assets) with attainable commodity bundles (food, services, facilities).

2. OVERVIEW OF PAST LIVELIHOOD ZONING EFFORTS

A considerable effort has already been dedicated on developing livelihood zones since the 1950s.

The Southern Development Investigation Team (SDIT) Report (1954) is perhaps the most comprehensive multi-disciplinary study of South Sudan. SDIT divided South Sudan into seven major ecological areas: the Central Rainlands; the Flood Region and the Equatorial region—

further divided into the Ironstone Plateau, Central Hills, Greenbelt and the South-eastern Hills—and Mountains classified into High Altitude Area, Lower Mountain Slopes and Hills and the South-eastern Plains (Annex 1).

Robinson (1987) identified four land resource zones based on agro-climatic potential. These were the Southern Clay plains, Iron Stone Plateau, Greenbelt and the Hills Areas/Other uplands (Annex 2). The hills areas are divided into Eastern foothills and Southern uplands. The report present a summary profile of each zone in terms of percent of area coverage, population density and present land use. The report also provides some agro-climatic profile for each of the zone, which are used in the classification criteria presented in the next section.

Dickie (1991) following the work done by SDIT (1954) and elaborates the systems of agricultural production of four zones: Green Belt; Ironstone Plateau and Central Hills; Colluvial Plains and the Flood region and identifies some opportunities and constraints within each of the zones.

WFP/Save the Children (2000) compiled six broad livelihood zones based on food economy research (1994-2000): Ironstone Plateau, Arid Zone, Nile-Sobat Corridor, Green Belt, Hills and Mountains and Flood Plains (Annex 3).

In June–September 2001 the South Sudan Technical Support Unit in collaboration with Tufts University and two secondees (one each from RASS–Relief Assistance South Sudan and SRRA–Sudan Relief and Rehabilitation Agency) summarised WFP reports archive into a summary of the livelihood systems in southern Sudan. Although this work was not completed, it identified 13 food economy zones and attempted to map the zones (Annex 4).

Most recently, The South Sudan Centre for Census Statistics and Evaluation, FEWSNET and Save the Children UK, under the umbrella of the Livelihoods Analysis Forum, have developed and refined the livelihood zones for South Sudan (SSCSE, 2007). This work divides South Sudan into seven broad zones: the Eastern flood plains, Western flood plains, Nile-Sobat Corridor, Ironstone plateau, Hills and Mountains, Greenbelt and Arid Zone (Annex 5).

The review of past studies shows that there already exists a rich source of information that contains physiographic and climatic dimensions that can be mapped. But there are a number of limitations: one, there are gaps in information availability because great bulk of data was collected during the conflict period which was restricted only to areas considered safe and secure. Another limitation is that because of the fragmented nature of the information base used, it is quite difficult to incorporate new information generated from current systematic studies such as the recently concluded Sudan Household Health Baseline Survey. This project takes a first step to develop a spatially explicit database which will form a basis for delineating livelihood zones.

3.0 METHODOLOGY

3.1 The Datasets

Global spatial data layers have become useful inputs for characterization and have been used extensively for mapping livestock production systems and poverty (Thornton *et al.* (2003) and Kruska *et al.* (2003). This study is aligned to the general methodology and classification approaches outlined by these studies. We delineate the major physiographic areas, using existing spatial data layers together with information from past literature highlighted in the previous section.

Four spatially-continuous (raster) datasets were used in the classification. These are Length of Growing Period, elevation, A Very High Resolution Radiometer (AVHRR) NDVI and FAO Soils of the World.

Length of growing period (LGP) was defined using weather/climate surfaces generated by Jones & Thornton (2000). The LGP defines a period when crop production is possible based on temperature and moisture limitations—roughly when the precipitation exceeds half the potential evapo-transpiration and the mean daily temperature during the growing period exceeds 5^{o}C (White *et al.* 2001). SRTM 500m Digital Elevation Model (DEM) was used for elevation while the FAO soil map was for the soils.

