BASAL METABOLIC RATE AND ENERGY COST OF PERFORMING FARM ACTIVITIES IN MAGUBIKE VILLAGE, KILOSA DISTRICT, MOROGORO, TANZANIA

BY

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ABSTRACT

Determination of basal metabolic rate (BMR), energy cost of various farm activities, physical activity level (PAL), total energy expenditure (TEE), nutritional status and work capacity (VO_2 max) was done to examine their influence on farmer's productivity. A cross sectional study involving 64 farmers was conducted on randomly selected households. Energy expenditure measurements were determined using the Douglas bag technique, VO_2 max was measured by the Rockport fitness test and nutritional status was assessed by BMI and Hb concentration. Analysis was done using student t - test, correlation analysis and regression analysis. Men's BMR was 4.7± 1.12MJ/day while that of women was 4.34 ± 0.77 MJ/day. Farmers mean PAL was 2.13 ± 0.26. TEE in men was 10.24 ± 3.1 MJ/day and that of women was 8.57 ± 2.1 MJ/day. BMR, PAL and TEE were all higher in men than women. The measured energy cost of digging and weeding were 6.56 ± 1.25 kcal/min; 5.67 ± 1.28 kcal/ min in men and 6.60 ± 1.49 kcal/min; 6.21 ± 1.38 kcal /min in women. Women had a higher BMI (22.4± 3.7) than men (20.9 ± 2.1). Increase in BMI was associated with decrease in percent FFM ($r = -0.811$, $P < 0.01$) but an increase in FM ($r = 0.812$, $P < 0.01$) and percent FM ($r = 0.914$, $P < 0.01$). VO_2max of males (45 ± 6.54 ml/kg/min) was higher than females (36± 6.49 ml/kg/min). Haemoglobin (Hb) concentration was the highest predictor of VO_2 max at 39 %. The energy expenditure of rural farmers is high and can be used to determine energy requirements. Work capacity is determined by their nutritional status (BMI, Hb concentration and body composition). Therefore, emphasis on good nutrition and provision of nutrition education remains crucial to farmers whose livelihood depends on physical strength in agriculture production. Furthermore, energy expenditure studies are necessary to validate appropriate energy requirements for farmers in Tanzania.

DECLARATION

I, HILDA NDANGUZI OCAN do hereby declare to the Senate of Sokoine University of Agriculture that the work presented here is my original work and has not been submitted for a degree award in any other University.

Hilda Ndanguzi Ocan — Date
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The above declaration is confirmed

Prof. J. Kinabo — Date
(Supervisor)

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DEDICATION

I dedicate this work to my family; my loving husband Ben and my children Rolex, John and Abigail. Thank you for standing with me.

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LIST OF ABBREVIATIONS

ACC/SCN	Administrative Committee on Coordination /Sub-Committee on Nutrition
AIDS	Acquired Immune Deficiency syndrome
BIA	Bioelectric Impedance Analysis
BMI	Body Mass Index
BMR	Basal Metabolic Rate
BTPS	Body Temperature and Pressure Saturated
CED	Chronic Energy Deficiency
CSPD	Child Survival, Protection and Development programmes.
DLW	Doubly Labelled water
FAO	Food and Agriculture Organisation
FFM	Fat Free Mass
FM	Fat Mass
GIEW	Global Information and Early Warning System (on Food and Agriculture)
Hb	Haemoglobin
HIV	Human Immunodeficiency Virus
HRM	Heart Rate Monitoring
IFPRI	International Food Policy Research Institute
Kcal	Kilocalories
Kg	Kilogram
KHz	Kilohertz
KJ	Kilojoules
MIDA	Moderate Iron Deficiency Anaemia
Min	Minute
MJ	Mega joules

PAL	Physical Activity Level
PANTIL	Program for Agriculture and Natural resources Transformation for Improved Livelihood
PAR	Physical Activity Ratio
RMR	Resting Metabolic Rate
SIDA	Severe Iron Deficiency Anaemia
SPSS	Statistical Package for Social Science
STPD	Saturated Temperature and Pressure Dry
TARP II	Tanzania Agriculture Research Project II
TEE	Total Energy Expenditure
TEF	Thermic effect of Food
UNICEF	United Nations Childrens Fund
UNU	United Nations University
URT	United Republic of Tanzania
VIF	Variance of Inflation Factor
WHO	World Health Organisation
WSN	White Spot Nitrogen

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Much attention recently has focused on the links between nutrition and productivity. Enhanced human capital in particular, is seen as a key component of increasing agricultural productivity in developing countries where labour is still a major input in crop production (ACC/SCN, 2000). In most Third World countries, agriculture is still mainly dependent on human labour and there is expenditure of large amounts of physical energy by subsistence farmers and other workers involved in farming.

Agricultural mechanization is progressing at a changeable pace, and in some countries, animal power is being harnessed to do work previously done by humans. Agricultural mechanization by no 6means always reduces labour demand. Often, it may increase the need for human labour; for example, if fields are ploughed with animal or tractor power, then a greater area may be cultivated, leading to greater demands for weeding and harvesting (Latham, 1993).

In Tanzania, mechanization in agriculture is minimal hence human labour still provides much of the power needed for economic productivity. Labour is normally contributed by the economically productive age group between 15 to 64 years in the community. In Kilosa district demographic data shows that for every 100 in the economically active group there are 97 dependants (URT, 2002a).

Food security in rural communities of developing countries, Tanzania inclusive is critically dependent on their ability to produce food. This ability is determined by a collection of variables, some of which are exogenous, such as rainfall and prices, and others are endogenous, such as the capacity of household members to perform heavy physical work (Ferro- Luzzi, 2001). For many small farmers, family labour represents their main or only asset for production. Any deterioration in the physical work capacity of the breadwinners is therefore potentially disastrous for the whole household, as well as for any other individuals who may depend on them (Ferro- Luzzi, 2001). Some analysts have suggested that, if under nutrition undermines adults' capacity to engage in heavy or sustained physical work or leads to loss of wages due to illnesses; the ultimate result will be impoverishment. This effect has become known as the "energy trap" (Longhurst, 1984; Dasgupta, 1997).

Studies carried out in Ethiopia (Ferro- Luzzi, 2001) have demonstrated that seasonal energy stress arises at times when energy needs to prepare for the next season's food supply increases coupled with declining household food stocks and purchasing power that results in reduced energy intake. This loss of bodyweight in adults or impaired growth in children has a significant human cost. In populations that lack large body fat stores, much of the loss of bodyweight consists of lean tissues, such as muscle mass and internal organs. Adults with very low bodyweight are more prone to illness, which can decrease income-generating capacity and cast the entire household into a downward spiral of impoverishment, and under nutrition (Ferro- Luzzi, 2001).

There are many ways in which nutrition may affect the productivity and well-being of farmers. Energy from food provides the fuel for human work; certain nutrients are essential for the proper functioning of the human body, and the synergism of malnutrition and infections means that nutritional status may influence a variety of infectious diseases and vice versa. Past malnutrition and ill health may negatively influence current functioning and reduce work capacity (Latham, 1993).

In Tanzania the nutritional status of most adults is still poor as about 50 to 85 % of the population in various age categories are anaemic and 10 to 30% of adult population are underweight (TARP II, 2003). Estimates of the year 2005 were that 1.3 million (6.5%) adult age 15-49 years old were infected with HIV/AIDS, and these are within the productive age (UNAIDS, 2005).

Poor nutritional status predisposes the body to diseases, affects energy levels and thus has a bearing on work capacity and productivity. Good nutrition increases resistance to infections and diseases, improves energy levels, and makes a person generally stronger and more productive. Hence, a proper understanding and definition of human energy requirements is crucial for the control and prevention of undernutrition due to insufficient intake of food energy (FAO, 2001). Human energy requirements are estimated from measures of energy expenditure plus the additional energy needs for growth, pregnancy and lactation. Energy expenditure comprises of three components; Basal metabolic rate (BMR), energy cost for performing various activities known as Physical activity level (PAL) and the thermic effect of food (TEF). Out of the three, BMR has the largest contribution to energy expenditure.

Estimates of energy requirements are generally based on estimates of energy expenditure and are thus expressed as multiples of BMR (FAO, 2001). A study conducted in rural

Gambia showed that 21 unsupplemented women, who lost 5 kg of body weight during the rainy period, lowered their BMR by a maximum of 50 kcal/d (Lawrence *et al.*, 1989). Since there was a related reduction of energy intake and thus an energy deficit, the findings suggested that lowered BMR was as early a response to energy imbalance as the loss of body weight occurs.

This study focused on rural farmers in Kilosa district in Morogoro Region. The aim of this study was: To establish human energy requirements of the rural populations, and determine energy cost of doing various farm activities. Also, to examine how nutritional status, energy levels and work capacity of farmers influence their productivity. In order to achieve these objectives, various activities were carried out, which included measurements of Basal metabolic rate, energy cost of various farm activities, BMI, Body composition , Hb (haemoglobin) level, VO_2 max, PAL, and Total energy expenditure of the farming community. This information was used to recommend for development of interventions to improve nutritional status and work capacity of the participating community.

1.2 Problem Statement

Agriculture continues to be the backbone of the Tanzania economy, presently accounting for about half the national income and is the source of livelihood for about 80% of the Tanzanians (IFPRI, 2000). The relative large size of the sector in the economy makes the overall growth performance and improvement in the living standards highly dependent in agriculture (IFPRI, 2000).

Productivity is normally contributed by the economically productive age group between 15-64 years (URT, 2002b). Though human labour provides much of the power needed for economic productivity the mean daily calorie available per capita is below the energy intake level of 2681 kcal/day or 11.26 MJ/day for developing countries (WHO/FAO, 2003). For the case of Tanzania, it is at 1940 kcal/day or 8.15 MJ/day (FAO, 1999).

A broad analysis identifies that where there is significant progress in reduction of energy intake or where there is existence of factors that affect human power such as malnutrition and diseases, work capacity is lowered (Latham, 1993). Strauss (1986), using data from Sierra Leone, used the predicted household energy intake per capita to explain household farm production. The results of the study suggested that household energy consumption was a positive, significant determinant of farm output; thus providing a solid support for the nutrition-productivity hypothesis.

According to Latham (1993), anaemic people especially those in developing countries are engaged in strenuous occupations and do perform important tasks. However, their capacity to endure high energy expenditures for long periods is often compromised by low haemoglobin concentration and in the end, this may seriously affect their work.

In a study on physical capacity for work and muscle strength in undernutrition, Payne *et al.* (1994) pointed out that one of the aspects that contribute to sustainable work output is the maximum rate of oxidation of energy-yielding substrate that an individual can achieve in the short term, measured by maximum oxygen consumption or VO_2max. However, virtually nothing is known about ergonomic efficiency in developing-country agriculture.

Although there are inconsistencies in the nutrition / productivity literature; few studies done so far show a consistent relationship between nutritional status and work capacity (Haddad, 2000). This link requires further and more focused studies so as to provide evidence that elucidates the pathway through which improved nutrition improves economic productivity.

1.3 Justification

Food insecurity is still a major crisis in sub Saharan Africa with most of the population without access to adequate food to meet their basic nutritional requirements (IFPRI, 2004). Review of literature shows most studies that have been looking at famine, food shortage and farmers work capacity have been conducted in Africa in the late eighties and early nineties. Results of these studies have shown evidence that seasonal fluctuations in food security that are manifested as energy stress are accompanied by decreased work capacity of undernourished individuals, an energy-sparing adaptive mechanisms due to reduced food intake (Ferro- Luzzi , 2001).

A loss of weight among adult workers adversely affects work output and productivity. This situation arises when there is shortage of food, or where energy and other nutrient needs of the household are not adequately met. This has been observed to occur at the time of the year when human labour requirements for food production are high (Ferro – Luzzi, 2001). There is a vicious cycle of malnutrition, ill health, decreased production, poverty and more malnutrition. This has serious implications not only for the household but also for national development (Chung, 1992).

Tanzania is among the twenty seven countries in Africa that have experienced food shortage in many parts of its regions (FAO/GIEWS, 2005). This has occurred at the peak season when agriculture activities are to begin. The shortage has partly been linked to drought and delayed rainfalls; but provides a good picture of how food production among farmers is subsistence and not enough to ensure annual household food security.

However, in Tanzania there has never been any study done linking nutrition and productive capacity or determination of energy levels and BMR of individuals. Yet, the design of appropriate food and nutrition security policy responses by Tanzania government may depend critically on understanding how energy levels influence work capacity and differentially affect individuals of different age groups and sex. .

This study was designed to investigate energy levels required for different farm activities, measure farmer's basal metabolic rate (a component of energy expenditure) and also study the effects of nutritional status as measured by BMI and body composition on energy expenditure, work capacity and productivity of rural farmers. Magubike village in Kilosa district in Morogoro was selected because it had a high prevalence of undernutrition in adults with 70% of adults having BMI of less than 20 (Kinabo *et al.,* 2006).

1.4 Objectives

1.4.1General objective

To establish the relationships between nutritional status, basal metabolic rate, energy levels, work capacity and productivity of rural farmers.

1.4.2 Specific objectives

i. To assess the nutritional status of the farmers.
ii. To determine farmers basal metabolic rate, and energy levels required for different farm activities.
iii. To determine physical activity level, work capacity and energy expenditure of farmers.
iv. To examine the factors that influence basal metabolic rate, work capacity and energy expenditure of farmers.
v. To examine the link between nutritional status, energy expenditure, work capacity and productivity of rural farmers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Energy Balance

The relationship between energy intake (a determinant of nutritional status) and energy expenditure is best explained in the concept of energy balance. Energy balance is achieved when our dietary energy intake (input) is equal to our total energy expenditure (output), plus the energy cost of growth in childhood and pregnancy, or the energy required for lactation. When this balance is maintained over a prolonged period of time it is considered to be in a steady state. This is presented by the equation:

Energy Intake = Energy Expenditure (FAO, 2001).

According to WHO (1985), some clinical situations have shown that where an improvement in nutritional status may be advisable, the energy requirement may be set at a higher level than the energy expenditure in order to produce temporarily, a positive energy balance. While in certain physiological states, such as during growth in children, or in pregnancy and lactation, the energy requirement may also be higher than the energy expenditure.

At the other extreme, when dealing with an obese individual or an obese population, again energy requirements would be derived from the energy expenditure, with a reduction to produce a negative energy balance; the amount and the duration of the energy imbalance would determine the rapidity and extent of the weight loss (Durnin,1992).

2.2 Body Size, Body Composition and Energy Balance

A study by Ferro-Luzzi (2001) showed that the examination of body size as assessed by BMI and body composition can be used to investigate the effect of energy imbalance on work capacity. Fat is known to be the main storage form of energy in the body, amount and changes in body fat can provide an indirect estimate of changes in energy balance. On the other hand the amount and changes in fat free mass, the other component of total body mass, which includes the muscles required for physical work, vital organs and skeleton, can be used to draw inferences about extent of muscle wasting, which has immediate impact on work productivity (Gibson, 1990). Different studies (Norgan & Ferro-Luzzi, 1982; Valencia *et al.,* 1992*)* have shown that at any BMI, women have a higher percentage fat than men, and BMI was more highly correlated with FM than with percentage fat and highly correlated with FFM. This confirmed that BMI is more a measure of size (kg) than of composition (percent) and as much a measure of lean as of fat mass.

A study done in Ethiopia by (Ferro- Luzzi, 2001) showed low BMI is associated with less Fat free mass (FFM) for both men and women. Additionally, in women low BMI is associated with a more marked decrease in fat mass (FM) than Fat free mass (FFM) while in men both fat mass (FM) and FFM are lowered.

