THE USE OF AGROCLIMATIC ZONES AS A BASIS FOR TAILORED SEASONAL RAINFALL FORECASTS FOR THE CROPPING SYSTEMS IN THE CENTRAL RIFT VALLEY OF ETHIOPIA

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INTRODUCTION

Ethiopia lies in the eastern Horn of Africa covering about 1,221,900 sq. km. The country's topography is composed of massive highland complex of mountains and dissected plateaus divided by Great Rift Valley running generally southwest to northeast. Great terrain diversity in the country determines wide variations in climate, soils, natural vegetation, and settlement patterns. The country normally receives its highest rainfall (50-80%) when the low-pressure center/trough is established in northern equatorial region following the sun's apparent movement towards the northern hemisphere. Some areas in the eastern and northeastern parts of the country also receive short ('belg') rain from as early as February to May as a result of the penetration of rain bearing winds into Ethiopia during this period (Camberlin and Philippon, 2001).

The rainfall is highly variable both in amount and distribution across regions and seasons (Tesfaye, 2003, Tilahun, 1999; Mersha, 1999). The seasonal and annual rainfall variations are results of the macro-scale pressure systems and monsoon flows which are related to the changes in the pressure systems (Haile, 1986; Beltrando and Camberlin, 1993; NMSA, 1996). The most important weather systems that cause rain over Ethiopia include Sub-Tropical Jet (STJ), Inter Tropical Convergence Zone (ITCZ), Read Sea Convergence Zone (RSCZ), Tropical Easterly Jet (TEJ) and Somalia Jet (NMSA, 1996). The spatial variation of the rainfall is, thus, influenced by the changes in the intensity, position, and direction of movement of these rain-producing systems over the country (Taddesse, 2000). Moreover, the spatial distribution of rainfall in Ethiopia is significantly influenced by topography (NMSA, 1996; Camberlin, 1997; Taddesse, 2000), which also has many abrupt changes in the Rift Valley.

However, the detail spatial and temporal variability of rainfall over the horn of Africa in general and Ethiopia in particular is highly complex and not well known yet. This variability of the rainfall and recurrent droughts in the country affects the lives of millions of people whose livelihood is mainly dependent on subsistence agriculture. Despite the fact that agriculture is the backbone in the country's economic development, as well as, the most weather sensitive sector, the communication of 'tailored' seasonal climate predictive information for flexible and improved decision making by the farmers in the risk management is minimal. Various analysts reasoned that the persistence of the subsistence nature of Ethiopian agriculture is partly due to the lack of proper understanding of the agro-climatic resources of the country. Proper agroclimatic zoning and seasonal climate forecasts are crucial elements in minimizing climatic risks. They can assist both agriculturalists and policy makers particularly in countries like Ethiopia where climatic risk is very high. The objectives of this paper are, therefore, to assess the status and role of agroclimatic zoning and potential for seasonal climate forecast on the agricultural activities of the Central Rift Valley of Ethiopia and to outline future needs.

AGROCLIMATIC ZONES OF ETHIOPIA

As the climate is rather complex, it has been the topic of many studies and several classification systems have been applied to the Ethiopian situation. The Ethiopian traditional system uses altitude and mean daily temperature to divide the country into 5 climate zones (Gemechu, 1977). Both the Köppen and the Thornthwaite classification systems have also been applied (Gonfa, 1996). Another broad classification can be made using the rainfall distribution though the year – giving the distinction between the mono-modal and the bi-modal and a diffuse rainfall region (Haile & Yarotskaya, 1987). However, the most useful for agricultural purposes is the agroclimatic zones which used the water balance concept, the length of the growing season (including onset dates) at certain probability levels (NMSA, 1996). In this way three distinct zones can be identified namely the area without a significant growing period (N), areas with a single growing period (S) and area with a double growing period (D) (Fig. 1). This information should be able to form the basis on which to build the seasonal forecasts with particular emphasis on the specific crop choices in each region.

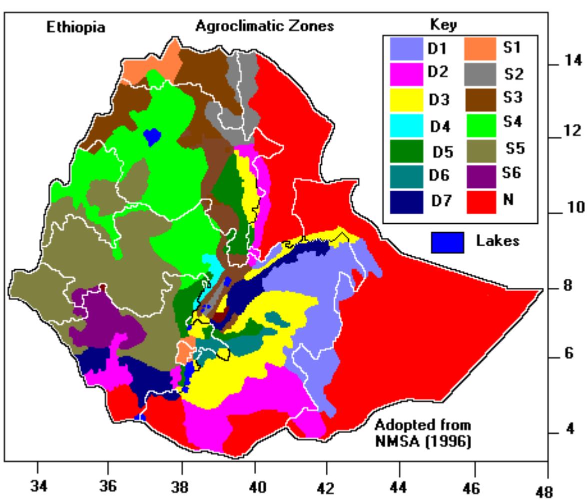

Fig. 1. Agroclimatic zones of Ethiopia (NMSA, 1996).

