 

# Opportunities of Bench Terracing in Tigray, Ethiopia: Taking Land to Water Perspective

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**Abstract**
Tigray is a province with undulating topographic arrangement (with high and rugged mountains; flat topped plateau, deep gorges, river valleys and plains). This land features has been a challenge for irrigation expansion using the water resource potential in the region and it has been also a reason for keeping many rural youths landless and unemployed. The overall aim of this review is therefore to see whether bench terrace could contribute in solving the underutilization of the existed water potential and problem of rural youths. Experiences from the region and abroad has shown that bench terrace is a multipurpose structure in enhancing sloppy agricultural land technology. On top of retaining soil and water loss, bench terrace is effective in creating new cultivable land for landless and unemployed youths in areas which are suitable for irrigation by diversion of perennial rivers, spate irrigation and earthen dam farming. It can be approach of taking cultivable land in to water instead of water to the cultivable land. But, it should be clear that all sloppy land would not mean suitable for bench terracing. It needs systematic selection of suitable sloppy land in reference to the alternative irrigation water availability and also unless compensated by cultivating perennial and cash crops, the costs for intensive labor input, continuous maintenance and loss of previous vegetations are the other negative dimensions of bench terracing.
**Keywords:** landless, irrigation, youth, bench terrace, Tigray

## 1. Introduction

Tigray is a province of great geographical diversity with high and rugged mountains; flat topped plateau, deep gorges, river valleys and plains. It is composed of highlands in the range of 2,300–3,200 meters above sea level (MASL), lowland plains with an altitude range of 500–1,500 MASL, mountain peaks as high as 3,935 MASL, and high to moderate relief hills (1,600–2,200 MASL). By virtue of the complexities in topography, Tigray has diversified agroecological zones and niches, each with distinct soil, geology, vegetation cover, and other natural resources (Taffere 2003). There is an essential difference between the highlands and the lowlands of the region in terms of climate, population distribution, and access to water resource, economic activities and lifestyle. Available studies in water resource indicate that the region is with about five perennial streams with flow rates of more than 10 liters per second. The loss of water through the three major drainage systems of the region during the annual rainy season is immense. In total through Tekeze, Mereb and Dennakil basins 9 billion cubic metres of water goes from Tigray to neighboring countries every year. It is also with about 9.21 billion cubic metres of rainfall per annum. Reasonable amount of ground water potential is also the other source of water in the region.

Although Tigray's water resource as figured out is not small, very little of it has been developed for agriculture and other purposes (To date only about 15,495ha of the potential irrigable land (324286ha) has been kept under irrigation. Many scholars agree that the spatial and temporal variation of water availability is the main bottleneck (Tassew 2000). Its distribution in terms of area and season does not give adequate opportunity for sustainable growth to the economy. The location of the water (deep gorges, separated by terrains and hilled areas) in reference to the location of arable land is not affordable to be used for irrigation by farmers' capacity (Awulachew *et al* 2010; Awulachew *et al* 2007). It is very costly beyond the farmers and government capacity. Even the time when the surface water can be existed in those deep gorges adequately is mismatched with the time that farmers' need it for irrigation. This could not be different with the case of ground water potential of the region. This problem has been complicated by the poor quality and small size of the arable land that the farmers owned and by the landless and unemployed youths. The undulating topographic arrangement of the region is not only challenge for expansion of irrigation by the water potential that the region owned, but is also a reason for the small arable land potential in the region. The potential of arable land in the region (1.5million ha) is not adequate to the rural dweller Tigrians. As a result huge numbers of youths in the region are still landless and unemployed. The land owners are also extremely small holders not more than 0.5ha per family. The small land size together with land degradation and climate variability kept the society in Tigray under food insecurity. This could be evidenced by the migration of rural youths to Middle East countries (Camfield 2011).

Taking the above challenges as a major environmental and socio-economic problem, the government of Ethiopia especially regional government of Tigray has been intervened with massive soil and water conservation practices. To solve the landlessness and unemployedness of youths, the hilled areas had been partitioned among the youths. But, significant successes are not achieved so far. Significant youths' number is still landless and unemployed. Even the youths who have got share from hilled areas are still with almost nothing benefit. Currently, the regional government of Tigray is in introducing a new soil and water conservation structure called bench terrace. Can this structure have value in the life of landless and unemployed youths? Is there a possibility that the land created by bench terrace could be integrated to irrigation opportunities? This is why this review was initiated.