2.3 Nutritional Status and Productivity

Anthropometric measurement especially height when related to BMI has been linked to productivity. A Study carried out in Kenya showed that, BMI and height appear to increase the capacity to carry out work (Kennedy and Garcia, 1994). A southern Indian study by Ferro-Luzzi *et al.* (1997) linked short stature (164 – 165 cm) men and (152 – 154cm) women with reduced work output and lower energy requirements.

However a study by Barac- Nieto *et al*. (1978) classified a group of 107 Colombian agriculture workers at height 164 cm as “nutritional normal”.

BMI is a function of weight and height; hence recommendations for dietary energy intakes are aimed at maintaining values of BMI between 18.5 and 24.9 kg/m^2 (FAO, 2001). At an individual level, a normal range of 18.5 to 24.9 kg/m^2 BMI is generally accepted (WHO, 2000).

In another study by Deolalikar (1988), it was observed that individual energy intake and weight-for-height explained wage rates and farm output. The study thus concluded that nutritional status as measured by weight-for-height is important in determining labour productivity. Other studies (Pryer, 1993; Shetty and James, 1994) have reported that adults with very low bodyweight are more prone to illness and at increased risk of mortality. Furthermore, the work capacity of an individual with a low body mass index (BMI) has been found to be lower than that of high-BMI individuals (Barac-Nieto *et al.*, 1980).

2.4 Energy Intake and Productivity

High levels of productivity demand adequate energy intake and reasonable health for those who labour to produce and harvest crops and are also involved in many other labour-intensive, work-related activities (Strauss ,1986; Latham, 1993; Dasgupta, 1997 and Ferro Luzzi, 2001).

These studies show that seasonal energy stress arises when the combination of reduced energy intake owing to declining household food stocks and increased energy expenditures in preparation for the following harvest season causes energy requirements to exceed supply (Latham, 1993 and Ferro- Luzzi, 2001). Ferro-Luzzi (1988) showed that, when adults are faced with persistent energy stress (low energy intake) they mobilize the energy stored in the body as adipose tissue, lower their physical activity in an attempt to increase the efficiency with which cells handle the energy available, thus resulting in low BMI and productivity. Strauss (1986) observed that the higher the level of food consumption, the higher the productivity of the population in the area.

2.5 Energy Expenditure and Basal Metabolic Rate (BMR)

The amount of energy used for basal metabolism in a period of time is called the basal metabolic rate (BMR). BMR represents 60 to 70 percent of daily total energy expenditure (FAO, 2001). BMR for an individual person is usually defined as the amount of energy [expressed in kilocalories or mega joules (MJ, per day] expended when the person is at complete rest, both physical (i.e. lying down) and psychological (Latham, 1997). It can also be expressed as kilocalories per hour or per kilogram of weight. BMR provides the energy required by the body for maintenance of body temperature; for the work of body organs such as the heart, muscles, breathing, liver, kidneys and brain (Latham, 1997). Basal metabolic rate (BMR) determination is important in the estimation of energy requirement. Studies conducted on African farmers over the years have continuously shown a variation, and loss of weight ranging from 0.7 kg equal to 1.4% of body weigh (Kennedy and Cogill, 1987). This variation results in a persisting decrease in BMR, even after adjusting for body weight and fat-free mass (FFM) losses and represents one of the earliest and best known adaptive responses to energy deficit, that has been extensively described under experimental and controlled laboratory conditions (Ferro-Luzzi *et al.*, 1987).

It is well established that measurement of basal metabolic rate (BMR) provides an important energy baseline for the determination of an individuals total energy requirement (Venkata *et al.*, 2004). The FAO/WHO/UNU (2006) recommendation on energy and protein requirements of humans, suggested that various components of energy expenditure be expressed as multiples of BMR. BMR is influenced by various factors including body mass, age, sex, state of health, weight, body composition, physiological state and temperature (FAO, 2001).

2.5.1 Nutritional anthropometric indices and their relationship to BMR

Several anthropometric parameters such as body weight and height, as well as their transformations such as BMI, have been studied for their associations with BMR. Comparison of the correlation coefficients obtained by both Schofield and James (1985) and by Soares and Shetty (1988) showed that BMR has a stronger correlation with body weight than with any other nutritional anthropometric index used as a single independent variable. In Schofield's (1985) analysis, the r value for body weight was 0.875 for males (n = 4809) and r = 0.851 for females (n = 2364). The correlations for height alone were r = 0.87 and r = 0.886 for similar numbers of males and females respectively. However, it was noted that the relationships are not perfect and the high correlations obtained with height were largely the result of the contributions of large numbers in the database. The analysis by Soares & Shetty (1988) demonstrated that at r = 0.80 body weight accounted for 64% of the variance while BMI had an r = 0.64 and height an r = 0.57, thus explaining only 41% and 33% of the variance respectively. However, the study found BMI was not as useful a predictor of BMR as body weight and so is not the most useful index for predicting the BMR of individuals or population groups when applying the factorial method to estimate human energy requirements. Other studies by Shetty (1993) and Ramirez-Zea ((2005), showed that the relationship between body weight and BMR is not necessarily one of simple linearity. Nevertheless, the correlations between body weight and BMR were good. There were differences which the study explained could be accounted for by differences in the body composition affecting not only the ratio of fat to fat-free mass (FFM) but also differences in the contribution of muscle and visceral tissues within the FFM.

2.5.2 Factors in BMR variability

Normal biological variability is also known to cause variability in BMR (Rutter *et al.*, 1978). These depend upon such factors as the previous nutritional state, absence of disease or infection, the body temperature, age, gender, body mass, body composition, the phase of the menstrual cycle in the female and the degree of wakefulness. The influence of these variables may seriously affect the apparent standardization which is thought to be attained by carefully controlling the other well-known factors of food, muscular activity and environment (Durnin, 1981). In broad terms, bigger people with more muscle and larger body organs have higher BMR than smaller people. Elderly people tend to have lower BMR than they had when they were young, and females tend to have lower BMR than males even on a per kilogram body weight basis (Latham, 1997).

BMR maximum value is reached during the first year of life from which there is a fall of about 20% by age 10 years; a slight decrease in the rate of fall during puberty, then a further decline until about age 20 years by which time BMR is only 70% of its rate at 1 year of age. Another 10% decrease then occurs by the age of 60 years. The effect of the increased relative proportion of muscle in the total body mass during growth, together with the effect of the low metabolic rate of the growing skeleton, results in the comparative lowering of BMR (Durnin,1981). Another study by Roberts and Dalall (2005) suggested that even after adjusting for changes in fat-free mass, BMR is 5 percent lower in older persons compared with young adults. This is explained by an increasing mass of adipose tissue and a decreasing mass of muscle and is more marked beyond 60 years. In his study, Keys *et al*. (1973), measured the BMR of 63 men at age 22 years and again after 19 years and found the BMR had decreased by 9% but there had been a gain in weight of 10.6 kg, which the authors suggested might have had some influence. Tzankoff and Norris (1978), from measurements on 959 men aged 20–97 year, also thought that reductions in muscle mass (estimated by creatinine excretion) might be largely responsible for the fall in BMR with ageing. This conclusion was re-inforced by a longitudinal study during 10-plus years on 355 men.

However, another study by Van Pelt *et al.* (2001), whose work on resting metabolic rate (RMR) showed that RMR per unit FFM declined with age in highly active men when there is reduction in exercise volume and energy intake. This decline does not occur in men who maintain exercise volume and /or energy intake at a level similar to that of young physically active men.

It has been suggested that BMR is a function of all the separate active tissues of the body and is dependent on the relative mass of these tissues (Durnin, 1981). However, the ratio of the mass of the different tissues in individuals of varying body size is not always the same: e.g. in adults, relative masses of muscle, skeleton and adipose tissue may vary considerably and there are basic differences in many tissues between infants and adults. Likewise, the metabolic rate of the same mass of tissue might differ as a function of age. Thus, BMR of apparently similar individuals will often vary markedly depending on their body mass, age and sex (Durnin, 1981).

BMR has also been connected to ‘lean body mass’ or, more correctly, the fat-free mass and a study by Ferro-Luzzi *et al.* (1994) observed that, populations that lack large body fat stores even at the less stressful times of the year, experience loss of weight with a large proportion of the loss consisting of lean tissues, such as muscle mass and internal organs which results in negative energy balance and significant lowering of BMR. However, in the case where the leanness is of semi-permanent or long-term duration, but is compatible with a level of nutritional status which does not inhibit a 'normal' lifestyle, particularly with regard to physical activity, then BMR and energy requirements are unlikely to be influenced in any important way (Ferro- Luzzi, 1990).

BMR values for males and females differ with females values having a lower rate. This difference has been associated with the larger adipose tissue mass in women (Durnin, 1981). More muscles in men and less fat causes a high ratio of fat free mass compared to fat mass and hence an increase in BMR. A study by Mitchell (1962) observed that, the phase of the female sexual cycle seems to result in the BMR being at its lowest during menstruation and highest immediately prior to menstruation. Hence, these periods are not recommended in the measurement of the BMR.

The nutritional status of an individual affects their BMR. This has been demonstrated by Classical experiments of Benedict (1915) which showed measurable falls in BMR after a few days of total fasting reaching a plateau level of about a 25% decrease after 20 days or so. This was further reinforced by the exceptionally extensive studies of Keys and his colleagues (Keys *et al.*, 1950). The investigations were carried out on 32 young men who lived for 6 months on a ‘European war-time famine diet’ which resulted in a mean loss of body weight in the group of 24% of the original weight. BMR fell to a value only about 70% of the initial rate. These declines in both body weight and BMR were interpreted as part of the process of adaptation to the nutritional stress. On the other hand, overfeeding causes an increase in BMR (Schutz, *et al.*, 1985). This has been related to the prolonged effect of food on metabolic rate with the effect of a large meal a day prior to BMR measurement being detected the following day (Schutz *et al*., 1985). The long effect of overfeeding results in increase in fat free mass and hence BMR.

External factors such as temperature, drugs and stress are also known to influence BMR. These have been known to result in increased cellular metabolic rate. Soares *et al.*, (1993), imputed differences in BMR in people of different races as being attributed to ambient temperature. The study showed on average BMR values measured in tropical regions are 4-5% lower than BMR measured in temperate zones.

2.6 Work Capacity

Physical work capacity is the ability of an individual to perform maximal physical work or maximum work per unit time (Spurr, 1984; Ferro-Luzzi, 1985; Collins and Roberts, 1988). It is a function of the intensity and duration of work, each individual has different capacities such as anaerobic, aerobic and endurance capacity, each with its own limiting factors. In practice, aerobic work capacity that is maximal oxygen uptake (VO_2 max) is the capacity most often considered (Spurr, 1990).

The maximal oxygen uptake (VO_2 max) is dependent on the body's capacity for a linked series of oxygen transfers (diffusion through tissues, circulation of haemoglobin, pulmonary ventilation). This volume is expressed as a rate, either as litre per minute (L/min) which is referred to as absolute VO_2 max or millitres per kg body weight per minute (ml/kg/min) referred to as relative VO_2 max .This capacity is dependent on (metabolically) active tissue which is nearly the same as a muscle cell mass.

VO_2 max varies considerably in the population. It is noted that the highest VO_2 max is at 6 l / min and the lowest is 2 l / min (Dasgupta, 1997). For example, in a young untrained male the average VO_2 max can be approximately 3.5litres/minute or 45 ml/min/kg, for a young untrained female it can be 2.0 litres/minute or 38 ml/min/kg. Sedentary individuals have VO_2 max ranges of 30-40 millilitres of oxygen per kilogram of body weight per minute -ml/kg/min (Macknight, 2006).

2.6.1 Work capacity differences in sex

A study by Seiler, (1996) explains that the "typical" young untrained male will have an absolute VO_2 max of 3.5 litres/min, while the typical same-age female will be about 2 litres/min; a 43% difference. This can be explained by the average 25% body fat in women compared to 15% in young men. If the body compositions differences are removed by dividing VO_2 by lean body mass the difference in maximal O_2 consumption decreases to perhaps 7-10%. Additionally, on average females have lower blood hemoglobin content than males, up to 10% lower and the female heart is slightly smaller relative to body size than the male heart, due to may be differences in androgen receptor density in the female heart. Thus, a smaller heart is expected to be a less effective pump. Therefore, the slightly lower oxygen carrying capacity of the blood (lower haemoglobin concentration) plus a somewhat smaller or less adaptive heart accounts for the gender differences in maximal oxygen consumption that are independent of body size and fat percentage (Seiler, 1996).

2.6.2 Work capacity and nutritional status (BMI)

A study by Barac *et al.* (1980) showed that over 80 percent of the differences in VO_2 max between mildly and severe malnourished people can be traced to their differences in their muscle cell mass. This is best measured by relative VO_2 max (ml/kg/min).

In another study of the Zigwa Boto men in Ethiopia, it was observed that maximal oxygen consumption (VO_2 max) increased markedly with BMI (Ferro-Luzzi, 2001). A step wise multiple regression analysis in a study by Spurr (1990) showed that VO_2 max is positively related to weight-for-height, total haemoglobin concentration, and daily creatinine excretion.

2.6.3 Work capacity, age and sex

According to Shephard (1999) the reduction of work capacity with age is associated with a progressive decline of cardiac pump function, a decrease of muscle strength, and a progressive impairment of heat tolerance. Seiler (1996) also reported that in a sedentary population, cardiovascular performance declines progressively with age. However, much of this decline is due to 1) physical inactivity and 2) increased body weight (fat). Maximal oxygen consumption declines about 10% per decade after age 25. However, if body composition is maintained and physical activity levels are kept constant, the decline in VO_2 max due to aging is only about 5% per decade. The study further reported that VO_2 max of adult females is approximately 20 % lower than that of adult males, it declines at a steady rate after age 20; but maintenance of an active lifestyle, greatly delays this inevitable process. Ultimately, cardiovascular capacity is reduced however, this is due to the unavoidable decline in maximal heart rate.

2.6.4 Work capacity, anaemia and productivity

Anaemia is usually defined as a low level of haemoglobin in the blood. Haemoglobin is the substance present in the red blood cells that transports oxygen from the lungs to various parts of the body. Physical activity is the factor that is most important in determining the total oxygen consumption of a healthy individual (Latham, 1993).

A study by Beutler (1980) showed that, a person with quite low levels of haemoglobin, or severe anaemia, has a reduced capacity to sustain energetic work of long duration. According to Latham (1993), work capacity is likely to be influenced in the anaemic individual by several factors, such as the level of haemoglobin in the blood, and the strenuousness of the work being done.

A study in Indonesia (Basta *et al*., 1979) showed a significantly lower work output for rubber plantation workers with anaemia. A series of studies on health and nutrition factors related to work performance in Kenya also examined the effect of anaemia (Brooks *et al.,* 1979; Latham and Stephenson, 1981). These studies showed a significantly lower level of productivity in anaemic road workers compared with non anaemic workers. In these studies, anaemia was believed to be due to several different causes, including dietary iron deficiency and parasitic infections (hookworm, schistosomiasis, and malaria).

Furthermore, a causal relationship has been reported from the human studies by Li *et al.* (1994) and Woodson *et al.* (1978). The studies demonstrated that changes in Hb resulted in significant changes in VO_2max, which ranged from a 30% decline after experimentally induced anemia to a 24% improvement after 12 wk of iron supplementation. The studies also suggested that both severe iron deficiency anaemia (SIDA) and moderate iron deficiency anaemia (MIDA) impair aerobic capacity, which can be corrected by increasing Hb concentration. Impairments were proportional to the severity of deficiency and range from roughly 10 to 50% reductions in VO_2max.

