ASSESSMENT AND CHARACTERIZATION OF FOOD TYPES CONSUMED BY *HADZABE* HUNTER-GATHERER NOMADS IN NORTHERN TANZANIA

BY

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ABSTRACT

The aim of this study was to assess and characterize the food types consumed by *Hadzabe* hunter-gatherer nomads in Karatu and Meatu districts, northern Tanzania. A total of 259 respondents from the target districts were involved in the study. Through cross-sectional study design, the data were collected using structured and semi-structured questionnaires to investigate the temporal patterns for the availability of food types consumed. Micronutrients (Cadmium, Copper, Chromium, Ferrous, Zinc, Magnesium in mg/l and %Calcium) and proximate composition of macronutrients were analysed in three common consumed roots (*Ekwa*, *Magharitako* and *Shumugo*). Overall, 47 varieties of plant species were consumed but only 15 among them were recognized by their scientific names. Twenty eight type of leaf vegetables, 16 root/tubers and 15 wild fruits/berries were identified among consumed plant materials and 29 animal species. Findings from spatial analysis demonstrated that honey (96.5%), meat (91.9%) and roots (76.4%) were found both during dry and rain season. The analyses of micronutrients showed that Cu, Cr, Mg and Fe (mg/l) in the samples exceeded the WHO Maximum Acceptable Residue Level (MARL). In particular, moisture content in *Shumugo* roots was higher (90%) than the WHO recommended levels. It is concluded that there are many varieties of wild food consumed and their availability depends on the season. The examined roots for micronutrients are probably toxic for Fe, Cr and Cu that requires further toxicity studies. There is need to raise awareness about the risks and hazards associated with nomadism, that include among other things inadequacy of vital nutrients in their diets that may cause malnutrition; and also toxic natural food types.

DECLARATION

I, MABULA MASUNGA MIGATA, hereby declare to Sokoine University of Agriculture that this dissertation is a result of my own original work and it has neither being submitted nor concurrently being submitted for a degree award in any other institution.

…….. **……**

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The declaration above is confirmed by

…….. **……**

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DEDICATION

This dissertation is dedicated to my beloved wife Mariam Athumani Kundy and my children Judith M. Masunga, Edith M. Masunga and Julius M. Masunga.

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LIST OF ABBREVIATIONS AND SYMBOLS

µg/l	Micrgrammes per litre
AOAC	Association of Official Analytical Chemists
Ca	Calcium
CCAC	Canadian Council of Animal Care
Cd	Cadmium
CGP	Chelsea Green Publishing
Cr	Chromium
CR-AFNNET	Coinigne R –African Natural Products Research Training Network
Cu	Copper
CV	Coefficient of Variation
DHHS	Department of Health and Human Services
DOI	Digital Object Identifier
ECF	Extra Cellular Fluids
EPA	Eicosapentaenoic Acid
FAAS	Flame Atomic Absorption Spectrophotometry
FAO	Food and Agriculture Organization
FEP	Flame Emission Photometry
ICPAES	Inductively Coupled Plasma Emission Spectrophotometry
IDF	Insoluble Dietary Fibre
IPCS	International Programme of Chemical Safety
MARL	Maximum Acceptable Residue Level
MDC	Meatu District Council
Mg	Magnesium
mg	Milligramme

Mmol/l	Millimole per litre
MPC	Maximum Permitted Concentration
NRC	National Research Council of the US
PEM	Protein Energy Malnutrition
PER	Protein Efficiency Ratio
pH	Hydrogen Ion Concentration
RDA	Recommended Daily Allowances
RELMA	Regional Land Management
RNI	Recommended Nutrient Intakes
SEAMIC	Southern and Eastern Mineral Centre
SOD	Superoxide Dismutase
TAC	Total Available Carbohydrates
TDF	Total Dietary Fibre
TDI	Tolerable Daily Intake
UN	United Nations
US	United States
USDA	United States Department of Agriculture
WFP	World Food Programme
WHO	World Health Organization
WMA	Wildlife Management Areas
XAFS	X-ray Absorption Fluorescence Spectroscopy
Zn	Zinc

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Depending on the type of nomads, there are different definitions that describe the drivers of the nomadic stray. Nomads are those people who move from one place to another in search of green pasture, food and water as three basic needs for both people and livestock (The Free Dictionary, 2010). Search for these basic needs subject them to have no permanent settlements. Hogg (1992) as quoted by Gritli (1997) stated that *"Nomadism is a rational adaptation of human life to the environment and a way of life."*

Most nomads asserted to exist in sub-Saharan Africa region, the North Africa, the Middle East and Central Asia are pastoral nomads. They live in sustainable relationships with their habitats through a series of adaptive strategies including spatial mobility and broad although controlled access to rangeland and water, herd diversification, prudent offtake rates, and exchange relationships with sedentary people (Horowitz, 1992).