## 2. Conceptual description of bench terrace

Bench terraces are a series of level or virtually level strips running across the slope at vertical intervals, supported by steep banks or risers (Sheng 1989). Bench terraces are mostly two in type. From these one is irrigation or level bench terrace. It is used where the crops need flood irrigation and impounding water. The second type of bench terrace is the upland bench terraces which can be sub divided in to reverse sloped type and outward sloped type (Sheng 2000).

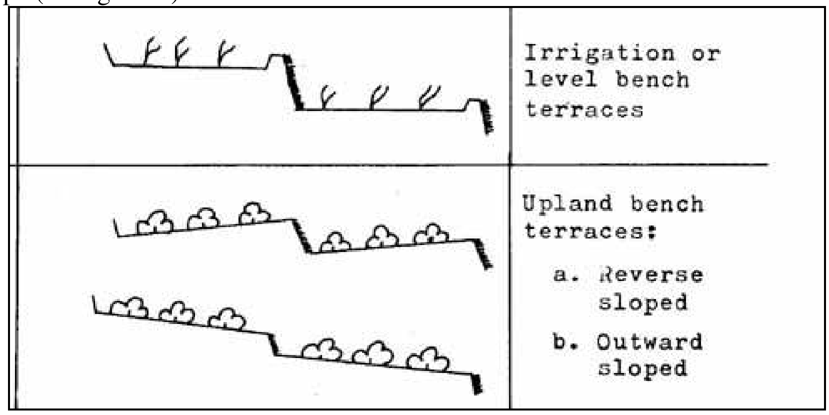


Fig. cross sectional view of bench terrace types (Sheng 2000)

## 3. History and Global Distribution of Bench Terrace

Terraces have a long history of use by agricultural cultures around the world. The earliest dating goes to China, around 2000 BC (Troeh and Thompson 1993). In Yemen, terraces 15 to 5 m high have been continuously cultivated for 3000 years (Vogel 1987). In Philippine, Srilanka and India, farmers have been building terraces for over 2000 years (Bennett, 1970). Terracing structures were used before 360 AD in Syria, which supported a population of 400,000 at that time (Bennett 1970). Knowledge of terracing was introduced in to Greece by 600 AD (Bennett, 1970). In Africa, a traditional method of terracing has been used for centuries (Thomas 1988). In Peru, the Incas and their predecessors had developed highly efficient methods of conserving soil on steep land, dating back to 1400 to 1532 AD (Burger 1992). Since the 1920's, modern agricultural societies have further developed designs, specifications and methodologies for terracing (Bennett 1970; Sheng 1981). Since then a clear definition and specification has been given for bench terrace (Sheng 1986). This technology of soil and water conservation is very young in Africa specifically in Ethiopia.

## 3. Opportunities of bench terrace

### 3.1 Soil Erosion Reduction and Moisture Retention Potential

The Ethiopian economy is heavily dependent on agricultural sector which is determined by soil fertility status and soil moisture. But, several studies have shown that extensive areas of the highlands in Ethiopia specifically Tigray are in the grip of accelerated erosion. An estimate in the mid-1980s showed that 3.7% of the highlands in Ethiopia had been seriously eroded that they could not support cultivation, while a further 52% had suffered moderate or serious degradation (Kruger *et al* 1996; Wood, 1990). On arable land, soil erosion averages about 42 tones $ha^{-1}$ $year^{-1}$ and causes an average annual reduction in soil depth of 4 mm (Hurni1988). This could rise to 300-400 t/ha/ year on intensively cereal cultivated fields (Daniel *et al.* 2001). Due to this long live degradation of land and climatic variability, frequent droughts and famines has been experiencing in Ethiopia especially in Tigray (Demeke *et al* 2004; Christiansen *et al* 2011). Over the past 30 years agricultural production in Ethiopia has never been sufficient to feed the population and this gap has been filled by food aid. Land degradation in the form of soil erosion and declining soil moisture is one serious reason to agricultural production insufficiency.
Recognizing land degradation as a major environmental and socio-economic problem, the government of Ethiopia especially the regional government of Tigray has made several interventions. Large-scale conservation schemes were initiated particularly after the famines of the 1970s. Since then, huge areas have been covered with different soil and water conservation structures and millions of trees have been planted (Herweg, 1993; Admassie, 2000). Those soil and water conservation structures had been contributing differently in alleviating