2.6.5 Work capacity, under nutrition and productivity

A study in nutritionally normal and malnourished men (Durnin *et al.*, 1990) has shown that the physical work capacity, as measured by the VO2 max is dependent on nutritional status such that, relative to the degree of malnutrition, undernourished subjects have depressed work capacities due largely to decreased muscle mass. Viteri, (1971) showed that poorly nourished Guatemalan men had a lower working capacity and work output because of reduced lean body mass, earlier appearance of oxygen debt, and decreased tolerance to oxygen debt. The study also demonstrated that increased protein-energy intake over a long time period in chronically sub - optimally nourished men produces a beneficial effect on body composition and physical work capacity.

2.7 Measurement of Energy Expenditure

Energy expenditure is key in the assessment of energy requirements. For many population groups in developing countries, food in adequate quantities may not be available. If food intake alone is measured, true energy requirements may not be obtained. When energy expenditure is measured, better information is gathered; this is particularly important in providing essential "base-line" data that will later allow an evaluation to be made of the effect of food supplementation (Durnin, 1990). It may be measured by several different standard 'direct calorimetry', which refers to the direct measurement of heat output in a calorimeter; or “indirect calorimetry” which refers to the measurement of energy expenditure from O_2 intake or CO_2 output (Durnin, 1992).

2.7.1 Direct calorimetry

Calorimetry in man, as its name implies, is the measurement of the heat emitted from the human body. This is an accurate method used to quantify human energy expenditure during rest and physical activity. Energy can be measured as heat, as it is one of the most conveniently handled forms of energy (Durnin, 1981). The heat is measured directly by putting the individual inside a specially constructed calorimeter. A known volume of water at a specified temperature is circulated through a series of coils at the top of the chamber. The water absorbs the heat produced and radiated by the subject, similar to bomb calorimeter. The entire chamber is insulated and ventilated with exhaled air passing from the room through chemicals that remove moisture and absorb carbon dioxide. The change in temperature of water in and out is monitored, measured and calculated to determine heat emitted.

Much of the classical and fundamental work on energy metabolism was done in this way, in particular the excellent and distinguished studies of Atwater and Benedict (1899). The use of this technique with a properly constructed calorimeter has been known to incur no appreciable error in the actual measurement, but there are considerable disadvantages. Firstly, construction and operation of the apparatus is time-consuming and costly and very few of these instruments were ever made; secondly, the measurement must be made during a period of several hours, because of the large volume of the apparatus and the time-lag between alterations in the heat content inside the calorimeter chamber caused by the presence of the human being and their measurement. Hence, even though considered the best, this is not a method for measuring large numbers of individuals (Durnin, 1981).

2.7.2 Indirect calorimetry

Indirect calorimetry or respiratory calorimetry is a commonly used method of estimating energy expenditure through measurement of the oxygen consumption of an individual, usually during a period varying from 10 to 30 minutes. It is based on the principle that during oxidation of organic molecule in the body, oxygen in consumed in amount related to the energy or heat liberated. For each litre of oxygen consumed there is a known amount of heat which is being liberated by the body. The amount of heat liberated per litre of oxygen consumed is not constant. It varies depending on proportion of carbohydrate, fat or protein being oxidized. Measurement of oxygen consumption, therefore provide an estimation of the amount of heat liberated by the body, thus metabolic rate (Kinabo, 1990). Indirect calorimerty can further be divided into open-circuit and closed –circuit technique.

Open-circuit spirometry provides a relatively simple way to measure oxygen consumption. The subject inhales ambient air that has a constant composition. Changes in oxygen and carbon dioxide percentages in the expired air compared with percentages in inspired ambient air reflect ongoing energy metabolism. Analysis of the volume of air breathed during a specific time period and analysis of exhaled air provide a way to measure oxygen consumption and infer energy expenditure (Kinabo, 1990).

Closed-circuit spirometry is currently used in hospitals and research laboratories to estimate resting energy expenditure. In this technique the subject breathes 100% oxygen from the prefilled spirometer. The subject re-breathes only the gas in the spirometer, while exhaled carbon dioxide is absorbed by a canister of soda lime. The change in the volume of the system is used to measure the rate of oxygen removal from the system and subject's oxygen consumption.

2.7.3 Non calorimetric methods

2.7.3.1 Factorial estimates of total energy expenditure and physical activity level

According to WHO, (1985) energy requirements of adults can be calculated from factorial estimates of habitual total energy expenditure (TEE). This is because the diversity in body size, body composition and habitual physical activity among adult populations with different geographic, cultural and economic backgrounds does not allow a universal application of energy requirements based on TEE measured with Double labeled water (DLW) or Heart rate monitoring-(HRM) in groups with a specific lifestyle (FAO, 2001). Consequently, habitual physical activity and body weight are the main determinants for the diversity in energy requirements of adult populations with different lifestyles (James and Schofield, 1990).

Furthermore, growth is no longer an energy-demanding factor in adulthood, while BMR is relatively constant among population groups of a given age and gender. Thus, requirements of a specific individual are based on that person's actual TEE or BMR, or on estimates that take into account the individual's habitual physical activity and lifestyle characteristics. Hence, to account for the differences in physical activity, TEE is estimated through factorial calculations that combined the time allocated to habitual activities and the energy cost of those activities. The calculation involves:

- Establishing time allocated to habitual activities. This is done through a 24 hour activity diary method that records all activities conducted in a 24 hour period and the time used in each activity (WHO, 1985)
- Combining the time allocated to habitual activities and the energy cost of those activities also referred to as physical activity ratio (PAR) gives the value of PAL.

To account for the differences in body size and composition; energy cost of activities (PAR) is calculated as multiple of BMR per minute (WHO, 1985).

- Determining BMR and then calculating TEE which is equal to 24 hours energy requirement. This is expressed as a multiple of BMR per 24 hour by using the PAL value. Hence; TEE= BMR * PAL (James and Schofield, 1990).

2.7.3.2 Energy cost of activity (Physical Activity Ratio –PAR)

PAR is the energy cost of an activity per unit of time (usually a minute or an hour) expressed as a multiple of BMR. It is calculated as energy spent in an activity/BMR, for the selected time unit (FAO, 2001). Energy cost of activities, or PAR, is similar for men and women (WHO, 1985). The effect of gender comes out when the PAR value is converted into energy units, because men have higher BMR for their body weight than women, and this difference is accentuated by the heavier weight of men. Consequently, the energy cost of most activities as a function of BMR is applicable to both men and women on individual, social and cultural features that promote or limit habitual physical activity among older adults. Published research papers by WHO (1985) provides energy costs of different activities that are used in different research.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location of the study area

The study was conducted in Morogoro Region in Kilosa District, in the Ward and village called Magubike. Morogoro region has five districts i.e. Morogoro Urban, Morogoro Rural, Kilosa, Ulanga, Mvomero, and Kilombero. Morogoro region lies between latitude 5º 58” and 10º.0” to the South of the Equator and longitude 35 º 25” and 35º 30” East. It occupies a total of 72,939 square kilometers which is approximately 8.2% of the whole area of Tanzania Mainland.

3.1.2 Population

Kilosa district has a population of 489,513, with an average of 4.6 people per households (CSPD, 2005). Magubike village has a population of 7,349 inhabitants among these 2,562 are male, 2,861 female, 1,078 are children above five years and 848 are children below five years. The village has high prevalence of undernutrition in adults with 70% of adults having BMI of less than 20 (Kinabo *et al.*, 2006).

3.1.3 Climate

The annual rainfall ranges from 600mm in low lands to 1200mm in the highland plateau. There are areas which experience exceptional drought with less than 600mm of rainfall. These areas are Gairo and Mamboya divisions in Kilosa districts, Ngerengere division in the east of Morogoro Rural districts. The mean annual temperature varies with altitude from the valley bottom to the mountaintop. The average annual temperature varies between 18°C on the mountain to 30°C in river valley. In most part of the region the average temperature are almost uniform at 25°C. There are two rainy seasons: The long rain which starts in the late March and last till early June and the short rains, which last from October to November. The hot seasons run from July to September.

3.1.4 Agriculture production / occupation

Most villagers are subsistence farmers growing maize, cassava, sorghum and increasing numbers are petty traders. Most households keep domestic animals such as chickens, duck and few goats. Food shortage months include February through March (Lean season) while adequate food periods include July through September (harvest period).

3.2 Research Design

A cross sectional design involving in depth biological study was used in this study. This involved measurements of basal metabolic rate (BMR) of adults conducted under laboratory environment, determination of nutritional status assessed by their body mass index (BMI) and body composition, assessment of haemoglobin (Hb) concentration, determination of energy cost of farm activities i.e. digging , weeding and , energy cost of house activities in the field, and determination of work capacity.

3.3 Sample Design

3.3.1 Population and sampling unit

The Population from which the sample of this study was drawn from involved individual farmers and their households in Magubike village.

3.3.2 Sampling frame

Magubike village is made up of ten hamlets. These include Chimale A, Chimale B, Lugofu, Ipandole, Mjini, Sokoni, Mgalai, Mtunye, Mazimbo and Makangalawe. Under the PANTIL Nutrition intervention project 60 (sixty) households were selected. A village register was used to obtain a list of all households in each hamlet from which sampling units were selected. Selection of households per hamlets took into consideration the population size in each hamlet as this was not equally distributed. The research worked with adults in the project selected households.

3.3.3 Sample size

The sample size for this study was 38 households. These were randomly selected from the 60 households participating in the PANTIL nutrition intervention project conducted in 2006. The sample size of 38 is statistically, a minimal acceptable sample from which statistical inferences can be made on the population. The said sample took into consideration the high financial costs of equipments that were used to determine basal metabolic rate and energy expenditure. Also, project baseline data had shown minimum variations in the variables of interest like BMI, farm size and income among households in the population.

3.3.4 Sampling procedure

Random sampling procedure was used to select the households that were involved in the study. The sixty households were allocated numbers 1 – 60. The numbers were then written down and randomly picked to obtain the 38 households. The inclusion criteria required that participants be in good general health and have no known current infections.

3.3.5 Level of significance of the study

The study was done at 95% confidence interval and tested at 0.05 level of significance. The above power of the study has been chosen in reference to other studies conducted that measured BMR and energy expenditure (Durnin, 1981).

3.4 Data Collection

Data collected included information on the nutritional status as measured by BMI; demographic characteristics of households, socio-economic factors such as farm size, household food stock and household source of income. Also measurements were done to determine haemoglobin level of farmers, basal metabolic rate (BMR), body composition, work capacity, physical activity level (PAL), energy expenditure and energy costs while digging, weeding, and doing household chores.

3.5 Materials and Equipments

The study used the following tools and equipment:

3.5.1 Tools

Questionnaires were used to collect information on household characteristics i.e. household size, sex, age and level of education, marital status and sex of the household head. Other information included socio-economic situation, and factors that determine the nutrition and productivity level of households. Face to face interviews were conducted at the households.

3.5.2 Equipments

a) **To assess nutritional status:** Stadiometer (The Leicester Height measure) and a Seca weighing scale (Vogel &Haike, Hamburg, Germany).

b) **To measure haemoglobin:** An electric/battery- operated Hemocue photometer (Hemocue AB, Angelholm, Sweden), disposable cuvettes, sterile disposable lancets, disposable gloves, methylated spirit and cotton wool

c) **To determine body composition**: A Tanita body composition analyzer (Model BF 350) Tokyo, Japan.

d) **To determine Work capacity**: A 16¼ inch high bench, a stop watch, a heart rate monitor.

e) Equipments used to measure metabolic rate using the open circuit Indirect calorimetric (Douglas bag technique) included:-

i. The Douglas bag – (Cranlea & Co.Birmingham, UK), this is a large non diffusible plastic bag with 100 litres capacity.
ii. Flexible corrugated plastic tubing (length 122cm ID 2.86 cm)(Cranlea & Co.Birmingham,UK),
iii. Mouth piece, nose clip and stop watch.
iv. Gas meter – (Harvard Apparatus Ltd, Edenbridge, Kent, England) To measure expired air volume.
v. Oxygen analyzer – Servomex type 572B portable paramagnetic oxygen analyzer. Wagtech International Ltd, Thatcham, Berkshire, England.
vi. Gasman- a personal gas (oxygen) monitor for oxygen analysis. Crowcon Detection Instruments Ltd. Backlands Way, Abingdon ,UK
vii. Stop watch and Thermometer – To measure time and temperature.
viii. Oxygen free nitrogen (WSN) British Oxygen Co. Ltd, Nairobi, Kenya
ix. Bed

3.6 Determination of Metabolic Rate

3.6.1 Calibration of gas analyser

The oxygen analyzer was calibrated on each test day before the start of the experiment. The analyzer was set at zero by introducing oxygen free nitrogen. The white spot nitrogen (oxygen free nitrogen) was supplied by the British Oxygen Co. Ltd, Nairobi, Kenya. The span of the oxygen analyzer was set at 20.93% using ambient air with hand aspirator connected through a drying tube which had a drying agent (silica gel). The drying tube helped to prevent entrance of particles and condensate into the analyzer in addition, the removal of water vapour from the air. Oxygen free nitrogen was introduced again to calibrate to zero. Due to the potential effect of tilt upon the analyzer accuracy, once calibrated the analyzer was not moved from its position.

3.6.2 Collection of expired air (Open circuit indirect calorimetric method using the Douglas bag technique)

In the open circuit method the individual was fitted with a nose clip and breathed through a light weight mouthpiece connected to a two way resistance valve. The subject inspired ambient air and the expired air was directed through flexible plastic tubing into the Douglas bag (100 litres capacity) (Fig 1). A tap was fixed between the bag and one end of the plastic tubing. This was used to allow the subject to breathe either into the bag or the atmosphere. The subject was given time (4-5 min) to be in respiratory equilibrium under the experimental conditions before actual gas collection. In this experiment timing started at the point at which one rotated the valve plate to begin collection and the valve was closed immediately after timing had been stopped. After every usage by one person the mouthpiece was sterilized using jik and hot water mixed in the ratio of one to six as recommended by the Ministry of Health Tanzania. The collected expired air sample in the Douglas bag was then analyzed. In the analysis the following were observed:

- The volume of air breathed out. (The values were corrected at standard temperature and pressure dry (STPD)
- Percentage of oxygen exhaled which was analysed using an oxygen analyzer.

Figure 1: Determination of BMR using a Douglas bag

Figure 2: Analysis of expired air

3.6.3 Analysis of expired air

A sample of expired air was introduced into the servomex oxygen analyser. The drying tube supplied with the analyzer was fitted before the analyzer inlet then, the Douglas bag was connected through a side tube that is attached to the bag. A minute was allowed for the reading on the analyzer to stabilize then displayed readings were recorded and were taken to represent oxygen content in expired air. The side tube was shut off and the volume of expired air was measured using the gas metre (Fig 2). The volume of expired air (pulmonary ventilation**)** was then corrected for the amount of water vapour at standard temperature and pressure dry (STPD) using correction factors from a standard nomogram (Consolazio *et al.*, 1963).

3.6.4 Calculations of metabolic rate

In this study, metabolic rate was calculated using Weir's (1949) method. The oxygen content of inspired air was determined using a portable oxygen gasman –monitor (Crowcon Detection Instruments UK). This unit is electronically calibrated to read the atmospheric oxygen immediately after switching on and setting it at zero. By calculating the difference between the percentage of oxygen in inspired and expired air, the percentage utilized was arrived at. This value was then multiplied by the volume of expired air and corrected to standard temperature and atmospheric pressure dry (STPD: Zero degrees centigrade, 760 mm Hg) to determine the amount of oxygen consumed. In earlier studies of energy expenditure, it was considered essential to determine carbon dioxide production as well as oxygen consumption; but it was calculated that the error involved in eliminating determination of carbon dioxide is at most ± 0.5% (Durnin and Passmore, 1967). According to Weir, (1949) and Consolazio *et al*. (1963) the calorific value of expired air is independent of CO_2 in the expired air, and thus on the respiratory quotient. Hence in this study it was considered unnecessary to determine carbon dioxide production; thus the use of Weirs equation which yields an estimate of per minute energy expenditure in kilocalories to two decimal places.