The arid and semi-arid areas of the earth cover some 50 million km^2 or 35% of the earth's land surface area, with a total human population of about 600 million people. Of this total, some 30-40 million are believed to have "animal-based" economies and the majority are pastoralists. Within the 30-40 million, 50-60% are found in Africa, 25-30% in Asia, 15% in all America, and less than 1% in Australia. In terms of the number of pastoralists, countries that rank high are Sudan, USA, Somalia, Chad, Ethiopia, Kenya, Mali, Mauritania, India and China, each with about 1 million or more pastoralists including men, women, and children (Stanford, 1983).

The people of Meatu district are *Sukuma, Nyiramba, Nyaturu, Taturu* and *Tindiga (known as Wahadzabe).* Those of Karatu district are *Maasai, Iraq, Datoga (Barbaig) and Hadzabe.* The *Tindiga* and *Taturu* people are nomads. Their nomadic way of life makes it difficult for the government to provide them with the required essential services such as health, education and social services.

In Tanzania, districts like Mbulu, Karatu and Meatu are some of the rare districts in the country ever inhabited by *Hadzabe* tribe. The survival of these people depends on the naturally occurring wild roots (*ng'wabi* and *undoshibu*), honey, red meat, fruits (*embele, ngobabe, kongolo & ubuyu*) and alcohol. As the dense forest goes on losing, their lives become even harder to searching foods for their daily lives. Other similar pastoralist nomads are found in Mbarali (Usangu) valley, Hanang and Kilosa, who differ from *Hadzabe* due to the varied purpose of their nomadic stray (Commission on Nomadic Peoples, 1991).

1.2 Problem Statement

There is a wide variation of malnutrition among people of Meatu district. While factors for variation of this problem among the community were not clearly understood at the biggining of this study, the *Hadzabe* people, who are nomads in nature, seemed to be greatly affected for more than 4% compared to other people in Meatu and Karatu districts. In 2006–2008, the disparity of nutritional status was 1440 out of the total population of 304 000, being higher when comparison was made between nomads and non-nomads (Commission on Nomadic Peoples, 1991).

Increase of nomadism causes increase in poor sanitation, poor housing, and insufficient quantity and quality of food, leading to a poor nutritional status. Although the availability of naturally occurring plant roots as food to nomads is not a problem to *Hadzabe* people, this does not ensure a sustainable food security for improvement of their nutritional status (Gritli, 1997).

1.3 Significance of this Study

The findings from this study will assist in generating a new knowledge on food profile consumed by nomads, knowing the sustainability and food security, and subsequently help to design the appropriate interventions relevant for rescue of hunter-gatherer nomads from malnutrition.

1.4 Objectives

1.4.1 Overall objective

The main objective of this study was to assess and characterize the common food eaten by *Hadzabe* nomads in Karatu and Meatu districts, northern Tanzania in view to establish a new knowledge on food profile consumed by nomads, knowing the sustainability and food security for subsequent development of a programme to control malnutrition.

1.4.2 Specific objectives

i) To establish baseline information on the types of food consumed by *Hadzabe* in the study area.

ii) To determine the availability patterns of different food types identified on objective i.

iii) To assess the nutritive value of the most common identified food type in the study area.

1.5 Research Questions

i) Which types of food are consumed by *Hadzabe* tribe?

ii) What is the availability pattern of common types of food consumed by *Hadzabe*?

iii) What is the nutritive value of common identified foods eaten by *Hadzabe*?

1.6 Hypotheses

i) Hypothesis I

Null Hypothesis (H_O): There is one type of food consumed by *Hadzabe* nomads.

Alternative Hypothesis (H_A): There are many different types of food consumed by *Hadzabe* nomads.

ii) Hypothesis II

Null Hypothesis (H_O): The availability pattern of food types consumed by *Hadzabe* is not seasonal dependent.

Alternative Hypothesis (H_A): The availability pattern of food types consumed by *Hadzabe* is seasonal dependent.

iii) Hypothesis III

Null Hypothesis (H_O): There are inadequate nutritive values in most common consumed by *Hadzabe*.

Alternative Hypothesis (H_A): There are adequate nutritive values in most common food consumed by *Hadzabe*.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Type of Nomads

The word ‘nomad’ is derived from the Greek word for pasture which means ‘nomos’. Nomadic pastoralists, hunter-gatherer nomads and traders/craft workers are the three types of known nomads (Commission on Nomadic Peoples, 1991).

2.1.1 Nomadic pastoralists

These are nomads who move with their households in search of pasture for their animals. There are an estimated 30-40 million of them in the world (Gritli, 1997). Livestock is central to their livelihood and the basis of their culture. Their movement is seasonal, linked to rainfall and the availability of good forage for their animals. Goat herders in the Peruvian Andes graze their animals on richer grasses at lower altitudes during the wet season, and move to higher altitudes during the dry season (Gritli, 1997). Of the 60 000 Sami in Scandinavian countries only 6000 are still nomadic. They may migrate with their reindeer up to 300 kilometres from sheltered forests in the winter to coastal grasslands in the summer (Carmichael, 1991).