3.2 Classification and Delineation

The datasests were individually classified according to SDIT (1954), Robinson (1987) and Dickie (1991) and individually evaluated for their suitability to define and delimit the different physiographic and agro-climatic zones using existing information and expert opinion. It was found that each layer had a different relative strength in defining the zones.

Consequently, LGP was used to define the arid, hyper-arid and the greenbelt; Dominant soil types were used to define the colluvial plains and the ironstone plateau. Elevation was used to identify the floodplains, high altitude areas and lower hills and mountain slopes. Permanent swamps were defined using the long-term NDVI for February corresponding to the driest month in South Sudan. The criteria used to identify these zones are outlined in Figure 1.

The images were classified using RECLASS function and combined using MATH function in ArcGIS 9.0® into 10 physiographic units (Figure 2). The descriptive parameters (LGP, elevation, dominant soil type and vegetation) of the combined raster dataset were obtained using ZONAL STATISTICS function, which are presented in Table 1.

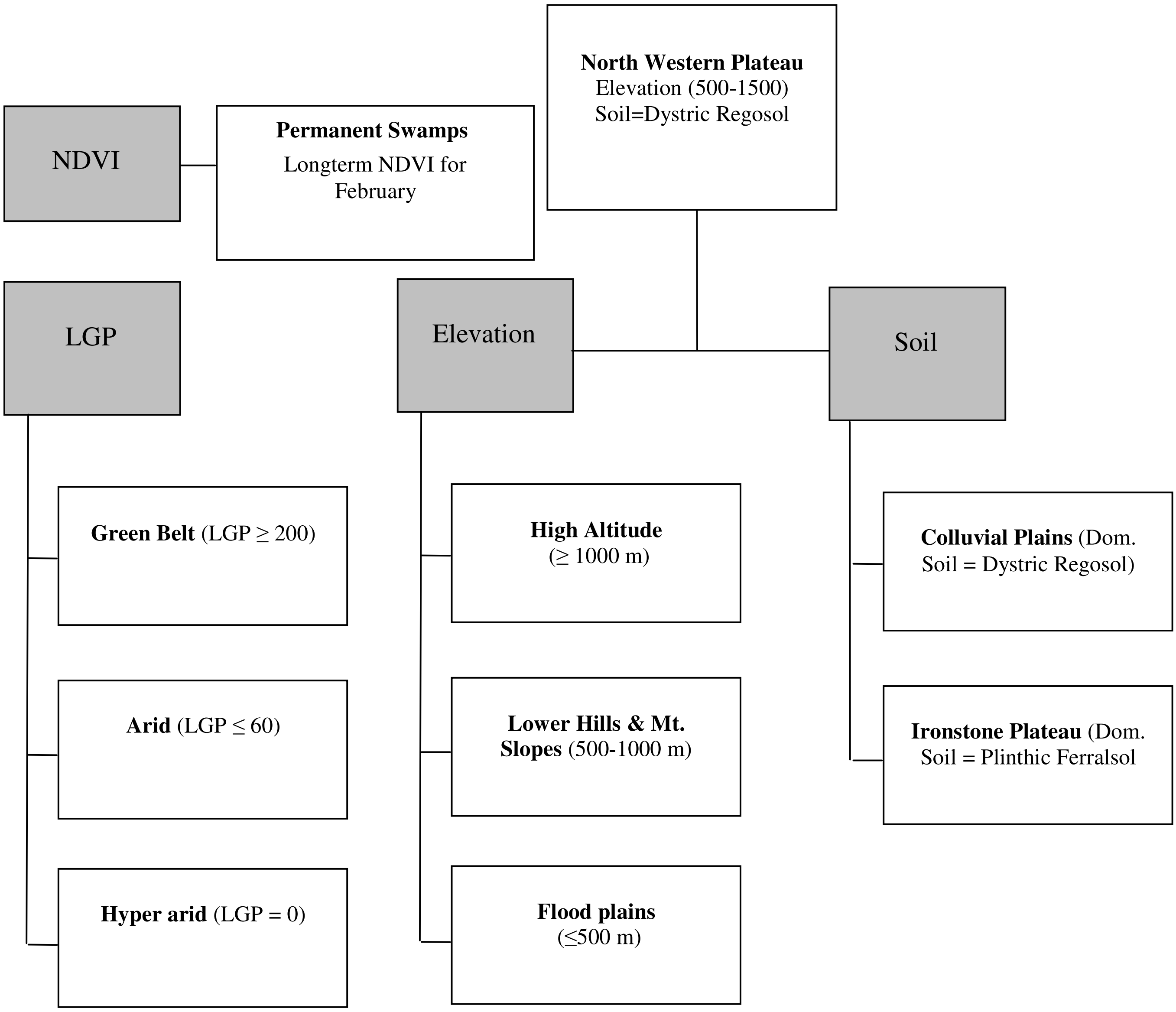

Fig. 1: Classification Criteria

4. RESULTS AND DISCUSSION

Figure 2 is the combined dataset of the spatially-continuous data layers discussed in the previous section. It shows the 10 physiographic areas based on past literature on South Sudan, which also approximate the broad livelihood zones outlined in the previous studies. By combining spatially-continuous datasets with past studies since 1950s, we provide a comprehensive framework for understanding the spatial context of livelihoods opportunities and constraints.

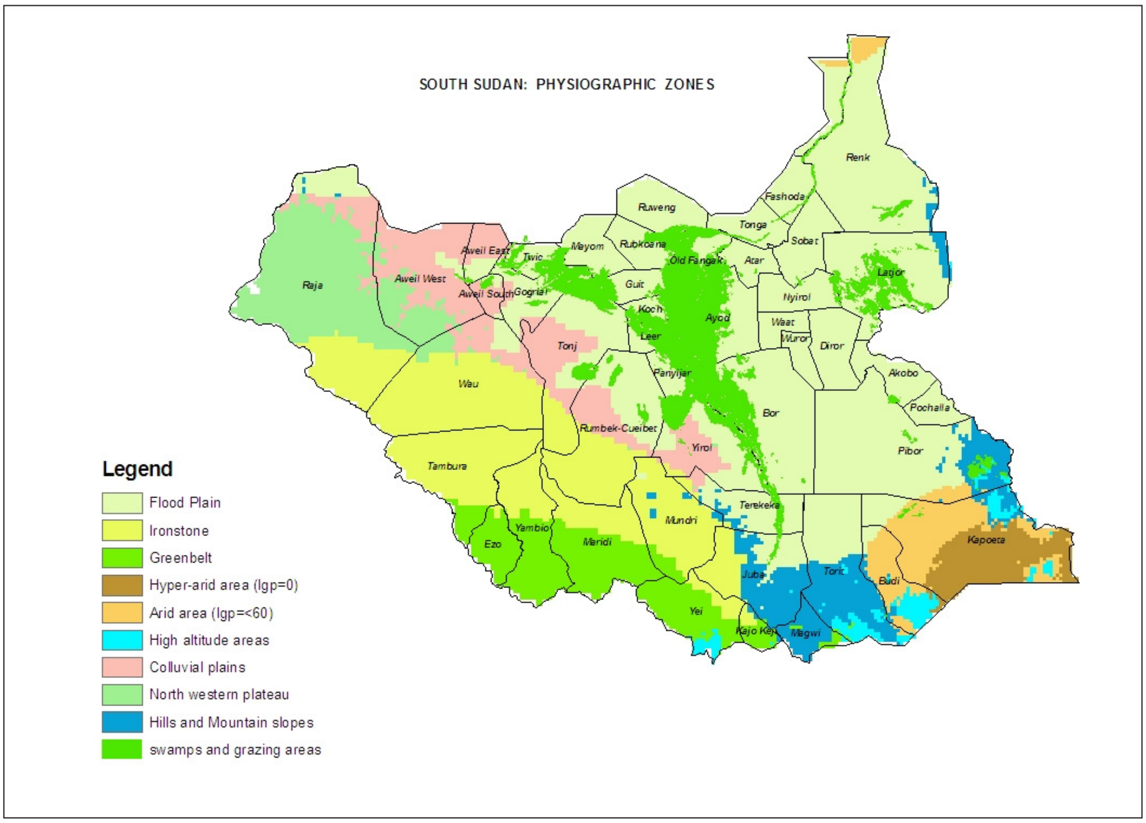

Figure 2: South Sudan Physiographic zones.