 

the long lived problems of soil erosion and moisture stresses. Different hisses and positives have been forwarded by the farmers at different level for each soil and water conservation structures. Efficiency of the structures in conserving soil and water, tendency of consuming more land, being home for different crop pests , delayed results and others are few examples why farmers have been claiming to the structures (Admassie, 2000; Taddese, 2001). The approach how the government intervened has been also claimed by some researchers in the area (Wood, 1990; Herweg and Ludi, 1999; Eylachew *et al.* 2003; Asfaw 2006; Mitiku, 2006). These are the justifications given by researchers why they conclude as the achievement is not comparable to the cost invested.

Unlike other soil and water conservation structures, bench terrace has not been well introduced to the region and to the country as whole. Bench terrace is found to be very important structure to reduce run-off or its velocity and to minimize soil erosion in many countries. In Jamaica, research show that bench terrace can reduce erosion by 90-95% or more (Sheng, 1989). In Burundi, on 49% slope of land, bench terraces reduced the soil loss from 150 tons/ha/yr to 5-11 tons/ha/yr (Durand 1984; Fagl and Mackie 1988; Roose 1988). In SierraLeone, research results show that soil loss from 31% sloped land was reduced by bench terracing from 41-55 tons/ha/yr to 7- 5 tons/ha/yr (Millington 1982; Lal 2001). So, a bench terrace is considered to be among the most effective structural erosion control and moisture retaining measures.

**3.2 Cultivable land formation**

In general speaking, bench terraces are particularly suited to societies with an area where there are food shortages or high unemployment rates, with small land holdings size and in areas where crops require flood irrigation (FAO 1988). Tigray, northern Ethiopia, is a province of smallholder agriculture in which the intensity of recurrent droughts affects the livelihoods of the agricultural communities and the whole economy. Even in a year of good rain, the occurrence of floods affects the livelihoods of riparian residents with little capacity to neither protect from the seasonal flood nor mitigate the impact. In the 2000 cropping season of Ethiopia, 87.4 % of rural households operated less than 2 hectares; whereas 64.5 % of them cultivated farms less than one hectare; while 40.6 % operated land sizes of 0.5 hectare and less (CSA 2003; Negatu 2005).

The population in Ethiopia is predominantly young. The youths and adolescent populations together account for about 40.6% of the total population in 2011 (CSA and ICF 2012). However, the majority of young people in rural Ethiopia do not have access to land despite their constitutional right to access land in the community they live. The 2012 national level land use survey shows that the youth (18-29 years old in this case) accounts for 21% of rural land holders in Ethiopia. Young female land holders are even rarer with only 3% of land holders identified as women aged 18-29 years. The average age of the household heads (which is the same as the land holder in majority of the cases) is 43 years old. This could not be different in Tigray province, northern Ethiopia (Gebeyehu 2013).

Different studies have showm that landholding is one of the factors that constrain farm income and the level of household food security (Nega *et al* 2003; Gebeyehu 2013; Bezu and Holden 2013). As landholding declines, per capita food production and farm income also decline. Extremely small sized farms cannot be made productive even with improved technology and certainly not enough to address rural poverty issues by the extension programmes. Because of high vulnerability to food and income insecurity, farmers with relatively small farm holdings turn frequently to trading crop residue and animal manure as a source of fuel, rather than applying them for soil fertility improvement. The increasing decline of farm size also leads to a reduction of fallowing practice or shortening of fallow cycles, and rotation, with a consequence of declining soil quality and fertility in some highland areas. The diminishing farm size has not only affected the profitability and level of technology use, but also the sustainability of rural livelihoods (Mitiku *et al* 2001). A study carried out at national level, for instance, indicates that, the average farm size can generate only about 50% of the minimum income required for the average farm household to lead a life out of poverty. The major challenges to land policy in Ethiopia have been the growing population, the small size of land holdings in many areas, and, as a result of these two, the rising number of landless people, on one hand, and the need to create an enabling environment for agricultural development and a growing economy on the other hand. Complicating this already difficult equation, land policy is still often regarded in Ethiopia as part of welfare and food security policy and as a way to dampen rural-urban migration.