2.1.2 Hunter-gatherers nomads

In anthropology, hunter gatherer is defined as a way of life led by certain societies of the Neolithic based on the exploitation of wild plants and animals. They are relatively mobile, and their groups have fluid boundaries and composition. Typically, men hunt and women gather and hunt small game (Marlowe, 2010). The Inuit of the Canadian Arctic, native people of the Amazonian rainforest, indigenous Australians, Native Americans,

such as the Nukak-Makú, Comanches and many other plains Indians are known as nomads. In Africa, groups like the San of the Kalahari Desert, various groups of Pygmies, such as the Ituri of rain forest in the Democratic Republic of the Congo, the Bushmen of Southern Africa moved from campsite to campsite, following game and wild fruits and vegetables (Marlowe, 2010).

2.1.3 Traders and craftworkers nomads

These nomadic people are alternatively known as “peripatetic nomads” **(**Commission on Nomadic Peoples, 1991). They are neither pastoralists nor hunter-gatherers common in industrialized nations. In the west countries, the best known of these are the Rom or Gypsies, sometimes known as travelers. Originally from northern India, the Rom moved north-west about 1000 years ago and scattered across Europe, working as petty traders, musicians, farm workers and day-labourers (Mehraby, 2007).

2.2 Type of Nomads Found in Tanzania

The nomads found in Tanzania are hunter-gatherers that include *Hadzabe* commonly found in forests of Meatu, Karatu and Yaeda Chini in Mbulu district (Marlowe, 2010). They normally spend a day time in hunting animals (males) and female carry their belonging and build temporary structures as shelters. Pastoralist nomads are Wasukuma in Mbarali (Usangu valley), Maasai and Wasukuma in Kilosa district, Datoga or barbaig tribe in Hanang and Maasai of Ngorongoro district. Other kinds of nomads found in this country are called peripatetic nomads who move from place to place offering a specific trade. Peripapetic nomads are found moving and offering auction mats business countrywide.

***Hadzabe* tribe**

Hadzabe also known as *Hadza* people or *Tindiga* is an ethnic group not closely related to any other people. The *Hadzabe* typically resemble the Pygmy groups like *Mbuti* and *Baka* (Cameroon and Gabon) as well as in populations that speak Northern Khoisan click languages, such as the Ju|'hoansi (Knight, 2003; Wikipedia, 2010). This ethnic group is found in northern part of Tanzania, around Lake Eyasi in the central Rift Valley and in the neighbouring Serengeti Plateau. They are almost 1000 in number. Some 300–400 live as hunter-gatherers, much as their ancestors did for thousands of years. They are the last functioning hunter-gatherers in Africa (Knight, 2003; Marlowe, 2010).

The survival of these people depends on the naturally occurring wild roots (*ng'wabi* and *undoshibu*), honey, red meat, fruits (*embele*, *ngobabe, kongolo & ubuyu*) and alcohol (Marlowe, 2010). So far no characterization of their food types or nutrients has done before.

2.3 Plant Roots Used by Nomads

Often the prehistoric people of Mondana dried roots and then mashed with a stone *mano* and metate to create flour used in cooking. A metate is a large flat stone with an indented area to place roots. The mano is a smaller hand held stone used to mash and grind root back forth with the metate indented area until the root is finely grind. *Mano* is the Spanish word for "hand," and it refers to a stone that is held in one or both hands and moved back and forth against a larger stone in order to grind seeds, nuts, and other hard materials. *Metate* is derived from *metatl,* a word used by native peoples in central Mexico to describe the larger stone against which the *mano* is ground. Berries and fruits were staples in many prehistoric diets especially during the fall. The people harvested service

berry, huckleberry, gooseberry, currant and buffalo berry ripened in late summer. Berries and fruits were eaten fresh (CCAC, 2008).

2.4 Historical Perspective of *Hadzabe* Hunter-gatherer Nomads

The *Hadza* tribal term is qualified by *Hadzabe* as a plural term "*Wahadza"* a singular name of *Hadza* is *Hadzago* "*Mhadza*". However, a conclusive name of *Hadza* tribe is *Hadzabe*. They were formerly thought to belong into a group of Khoisan people of South African nomads of click speaking language. Their neghbour tribes are *Datoga, Masai, gorowa Iraqw* and *Sandawe* in Karatu district, while in Meatu district their neghbours are *Sukuma, Isanzu, Nyiramba, Taturu* and *Nyaturu* (Nyoni, 2008).