This data layer also provides a platform for incorporating the socio-economic data from more formal surveys such as the recent Sudan Household Health Survey (SHHS). This survey, covering 10,000 households in South Sudan, is monumental because it is the first formal baseline survey conducted by the Government of South Sudan in more than 20 years. Therefore, it is hoped that incorporating the physiographic zones, with the SHHS would be very useful in providing baseline livelihood profiles for monitoring recovery and development programmes.

There are additional potential applications of this combined dataset. Table 1, indicating the bio-physical parameters for each zone derived through the combined dataset, shows that the dataset can be used as a quick programming tool for geographical targeting and priority setting for development programmes.

In the absence of detailed site-specific studies, it is feasible to do broad-based definition of agricultural potential, recommendation domains for agricultural technologies and the selection of sentinel sites for livelihood monitoring using this dataset. Other applications can be in contingency planning for hazards such as floods and droughts and for mapping human and livestock diseases.

Table 1: Bio-physical parameters derived from the combined dataset

Physiographic /Climatic region	Avg LGP (days)	Elevation (m)	Dominant Soil type	Vegetation
Flood plain	121	415 (374-500)	Chromic Vertisols	Deciduous shrubland/ sparse trees
Ironstone	178	581 (432-999)	Plinthic Ferralsols	Deciduous woodland
Greenbelt	214	723 (531-1000)	Plinthic Ferralsols	Mosaic Forest / Savanna
Hyper-arid	0	536 (366-1000)	Chromic Vertisols	Croplands (>50%)
Arid	43	552 (383-1000)	Chromic Vertisols	Croplands (>50%)
High altitude areas	146	1293 (1001-3055)	Eutric Nitosols	Mosaic Forest / Savanna
Colluvial	131	448 (404-511)	Dystric Regosols	Deciduous shrubland/ sparse trees
North western plateau	133	614 (483-1000)	Dystric Regosols	Deciduous woodland
Lower hills and mt. Slopes	143	661 (501-1000)	Ferric Luvisols	Deciduous shrubland/ sparse trees

The next two steps towards transforming the physiographic zones into a livelihood zone will be: 1) to derive accessibility indices using other GIS layers to show the potential degree of market orientation of the zones and 2) Incorporate socio-economic profiles from the SHHS survey.

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Annex 1: Southern Sudan: ecological areas (SDIT, 1955)