DESCRIPTION OF CLIMATE OF THE CENTRAL RIFT VALLEY

The Central Rift Valley covers an area between the Yerer Fault from the western edge and Abjiata lake / Shashamane on the southern side to Miesso on the eastern edge. This area covers a variety of agroecologies characterized by extensive areas of low rainfall and limited areas receiving adequate rainfall, such as the highland area around Arsi Negelle (Fig. 2). Despite the rainfall being highly unpredictable, the region is of central importance for the national food security and foreign exchange earning through production of export crops (white beans). Hence its importance in the overall economic development plans of the country is vital.

Table 1: Summary of climate data for Arsi Negelle, Meiso, Melkassa and Awassa (from NMSA and EARO).

Station	**Lat. N**	**Long. E**	**Alt m**	**Tradition**	**Köppen**	**Thorn-thwaite**	**Rainfall Regime**	**Agro-climate Zone**
Arsi Negelle	7°20'	38°09'	1960	Weina Dega Subtropical	Tropical rainy climate (AW) Or Hot semi-arid climate (Bsh)	Semi-arid	Three seasons (Bega, Belg & Kremt) Or Bimodal type I	S3
Mieso	9°20'	41°11'	1470	Quolla Tropical	Tropical rainy climate (AW) Or Hot semi-arid climate (Bsh)	Semi-arid	Three seasons (Bega, Belg & Kremt) Or Bimodal type I	D3
Melkasa	8°24'	39°21'	1550	Weina Dega Subtropical	Tropical rainy climate (AW) Or Hot semi-arid climate (Bsh)	Semi-arid	Three seasons (Bega, Belg & Kremt) Or Bimodal type I	S3
Awassa	7°05'	39°29'	1700	Weina Dega Subtropical	Tropical rainy climate (AW) Or Hot semi-arid climate (Bsh)	Semi-arid	Three seasons (Bega, Belg & Kremt) Or Bimodal type I	D3

S3: In this zone there are four thermal zones (T2, T3, T4 & T5). The growing period is adequate to meet the full water requirements of short maturing crops in most years. The range of crops suitable in this zone is quite large. Moisture conservation methods are desirable.

D3: Four thermal (T2, T3, T4 & T5) are present. One of the two growing periods are adequate for rain-fed crop production in most years (NMSA, 1996).

LONG-TERM RAINFALL OUTLOOKS

The meteorological station network in Ethiopia is sparse by the standards of the World Meteorological Organization (WMO), nevertheless part of this inadequacy could be remedied by use of the satellite based rainfall data. Currently, the National Meteorological Services Agency (NMSA) has 95 principal and over 400 other weather stations (Haile, 1996). In addition to these more than 32 weather stations of varying standards operate under the Ethiopian Agricultural Research Organization (Mamo, 2001), the Ministry of Agriculture (MOA) has more than 100 weather stations distributed across various agro-climates and some NGOs working in Ethiopia have their own early warning system (Glantz, 1996). Seasonal forecasts have become routine and operational though the use of global climate models being initialized using the satellite measured sea surface temperatures (SST) (Mason, Joubert, Cosijin & Crimp, 1996). Conceptually the tropics have a relative advantage in terms of seasonal climate outlook, because the weather systems in the tropics show a more systematic annual variation between summer and winter. In Ethiopia, NMSA has been issuing seasonal weather outlook since September 1987 using ENSO-related information as the critical set of inputs. In case of agriculture these general purpose climate outlooks have limited usefulness from the strategic decision making point of view.

It is strongly believed that the inadequacy of specific tailored climate information in the agricultural arena has severely hindered technology development and transfer efforts. To be able to develop such a tailored seasonal forecast a detailed study of the agricultural systems and the climate sensitive decisions should be made. An initial attempt to characterize two of the zones in the Central Rift Valley follows.

DESCRIPTION OF AGRICULTURAL SYSTEMS IN THE CENTRAL RIFT VALLEY

There are a large variety of crops grown in the Central Rift Valley (CRV) under various agricultural systems allowing for much flexibility. Traditionally many of the decisions are made on the timing of the onset of the rains. In order to assess the potential use of seasonal forecasts the type of decisions and the factors including climate that affect them need to be documented. A first attempt has been made to characterize some of these decisions for two selected areas in the CRV (Table 2). For instance in the areas of low rainfall, the dominant crop for food security is maize and the dominant cash crop is white beans. However, the decisions about land allocation for each crop are dependent on a range of factors which vary each year, the demand for other resources including labour and land preparation. The best planting dates will depend on the onset of rains. If the rains come during March/ April (Belg) then the medium duration maize and beans can be planted during April and until the end of May. If the rains are delayed and adequate rains are only received later, then Teff and beans or short duration maize can be planted during June until the end of July. If the Kiremt rains are late the only choice is Teff which can still be planted in July. But as indicated on the table the Teff has a high labour requirement for both crop establishment and for harvesting.