Little is known about ethnic or historic origins of the *Hadza* people. Even the time of their arrival in Meatu, Mbulu and Karatu districts has been difficult to estimate. The *Hadzabe* are hunter-gatherers for animals and collect honey, fruit, tubers and berries for food. They also use a wide variety of plant species for medicinal purposes (Nyoni, 2008). *Hadzabe* nomads lived in prehistoric man styles of gatherering food and spent nearly the entire life in search for food. However the common food including roots eaten was milk, honey, roots and red meat (Mottram *et al.*, 1974).

The *Hadza* do not have chiefs or leaders, nor even a village elder system. Occasionally, they have a single powerful man to influence the community. In contrast to surrounding tribes the *Hadza* are very egalitarian. They have no properties of their own. *Hadza* have lost land from encroachment by farmers and destruction of woodlands. Ironically, what causes the destruction of forest is the demand for charcoal from the neighbouring Ngorongoro Conservation Area (Wikipedia, 2011).

Most of the older *Hadza* have not been to school like Gudo and Naftal nomads in South Africa. The bush-dwelling *Hadza* are suspicious of their educated, 'modernized' tribe mates. They cannot read nor write but they can start a fire with a stick, find bush food, make sandals, adornments, bows and arrows, hunt animals, gather honey and look after the interests of their kin. The older *Hadza* twinkle with teasing, teach their grandchildren their stories and songs as well as where to find water and food. It could be heard the strong, shrill voices of the women as they tease, scold, soothe and sing. If nothing else, the *Hadza* are joyful people; to be among them lifts one's spirits - when they are not begging and cajoling you for something **(**Jones *et al.*, 2002).

The future of the *Hadzabe* is very uncertain. Their existence is threatened by land encroachment by farmers and herders, lack of game to hunt, diseases including tuberculosis (TB) and HIV/AIDS and substance abuse **(**Jones *et al.*, 2002).

2.4.1 *Hadzabe* versus other hunter-gatherer nomads on dietary statistics

Jones *et al.* (2002) clarified the difference that existed amongst three nomads of the world including the *Hadzabe* relative to food types foraged and the results were as summarized in Table 1.

Table 1: Caloric intake by percentage to three nomadic hunter-gatherers

Food type	Kung (San-Bushmen) Kalahari	Hadzabe (East Africa)	Ache (Paraguay)
Meat from hunting	29	11.1	56
Plants and insects	0	0	26
Mongongo nuts	58	0	0
Honey	0	21.4	18
Berries	0	21.2	0
Baobab fruit	0	13.5	0
Misc. fruit & vegetables	13	0	0
Nonpaleo: Tubers	0	22.8	0
Grains	0	9.9	0

Source: Jones *et al*. (2002)

Jones *et al.* (2002) systematically recorded dietary intake in the forest and suggested that about 80% of the energy in the diet comes from meat, 10% from palm starch and hearts, 10% from insect larva and honey, and 1% from fruits. Total energy intake is approximately 2700 kcal per person daily, and males acquire about 84% of all calories consumed. Ache seemed mostly carnivorous with 80-90% meat consumption.

But, the question of why men hunt rather than spend all day extracting palm resources cannot be explained by energy maximization, since men obtain about 750 calories per hour hunting, and around 1000 calories per hour extracting palm starch and hearts. An average of 56% was from mammal meat, 18% was from honey, and the remaining 26% was from plants and insects.

2.4.2 Life expectancy on births and deaths of *Kung, Hadzabe* and *Ache*

While these groups have significant infant, child and adult mortality, they also have significant numbers of elderly. Table 2 shows the percentage of expectancy on three world nomadic groups.

Table 2: Percentage of life expectancy on three nomadic groups

Life Expectancy on birth and death	Kung (San-Bushmen) Kalahari	*Hadza* (East Africa)	Ache (Paraguay)
Life expectancy at birth	30	32.5	37.1
Infant mortality	0.20/0.15	0.21	0.12-0.18
Life expectancy at 20	34	41.4	39.8
Life expectancy at 45	20	23	22.1
Percent over 60	8.5	8.8	5.5
Lifetime live births	4.7	6.2	8.2
Population growth rate Units	0.0026	0.013	0.025
Causes of adult mortality %:			
Illness	88	39	17
Violence	11	4	73
Homicide	0	3	0
Accident	0	1	0
Other	0	17	0
Unspecified	0	40	0
Causes of child mortality %:			
Illness	90	0	32
Violence			
Homicide	0	0	31

Source: Hill and Hurtado (1989)

In both these populations, about 20% of children die in their first year, and 60% survive to 15. Lifetime fertility - number of live births - is 7.2 among the Ache, with an average interval between births of 38 months, compared to 4.7 and 48 months for the Kung (Hill and Hurtado, 1989).