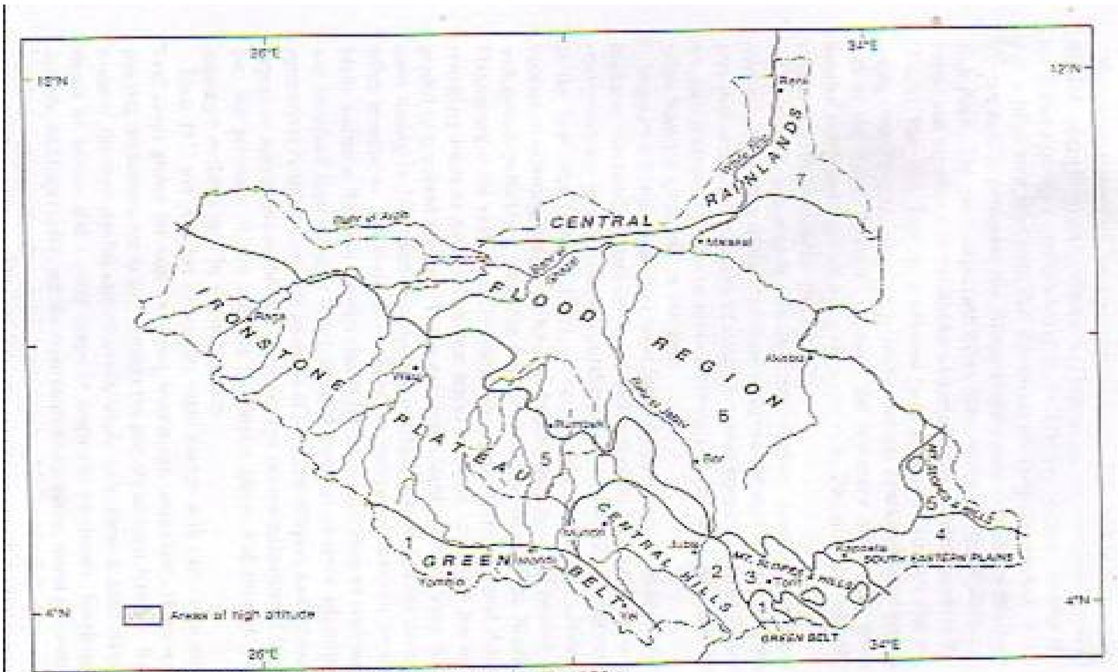
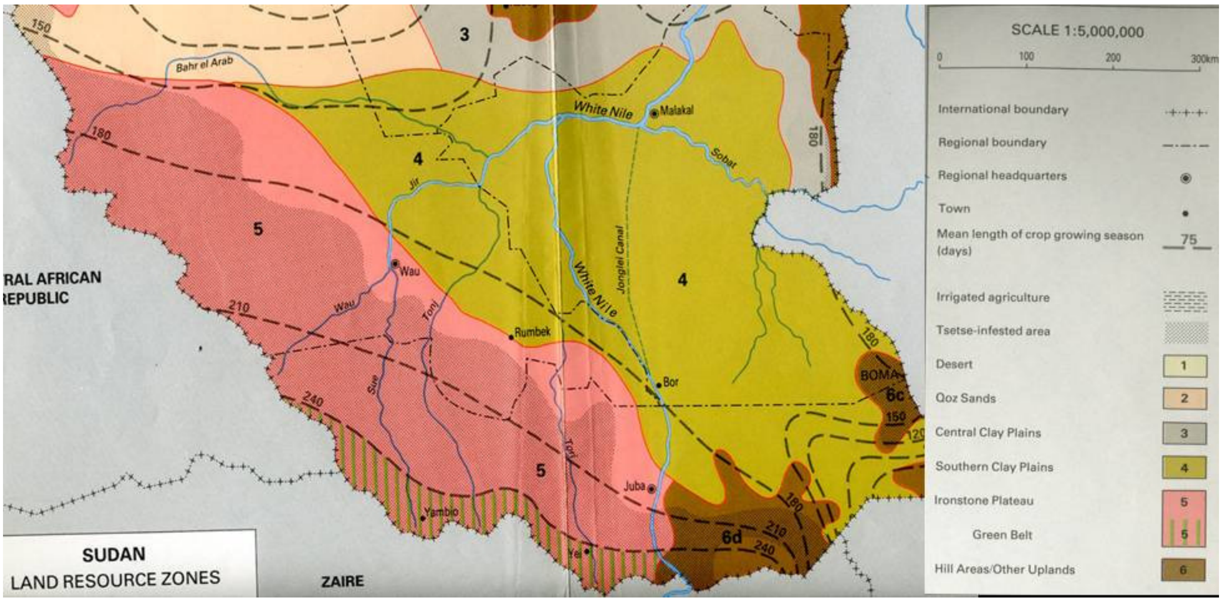
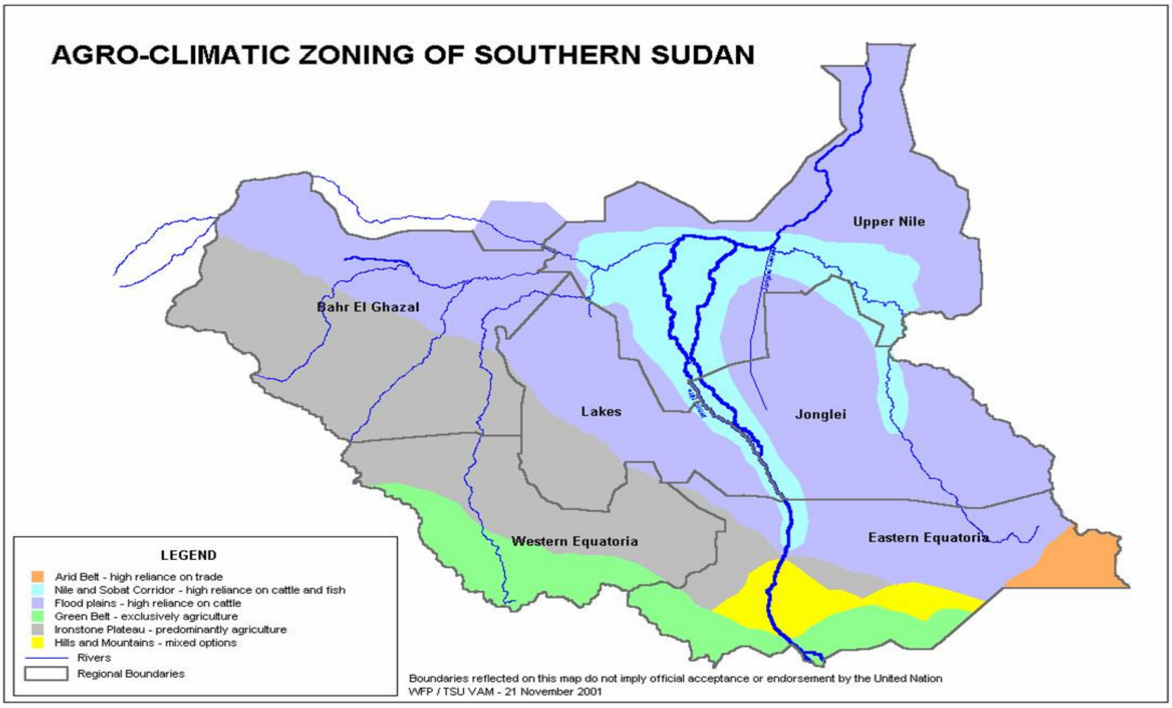