Due to the resistance of farmers for adoption of agricultural technologies and inputs, limited land production potential and other land size based problems; the government ceased further sharing of land for youths. Instead, it is in favor to find ways for increasing the size of farms cultivated by farmers to an adequate level for which technology use would be rewarding and sustainable. Scientific studies (Negatu 2005 ; Bezu and Holden 2013) has been recommending for policy makers to find ways for increasing the size of farms cultivated by farmers and ways how young farmers could be incorporated to the sector. The undulating topographic arrangement of land mass kept the region with about 1.5 million ha potential of arable land only. This potential of arable land is extremely small to share it among the total rural population (4million) of the region. Accordingly, the regional government has to mobilize towards sustainably using the hilly and a sloppy land mass of the region which holds about 80%. Bench terrace is therefore the very recommendable Sloping Agricultural Land Technology (SALT) in areas dominated by terrains and gorges like in Tigray. By bench terrace, landlessness and unemployedness problems of significant number of youths in the region could be solved.

**3.3 Bench terraces and Irrigation opportunities**

Irrigated agriculture is at the heart of the agricultural development-led industrialization and food security strategy of the Ethiopian Government. Increased availability of irrigation and less dependency on rain-fed agriculture is taken as a means to increase food production and self-sufficiency of the rapidly increasing population of the country. In line with the development policy of the country, the Regional Government of Tigray is promoting irrigation development so as to increase and stabilize food production in the region. To accommodate this, the water resource potential of the region is immense. Studies indicate that the region is with about five perennial streams with flow rates of more than 10 litres/second. The loss of water through the three major drainage systems of the region (Tekeze, Mereb and Dennakil basins) is about 9 billion cubic metres. The region has also about 9.21 billion cubic metres of water potential from rainfall. If the 9 billion cubic metres of runoff was used, 100 thousand hectares (ha) of land could have been irrigated. The agricultural yield would have been also improved more than five times.

But, according to studies, the spatial and temporal variation of access for water is the main challenge for irrigation in the region (Sleshi 2010). Its distribution in terms of area and season does not give adequate opportunity for sustainable growth to the economy. The location of the water (deep gorges, separated by terrains, hilled areas and very far from arable land) is too costly for farmers and government to take off to the arable land. Even, the time when the surface water can be existed in those deep gorges adequately is mismatched with the time that farmers' need it for irrigating their land. The water flow along most of the gorges is temporal and/or too limited which is cost ineffective for diverting to arable land. This would have been cost effective if the arable land was near the water resource. So, bench terrace is a soil and water conservation structure which enhances sloppy agricultural land technology. Cultivable land can be created from the sides of the gorges where perennial water flow is existed, in areas which are suitable for spate irrigation and in gorges which are cost effective and suitable for earthen dam construction. Once the land is created, it could be shared among landless and unemployed youths in the region. Since the land is created in areas rich in water potential, it could be assumed as an approach of taking land to the water potential area which is an opposite of the approach of taking water to cultivable land.

Though it may not be question for societies like in Tigray, the intensive labor requirement of bench terrace construction (800 man days/ha/yr are necessary to construct bench terraces on 49% slopes in case of Ruwanda and In Sierra Leone 708 man days/ha/yr is required for 31% slopes) and the maintenance labor costs are very challenging (Durand 1984; Roose 1988). The designing and specification cases of bench terraces are too complex for the farmers in Tigray unless supported by experts. Clearing of vegetation from the sloppy land during bench terrace construction is also another negative dimension of bench terraces. This all problems could be compensated by cultivating perennial and marketable crops.

## 4. Conclusion

The undulating topographic arrangement of Tigray region has been challenging to use the water resource potential in the region. Tigray has only 1.5 million ha potential of arable land from the 8 million ha total land mass. This potential of arable land in Tigray is extremely small to share it among the total rural population (4million) of the region. Accordingly many rural youth of the region are landless and unemployed. This has been a pushing factor to migrate rural youths to urban part of the country and to Middle East countries. Moreover due to squeezed arable land potential, most formers in Tigray are small holders and as a result they have been reluctant in adopting Agricultural technologies and extension services. This could tell us that further sharing of land from the small holders for youths could mean strengthening the reluctances. Instead, the government and policy makers has been in efforts to find ways for increasing the size of farms cultivated by farmers to an adequate level for which technology use would be rewarding and sustainable and how young farmers could be incorporated to the sector.