By contrast in the areas that normally receive adequate rainfall (e.g. Arsi Negelle and Awassa) the main crops grown are wheat and maize for food security and potatoes, onion and tomatoes as cash crops (Table 2). In this region there is no choice but to plant long duration wheat and maize varieties during April, to supply adequate biomass for fodder as well. If the onset of the rains is delayed then the cash crops will probably be planted during June and July. Although there are many options open to the farmers in the CRV, the traditional wisdom has determined the above decisions. It may be possible to explore other options using the long-term weather dataset and crop-climate models. The various combinations and the balance of labour and other resources will also need to be considered. The performance of various different combinations of cropping systems under the different distribution of rainfall over the years and different ENSO conditions can be characterized using the models. Together with the seasonal rainfall forecasts, these probabilities can help to develop the various scenarios available to the farmers whatever level of risk they choose. Some of the decisions that can be made affect the land preparation, crop and variety choice, fertilizer application rate, soil/water conservation measures and disease and pest control practices. The balance of land apportioned to the cash crops versus the food crops can also be addressed. These types of tailored seasonal forecasts for a specific agroclimatic zone need to be developed together with the farmers themselves in a participatory manner. The potential of double cropping or crop choice according to the seasonal rainfall forecast can help in making the decisions as to which crop and where and when to plant.

THE WAY FORWARD

The main assumption behind this status report is that seasonal climate predictions are possible for the Central Rift Valley in Ethiopia. However, this calls for the knowledge of how the atmosphere responds to certain global situations, on a regional and local scale to be incorporated into predictions at a crop management level. Together with a detailed participatory analysis of the farmers' current practices and preferences and the application of crop models it would be possible to develop some viable options for crop choices and optimal planting dates under different ENSO scenarios.

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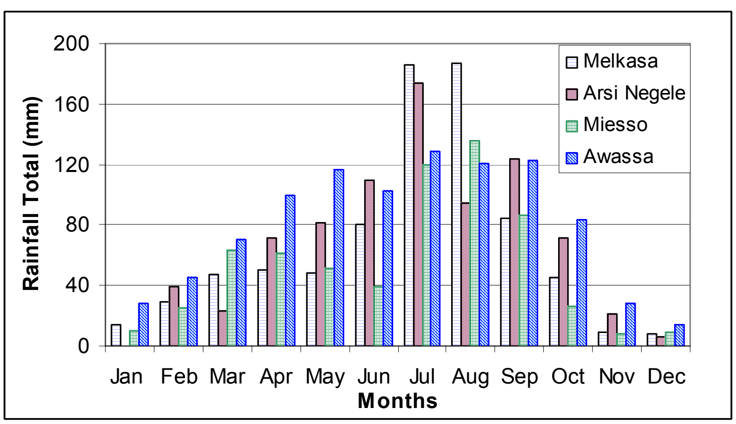

Fig. 2. Annual distribution of long-term mean monthly rainfall for Melkasa, Arsi Negelle, Meisso and Awassa in the Central Rift Valley (from NMSA & EARO).

Table 2. Various decisions taken by farmers in the low and adequate rainfall agro-climatic regions of the central rift valley of Ethiopia

Agroclimate Zone	**Crops**			**Order of choice**	**Date of Sowing**	**Variety preference**	**Land preparation**	**Labour requirement**	**Harvest date**
	Dominant	Secondary	Cash						
S3 Single growing period low rainfall areas Melkassa & Miesso	Maize		Maize	3	Early April to Early May	Medium duration	3 times	medium	Starts in early October
			Beans	1			2 X	least	
		Sorghum		4			3 X	medium	
	Beans	Teff	Teff	2	Late June to early July	Short duration	4 X	greatest	Late Oct to November
			Teff		Late July	No choice	4 X		
D3 Double growing period, adequate rainfall Awassa & Arsi Negelle	Wheat		Wheat		Early to late April	No choice, long duration		medium	November & December for long duration
	Maize						3 X	medium	
	Barley		Barley						
		Teff	Teff			medium	4 X	high	
		sorghum							
			Potatoes		June & July & August	Replanting if failure		high	
			Onion					high	
			Tomatoes					high	