Ache men spend about 6.7 hours per day in "subsistence activities" - searching, acquiring resources, and processing food - and another 0.6 hours per day making tools. Women spend about 1.9 hours per day in subsistence activities, another 1.9 hours per day moving camp, and 8 hours per day in light work and child care. Men provide 87% of the calories in the Ache diet and close to 100% of the protein and fats (Hill and Hurtado, 1989).

It is reported that on a foraging trip, camp members woke up early, eat whatever is left over from the previous day, and set out in search of food. Men lead the way, carrying only bows and arrows, and women and children follow, the women carrying young

children and the family's possessions in a woven basket. Some men walk with their wives and carry children on their shoulders. Ache foragers do not walk on trails but break a new path through the forest each day. Usually the leaders set out in the direction of an area known or thought to contain important food resources (Hill and Hurtado, 1989).

After walking together for about an hour, the two sexes separate, with men walking further and more rapidly in search of game, and women and children slowly progressing in the general direction the men have set out. Men generally eat very little during the day, but women and children sometimes collect and eat fruits and insects while men hunt, and women often process palm trunks for the starchy fiber near the end of the day. This snacking usually accounts for less than 5% of all food consumed (Hill, 1984).

Hill (1984) continues to report that all camp members come together again at the end of the day, when they clear a small camp in the underbrush, build fires, prepare and share

food extensively. Evening is considered the most pleasant time, with band members enjoying their only large meal of the day, and joking and singing in the night. While in the forest the Ache sleep on the ground or on palm-leaf mats in a small circle. They build palm-leaf huts to sleep in only if it begins to rain. The next morning the band moves on again in search of food unless there is heavy rainfall throughout the day.

2.4.3 Differences of *Hadzabe* from other nomads

About 70% of the foods were brought into camp by the Hadzabe excluding 30% which was consumed while hunting or gathering. Others were food grains which offered as gifts from missionaries. The *Hadzabe* retained a largely hunter-gatherers life style although they had been in contact with agriculturalists for a century or more (Dew, 2009).

Dew (2009), assessed and made a comparison between Ache and Kung, the Ache live in a "malaria varies" area, while the Kung live in an area that's a patchwork of different colours. However she became surprised, to see the Kung who live in a desert, if malaria is the main cause of their high illness rate. She concluded that mortality data from early in the last century on the *Hadza* from Africa provided a more direct comparison.

Other interesting thing was high amount of honey in the diet. This is not unique to the Ache and the *Hadza* of East Africa who also ate a lot of honey - and incidentally also ate a diet based on meat, which was not true of the Kung that was unjustifiably. Perhaps it meant they had very little honey (depending upon the amounts of larva eaten) and probably Bee's didn’t produce it quick enough honey for a sustainable resource (Dew, 2009).

But also a match was done by Dew (2009) assuming the upper range for honey, 10% of 2700 calories is 270 calories, which is 67.5 g of sugar, and since honey is 17 g of sugar per tablespoon that would equal about 4 tablespoons of honey per day. Which is not a huge amount, but there is no idea of how much honey is actually available in the wild.

Kallyn (2009), say it also doesn't matter how much honey or how many grubs are collected if women you don't get to eat any of it anyway because you're a woman and it was already all fed to the dogs. The order of food distribution sequentially followed beginning with old men, warriors, young men, children, dogs, and women. The women were actively prevented from eating many foods, and they only got to eat whatever permitted foods were left over after all those other groups got their fill.

2.5 Proximate Composition of Various Honeys

Honey gets its sweetness from the monosaccharides fructose and glucose and has approximately the same relative sweetness as that of granulated sugar (74%) of the sweetness of sucrose, a disaccharide. Most micro-organisms do not grow in honey because of its low water activity of 0.6. (Lee *et al*., 2008)

However, honey sometimes contains dormant endospores of the bacterium *Clostridium botulinum*, which can be dangerous to infants as the endospores can transform into toxin-producing bacteria in the infant's immature intestinal tract, leading to illness and even death (Lee *et al.*, 2008).

Lee *et al*. (2008) reported that honey has antimicrobial activities. It was observed that the isolated more than two thousand bacterial strains from six US domestic honeys and two

manuka honeys from New Zealand were screened for production of antimicrobial compounds.

Hui and Nakai (1996), found almost same profile of nutrients, specifically protein, fat, sucrose and invert sugar samples that were collected in different areas.

2.6 Micronutrients

The dietary requirement for a micronutrient is defined as an intake level which meets a specified criterion for adequacy, thereby minimizing risk of nutrient deficit or excess. This criterion cover a gradient of biological effects related to a range of nutrient intakes which at the extremes include the intake required to prevent deaths associated with nutrient deficit and access (WHO/FAO, 2004).

2.6.1 Magnesium

2.6.1.1 Biological role of magnesium

WHO and FAO of the UN (2004) describe magnesium (Mg) in its biological roles in the human body as a cofactor of many enzymes involved in energy metabolism, protein synthesis, RNA and DNA synthesis and maintenances of electrical potential of nervous tissues and cell membranes.