Weirs equation used to estimate energy expenditure was:

$$\text{Energy expenditure (kcal/min} = 4.92\text{V} \frac{[20.93\ \ \text{Oxygen content of expired air in \%}]}{100}$$

Where,

V = the corrected volume of expired air per minute. (This is the metred volume converted to STPD/min).

20.93 = percentage of oxygen in inspired air

4.92 = kilocalories of energy liberated from each litre of oxygen utilized by the body. It is a conversion factor used for low to moderate work levels where it is assumed a mixed food substrate is being oxidized. (In case of maximum work capacity where a higher proportion of carbohydrate is utilized the factor used will be 5).

Data presented in Table 1 were taken:

Table 1: Data and measurements recorded

Variable to be recorded	Method of calculation
A. Sampling period (min)	data
B. Barometric pressure/temperature (mmHg/°C)	data(obtained from meteorology dept
C. Standard temperature, pressure (STPD) correction factor of air	Calculated as shown below
D. Final gas-meter reading (litres)	data
E. Initial gas-meter reading (litres)	data
F. Volume of expired air (litres)	D – E
G. Volume corrected to STP	C x F
H. Volume corrected to STP/min	G/A
I. Oxygen tension in inspired air (mmHg)	data
J. Oxygen tension in expired air (mmHg)	data
K. Per cent oxygen in expired air	(J x 20.93)/l
L. Per cent oxygen consumed	20.93 – K
M. Volume of oxygen consumed (litres/min)	L x H/100
N. Kcal expended/min	M x 4.92

3.6.5 Correction Factor

Volume of expired air (body temperature and pressure saturated with water vapour BTPS) was corrected for moisture at standard temperature and pressure, dry (STPD 0º C, 760mm Hg, dry) using a correction factor:-

$$V_{STPD} = [\mathrm{V_{BTPS}}] \text{ X } \frac{[273]}{273 + \mathrm{T}^0 C} \text{ X } \frac{|\mathrm{P_b} - \mathrm{P}_{\mathrm{H}_2 O}|}{760 mmHg}$$

Where:

P_b = Atmospheric pressure in mmHg

P_{H2O} = Partial Pressure of water obtained from table (Appendix 1)

$T\ ^oC$ = temperature of the expired air which is the same as body temperature.

3.7 Measuring Basal Metabolic Rate (BMR) and Conditions Observed

A total of 71 farmers were scheduled to participate but only 64 were measured with 7 drop outs due to sickness. To carry out the measurements, a group of four (4) farmers arrived daily from Magubike village, a day before measurements were to be done. The farmers were housed in a rest house near the BMR laboratory. The meals, drinks and activities done were monitored to ensure compliance with conditions required for BMR measurements. An interval of one hour was used to differentiate and schedule the last (evening) meal given to the individual farmers. This was done to ensure that farmers do not become hypoglycemic as they waited to be measured in the morning. The basis for measurement of BMR was through measuring oxygen consumption and converting it into energy units usually expressed as kJ (or kcal) per unit of body size (Durnin (1981 cited by FAO /UNU, 2006). BMR was measured accurately with small intra-individual variation by indirect calorimetry under standard conditions as described by Benedict (1915) this included:

i. Subject being awake and in the supine position,
ii. Measurements were taken 12 hours after a meal, following eight hours of physical rest and no strenuous exercise in the preceding day.
iii. The subjects were directed to abstain from caffeine containing beverages and alcohol on the night before the test day.

iv. Subject had to empty their bladder 30 minutes before the test.

v. Subjects were allowed to rest lying in bed in the supine position for 30 min in a state of mental relaxation under ambient environmental temperature that did not evoke shivering or sweating.

vi. Subject's health conditions were examined to ensure that, they were in general good health.

vii. In female subjects, the stage of her menstrual cycle was also recorded.

3.7.1 Procedure for measuring BMR

The subject's height (cm), body weight (kg), age and gender were recorded. The body temperature was determined and recorded. Room temperature, percent humidity and barometric pressure were also recorded.

Measurements were done repeatedly twice early in the morning under laboratory conditions. The subject was made to lie on the bed in a post absorptive state in a supine position for ≥ 30 minutes as the measurements were taken and were instructed to lie quietly until measurements were completed. After the subject had become accustomed to breathing through the equipment, two ten minutes sample of expired air were collected in the Douglas bags, analysed and metabolic rate calculated. The coefficient of variation of the two samples was calculated to ensure it is less than 3 percent. If there were any discrepancies a third measurement was taken. The average metabolic rate calculated from the two measurements was taken to represent the BMR of the subject.

3.8 Determination of Body Composition

The body composition of each subject was determined using a Tanita body composition analyzer (Model BF 350, Tokyo Japan**)**. The analyzer uses the "foot to foot" pressure contact electrode Bioelectrical Impedance Analysis (BIA) technique (Nunez *et al.*, 1997). This measures impedance (resistance to an electrical signal). It is based on the fact that lean tissues have a high water and electrolyte content, and thus provide a good electrical pathway (Heyward, 1996). Fat mass contains a lower percentage of body water, and thus is a poor conductor of the electrical signal. The analyser operates on the principle that; when a subject is made to stand on the analyser foot mark, a low energy, high frequency, and electrical signal (50 kHz, 5 of electrical 500 micro amps) is induced. A measurement of the baseline resistance to the flow of electrical current is then made. The resistance measurement relates directly to volume of the conductor which determines total body water, lean body mass and fat mass.

Before each subject was measured, height, gender and age information were first set on the analyser. The subject was then made to stand bare foot on the analyser's foot mark. The percent body fat was then calculated and displayed by the analyser through a formula that combined the measurements set and impedance.

The following formulas where then used to calculate percent FFM and Fat mass (FM).

% Free Mass (% FFM) = 100 - % Body Fat

Fat mass (FM) = Body weight x % Body Fat

Fat Free Mass (FFM) = Body weight x % FFM

In order to obtain the most accurate results the following conditions were given to subjects and observed prior to the test (Heyward and Stolarczyk, 1996):

i. No alcohol was consumed 48 hours before the test
ii. Subjects avoided intense exercise 12 hours before the test
iii. Eating and drinking (especially caffeinated products) was avoided 4 hours before the test
iv. Subject had to empty bladder 30 minutes before the test.

3.9 Anthropometry

Anthropometric dimensions were measured using the standard protocol. Anthropometric measurements of weight and height were performed by the same investigator to avoid any observational errors.

3.9.1 Height

Height was measured to the nearest 1cm using a Leicester height measure stadiometer. The subject was made to stand straight with the head positioned such that, the Frankfurt plane was horizontal, feet together, knees straight, and heels,buttocks,and shoulder blades in contact with the vertical surface of the stadiometer. Arms were made to hang loosely at the sides with palms facing the thighs; while the head was in contact with the vertical surface (Gibson, 1990).

3.9.2 Weight

Weight was measured to the nearest 0.1kg using a portable digital Seca scale (Vogel & Haike, Hamburg, Germany). The scale was placed on a hard flat surface, and checked for zero balance before each measurement. The subject was instructed to remove excess clothes and remain with light clothes only. The subject was instructed to stand unassisted in the centre of the platform, and asked to look straight ahead while relaxed.

3.9.3 Body mass index (BMI)

Body mass index (BMI; Kg/m^2) was calculated as body weight (Kg) / height (m^2) Cut off points used to categorise BMI were as follows with less than 16 to 18.4 representing the category for chronic energy deficient adult (CED).

Table 2: Body mass index classification (BMI)

Classification	BMI Category Kg/m^2
Severe thinness	< 16
Moderate thinness	16 .0 - 16.9
Mild thinness	17.0 - 18.4
Underweight	< 18.5
Normal Range	18.6 – 24.9
Overweight	25 – 29.9
Obese (Class I)	30 - 34.9
Obese (Class II)	35 – 39.9
Obese (Class III)	> 40

Source: WHO, 2004

3.10 Measuring Energy Cost while Performing Various Activity

A Douglas bag was used and volume of oxygen utilized per minute was measured and used to determine energy cost of activity (Fig 3 to Fig 6). Two different readings were taken after every 5 minutes and an average obtained. Measurements were taken when farmers were carrying out agriculture activities which included tilling the land; weeding, also house chores. Volume of expired air was measured using a gas meter.

Figure 3: Measuring energy cost of digging

Figure 4: Measuring energy cost of weeding

Figure 5: Measuring energy cost of Pounding

Figure 6: Measuring energy cost of fetching water

3.10.1 Analysis of expired air

In the field, analysis of expired air to determine oxygen consumption was done using a portable oxygen gasman monitor (Crowcon Detection Instruments UK). This unit is electronically calibrated to read the atmospheric oxygen immediately after switching on and setting it at zero. A flow cap fitted onto the front of the unit, over the sensor was then attached to the small tube outlet of the Douglas bag. After 30 seconds the gasman displayed a stable reading of the percentage oxygen content in the bag.

Energy used in each activity was recorded (Appendix 2) and calculated using the above mentioned Weirs equation. Physical activity ratio (PAR): The energy cost of an activity per unit of time (usually a minute or an hour) was then calculated as energy spent in an activity/BMR, for every minute.

Hence:

$$\text{Energy cost of land tilling} = \frac{\text{Average Energy spent in activity}}{\text{BMR}}$$

3.11 Determining Physical Activity Level (PAL)

A 24 hour activity diary (Appendix 3) was used to record detailed information on how the 24 hours of the average day was spent by each farmer and hence used to determine Physical activity level (PAL). The recording was done for two week days and one weekend day. This method involved a combination of a timed activity record, i.e. the average total duration of each of the 'important' activities throughout the whole 24 hour of the day, and an energy value (in kcal or kJ/min) for each of these activities; 'important' was defined as either occupying a significant period of time or else involving considerable physical effort Durnin (1981), cited by FAO /WHO/UNU (2001).

The energy values for the activities were derived from both published data using a short list, largely based on earlier data given by James and Schofield (1990), and published by FAO /WHO/UNU (2001) also by actual measurement of oxygen consumption.

The diary was compiled by the farmers themselves and checked for accuracy by trained village nutrition workers who lived among the farmers and played the role of observers. To determine PAL, the time allocated to habitual activities was multiplied to the energy cost of those activities (Appendix 4). To account for the differences in body size and composition; energy cost of activities also referred to as physical activity ratio (PAR) has already been calculated as multiple of BMR per minute (WHO, 1985).

3.12 Determining Total Energy Expenditure

The 24-hour energy requirement was then expressed as a multiple of BMR per 24 hours by using the determined PAL values (James and Schofield, 1990). BMR values used were those measured under laboratory conditions. TEE which is equal to 24 hours energy requirement was then expressed as a multiple of BMR per 24 hour by using the PAL value.

Hence:

$$\text{Total Energy Expenditure (TEE)} = \text{BMR (Measured)} \times \text{PAL}$$

3.13 Determination of Work Capacity

The activity work capacity was measured by relative VO_2 max (ml/min/Kg). The subject's maximally aerobic capacity was measured under conditions that maximally stress the delivery capacity of the heart thus a Rockport fitness walking test was conducted. The subjects were timed to walk (not jog or run) for one mile (1609 metres).

The timing was in minutes and hundredths of seconds required to complete the walk. At the end of the mile the time was taken and the person's heart rate at the end of the walk was recorded. The heart beats of each subject was measured in two ways: by using a heart rate monitor and by counting the heart beats for 15 seconds. The number of beats in 15 seconds was then multiplied by 4 to give the "pulse rate". After the test the following variables were used to calculate VO_2 max.

- Weight
- Age in years
- Gender (women are given a value of 0 and men a value of 1)
- Time to complete the one mile walk (in minutes and hundreds of seconds)
- Heart rate in beats per minute (recorded immediately after stopping).

The formula for the VO_2 max calculation used was:

$$VO_2 \text{ max} = 132.853 - (0.0769 * \text{Weight}) - (0.3877 * \text{Age}) + (6.315 * \text{Gender}) - (3.2649 * \text{Time}) - (0.1565 * \text{Heart rate})$$

The VO_2 max values obtained were then assessed and compared with VO_2 max normative data table. In the assessment of VO_2 max value, the age group and gender were considered. The VO_2 max assessment is based on the Cooper VO_2 max table (Table 3) that comprises the following grades: Very Poor, Poor, Fair, Good, Excellent and Superior.

Table 3: Normative data for VO_2max

Female (oxygen values in ml/kg/min)

Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<25.0	25.0 - 30.9	31.0 - 34.9	35.0 - 38.9	39.0 - 41.9	>41.9
20-29	<23.6	23.6 - 28.9	29.0 - 32.9	33.0 - 36.9	37.0 - 41.0	>41.0
30-39	<22.8	22.8 - 26.9	27.0 - 31.4	31.5 - 35.6	35.7 - 40.0	>40.0
40-49	<21.0	21.0 - 24.4	24.5 - 28.9	29.0 - 32.8	32.9 - 36.9	>36.9
50-59	<20.2	20.2 - 22.7	22.8 - 26.9	27.0 - 31.4	31.5 - 35.7	>35.7
60+	<17.5	17.5 - 20.1	20.2 - 24.4	24.5 - 30.2	30.3 - 31.4	>31.4

Male (oxygen values in ml/kg/min)

Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<35.0	35.0 - 38.3	38.4 - 45.1	45.2 - 50.9	51.0 - 55.9	>55.9
20-29	<33.0	33.0 - 36.4	36.5 - 42.4	42.5 - 46.4	46.5 - 52.4	>52.4
30-39	<31.5	31.5 - 35.4	35.5 - 40.9	41.0 - 44.9	45.0 - 49.4	>49.4
40-49	<30.2	30.2 - 33.5	33.6 - 38.9	39.0 - 43.7	43.8 - 48.0	>48.0
50-59	<26.1	26.1 - 30.9	31.0 - 35.7	35.8 - 40.9	41.0 - 45.3	>45.3
60+	<20.5	20.5 - 26.0	26.1 - 32.2	32.3 - 36.4	36.5 - 44.2	>44.2

Source: The Cooper Institute for Aerobics Research, Dallas TX, (1997)

3.14 Haemoglobin Determination

The haemoglobin concentration was determined from a finger prick capillary blood samples. This was carried out using hemocue meter (Vanzetti, 1996). An electric/battery-operated Hemocue photometer (Hemocue AB, Angelholm, Sweden) with disposable cuvettes was used. The middle finger was used to collect blood sample. The puncture site was cleaned with spirit and allowed to dry. The site (at the side of the tip) was then pricked with a sterile disposable lancet then a drop was filled in the cuvette by capillarity in one continuous process until the centre of the cuvette was completely full. Immediately the filled cuvette was introduced into the holder of the hemocue and pushed into position for reading which took 15-30 seconds. Haemoglobin was expressed as g/dl.

Based on the results; subjects were categorized into different categories according to their haemoglobin concentration (WHO, 1997).

3.15 Pre-testing of Procedure

Prior to the actual laboratory work of collecting data on BMR or field data of energy levels required for various farm activities, 4 students from the university were used to pre-test the procedure, equipments and tools for validity and reliability.

3.16 Data Analysis

Statistical Package for Social Sciences (SPSS) version 11.5 was used to analyze the data.