Accordingly, the regional government has to mobilize towards sustainably using the hilly and a sloppy land mass of the region which holds about 80%. Bench terrace is therefore the very recommendable Sloping Agricultural Land Technology (SALT) in areas dominated by terrains and gorges like in Tigray. By bench terrace, landlessness and unemployedness problems of significant number of youths in the region could be solved. Cultivable land can be created along the sides of the gorges where perennial water flow is existed, in areas which are suitable for spate irrigation and in the two sides of river valleys and gorges which are cost effective and suitable for earthen dam construction. Once the land is created, it could be shared among landless and unemployed youths in the region. Since the land is created in areas rich in water potential, it could be assumed as an approach of taking land to the water potential area which is an opposite of the approach of taking water to cultivable land. But, it should be followed by systematic selection of suitable sloppy land in reference to the alternative irrigation water availability and cultivating perennial and cash crops

**References**

Admassie Y (2000). Twenty years to nowhere: property rights, land management and conservation in Ethiopia. Red Sea Press, Lawrenceville, NJ.

Asfaw G (2006). Evaluation of Failures and Design Practices of River Diversion Structures for Irrigation: Case of Oromia Regional State. M.Sc. Thesis. Arba Minch University

Awulachew S; Lambisso R; Asfaw G; Yilma A; Moges S (2010). Characterizing, assessment of performance and causes of underperformance of irrigation in Ethiopia. Ethiopian Journal of Development Research, (In press)

Awulachew S; Yilma A.; Loulseged M.; Loiskandl W; Ayana M; Alamirew T (2007). Water resources and irrigation development in Ethiopia. Colombo, Sri Lanka: International Water Management Institute (IWMI) 66p. (IWMI Working Paper 123)

Bennett H (1970). Soil Conservation McGraw-Hilly Book Company, Inc, New York

Bezu S `and Holden T (2013). Land Access and Youth Livelihood Opportunities in Southern Ethiopia. No. 11/13, Ås, Norway: Centre for Land Tenure Studies, Norwegian University of Life Sciences

Burger R (1992). The sacred center of Chavm de Huantar In R Townsend (ed ), The ancient Amencas, art from sacred landscape Prestel Verlag, Mumch, Germany

Camfield L (2011). 'From School to Adulthood: Young people's pathways through schooling in urban Ethiopia', European Journal of Development Research, 23(5):679-694

CSA and ICF (2012). Ethiopia Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International.

CSA (2003). Ethiopian Agricultural Sample Enumeration: Statistical Report on Farm management practices, Livestock and Farm Implements. Addis Abeba (2003).

Demery L and Kuhl J (2011) 'The (Evolving) Role of Agriculture in Poverty Reduction: An empirical perspective', Journal of Development Economics, 96:239-254

Daniel D; Betru N ; Diribu J and Berhanu F (2001). Soil and water conservation manual /guideline for Ethiopia. Soil and Water Conservation Team, Natural Resources Management and Regulatory Department, Ministry of Agriculture. Addis Ababa, Ethiopia.

Demeke M; Kelly V; Jayne S; Said A; Vallee C and Chen H (1998).Agricultural market performance and determinants of fertilizer use in Ethiopia, working paper number 10. Ministry of Economic Development and Cooperation,Addis Ababa.

Durand H (1984) Resultats des expenmentatlOns sur l'eroslOn des sols dan la region de Mummva (Burundi) Mission Forestlere Crete Zaire NIl, BUjumbura 12 pp

Eylachew Z (2003). Watershed Thinking in Natural resources conservation for sustainable land use in Ethiopian journal of water science and technology 7(1) : pp.13-16

Fagl A and Mackie C (1988). Watershed management In Java's upland Past expenences and future directIons In W C Moldenhauer and N W Hudson (eds), Conservation Farm10g on Steeplands SOIl and Water ConservatIon SOCIety, Ankeny, Iowa, pp 254

Food and Agncultural Organilzatlon of the United Nations (1988). Watershed management field manual Slope treatment measures and practices *FAO,* Rome, Italy

Gebeyehu H (2013). Towards Improved Transactions of Land Use Rights in Ethiopia. Paper: presented on the 2013 World Bank Conference on Land and Poverty, Washington, DC.