Between 50% and 60% of body magnesium is located within bone, where it is thought to form a surface constituent of the hydroxyl appetite (calcium phosphate) mineral component. However, the proportion of body magnesium in this exchangeable form declines significantly with increasing age.

2.6.1.2 Population at risk for, and consequences of magnesium deficiency

Pathological effects of primary nutritional deficiency of magnesium occur less frequently in infants (Lonnedal, 1995). But in adult this is observed relatively less common if its intake is accompanied by prolonged diarrhea or excessive urinary magnesium losses (Shills, 1988). Studies have shown that, a decline in urinary magnesium excretion during protein energy malnutrition (PEM) is accompanied by a reduced intestinal absorption of magnesium (Waterlow, 1992).

Most of early pathological outcomes of depletion are neurological or neuromuscular defects (Shills, 1988) some of which probably reflect the influence the magnesium and potassium. Thus, a decline in magnesium status produces anorexia, nausea, muscular weaknesses, lethargy, staggering and, if deficiency is prolonged, weight loss. Further increase of severity and duration of depletion are manifestation of hyperirritability, hyperexcitability, muscular spasms and tetany, leading ultimately to convulsions. An increased susceptibility to audiogenic shock is common observed in experimental animals. Cardiac arrhythmia and pulmonary oedema frequently have fatal consequences (Shills, 1995). However, etiology of coronary heart diseases may be a factor due to suboptimal status but this requires further evidence (Elwood, 1994).

2.6.1.3 Dietary source, absorption and excretion of magnesium

The absorption of magnesium appears to be greatest within the duodenum and ileum and occurs by both passive and active processes (Greger *et al.*, 1981), but the high intake of dietary fibre (40 – 50 g/day) lower magnesium absorption. This is probably attributable to the magnesium-binding action of phytate phosphate associated with the fibre (MacConce

and Widowson, 1942). However, consumption of phytate and cellulose rich products increases magnesium intake (as they usually contain high concentration of magnesium). In contrast high intake of zinc (142 mg/day) decrease magnesium absorption and contribute to a shift towards negative balance in adult males. In the extent several studies have now shown that dietary calcium intake in access of 2600 mg/day (Greger *et al.*, 1981) particularly if associated with high sodium intakes contribute to a shift towards negative magnesium balance or enhance in urinary output (Quarme and Disks, 1986).

2.6.1.4 Recommended intakes for magnesium

Physiological availability of magnesium in human milk meets the infants' requirements. The intake of maternal milk from exclusively human milk fed infants 1–10 months of age ranges from 700 to 900 ml/day in both industrialized and developing countries (WHO/NUT98, 1998).

Daily intake of 23 mg from maternal milk yields 18 mg available magnesium, a quantity similar to that of the 36 mg or more suggested as meeting the requirements of young infants given formula or other foods.

2.6.1.5 Upper limit of magnesium

Magnesium from dietary sources is relatively harmless. Contamination of food or water supplies with magnesium salt has been known to cause hypermagnesaemia, nausea, hypotension, and diarrhea. Intakes of 380 mg magnesium as magnesium chloride have produced such signs in women. Upper limits of 65 mg for children aged 1-3 years, 110 mg for children aged 4-10 years, and 350 mg for adolescents and adults are suggested as

tolerable limits for the daily intake of magnesium from foods and drinking water (Food and Nutrition Board, 1997).

2.6.2 Zinc

2.6.2.1 Role of zinc in human metabolism processes

WHO/FAO (2004) elaborates that, zinc is an essential component of a large number (>300) of enzymes for synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids as well as in the metabolism of other micronutrients.

Zinc plays a central role in the immune system affecting a number of aspects of cellular and humoral immunity (Shanker and Prasad, 1998). The manifestations caused by zinc deficiency in human are growth retardation, delayed sexual and bone maturation, skin lesions, diarrhea, alopecia, impaired appetite, increased susceptibility to infections mediated via defects in the immune systems and the appearance of behavioural changes. The demonstrated signs of mild zinc deficiency in human are reduced growth rate and impairments. Other effects such as impaired taste and wound healing, which have been claimed to result from low zinc intake, are less clearly observed.

2.6.2.2 Dietary sources and bioavailability

Zinc availability from the diet can be improved by decreasing the phytate content and including sources of animal protein. Lower extraction rates of cereal grains will result in lower phytate content but at the same time the zinc content is decreased, so that the exact effect can be reduced by activating the phytate present in most phytates-containing foods or through the addition of microbial or fungal phytates. Phytases hydrolyses the phytate to lower inositol phosphates resulting in improved zinc absorption (Narvet *et al.*, 1985).

Germination of cereals and legumes increases phytate activity and addition of some germinated flour to ungerminated maize or sorghum followed by soaking at ambient temperature 12-24 hours can deplete the phytate content substantially (Gibson *et al.*, 1998).