Descriptive analysis: Descriptive statistics were used to obtain frequencies, mean, percentage, range and standard deviation. Cross tabulations were used to get joint frequencies and percentage distribution of various data. Student T- test was performed to test significance difference between means of males and females for the variables age, height, weight, BMI, percent FM, KgFM, percent FFM, Kg FFM, Hb concentration, BMR, VO_2 max, PAL, and TEE.

Bivariate Correlation analysis: Correlation analysis was done to determine the nature and degree of linear association between the following variables: BMI and energy expenditure; BMI and (VO_2 max) work capacity; height and energy expenditure; BMR and BMI; height and BMI; Hb and work capacity (VO_2 Max); Hb and Energy Expenditure, height and work capacity (VO_2 max).

Regression analysis: This *was* done to observe the causal - effect relationships among variables and determine the best linear model that predicts VO_2max from the variables.

The following regression model was employed:

$Y = ß0 _{+} ß1 X_1 + ß_2 X_2 + ß_3 X_3 + …….. ß_n X_n + e$

Where:

Y = A dependent variable representing Work capacity (VO_2max)

$ß_0$ = a constant

$ß_1$ to $ß_n$ = Regression coefficients of independent variable

X_1 to X_n = Independent variables

e = Random error term

CHAPTER FOUR

RESULTS

4.1 Introduction

The results of the study are presented in this chapter in two main sections. The first section is in-depth biological results of farmers in the study. It provides result measurements of BMR , PAL, TEE, BMI, Hb, body composition, energy costs of various farm activities (PAR), and work capacity (VO_2 max). It explains the inter linkage and relationship between the results measured. The second section explains the results of the cross sectional survey. It describes farmer's household agriculture production. It also examines farm activities, factors affecting productivity and their link to household food security as well as, the ultimate effect of food insecurity on household food consumption and nutritional status of farmers.

4.2 Physical Characteristics of Farmers

The physical characteristics of farmers are presented in Table 4. The study involved 64 farmers of which 33 were males (51.6 %) and 31 females (48.4 %). The mean age of male farmers was 46 ± 12 years (range 29 -71 years) and that of female farmers was 39 ± 10 years (range 25 – 62 years). There was a significant difference in height between the two genders ($p < 0.01$). The males in the study were taller than females; the former having a mean height of 162.7 ± 6.88 cm and the latter 152.71 ± 5.56cm. Likewise, the mean weight of male farmers though not significant ($p > 0.05$) was slightly higher than that of female farmers at 55.50 ± 7.16 kg and 52.25 ± 9.74 kg, respectively.

Table 4: Physical characteristics of farmers

Sex	n	Percent	Age (yrs) Mean ± SD	Height (cm) Mean ± SD	Weight(kg) Mean ± SD
Male	**33**	**51.6**	**46 ± 12**	**162.7±6.88**	**55.50 ± 7.16**
Female	**31**	**48.4**	**39 ± 10**	**152.71 ± 5.56**	**52.25 ± 9.74**
Total	**64**	**100.0**	**43 ± 11**	**157.87 ± 7.99**	**53.92 ± 8.60**

The distribution of farmers into three different age categories based on ability to participate in economic activities resulted in three group; a young adult age group of 18 -35 years, middle aged from 36-64 years and old citizen age 65 + as presented in Table 5.

Table 5: Distribution of farmers based on economic participation

Age category(yrs)	Males		Females		Total	
	n	Percent	n	Percent	n	Percent
18 -35	7	10.0	11	17.2	18	28.1
36-64	22	34.4	20	31.3	42	65.6
65 +	4	6.3	0	0.0	4	6.3
Total	33	51.6	31	48.4	64	100.0

The results showed that 94.0 % of farmers were between 18- 64 years old which consisted of economically active age grouping. About 6 % that featured only men were above 65 years; the age considered as being not economically active. There were more women (48.5%) in the economically active group than men (44.4%).

4.3 Farmers Nutritional Status

4.3.1 Body mass index

The results showed that the farmer's nutritional status as measured by their BMI was normal at 21.6 ± 3.1. Women had a higher BMI of 22.4 ± 3.7 compared to that of men (20.9 ± 2.1). However this difference between sexes was insignificant ($p > 0.05$). The BMI categories presented in Table 6 show that 78.1 % (n = 50) of farmers had normal BMI, and 10.9 % were classified as underweight. Overweight was observed in 9.4% of the farmers. A higher percent of overweight was observed in females 7.8% than in males 1.6%. Obesity was observed in one female subject.

Table 6: Classification of farmers according to BMI

BMI category Kg/m^2	Male		Female		Total	
	n	Percent	n	Percent	n	Percent
Underweight (< 18.5)	3	4.7	4	6.2	7	10.9
Normal (18.5- 24.9)	29	45.3	21	32.8	50	78.1
Overweight (25 – 29.9)	1	1.6	5	7.8	6	9.4
Obese 1 (30 -34.9)	0	0.0	1	1.6	1	1.6
Total	33	51.6	31	48.4	64	100.0

4.3.2 Body composition

In this study, body composition as a measure of nutritional status was expressed as kilograms of fat mass (FM), kilograms of fat-free mass (FFM), Fat mass as a proportion of total body weight (percent FM) and fat- free mass as a proportion of total body weight (percent FFM). Result presented in Table 7 show that body fat (FM) and percent FM were higher in females than in males. The mean fat mass and percent FM in females was 13.83 ± 6.87 kg and 25.30 ± 7.72 % respectively, compared to that of males at

8.63 ± 3.10 kg and 15.21 ± 3.90 %. The observed differences were significant ($p < 0.01$). Furthermore, there was significant differences ($p < 0.01$) in kilograms of fat- free mass (FFM) and percent FFM; however, both were observed to be higher in males than females. The fat- free mass and percent FFM in males were 46.89 ± 4.90 kg and 84.81 ± 3.91 % respectively and in females the values were 38.38 ± 3.57 kg and 74.70 ± 7.71 %.

Table 7: Body composition of the participating farmers

Sex	Fat mass (kg)	%FM	Fat-free mass(kg)	%FFM
Male (n=33)	**8.63 ± 3.10**	**15.21 ± 3.90**	**46.89 ± 4.90**	**84.81 ±3.91**
Female (n = 31)	**13.83 ± 6.87**	**25.30 ± 7.72**	**38.38 ± 3.57**	**74.70 ± 7.7**
Total (n = 64)	**11.15 ± 5.85**	**20.10 ± 7.87**	**42.77 ± 6.05**	**79.92 ± 7.88**

The results further indicated a significant association ($r = -0.811$, $p < 0.01$) between farmer's mean BMI (21.63 ± 3.08) and percent FFM value in both sexes. Increase in BMI being associated with a decrease in percent FFM. However, there was no significant association between BMI and absolute FFM ($p > 0.01$) Likewise, a significant association ($r = 0.914$, $P < 0.01$) was observed between BMI and percent FM; and BMI and FM ($r = 0.812$, $p < 0.01$); an increase in BMI being associated with an increase in percent FM and FM in both genders and vice versa. Combined age data of both sexes was insignificantly related ($p > 0.05$) to both parameters. However, when age was considered separately for each sex, there was a significant relationship between age and percent FFM ($r = - 0.357$, $p = 0.042$), and age and percent FM ($r = 0.352$, $p = 0.045$) in males. While percent fat free mass decreased with age, percent fat mass increased with age. In the case of females, the two mentioned parameters were not significantly affected ($p > 0.05$) with age.

Table 8: Comparison of BMI category and body fat category

Body Fat category		BMI category					
		Moderate underweight	Mild underweight	Normal	Overweight	Obese	Total
Under fat	n	2	4	9	0	0	15
	%	3.1	6.3	14.0	0.0	0.0	23.4
Healthy	n	0	1	41	2	0	44
	%	0.0	1.6	64.0	3.1	0.0	68.8
Over fat	n	0	0	0	4	0	4
	%	0.0	0.0	0.0	6.3	0.0	6.3
Obese	n	0	0	0	0	1	1
	%	0.0	0.0	0.0	0.0	1.6	1.6
Total	n	2	5	50	6	1	4
	%	3.1	7.8	78.1	9.4	1.6	100.0

Comparison of BMI and body fat category (Table 8) showed subjects who were underweight (9.4%), according to the BMI classification were also under fat. Most of the subjects (64%) with normal BMI classification were healthy in terms of percent body fat classification. However, 14% of those with normal BMI classification were under fat. This was more so with individuals with BMI ranging from 18.5 – 19. Generally those with overweight and obese BMI classification were likewise over fat and obese in body fat categories. Results further showed significant correlation (χ^2 = 121.9, p= 0.000) between percent body fat category and the BMI classification such that percent body fat could be predicted from BMI values.

Table 9: Comparison of sex and percent body fat categories

Sex	Body fat categories							
	Under fat		Healthy		Over fat		Obese	
	n	percent	n	Percent	n	percent	n	Percent
Male n = 33	4	6.3	28	43.8	1	1.6	0	0.0
Female n = 31	11	17.2	16	25.0	3	4.7	1	1.6
Total n = 64	15	23.4	44	68.8	4	6.3	1	1.6

Results from Table 9 show that most of the farmers were healthy (68.8 %) as indicated by their percent body fat; of this percent males were more than females. More females were observed to be under fat (17.2 %) than males (6.3%). Obese and over fat was observed in one female (6.3%) only and not in males.

4.4 Basal Metabolic Rate (BMR)

The mean BMR of farmers was 1078 ± 232 kcals/day (4.53 ± 0.97 MJ/day). The mean BMR for males was higher at 1120 ± 267 kcals/day (4.7 ± 1.12 MJ/day) than for females which was at 1034 ± 183 kcals/day (4.34 ± 0.77 MJ/day). This disparity in BMR observed between the two sexes was not significant ($p > 0.05$).

4.4.1 Factors affecting farmer's BMR

There are a number of factors that influence BMR. In the present study it was observed that weight, height, kg FFM had a significance influence on BMR. Other factors such as age, BMI and kg FM did not show significant influence.

Table 10: Factors influencing BMR in farmers

Variables	Basal Metabolic Rate (n= 64) r value	p value
Kg FFM	0.381	0.002**
Kg FM	0.061	0.061
Age	-0.244	0.052
Weight	0.311	0.012*
Height	0.273	0.029*
BMI	0.150	0.238
Temperature	- 0.034	0.788

*Significant at 0.05 ** Significant at 0.01

The results as shown in Table 10 indicated a significant association ($p < 0.01$) between kilograms fat free mass of farmers and their BMR. An increase in lean tissue mass among farmers resulted in an increase in BMR. There was also a significant relationship ($p < 0.05$) between weight, height and BMR. The greater the body size (body mass) and stature of the individuals the higher the BMR.

4.5 Work Capacity (VO_2max in ml/kg/min)

The mean work capacity of farmers was determined by their VO_2max. The VO_2max of male farmers was significantly higher ($p< 0.01$) at 45.36 ± 6.54 ml/ kg/min than that of female farmers 36.0 ± 6.49 ml/kg/min (Table 11). Using the Cooper VO_2 max assessment table (Cooper Institute, 1997) both results are categorized as above good.

Table 11: Farmers VO_2max

Gender	VO_2max (ml/kg/min)	t-test	p value
Male (n =33)	45.36 ± 6.54	5.748	0.000
Female (n = 31)	36.0 ± 6.49		

4.5.1 Farmers work capacity (VO_2max assessment categories)

Assessment of VO_2max based on the Cooper VO_2max normative data graded 70.3% of farmers as having excellent to superior VO_2max (Table12). Out of this percentage, 42.2% were males and 28.1% females. Most females (15.6%) were either graded as having superior or good VO_2max. Poor VO_2max was only observed among few female farmers and at a very low percent (1.6%).

Table 12:VO_2max assessment on the Cooper VO_2max normative table

Sex			VO_2 max categories					
			Superior	Excellent	Good	Fair	Poor	Total
Male	n = 33	n	9	18	5	1	0	33
		%	14.1	28.1	7.8	1.6	0.0	51.6
Female	n = 31	n	10	8	10	2	1	31
		%	15.6	12.5	15.6	3.1	1.6	48.4
Total	n = 64	n	19	26	15	3	1	64
		%	29.7	40.6	23.4	4.7	1.6	100.0

4.5.2 Factors affecting farmers work capacity (VO_2 max)

The results in Table 13 show factors observed in the present study to have effect on the work capacity of farmers. The study results showed six factors to have significant ($p < 0.01$) relationship with the observed VO_2max in farmers. Farmer's nutritional status (BMI), age and body fat had negative relationships with VO_2max. Their increase resulted in the decrease of VO_2max and vice versa. In contrast Hb, height and fat free mass (kg FFM) had a positive relationship with VO_2max. Their increase caused an increase in VO_2max and their decrease, a reduction in VO_2 max.

Table 13: Factors affecting VO_2max

VO_2max (ml/kg/min)	
Variable	**r – value**
BMI	**- 0.447****
Hb	**0.625****
Age	**- 0.437****
Height	**0.544****
Fat free mass(FFM)	**0.465****
Body Fat (FM)	**- 0.556****
Weight (Kg)	**-0.050**

** Correlation is significant at 0.01 levels

4.5.2.1 Relating work capacity with age

Results of farmer's work capacity assessed against age are presented in Table 14. The age classification of farmers placed most farmers (65.6%) in middle age range of 36-64years. The results that revealed that about 60% of farmers in this age class had VO_2max assessment ranging from good to superior with the excellent grade accounting for 28.1%. Farmers within the economically productive age that ranged from 18 -35 years old were 28.1% and of this percentage, 26.6% had VO_2max graded between excellent and superior; the superior grade accounting for 17.2%. Even among the elderly age (65+), VO_2max ranged between good and excellent.

Table 14: VO_2max classified according to age category

Age category (years)		VO_2 max categories					Total
		Superior	Excellent	Good	Fair	Poor	
18-35	n	11	6	1	0	0	18
	%	17.2	9.4	1.6	0.0	0.0	28.1
36-74	n	8	18	12	3	1	42
	%	12.5	28.1	18.8	4.7	1.6	65.6
65+	n	0	2	2	0	0	4
	%	0.0	3.1	3.1	0.0	0.0	6.3
Total	n	19	26	15	3	1	64
	%	29.7	40.6	23.4	4.7	1.6	100.0

4.5.2.2 Relating nutritional status and individual work capacity

Table 15: BMI and VO_2max category

VO_2 max		BMI					Total
		Moderate underweight	Mild underweight	Normal	Overweigh t	Obese 1	
Superior	n	1	3	15	0	0	19
	%	1.6	4.7	23.4	0.0	0.0	29.7
Excellent	n	1	2	22	1	0	26
	%	1.6	3.1	34.4	1.6	0.0	40.6
Good	n	0	0	12	3	0	15
	%	0.0	0.0	18.8	4.7	0.0	23.4
Fair	n	0	0	1	2	0	3
	%	0.0	0.0	1.6	3.1	0.0	4.7
Poor	n	0	0	0	0	1	1
	%	0.0	0.0	0.0	0.0	1.6	1.6
Total	n	2	5	50	6	1	64
	%	3.1	7.8	78.1	9.4	1.6	100.0

Comparison between BMI classification and VO_2max categories (Table 15) showed that farmers with superior (29.7%), excellent (40.6%) and good (23.4%) VO_2max were mostly those with normal BMI at 78.1%. On the other hand, individuals with increased BMI; that is overweight or obese had fair or poor VO_2max assessment; and underweight was associated with excellent or superior VO_2max assessment.

