CHAPTER 2
MATERIALS AND STUDY METHODOLOGIES

2.1 Site Selection

Three contrasting sites in Agro-ecological Zones I, II and III were selected for the study. Annual rainfall totals of 400 mm - 800 mm; 800 mm - 1000 mm and 1000 mm - 1500 mm in Agro-ecological Zones I, II and III respectively, are major parameters of relevance to understanding Dambo development and utilization for crop production.

2.2 Land Use and Constraints Analysis

In the context of development efforts, situation analysis involved investigation of features and characteristics of the Dambo areas with the potential target groups of farmers in three different agro-ecological zones of Zambia i.e. Region I (Noole Dambo); Region II (Mugabi Dambo) and Region III (Chipala Dambo in Ndola rural District). Intervention areas regarding crop production in Dambos were identified using Participatory Situation Analysis (PSA) involving all relevant groups in an active way with due regard to gender consideration. Other Dambo areas of Kanchele, Siachitema, Chalata and Musofu were surveyed to assess the socio-economic impact of the developed technology.

Land use practices in each of the selected Dambos were characterized. Crop production constraints were highlighted and prioritized by farmers. Cropping calendars were developed for each of the selected sites. Participatory approaches helped to identify real-life situations and to understand the socio-economic implications of Dambo use and solutions to constraints related to their uses. This does not necessarily mean involving everybody in everything but rather aims at integrating all concerned groups for specific function and potential. Catchment sites were described *in situ*, their geology studied from a standpoint of hydrology which is being monitored in detail.

2.3 Catchment Hydrology of Dambos

Noole, Chipala and Mugabi Dambos were characterized in terms of their hydrology and the effects that climatic parameters such as temperature, evapotranspiration and rainfall would have on their wetness attributes. Soil physical parameters and their relevance to water movement were studied. Infiltration tests, using the double ring infiltrometer method, were carried out. Dambo major zones were delineated and characterized in terms of slopes, wetness and limitations for crop production.

2.4 Water Table Monitoring

Piezometric wells were sunk at Noole, Chipala and Mugabi Dambos. Auger holes of 75 mm diameter were made using a galvanized pipe and hand auger to drill up to 4 m deep to the water table in a sand layer of each of the Dambo zones, forming a cross-section. Aluminium pipes of 3 m lengths were cut and made ready to be inserted in the auger holes. The 2 m bottom end of each pipe was perforated by cutting small slots using a hack saw blade. The pipes were pushed in each of the auger holes with the slotted part in the bottom side of the auger hole and only a 30 cm length of the pipe was left above ground surface.

The slots allow water to enter the pipe and remain in equilibrium with the water table. Water table measurements were done using a whistling tape which is graduated throughout its length. The tape is lowered into the piezometric pipe and upon touching the water surface, it whistles, signalling the presence of a water table. Readings were recorded from the whistling measuring tape every two days throughout the year. Records from the author's research funded by the International Foundation of Science were used in order to show trends in wetness and response to climatic changes.

2.5 Soil studies

2.5.1 Soil Moisture Availability

Water holding capacities (WHC) of all soils studied were determined on undisturbed soil samples placed in a soil-moisture extractor at pF 2.0 (equal to 1.45 p.s.i or 0.1 bar or 10 kPa tension) and pF 4.2 (equal to 225 p.s.i. or 15 bar or 1500 kPa tension). The field capacity (FC) ranges between pF 1.8 and 2.5, at which pF 2.0 was applied as the average value. The samples were also subjected to soil-moisture extractions at 0.3 bar (30kPa), 1 bar (100kPa) and 2 bar (200kPa) pressures as well, in order to cover an irrigation soil moisture depletion range between field capacity and permanent wilting point (PWP). The soil moisture content between field capacity and permanent wilting point is considered as the soil-water available to plants. Five soil profiles were sampled with five soil samples from each profile sampled at 0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm and 80-100 cm soil depths. The available moisture capacity is expressed in a meter profile depth.