2.6.2.3 Populations at risk for zinc deficiency

Inadequate zinc deficient in infants, children, adolescents and pregnancy women is observed as a result of impaired role of zinc in cell division, protein synthesis and body growth. Zinc responsive stunting has been identified in several studies. For example a more rapid body weight gain in malnourished children from Bangladesh supplemented with zinc was reported (Simmer, 1988). However, growth promoting effect of zinc supplementation has proved failure by other studies. In one study of interventional containing 1834 children under 13 years of age with a mean duration of approximately 7 months and mean dose of zinc of 14 mg/day (214 µmol/day), showed a small but significant positive effect of zinc supplementation on height and weight increase (Brown *et al.*, 1998).

Table 3: Recommended nutrient intake (RNI) for dietary zinc (mg/day) to meet the normative storage requirements from diets differing in zinc bioavailability

Group	Assumed body weight in kg	High bioavailability	Moderate bioavailability	Low bioavailability
Infants and children				
0-6 months	6	1.1[b]	2.8[c]	6.6[d]
7-12 months	9	0.8b,2.5e	4.1	8.4
1-3 years	12	2.4	4.1	8.3
4-6 years	17	2.9	4.8	9.6
7-9 years	25	3.3	5.6	11.2
Adolescents				
Females, 10-18 years	47	4.3	7.2	14.4
Males, 10-18 years	49	5.1	8.6	17.1
Adults				
Females, 19-65 years	55	3.0	4.9	9.8
Males, 9-65 years	65	4.2	7.0	14.0
Females, 65+ years	55	3.0	4.9	9.8
Males, 65+	65	4.2	7.0	14.0
Pregnant women				
First trimester	-	3.4	5.5	11.0
Second trimester	-	4.2	7.0	14.0
Third trimester	-	6.0	10.0	20.0
Lactating women				
0-3 months	-	5.8	9.5	19.0
3-6 months	-	5.3	8.8	20.0
6-12 months	-	4.3	7.2	14.4

Source: WHO/FAO (2004)

[a] For information on diets

[b] Exclusively human-milk fed infants. The bioavailability from human milk is assumed to be 80% assumed coefficient of variation, 12.5%

[c] Formula-fed infants. Applies to infant fed whey-adjusted milk formula and to infant partly human-milk-fed or given low phytate feeds supplemented with other liquid milks; assumed coefficient of variation, 12.5%

[d] Fomula fed infants. Applicable to infants fed as phytate rich vegetable protein-based formula with or without whole-grain cereals; assumed coefficient of variation, 12.5%

2.6.3 Calcium and its general roles

Given below are the roles, chemistry, risk population and nutritional factors affecting utilization of consumed dietary calcium.

2.6.3.1 Population at risk for calcium deficiency

It is clearly elaborated by WHO/FAO (2004) that calcium retention of ultimate consideration to growth especially the children under 2 years of age and during puberty and adolescence. These age groups therefore constitute populations at risk for calcium deficiency as to pregnancy women in the last trimester, lactating women, postmenopausal women and elderly women. For dietary calcium recommended allowances Table 4 describes the intake level.

Table 4: Recommended calcium allowances based on North American and Western European data

Group	Recommended Intake (mg/day)
Infants and Children	
0-6 months	
Human milk	300
Cow milk	400
7-12 months	400
1-3 years	500
4-6 years	600
7-9 years	700
Adolescents	
10-18 years	1300[a]
Adults	
Females	
19 years to menopause	1000
Postmenopause	1300
Males	
19-65 years	1000
65 + years	1300
Pregnant women (last trimester)	1200
Lactating women	1000

Source: WHO/FAO (2004)

[a] Particularly during the growth spurt

2.6.3.2 Upper limit requirements of calcium intake

Urinary calcium also rises very slowly with intake (slope of 5 – 10%) and the risk of kidney stones from dietary hypercalciuria must also be negligible (Curhan *et al*., 1997; Curhan *et al*., 1993). However, in practice an upper limit on calcium intake of 3 g (75 mmol) is recommended.

2.6.4 Chromium and its general role

Chromium concentrations in human tissue decline with age, except for lungs in which chromium accumulates. Parity, juvenile diabetes, and coronary artery disease are associated with low-chromium concentrations in hair or serum (IPCS, 1988).

The intestinal absorption of dietary chromium at daily intakes of 40 µg/day and more is approximately 0.5% are absorbed with an increasing efficiency, up to about 2% of the total (IPCS, 1988). Absorbed chromium is excreted almost completely through the urine.

2.6.4.1 Estimated safe and adequate daily dietary intakes

The tentative recommendations for young age groups are derived by extrapolation on the basis of expected food intake. Until more precise recommendations can be made, the consumption of a varied diet, balanced with regard to other essential nutrients, remains the best assurance of an adequate and safe chromium intake.