Fig. 17.1. Southern Sudan: ecological areas (After SDIT (1955)).

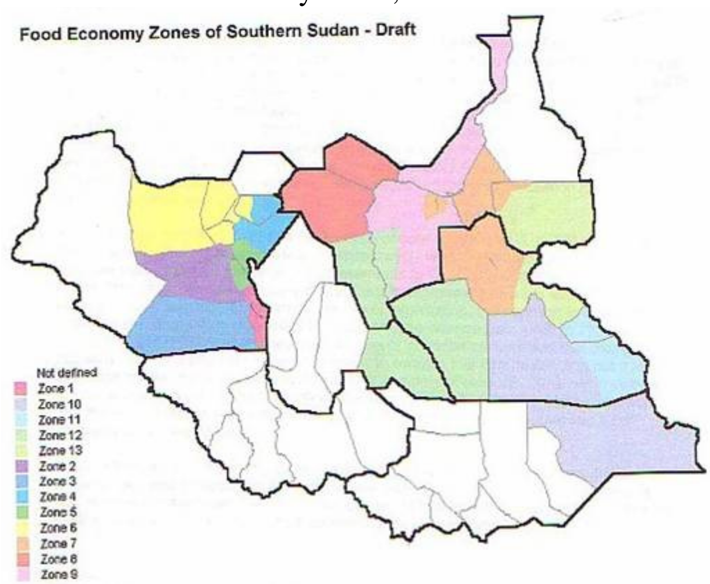
Annex 2: Land Resource Zones (Robinson, 1987).



Annex 3: Food Economy Zone (WFP/Save the Children UK, 2000)



Annex 4: Food Economy zones, 2001.



Annex 5: Livelihoods Analysis Forum Livelihood Zones, 2006.