4.5.2.3 Work capacity (VO_2max) and anaemia (Hb)

The results indicated the mean Hb concentration of farmers to be 13.31 ± 1.82. This measurement was higher in males than females at 14.3 ±1.70 and 12.25 ± 1.28 respectively. The observed variation was highly significant ($t = 5.04$, $p = 0.000$).

However, there was almost no prevalence of anaemia (Table 16) among the farmers in the study. Results indicated 95.3% of farmers had normal Hb concentration and only 4.7% were moderate anaemic. This could possibly explain the significant ($p < 0.01$) and positive relationship observed between VO_2max and farmers Hb (Table 16). Furthermore, the results (Table 15) showed that 90.6% of farmers with normal Hb had VO_2max ranging from good to superior, majority (40.6%) having excellent VO_2max. Farmers who were moderately anaemic had good and poor VO_2 max.

Table 16: Hb classification and VO_2max categories

Hb		VO_2 max categories					
		Superior	Excellent	Good	Fair	Poor	Total
Moderate	n	0	0	2	0	1	3
Anaemic	%	0.0	0.0	3.1	0.0	1.6	4.7
Normal	n	19	26	13	3	0	61
	%	29.7	40.6	20.3	4.7	0.0	95.3
Total	n	19	26	15	3	1	64
	%	29.7	40.6	23.4	4.7	1.6	100.0

4.5.3 Analysis of the relationship between work capacity and correlating factors

In Table 17 the regression coefficients for the relationship between VO_2max and BMI, age and hemoglobin are presented. The results of a stepwise multiple regression analysis showed that haemoglobin concentration best explained the variation in work capacity by 39%. The inclusion of age and BMI increased the value of R^2 and haemoglobin concentration, age and BMI significantly explained the variation in work capacity among farmers by 60%.

Table 17: Regression coefficients for the relationship between VO_2max and BMI, age and haemoglobin.

Independent variables	R^2	Beta value	t value	Significance	Collinearity Statistics Tolerance	VIF
Haemoglobin	**0.390**	**0.47**	**5.22**	**0.000**	**0.812**	**1.232**
Age	**0.539**	**-0.42**	**- 5.10**	**0.000**	**0.978**	**1.023**
BMI	**0.604**	**-0.28**	**- 3.14**	**0.003**	**0.813**	**1.231**

B = $ß_0$ = 41.95 Adjusted R = 0.584
Std Errors = 9.46b

Assumption of no multicollinearity:

$$VIF = \frac{\sum VIF}{k} = \frac{1.232 + 1.023 + 1.231}{3} = 1.162$$

Where:

VIF = Variance of Inflation Factor
k = (number of predictors)

From the results the following regression model was obtained;

Work capacity = $ß_0$ + $ß_1$Haemoglobin – $ß_2$Age – $ß_3$BMI

Work capacity = 41.95 + (0.47 Haemoglobin concentration) – (0.42 Age) – (0.28BMI) + 9.46

The model showed a unit increase in haemoglobin concentration causes 0.47 increase work capacity; while a unit increase in age and BMI caused a decrease in work capacity by 0.42 and 0.28 respectively. Based on t-values haemoglobin concentration had the highest contribution as a predictor of work capacity, followed by age, then BMI. Furthermore, there was no collinearity within the data.

4.6 Physical Activity Level (PAL) and Total Energy Expenditure (TEE) of Farmers

Farmer's physical activity level was determined using a 24hour activity diary. The results (Table 18) show that the mean PAL of farmers was 2.13 ± 0.26. Male farmers had higher PAL compared to female farmers. The mean PAL for male farmers was 2.20 ± 0.25 and that of female farmers was 2.05 ± 0.23. The variations in PAL between the two sexes were significant at (t = 2.43, p = 0 .018).

Farmer's TEE was determined by multiplying their measured BMR * PAL. The results (Table 18) indicated the mean TEE to be 2246 ± 731 kcal (9.43 ± 3.1 MJ). The TEE of males was higher than that of females at 2438 ± 731 kcal (10.24 ± 3.1 MJ) and 2041 ± 490 kcal (8.57 ± 2.1MJ) respectively. The difference in TEE between sexes was significant (t = 2.54, p = 0.014).

Table 18: Farmer's total energy expenditure and physical activity level values

Sex	PAL	t- value	p-value	TEE (kcals)	t-value	p- value
Males	**2.20 ± 0.25**	**2.432**	**0.018**	**2438 ± 731**	**2.54**	**0.014**
Females	**2.05 ± 0.23.**			**2041 ± 490**		
Total	**2.13 ± 0.26**			**2246 ± 731**		

The study results further indicated a significant association (p < 0.0 1) between variables of height, fat free mass (Kg FFM) and TEE. However, Weight, BMI, fat mass (Kg FM), and age showed no significant (p > 0.05) correlation with TEE.

4.6.1 Factors relating to PAL

Physical Activity Level (PAL) is dependent on weight, type of activity, duration and intensity of the activity. In this study the results showed the mean PAL of farmers to be 2.13 ± 0.26. It was observed that common activities among farmers that took long time had high energy cost and could have possibly contributed to the observed PAL. These are presented in Table 19. Labour intense farming activities such as digging, weeding, and some house chores were observed to have high time duration. Apart from farming activities, females also performed house chores e.g. fetching water, firewood, washing, which had long durations. Also, walking was observed to be a common way of life in the community and took a substantial part of the farmer's time.

Table 19: Common activities among farmers and their average duration

Activity	Average duration (hours) in a day
Digging (hand –hoe)	5.5
Weeding (hand – hoe)	4.5
Fetching fire wood	1.5
Fetching water	1.0
Cooking	1.6
Washing Clothes	1.0
Child care (bathing, dressing)	1.0
Walking	3.7

Table 20: Energy expenditure in farm activities

Sex	PAR (digging) (kcal/min)	PAR (weeding)	Time digging (hrs)	Time weeding (hrs)	TEE In digging (kcals)	TEE in weeding (kcals)
Male	6.56	5.67	5.5	4.5	1045	411
Female	6.60	6.21	5.5	4.5	1144	643

Energy expenditure in farm activities that is digging and weeding was generally higher in females than males (Table 20). This is explained by the high energy costs in both activities in females.

4.6.2 Factors relating to TEE

Total energy expenditure in farmers was a product of their BMR and PAL. Analysis of factors relating to TEE presented in Table 21 showed a significant association ($p< 0.01$) between TEE and farmers fat free mass (Kg FFM) and height. However, fat mass (Kg FM), weight and age were not significantly related to TEE ($p > 0.05$).

Table 21: Factors relating to TEE

Total Energy Expenditure (TEE) in Kcals	
Variables	**r value**
Fat free mass (FFM)	**0.380****
Fat mass (FM)	**- 0.088**
Height	**0.323****
Weight	**0.209**
Age	**- 0.137**
BMI	**0.004**

4.7 Energy cost of farm activities

Energy cost of farm activities; digging, weeding and of pounding and fetching water were measured in eighteen farmers and compared to the established WHO data as shown in Table 22.

The measured energy costs of digging, weeding and fetching water were higher in the present study than the established WHO data. In the present study, the energy cost of digging was higher in females than males similar to WHO results. However, the energy cost of weeding was higher in females than males contrary to the WHO data, where females had lower energy cost of weeding than males.

Table 22: Measured energy cost of activities

Activities	Males (n = 9)		Females (n = 9)	
	Present study (kcal/min)	WHO Kcal/min	Present study (kcal/min)	WHO (kcal/min)
Digging	6.56 ± 1.25	5.6	6.60 ± 1.49	5.7
Weeding	5.67 ± 128	4.0	6.21 ± 1.38	3.7
Pounding grain			5.41 ± 2.54	5.6
Fetching water			5.38 ± 1.57	4.5

4.8 Farming and Agriculture Production

4.8.1 Farm size and production

The cross sectional survey results showed that farm sizes in the village ranged from 1 acre to 4 acres. The mean farm size was 0.9 ± 0.9 ha. Maize was the main staple grown in the area, both as food and cash crop. Crop yields per season were highly dependent on the amount of rainfall. Hence, any presence of drought led to poor production and insufficient food stock. Results showed that for the year 2005/2006 maize yield was low at 2.8 ± 4.8 bags per ha.

4.8.2 Productivity in the area

Agriculture production in the village was through the use of the hand hoes and it was labour intensive. Farming implements used were mainly hand hoes and machetes. The average number of hand hoes and machetes per household was 3 and 1, respectively. Furthermore, majority of farmers (94.7%) did not use any organic or inorganic fertilizers in their farms and this possibly contributed to the low production (Table 23).

Table 23: Fertilizer usage among farmers

Use of fertilizer (n = 38 hh)	Number	Percent
Yes	2	5.3
No	36	94.7
Total	38	100.0

hh = households

4.8.3 Time allocation in farm activities and division of labour

The results showed that both genders were involved in all farm activities from digging to harvesting. Early land preparations such as bush clearance, were mostly done by male farmers. Results of time allocation in pre and post harvest activities are shown in Table 24. Land preparation (11.6 ± 7.2 days) and weeding (11.9 ± 6.1 days) were pre harvest activities observed to take more days; weeding being more dominant. Post harvest activities that include shelling, winnowing, grinding and pounding were mainly done by female farmers. In this study, shelling was the post harvest activity that occupied more time taking 6.7 ± 3.1 hours per day.

Table 24: Mean time allocation in farm activities

Farm activities	Mean hours per day used	Mean days used
Land Preparation	6.9 ± 2.0	11.6 ± 7.2
Planting	7.1 ± 2.5	3.1 ± 2.8
Weeding	7.3 ±2.0	11.9 ± 6.1
Transplanting	4.5 ± 2.3	2.3 ± 4.8
Harvesting	8.6 ± 1.9	5.8 ± 4.7
Transportation of harvests	8.1 ± 2.8	2.4 ± 1.6
Shelling	6.7 ± 3.1	3.8 ± 2.6
Winnowing	4.4 ± 3.1	2.5 ± 1.5
Grinding	2.8 ± 2.5	2.1 ± 1.8
Pounding	1.6 ± 0.5	

4.8.4 Food storage and food availability

The study observed that food storage is a common practice in the community. Sacks were most commonly used by most households (94.7%) and the remaining 5.3 % used kitchen and house roofs or ceiling. However, the study observed that between January and March most households (94.6 %) experienced food shortage, only 5.4 % did not. It was further observed that 65% of the stored food was used for consumption, 10% for brewing, 15% for selling and 10% for seeds. Due to the absence of alternative cash crops stored food was often sold to solve household cash needs. Sickness and diseases at 88.2% were the most common problem that initiated sale of stored food, the remaining 11.8% sale of food was due to small household needs such as buying cooking oil, soap, sugar, and salt.

Farmers used different coping methods to manage food shortage (Table 25) the most dominant method at 55.6% was the selling of human labour in exchange for cash. Selling of household items (16.7%) and reduction of numbers of meals per day (11.1%) were among the methods practiced.

Table 25: Coping methods during food shortage

Coping Methods	Number	Percent
Sell household items	6	16.7
Ask relative and friends	2	5.6
Reduce number of meals	4	11.1
Sell animals to buy food	3	8.3
Sell of human labour	20	55.6
Migrate	1	2.8
Total	36	100.0

CHAPTER FIVE

DISCUSSION

5.1 Physical Characteristics of Farmers

The study has shown that there is a great variation in the ages of farmers involved in agriculture production. In the villages agriculture serve as the main source of livelihood and thus involvement in agriculture productivity started early and till late in life. However, the study observed less involvement of youth age 35 year old or less in agriculture; the most dominant economically productive age group was from 36 -64 years, majority of them being females. Also, females in the late age of 62 years and men beyond the age of 64 years were still involved in farm activity. According to URT (2002 b), the economically productive age in Tanzania is between 15- 64 years old. It is possible that the quantitative decline of working-age population could be linked to the observed reduction in the growth of output and income, and possibly to the overall economic performance, while the continual involvement of the elderly in agriculture suggests a decrease in the age related dependency. UNICEF and URT (1990) pointed out that in Tanzania like many other developing countries, women play a key role in agriculture and development. Thus, the high involvement of women in agriculture activity in the study area points out their importance, role, and contribution in economic development which start at household to the national level.

Anthropometric measurements showed that males were taller and heavier than their female counterparts. Both sexes in this study were somewhat shorter when compared to the results by Ferro Luzi *et al*. (1997) which rated males of height 164 - 165 cm and females of height 155-159cm as short. The short stature observed could be a result of a process of adaptation to repeated energy stress during childhood to the end of growth spurt. Furthermore, comparison of the two sexes indicated that males had higher work capacity and energy expenditure than women thus suggesting that, stature which has a bearing on body size influences energy expenditure, BMR and work capacity. Different studies (Kennedy and Garcia, 1994; Ferro- Luzzi, 2001) have reported that short stature is associated with reduced work output and with significantly lower energy requirement. Nevertheless, the height and weight of females were higher than the established cut-offs indicators for women's nutritional status of 145cm and 45kg which indicates stunting and underweight (ACC/SCN, 1993).

5.2 Farmers Nutritional Status (BMI and body composition)

Farmer's nutritional status as measured by their BMI (21.6 ±3.1) was within the generally accepted standard of healthy normal nutritional status (WHO, 2000). The higher BMI in females than males could be explained by the body composition analysis results (Table 7) which showed high fat mass (kg FM) and percent fat mass (%FM) in women than men and, high fat free mass (kg FFM) and percent fat free mass in males than females. This suggests females had more fat deposit while the males were leaner. These results are similar to the findings of Norgan and Ferro-Luzzi, (1982) and Valencia *et al.* (1992) that have shown that at any BMI, females have a higher percent fat than males.

Science explains that fat deposition is gender and age specific. Although males and females all do tend to fatten up with age, throughout most of their lives females have a higher percentage of body fat than males. This gender difference begins early in life and the increase in fat appears to result from a lower female basal fat oxidation rate and it is accomplished by expanding fat cell size, not number. The general acceleration in body fat accumulation, particularly sex-specific fat, is attributed mostly to changes in female hormone levels. Hormones drive the deposition of fat around the pelvis, buttocks, and thighs of females and the bellies of males. Fat deposition is known to be physiologically advantageous in females during pregnancies and acts as reserve storage for the energy demands of lactation.

Additionally, increase in BMI was associated with both increase in percent fat mass (r = 0.914) an indicator of the proportion of the total body weight covered with fat, and fat mass (r = 0.812) an indicator of body weight as kilogram fat, but a decrease in percent fat free mass (r = -0.811) an indicator of lean tissue mass and insignificant association with fat free mass (kg FFM). Literature by Grande (1964) has shown that energy restriction always involves the loss of variable proportions of fat, tissue protein, and minerals. The observed high association between BMI and body fat mass both as weight and body proportion suggests that the subject's BMI was also a good indicator of their body composition; high BMI indicating high fat mass and low BMI indicating low fat mass and fat free mass in both sexes. Findings by Norgan & Ferro-Luzi (1982) explained that when BMI was more highly correlated with FM than with percent fat and highly correlated with FFM then BMI was a measure of size (kg) and lean mass than of body composition.

A study by Ferro-Luzzi (2001) observed similar results that linked BMI and fat mass. High fat mass was observed in Ethiopian farmers with adequate BMI. However, low BMI with low fat mass and fat free mass was observed in undernourished men and women, with a more marked decrease in fat mass in women.

Results further showed that 68.8% of farmers (Table 9) were healthy as indicated by their percent body fat. This could also be linked to the high percentage of farmers (Table 6) in the normal BMI category. These observations could be associated with the season change at the time the study was conducted. The study was done half way through the rainy season, which although there was a rise in energy expenditure there was also a gradual rise in household food stock and energy intake. Farmers were harvesting maize, sweet potatoes, vegetable and greens planted during the short rains. An earlier baseline study by Kinabo *et al.* (2006) at the beginning of the farming season after an episode of drought which often occurred in the area, had shown low BMI among the farmers with total underweight (severe, moderate, mild) to be 33% in males and 24% in females.