Herweg K (1993). Problems of acceptance and adoption of soil conservation in Ethiopia. Topics in Applied Resource Management, 3:391-411.

Herweg K and Ludi E (1999). The performance of selected soil and water conservation measures - case studies from Ethiopia and Eritrea. Catena, 36:99 - 144.

Hurni H (1988). Degradation and conservation of soil resources in the Ethiopian highlands. Mountain Research and Development, 8:123 - 130.

Kruger H; Berhanu F; Gebremichael Y; and Kejela K (1996). Creating an inventory of indigenous SWC measures in Ethiopia. In I. S. C. Reij, and C. Toulmin (ed.), Sustaining the soil: Indigenous soil and water conservation in Africa., pp. 170-180. IIED, London

Lal R (2001). Soil degradation by erosion. Land Degradation and Development, 12:519 -539

Millington T (1982) Soil conservation techniques for the humid tropics Appropriate Technology, 9 (2) 17-18

Mitiku H; Karl H and Brigitta S (2006). Sustainable Land Management - A New Approach to Soil and Water Conservation in Ethiopia , Mekelle Univerity.

Mitiku H; Eyasu Y and Girmay T (2001). Land Tenure and Plot Size Determination Issues in Small- Scale Irrigation Development in Tigray, Northern Ethiopia. Paper presented for the Workshop on 'Current Issues on Land Tenure in Ethiopia', Addis Ababa, Ethiopia, April 6-7, 2001.

Nega B; Adenew B and Gebresellasie S (2003). Current land policy issues in Ethiopia. Land Reform 3:103 -124

Roose E (1988) Soll and water conservation lessons from steep slope farmmg 10 French-speakmg countnes of Africa In W C Moldenhauer and N W Hudson (eds), ConservatIOn farmmg on steeplands SOil and Water Conservation SOCiety, Ankeny, Iowa, pp 129

Seleshi B (2010). Irrigation potential in Ethiopia; Constraints and opportunities for enhancing the system. International Water Management Institute

Sheng T (1986). The need for Soil conservation structures for steep cultivated slopes In the humid tropics In Watershed conservation, A collection of papers for develop countries Chinese soil and Water Conservation Society, Taipei, Taiwan, pp 25-32

Sheng T (1989). Soil conservation for small Farmers In the Humid Tropics FAO Soils Bulletin 60 Food and Agricultural Organization of the United Nations, Rome

Sheng T (1981). Technical Notes on Terraces. UNDP/FAO JAM/78/006 Project Paper, Kingston, Jamaica.

Sheng, T (2000). Terrace System Design and Application Using Computers. In Laflen et al., ed: Soil Erosion and Dryland Farming: pp.381-390. CRC Press. Boca Raton, Florida.

Taddese G (2001). Land degradation: a challenge to Ethiopia. Environmental Management, 27:815 - 824.

Taffere B (2003). "Efforts for Sustainable Land Management in Tigray: The Role of Extension." In Policies for Sustainable Land Management in the Highlands of Tigray, Northern Ethiopia: Summary of Papers and Proceedings of a Workshop Held at Axum Hotel, Mekelle, Ethiopia, 28-29 March 2002, edited by B. Gebremedhin. Issue 54 of Socio-Economics and Policy Research Working Papers. Mekelle University, Mekelle, Ethiopia, International Livestock Research Institute, International Food Policy Research Institute.

Tassew W (2000). Economic Analysis and Policy Implications of farm and off farm Employment: a case study in the Tigray Region of Northern Ethiopia. Mansholt Institute. Wageningen University

Thomas B (1988). Conservation of cropland on steep slopes in eastern Africa In WC Moldenhauer and NW Hudson (eds), Conservation farming on steep lands Soil and Water Conservation Society, Ankeny, Iowa

Troeh, F R and Thompson L M (1993). Sods and soil fertility Oxford University Press, New York

Vogel H (1987). Terrace farming Yemen Journal of Soil and Water Conservation 21 18-21

Wood P (1990). Natural resources management and rural development in Ethiopia. In B. S. A. C. E. C.F.S. Pausewang (ed.), Ethiopia: Rural Development Options, pp. 187-197,Worcester, UK.