2.5.2 Particle Size Analysis

Particle size analyses were done using the International pipette method as described by Loyland and Stuhaug (1987) in which 20 g of soil from each sample was treated with sodium pyrophosphate as a dispersing agent, stirred for 5 minutes in a high speed stirrer and made up to a volume of one liter in a hydrometer jar. Pipette samples were taken at the appropriate times to measure suspended silt and clay. Particle sizes were measured in percent for sand, clay and silt.

2.5.3 Bulk Density

Bulk density is defined as the ratio of the mass of a unit volume of dry soil, air space included. It is expressed as $g.cm^3$ or $kg.m^3$. Bulk density is required for the determination of soil moisture contents on volume percentage basis. In general bulk density is also an indicator of the soil structure. Five soil cores of 100 cm^3 each per sampling site were dried at 105^oC then weighed and the bulk density calculated.

2.5.4 Soil Profile Description

Soil profile pits to a depth of about 100 cm were dug. For practical purposes of the field applications and understanding of various Dambos in different locations and their behaviour to soil chemical changes as a result of water movement in the profile, soil sections of 20 cm depth were preferred. Descriptions were made in the 0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm and 80-100 cm soil layers. Munsell colour charts were used for soil colour annotation.

2.6 Development of technological packages

2.6.1 The Treadle Pump

On the basis of constraints analysis for crop production based on current land use practices, prioritization and ranking of constraints in terms of their importance was done. Water lifting being the most limiting factor for crop production, development of a treadle pump as a device to lift water was embarked on. A prototype from Bangladesh was obtained, tested with farmers in the field and modified to suit Zambian conditions,eg. for use where rivers form banks and flat terrains like Dambos. The device was modified with the aid of small metal fabricating manufacturers and later tested in the field. The tests were conducted for suction lift of the device, discharge rate, energy requirements for manual pumping, durability and adaptability.

After an appraisal by farmers in the field, mass production with the help of an NGO, i.e IDE (International Development Enterprises), was embarked on by training small producers in the manufacturing of the pump. This would ensure local availability. Quality control of the manufactured pumps was conducted by trained staff from IDE.

2.6.2 The Clay Pot Sub-surface Irrigation

The clay pot was identified to have attributes of discharging water through its micro-pores which could in fact effect sub-surface drip irrigation when buried in the ground with only the neck and mouth appearing above the ground surface level. Water is poured into the clay pots using a watering can or a hose pipe. The mouth is covered with a clay lid in order to eliminate direct evaporation of water from the clay pot.

The lid also prevents rodents and birds from drinking the water from the pots and thus ensuring that all the lost water is available for uptake by the plants that are planted adjacent to the clay pot. The clay pots vary in sizes and capacities. Clay pot sizes of 1 liter to 5 liters were used in the evaluation.

2.6.3 Technology Dissemination

To disseminate these technologies to a wide range of farmers, field demonstrations were conducted between 1997 and 1999. Demonstrations were conducted using the massive network of technical staff of the Ministry of Agriculture Food and Fisheries (MAFF) in the selected Dambo areas and later throughout the country due to popular requests from farmers. To make the technologies sustainable, an affordable price was negotiated from manufacturers of the treadle pump and the rural women who make clay pots. A retail network of treadle pumps in five provinces of Zambia was created by recruiting shop

owners already dealing in sales of agricultural implements. The retailers were taught how to install, operate, maintain and repair the pump so that they too would show the farmer how to undertake correct installation and operation in the field. Marketing officers from IDE and MAFF technical staff helped to carry out this function in the demonstration areas which propelled massive adoption of the technology.

2.6.3.1 Technology Adoption and Evaluation

The technology development and adoption was coupled with a socio-cultural and economic impact evaluation on its use, farming system, the community and the dissemination chain, created i.e. the manufacturers of the pump, wholesale distributors, retailers and farmers as consumers in order to measure its impact and contribution to household food security and the country's economic growth at grassroot level.