Different studies (Ferro –Luzzi, 1988; Gibson, 1990; Latham, 1993 and Ferro- Luzzi, 2001) have explained that energy stress, which often leads to energy imbalance, occurs when energy intake is low compared to energy expenditure. Also, when adults are faced with persistent low energy intake, they mobilize the energy stored in the body as adipose tissue, thus resulting in low BMI, low physical activity and productivity.

Energy stress and imbalance seemed to be more common in females than in males. Results (Table 8) indicated under fat (17.2%) to be more in females than males (6.3%). The observed high work burden in females gives explanation to these findings. Apart from an input in farm activities, women were involved in all household chores and child care responsibilities which created a continuous high demand on their energy expenditure. The low obesity observed among studied subjects likewise explains the relatively non existence of non communicable diseases such as cardiovascular disease and heart diseases.

5.3 Basal Metabolic Rate

This study has shown that BMR was higher in males (1120 ± 267 kcals/day or 4.53 MJ/day) than in females (1034 ± 183 kcals /day or 4.34 MJ/day). Different studies (Mitchell, 1962; Durnin, 1981; James and Schofield, 1990) have explained similar findings equating these differences to various factors. In this study, factors affecting BMR are shown in Table 14. There was a great association ($P < 0.01$) between fat free mass (FFM) and BMR with an increase in lean tissue mass being associated with increase in BMR. This is further explained by the fact that fat is inert, and metabolic activities occur mainly in the lean tissue. Body composition results (Table 7) also showed a higher FFM in men than women which explains the findings; high BMR being a result of oxygen consumption and metabolism in muscles and visceral tissues within the FFM. These observations are similar to the observations made by Durnin, (1981); Ferro –Luzzi *et al.* (1994); Latham, (1997) and Robert and Dallal, (2005).

Weight and height (Table 10) also had a significant association ($p < 0.005$) with BMR. This is in line with the results by Schofield and James (1985), Soares and Shetty (1988) which showed a high correlation coefficient between weight ($r = 0.875$), height ($r = 0.87$) and BMR. The study inferred that weight had a stronger correlation than any other nutritional anthropometric index. Likewise, in this study the correlation coefficients of weight ($r = 0.31$) was higher than height ($r = 0.27$) but lower than those reported in other studies. Study results by Durnin (1981) have shown that BMR is a function of all the separate active tissues of the body and is dependent on the relative mass of these tissues hence the individual's weight and height.

These present study findings imply that with any given BMR there is a direct link to the weight of that individual and since BMR contributes 60 -70% of ones energy expenditure, there is a link to energy output. When an adult has adequate amount of food, body weight and body energy stores that are within the acceptable range of normality, their health will not be impaired and physiological function will not be compromised. Thus, they will have sufficient energy for economically necessary productive work and domestic chores as well as social and leisure activities. For farmers involved in agriculture productivity in rural Tanzania, matching energy output to energy intake is necessary if they are to sustain productive and economically vital activities many of which occur at the peak energy output periods such as planting, weeding and harvesting seasons. Lack of sufficient energy stores during this period results in energy deficiency phase taking place, body weight falls and BMR is lowered. In her study Ferro –Luzzi (1990) explained that energy imbalance leads to marked changes in body weight as well as quantity and quality of energy output. Therefore, long standing energy deficiency is reflected by both changes in body weight and activity pattern. If a person continues to work during a phase of seasonal food shortage, their weight drops with little or no evidence in decrease in physical activity. However, a steady state of low energy deficiency is reached because their lower body weight lowers their BMR.

Temperature and age (Table 10) did not have any influence on BMR. The effect of temperature among subjects could probably not be seen because their average body temperature was 36ºC. There was no noticeable temperature difference among the farmers.

Although the age range of farmers was 29 – 71 years in males and 25 – 62 years in females, the effect of increased aging causing a BMR decline due to reduced FFM as reported by Durnin (1981); Keys *et al*. (1973) ; Tzankoff and Norris (1978,) was not observed. However, the study results can be compared to the findings of Van Pelt *et al.* (2001), whose work on resting metabolic rate (RMR) showed that RMR per unit FFM declined with age in highly active men when there is reduction in exercise volume and energy intake. This decline does not occur in men who maintain exercise volume and /or energy intake at a level similar to that of young physically active men. Since the older farmers in the present study were still involved in farming activities it is plausible that their level of physical fitness delayed the decline of FFM and BMR.

5.4 Work Capacity

Generally a high work capacity was observed in farmers (Table 11) with male farmers having a higher capacity than their female counterparts. The cooper VO_2max assessment data (Table 12) graded 70.3% of farmers as having excellent to superior VO_2max; the majority in this percentage being males. Poor work capacity was very low (1.6%) and only observed among female farmers. This shows that farmers were physically fit and with a high work performance. However, this work capacity was not easily seen in their general work. This could possibly be because rural farming is subsistence and work performance is easily observed when heavy work is habitually sustained. Thus, to maintain agriculture activities which is heavy work that involve the use of hand hoes and intensive cultivation, farmers have to use strategies that maximize long term endurance over time rather than intensive effort per unit time to try and achieve high productivity. Such technique involve the use of work pace management which regulates their work intensity by regulating the rate of work and time of rest during physical activity. Panter- Brick (2003) has argued that in many arduous activities such as carrying loads, subsistence and wage- labour economy, work capacity has to be observed as endurance overtime rather than intensive effort per unit time. He further explained that work intensity, often evaluated in absolute or relative term as indexed by oxygen consumption and maximum work capacity is observed in relation to work context and considers human adaptability in terms of physical and behaviour management of heavy work.

The observed gender difference in work capacity is attributed to the fact that men tend to have bigger body sizes and high FFM than women do. High body fat and less fat free mass in women was also reported in this study (Table 7). Since oxygen consumption is directly influenced by FFM - the active tissue mass of the body, men tend to have higher work capacity than women. This is also because work capacity was determined by measuring oxygen consumption. A study by Seiler (1996) also reported that, apart from women having a higher body fat and less fat free mass (FFM) compared to men , normally the heart size scales in proportion to the lean body size. Due to this, the female heart is slightly smaller relative to body size than that of male; hence it is suspected to be a less effective pump.

The present study observed high haemoglobin concentration in the farmers. This was especially high in men than in women. High haemoglobin concentration could be associated with the rainy seasons that made a lot of green leafy vegetables and fruits easily available, thus providing good sources of iron and vitamins that could boost haemoglobin concentration levels. The observed lower haemoglobin concentration in women compared to men could be explained by their differences in hormonal status and monthly menstruation in women. Seiler (1996) has reported that on the average, females have up to 10% blood low haemoglobin concentration than males. Thus, the slightly lower haemoglobin concentrations, plus the smaller adaptive heart are sufficient to account for gender differences in VO_2max.

Studies such as those done by Basta *et al*. (1979); Beutler, (1980); Spurr (1984); Latham, (1993) and Fero –Luzzi (2001) have explained factors that include Hb concentration, BMI, age, height, fat free mass and fat mass as determinants of work capacity. Similar factors (Table 12) were observed to be significant ($P< 0.01$) in this present study. These could explain the generally high working capacity observed among the rural farmers.

5.5 Factors Influencing Work Capacity

5.5.1 Age

The reduction of work capacity with age has been associated with a progressive decline of cardiac pump function, a decrease of muscle strength, and a progressive impairment of heat tolerance (Shephard, 1999). However, part of the functional loss can be countered by regular physical activity, control of body mass, and avoidance of lifestyle habits such as cigarette smoking and alcohol consumption. In the present study work capacity was high across all age ranges from 18 to over 65 years. This could be attributed to the observed normal BMI classification among subjects which indicated good body mass and the general physical fitness that resulted from labour intensive farming. Furthermore, a continual progression of farming to late age was common in the village. This could have contributed to the high activity level of the older generation thus slowing down the rate of VO_2max reduction. These results are similar to those reported by Seiler (1996) who observed that a progressive decline in cardiovascular performance with age is observed in sedentary population due to physical inactivity and increased body weight (fat).

However, if body composition and physical activity levels are kept constant, the rate of declining is lowered by a half.

5.5.2 Nutritional Status

Evaluation of the different BMI categories (Table 15) showed that farmers with superior, excellent and good VO_2max were mostly those with normal BMI (78.1%). This showed that there was a link between nutritional status and work capacity. Good nutrition provides the body with energy to work, protection against diseases, builds up muscle strength and as a consequence provides an ability to perform more physical activities. A study done by Ferro Luzzi (2001) in Ethiopia indicated that maximal oxygen consumption (VO_2max) increased markedly with BMI. Other studies (Deolalikar, 1988; Ferro-Luzzi, 1988; Pryer, 1993; Shetty and James, 1994) have also linked BMI with work capacity. These studies have reported that low BMI results in low work capacity and this has been observed among farmers during the period of persistent energy stress where low energy intake results in the use of stored energy such as fat mass and or fat free mass. However, this is contrary to observations made in the present study, that showed overweight or obese individual to have fair or poor VO_2max assessment; while underweight was associated with excellent or superior VO_2max assessment. The high BMI of overweight or obese individuals can be linked to increased fat mass which reduces VO_2max (Seiler, 1996). On the other hand low BMI in this case could be due to low fat mass but high levels of fat free mass, which provided the observed excellent or superior VO_2 max assessment.

5.5.3 Haemoglobin concentration

In this study, increase in work capacity was significantly ($p < 0.01$) related to VO_2max and Hb concentration (Table 16). The mean Hb concentration of farmers was good; but a significant variation ($p < 0.01$) was observed between males and females, with males having a higher value compared to females. The lower work capacity in females in comparison to males could be related to their relative lower Hb concentration.

Oxygen in the body which is needed for aerobic metabolism in cells is transported bound to a protein molecule called haemoglobin. The proportion of oxygen transported in the blood depends on the oxygen carrying capacity of the blood, which is determined by the concentration of haemoglobin in the blood. High haemoglobin concentration increases the availability of oxygen to the tissues and the efficiency of oxygen exchange to the muscles and the myoglobin. Consequently the muscles can function more efficiently. Since in the present study it was observed that VO_2 max was proportional to haemoglobin concentration, males who had higher Hb concentration tended to have higher VO_2 max compared to females. This explains the differences observed between males and females in work capacity.

Furthermore, high VO_2max assessment grade from good to superior could be seen in 90.6% (Table 15) of farmers. Comparison of the study Hb concentration in males (14.3 g/dL) and females (12.25g/) to values established in a baseline study on the same population earlier of 12.5g/dl (males) and 11.6g/dl (females) by Kinabo *et al.*(2006) showed seasonal variation in haemoglobin concentrations. The baseline study was done at the beginning of the farming season at a period when farmers had experienced about three months of drought and food shortage. This suggested that Hb concentration during the study were elevated as the result of increased availability of green vegetable and fruits brought about by the rainy season. Furthermore, the results indicated that when farmers experience drought, food shortage and energy stress at the beginning of the farming season their work capacity is adversely affected and this in turn affects food production. Findings relating Hb concentration and work capacity have been reported in different studies (Basta *et al.,* 1979; Beutler, 1980; Latham, 1993). Their findings likewise indicated that work capacity and productivity was reduced in workers with low levels of haemoglobin concentration and increased with increased haemoglobin levels.

5.6 Level of Contribution of Different factors to Work capacity

The stepwise multiple regression analysis between VO_2max and BMI, age and haemoglobin concentration (Table 17) showed that the variables predicted work capacity by 60%. Among the variable haemoglobin concentration was the best predictor (39%) of work capacity variation in farmers. This showed that a person's age and nutritional status which indicated the available lean muscle mass and extent of muscle wasting together with haemoglobin concentration which, determines the amount of oxygen transported to the functioning muscles are important factors that influence an individuals work intensity. However, oxygen availability to functioning muscle seems to be prominent taking the highest priority.

Other human studies that have investigated the relationship between severe iron deficiency anaemia (SIDA) or moderate iron deficiency anaemia (MIDA) and aerobic capacity have also reported strong evidence of a causal relationship. All of the studies demonstrated that changes in Hb concentration resulted in significant changes in VO_2max, which ranged from a 30% decline after experimentally induced anaemia to a 24% improvement after 12 wk of iron supplementation (Woodson *et al.,* 1978 ; Li *et al.,* 1994;). The studies suggested that both SIDA and MIDA impair aerobic capacity, which can be corrected by increasing Hb concentration. Impairments were proportional to the severity of deficiency and range from roughly 10 to 50% reductions in VO_2max.

5.7 Physical Activity Level (PAL) of Farmers

PAL is energy expended when performing physical activities. It is the most variable and second largest component of TEE, affected by the nature and type of activity, sex, body size and duration of performing a task. PAL (Table 18) was high at 2.13 ± 0.26. The normal range of PAL for active to moderate lifestyle is between 1.70- 1.99 (FAO, 2001). The variation in PAL between sexes was significant ($p < 0.05$) with the value for men being higher than that in women. General evaluation of factors relating to PAL (Table 19) showed farming activities that included digging, weeding and house chores such as fetching water, fetching firewood and washing to have contributed to the high PAL in the study. Though females had a high activity burden than males the observed high PAL in males can be explained by the intensity with which they performed their designated activities. Comparison of the study PAL with the WHO (1985) classification rated farmers under the vigorous or vigorously active lifestyle category that has PAL values ranging between 2.00 – 2.40. This means that it is important for farmers to have adequate energy stores that will allow maintenance of energy balance and healthy state as well as meet energy demands that arise from agriculture activities.

5.8 Total Energy Expenditure (TEE)

The understanding of total energy expenditure (TEE) and caloric requirement for different kinds of manual work is essential (WHO, 1985). The report from the joint FAO/WHO/UNU (2001) meeting recognized that energy expenditure is key in the assessment of energy requirements. However, if food intake alone is measured, true energy requirements may not be obtained. When energy expenditure is measured, better information is gathered; this is particularly important in providing essential "base-line" data that will later allow an evaluation to be made of the effect of food supplementation programmes (Durnin, 1990). In the present study it was observed that males had higher TEE than females (Table 18). This was explained by the high BMR, FFM, height and VO_2 max in men, factors that showed a significant association ($P < 0.01$) with TEE. The TEE for men was 2438 ± 731 kcal/day (10.24 MJ/day) and for women the TEE was 2041 ± 490 kcal/day (8.57 MJ/day) both were above the mean daily calorie per capita of Tanzania which is 8.15 MJ/day or 1940 kcal/day (FAO, 1999), but below 11.26 MJ/day or 2681 kcal/day which is energy intake levels for developing countries FAOSTAT (2003), cited by WHO/FAO (2003). The observed TEE suggested that farmers have high energy expenditure due to labour demanding activities that dominate their way of life. Thus there is a need for their energy intake to reflect this energy demand. Further evaluation of the amount of energy spent in farm activities (Table 20) mainly digging and weeding showed higher values in females than males. This high energy expenditure in farm activities in females was due to division of labour in agriculture activities and long time allocated to these activities (Table 24) which seems to suggest that, in the farming seasons total energy expenditure in females is still very high. Therefore, to maintain energy balance high energy intake and good nutritional status is essential.

According to studies by Strauss (1986); Latham (1993); Dasgupta (1997) and Ferro Luzzi (2001), high levels of productivity demand adequate energy intake and reasonable health for those who labour to produce and harvest crops and are also involved in many other labour-intensive, work-related activities. Hence, in order to meet productivity demands improvement of energy intake of rural farmers is required especially during the labour intensive season.

5.9 Energy Cost of Farm Activities

Results of energy cost of activities; digging, weeding, pounding and fetching water were measured in eighteen farmers and the results were compared to the established WHO data as shown in Table 22. In this study, the energy costs of farm activities (digging and weeding) were higher in females than in males. Since energy cost of activity is calculated as energy spent in an activity/ BMR for selected time unit; the general high BMR in men due to high lean body mass and muscles could explain the above observed differences. The high lean body mass favours higher work intensity while providing less weight that is moved from one point to another. The energy costs of digging, weeding and fetching water were also higher in the present study than the established WHO values. It is plausible that the difference in the nutritional status and body composition of subjects in the study attributed to this variation.

5.10 Farming and Agriculture Production

5.10.1 Farming and agriculture production

Different studies (Ringia, 1990; Malima, 1993; Ishengoma, 1998) on farming and agriculture production in rural Tanzania argue that agricultural production is still low. Exogenous factors associated with low productivity mentioned in these studies include poor farming implements, non mechanization of agriculture, use of hand held hoes, poor rainfall, and lack of use of fertilizer. These results are similar to the present cross sectional survey findings of this study. Additionally, Ishengoma (1998) reported that most rural farmers have small plots which are poorly managed, resulting in small yields and ultimately food insecurity, hunger and poverty. Yet, for adequate household food production 2.1 to 5.0 hectares should be cultivated. In the present study, the mean farm size was 2.1 ± 0.96 hectares. This small size of land holdings can be related to farmer’s inability to cultivate large lands due to lack of improved farming implements, and poor nutritional status observed at the beginning of the farming season that results in low work capacity. Therefore in addition to providing farm inputs it is also crucial that farmers are encouraged to store enough food and to maintain good nutritional status.

5.10.2 Time allocation for farm activities and division of labour

Evaluation of time allocation for farm activities (Table 24) and division of labour indicated that women worked more and for longer periods than men. However, both sexes were involved in all pre harvest activities from digging to harvesting, but post harvest activities were mainly done by women. Furthermore, pre harvest activities like digging (land preparation) that had high energy cost of activity (Table 21) in women are activities that took more time. Apart from farm activities, women had to perform all house chores some of which required more energy for example pounding, fetching of water and firewood (Table 21).

Such similar findings were also reported by UNICEF and URT (1990) study on gender and division of labour. Women have many roles which include farming and all agriculture activities, household chores, fetching firewood and water, and child rearing while men tend to be more responsible for cash crop production, and tasks of clearing land for farming. This trend is the same in different regions in Tanzania but women responsibility varies according to customs of different regions, and social economic status within the household setting (Ministry of Agriculture, 1996).

Studies done by Kumar (1991); and Saito (1994), cited by Doss (1999) also report similar observations that women work more hours than men. As farm sizes increase, women (on per capita basis) allocate more labour to both household maintenance and agriculture, while men work slightly less in agriculture and much less in non agriculture activities.

5.10.3 Food storage and availability

The present study has shown that food storage was highly practiced in the community. However, food shortage was still common in most households (94.6%) between January and March. The use of food crops for cash to solve illnesses and purchase of small household needs like sugar and soap seem to contribute to a reduction in the amount of food stored. The low food availability could explain the poor nutritional status observed in these months as reported by Kinabo *et al.* (2006) in the baseline study just as the farming season began. Farmer's physical strength was used as an asset and selling of human labour in exchange for cash was the most highly used coping method (Table 25) during periods of food shortage. It is possible that this could have even made the farmers more worn out prior to the cultivation of their own land hence reducing their productivity

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Energy expenditure of rural farmers was high; it was above the mean daily calorie per capita available in Tanzania of 1940 kcal/day (FAO, 1999) but below the energy requirement of 2681 kcal/day for developing countries FAOSTAT (2003), as cited by WHO/FAO (2003). High energy expenditure was attributed to high energy costs of farm activities which were manual and labour intensive. High energy levels spent in farm activities, long activity durations and high activity frequencies, especially among women contributed to a high PAL which according to WHO (1985) classification placed farmers under vigorous active life style. Although needing further investigation, overall study results showed higher BMR in men than women due to higher FFM, height and weight which in this study were key factors that had direct bearing on individual BMR. Continuous involvement in labour intense farm activity showed a delay in FFM decline and thus BMR.

The present study also established that farmer's good nutritional status not only in terms of appropriate BMI and Hb concentration but also body composition (healthy percent boy fat classification) played an important role in enhancing farmer's physical fitness and work capacity which were necessary for their physical works and farm activities. Low nutritional status was common at the beginning of the farming season but progressively change as food stocks began to rise.

Furthermore, the results suggested that increase of the current low production and improvement of livelihood of farmers does not only require high work capacity and good nutritional status, but also improvement of farm implements, diversification of crops grown, mechanization of agriculture, improved use of manure, increased provision of extension service and involvement of income generating activities to diversify sources of income.

The results elucidate on one of the objective of this study stated earlier. It is herewith stated that, there is a relationship between farmer's nutritional status and their work capacity. Thus, emphasis on good nutrition remains crucial to rural farmers whose livelihood is still dependant on agriculture which is still at subsistence level and requires human labour.

6.2 Recommendations

From the present study findings, it was evident that there is a link between nutrition and productivity. The nutritional status of farmers is key in enhancing their work capacity which is necessary for productivity. Hence, more emphasis needs to be placed on proper nutrition and provision of nutrition education to rural farmers and their households in order to strengthen their knowledge and practice of nutrition.

There is also a need to encourage farmers to grow and maintain vegetable gardens, consume fruits, rear domestic animals and increase animal protein consumption. The practice of crop diversification to increase the variety of food available at household level is equally necessary.

Furthermore, since current household food security is still critically dependant on farmers' ability to produce food, the government should consider stagewise mechanization of agriculture together with continual emphasis on nutrition knowledge and education in order to improve agriculture productivity.

The present study also emphasizes on the importance of BMR determination of farmers in Tanzania and developing countries in general. It validates the point that energy requirement is best determined from energy expenditure of which BMR constitutes 60 – 70 % of it. The results suggest that current recommended energy requirement need to be met to compliment the energy needs of rural farmers.

HIV/AIDS is the current global challenge which not only affects the nutritional status of its individual victims and households but, it is a great threat to economies of nations which have agriculture as the backbone of their economic. The effect of HIV/ AIDS on the metabolic process in the body brings to question the period within which the current recommended energy requirement can remain relevant. Thus, studies that determine BMR and energy expenditure remain necessary and instrumental in providing the basis from which the appropriate energy requirements can be established.

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APPENDICES

Appendix 1: Vapour pressure (P_{H2O}) of wet gas at normal laboratory temperatures

T (º C)	P_{H2O} (mmHg)	T (º C)	P_{H2O} (mmHg)
21	17.5	31	33.7
21	18.7	32	35.7
22	19.8	33	37.7
23	21.1	34	39.9
24	22.4	35	42.2
25	23.8	36	44.6
26	25.2	37	47.1
27	26.7	38	49.7
28	28.4	39	52.4
29	30.0	40	55.3
30	31.8		

And the overall equation to convert a moist gas into one at STPD used:

$$\text{Gas volume STPD} = V_{ATPS} \cdot (273 / 273 + T\ ^{o}C) \cdot (P_B - P_{H2O} / 760)$$

Appendix 2: Energy cost of different farm activities and house chores

Activity /household chore	Average energy spentin activity	Av Energy Value /BMR =Energy cost of activity (PAR)

Appendix 3: 24 hour Activity Pattern

Time	Activity	duration

Appendix 4: Calculation of energy expenditure of an individual

Main daily activity	Time allocation (hours)	Energy cost	Timesx Energy cost	Mean Pal multiple of 24hr BMR

Appendix 5: A questionnaire to investigate aspect of seasonality in agriculture production

IDENTIFICATION

Household ID Numbe……………………Name of interviewer…………………...............

Respondents Name ………………………..Gender 1 = male ……. 2 = Female……..

Date……………………………………………………………………………..

SECTION A: GENERAL INFORMATION

Characteristics of Farmer and household

A 1: Is your household male or female headed?

1 Male
2 Female ( )

A 2: What is your age ( )

A 3: Marital status

1 Married ( )
2 Single
3 Divorced
4 Widowed
5 cohabite

A 4: How many people live in the household? (Number)

Males ( )
Females ( )
Children < 15 years ( )
Children ≤ 5 years ( )

A5: What level of education did you attain?

1. Primary Level
2. Secondary level ( )
3. No formal education
4. Not complete Primary level
5. Adult education

SECTION B: SOCIO –ECONOMIC
Productive labour force, Farming and livestock Production

B1: Who are the economically active household members?

	GENDER 1= Male 2= Female	AGE Yrs	MARITAL STATUS 1= Married 2= Single	EDUCATION 1=Primary 2=Secondary 3= no education 4=not completed Primary	PARTICIPATION IN AGRIC. 1= Full time 2= Part time 3= No	RELATION WITH HH HEAD 1= Wife 2= Child 3= Relative
1						
2						
3						
4						
5						
6						

B 2: How big is your farm size?
1= < 1 to 1.5 acres
2= 1.6- to 3 acres
3= 3.1 to 4.5 acres
4= 4.6 to 6.0 acres
5= > 6 acres

B3: Please give information on your household food and cash crop production

CROP CODE	CROP NAME	Yield Levels Kgs/Ha	Market Price
1	Maize		
2	Paddy/ rice		
3	tomatoes		
4	Cassava		
5	Castor oil(Nyonyo)		
6	S/potatoes		
7	Beans		
9	Amaranthus		
10	sunflower		
11	Legume leaves		
12	Cow pea leaves		
13	Pumpkin leaves		
14	s/potatoe leaves		
15	Groundnuts		
26	Cowpeas		
17	Lablab beans (fiwi)		
18	millet		

B 4 Please list the type of fruits available and eaten by the family

Month of the year/season	Fruits eaten

B 4 : Crop and farming practices used

CODE	Crop Name	Variety used 1=improved 2 =partially[im proved 3 = traditional	Inorganic fertilizer used 1 = Yes 2 = No	Use of organic manure 1 = Yes 2 = No	Pest & disease control 1 = Traditional 2 = recommended
1	Maize				
2	rice				
3	Tomatoes				
4	Cassava				
5	Beans				
6	S/potatoes				
7	Vegetables/greens				

B 5: Please give information on household agriculture implements (tools) used for farming

Code	Type of implement	Number	Market price
1	Tractor		
2	Ox -plough		
3	Hand -hoe		
4	Machete		
5	Axe		

B 6: The following farm activities are done by which household member?

Activity	Gender 1= Male 2= female	Number of Hours per day	Total days of activity duration
Land preparation /tillling			
Planting			
Weeding			
Transplanting			
Bird scare			
Harvesting			
transporting			

B 7: The following post harvest farm activities are done by which household member?

Activity	Gender 1= male 2= female	Number of hours per day	Total days of activity duration
Grinding			
shelling			
Winnowing			
Maize pounding			
storage			

B8: Please give information on your household livestock

Code	Type of livestock	Number	Market price
1	Traditional cow		
2	Dairy cows		
3	Goats		
4	Sheep		
5	Pigs		
6	Chickens		
7	Ducks		
8	Guinea pigs		

SECTION C: HOUSEHOLD FOOD SECURITY
Food storage

C1: Do you store food?
1 = Yes GO TO C2
2 = No ( )

C 2: Which of the following storage facilities do you use?

1 = sack (contain 7 debe)
2 = Gourds
3 = local granaries ( )
4 = house /ceiling
5 = drums
6 = others

C 3: How much produce do you normally store? (Consider in sack where 1 sack = 7 debe)

Type of produce	Amount 1 = 2 bags or less 4 = 10.1 to15 bags 2 = 2.1 to 5 bags 5 = above 15 bags 3 = 5.1 to10 bags
Maize	
Rice	
beans	

C 4: What factors determine the amount of food you store?

1. All food cultivated is stored for household use
2. Availability of other stored food
3. Level of production
4. Food requirement in household
5. Storage facility

C 5: Out of the food store how much is planned for;

1. Selling
2. Consumption
3. Seeds
4. Brewing
5. Loan payment

C 6: What household needs initiate the sale of food produce?

…………………………………………………………………………………………

…………………………………………………………………………………………

C 7: From the last harvest season to this years harvest time did you experience food shortage?

1 Yes GO TO C 5
2 No ( )

C 8: If there was shortage, which food items were in short supplies?

Type of food	Months	Total Duration 1= 1mth 5= 5mths 2= 2 mths 6= >5mths 3= 3 mths

C 9: What coping method do you use when the food stock is not enough?

1= Sell household items to buy food
2= Ask neighbours
3= Ask relatives and friends ( )
4= take one meal a day/reduce number of meals
5= sell animals to buy food
6= sell human labour to get money for food
7= migrate

C 10: Between man and woman who makes decision in the following;

Activity	Decision maker 1= man, 2= woman , 3 = both
1 Type of cash crop and acres to plant	
2 food crop and acres to grow	
3. amount of food produce to store	
4. amount of food produce to sell	
5. how to spend the money after selling	
6. choice of market	
7. Type of food to be prepared	

SECTION D: HOUSEHOLD INCOME

D 1: What is a major source of income for the family?

Source of Income	Type	Amount sold per year	income
1= sale of cash crop			
2 = sale of food crop			
3 = sale of livestock			
4 = sale of labour			
5= others			

D 2**:** Is the household involved in income generating activities?

Yes = 1 If yes go to D 3 ( )

No = 2

D 3: Which type of income generating activity/es is the household involved with?

Activity 1=selling food 2= petty trading 3= veg growing 4= poultryk/png 5= tomato growing	Who does it 1= male 2= female	Season done in the year 1= throughout the year 2 = after harvest 3= during farm season	Hours done per day	Income per day

SECTION E: HEALTH AND NUTRITION

E 1: How do you understand the term nutrition?

1. Porridge flour for children
2. Knowledge of different nutrients and the function in the body
3. I don't know

E 2: Mention the five groups of food necessary to provide a balance diet

……………………………………………………………………………………………

……………………………………………………………………………………………

E 3: What do you understand by the term malnutrition?

1. being sick
2. being thin
3. being unhealthy
4. A condition due to poor and unbalanced nutrient intake in the body
5. I don't know

E 4: Do you know cases of malnutrition in the community?

1. Yes   2. No

E 5: If yes what causes them?

1. Diseases   2 .Low income failure to buy food

( )

3. No knowledge on how to prepare balanced diet   4. Lack of food
5. Poor hygiene and sanitation   6.Lack of fruits and greens   7. I don't know

E 6: Have you been breastfeeding all your children?

1. Yes   2. No   ( )

E 7: Do you breast feed exclusively for six month?

1. Yes   2. No   ( )

E 8 : If no when do you introduce other food to the baby?

1. at 1 month or less
2. at 2 - 3 months
3. at 4 month
4. Others

E 9: When do you stop breast feeding the child?

1. at 12 to 18 months
2. at 24 months
3. above 24 months

E 10: Family Feeding Practice

Type of food	Frenquency of consumption (weekly)				
	Daily	Once	2x	3x	Special days
Maize (ugali)					
Rice					
S.potatoes					
potatoes					
Cassava					
Beans					
Legumes					
Ground nuts					
Meat					
Fish					
Dagaa					
Milk					
Chicken					
Eggs					
Greens(mboga za majani)					
vegetables					
Sugar					
Fat/oils					

SECTION F: ESTABLISHING DIVISION OF LABOUR WITHIN THE HOUSEHOLD

F 1 : List of all activities performed by Women

F 2: List of all activities performed by men