2.6.4.2 Excessive intake and toxicity

The toxicity of trivalent chromium, the chemical form that occurs in diets, is so low that there is a substantial margin of safety between the amounts normally consumed and those

considered to have harmful effects. No adverse effects were seen in rats and mice consuming 5 mg/liter in drinking water throughout their lifetimes, and no toxicity was observed in rats exposed to 100 mg/kg in the diet (IPCS, 1988).

2.6.5 Copper and the general roles

Copper is an essential nutrient for all vertebrates and some lower animal species (Davies and Mertz, 1987). Several abnormalities have been observed in copper deficient in animal, including anemia, skeletal defects, demyelinization and degeneration of the nervous system, defects in pigmentation and structure of hair or wool, reproductive failure, myocardial degeneration, and decreased arterial elasticity (NRC, 1989).

2.6.5.1 Chemistry of copper

Copper is a transition element and shares similarities with ion such as the formation of highly stable complexes and easy electron transfer.

$$Cu^{2+} \underset{-e^-}{\overset{+e^-}{\rightleftharpoons}} Cu^{+}$$

In the redox reactions of the terminal oxidase of copper enzymes react directly with molecular oxygen. Terminal oxidation in living cells is therefore catalysed by copper and not ions (NRC, 1989).

2.6.5.2 Population at risk of copper deficiency

The concentration of copper in human fetus increases substantially during gestation in about half of the total fetal copper accumulating in the liver (Widowson *et al*., 1974). The relatively constant copper concentrations in most tissues indicate sufficient dietary intake

and effective homeostatic control of copper. However, epidemiological and experimental animal studies suggest a positive correlation between the zinc-to-copper ratio in the diet and the incidence of cardiovascular diseases (Heaney, 1993).

2.6.5.3 Dietary sources and usual intake of copper

Organs like liver are the richest sources of copper in the diet, followed by sea foods, nuts and seeds. The concentration of copper in drinking water is highly variable. It is much influenced by the interaction of the water acidity with the piping systems. Copper containing fungicides spread on agricultural products may be met as adventitious additional copper supplement in food. Human milk contains approximately 0.3 mg/liter; cow's milk only about 0.09 mg/liter (Varo *et al.*, 1980).

For male and female adults daily intake of copper based on the extensive analysis done by the US food and drugs administration is averaged about 1.2 and 0.9 mg, respectively, from 1982 – 1986 (WHO/FAO, 2004)

2.6.5.4 Excessive intake and toxicity of copper

FAO/WHO expert committee concluded that no deleterious effects can be expected in humans whose copper intake is 0.05 mg/kg body weight per day (FAO/WHO, 1971). Intakes of copper diets in the US supply 5 mg/day, and an occasional intake of up to 10 mg/day is probably safe for human adults. However, over toxicity from dietary sources is extremely rare in the US population (NRC, 1977).

2.6.6 Cadmium

2.6.6.1 Chemistry of cadmium

Cadmium and its congeners are not considered transition metals, in that they do not have partly filled d or f electron shells in the elemental or common oxidation states (Cotton, 1999). Average concentration in the earth's crust is between 0.1 and 0.5 parts per million (ppm). It was discovered simultaneously by Stromeyer and Hermann, both in Germany, as an impurity in zinc carbonate (Kirk-Othmer, 1999).

2.6.6.2 Biological and neurological roles of cadmium

Cadmium has no known useful role in higher organisms (Hogan, 2010). A role for cadmium in lower lifeforms has recently been found. A cadmium-dependent carbonic anhydrase has been found in marine diatoms. Cadmium performs the same function as zinc in other anhydrases, but the diatoms live in environments with very low zinc concentrations and thus they utilize cadmium to perform functions normally carried out by zinc. The discovery relied on the use of X-ray absorption fluorescence spectroscopy (XAFS) (Lane and Morel, 2000), shown that highest concentration of cadmium can be absorbed in the kidneys of humans, and up to about 30 mg of cadmium is commonly inhaled throughout childhood and adolescence and, since cadmium replaces zinc it plays an important roles in type II diabetes mellitus if zinc is depressed (Lane and Morel, 2000).

Cadmium is a transferable element in the soil and is taken up by plants primarily through the roots. The cadmium transfer into plants is determined by cadmium levels, pH values, and humus levels. These factors determine cadmium levels in the soil solution and thereby the plants' availability to cadmium. The accumulation even at low soil levels of < 1 mg/kg, with pH values under 6.5 is of high risk. These pH values and soil

contamination levels are due to the test done to agricultural areas. Any plant contamination can be traced directly to soil situations (Hogan, 2010).

Enzymatically degraded to cadmium-cysteine complexes in the biliary tree, cadmium re-enters the small intestines (Zalups, 2003). Neurologically, cadmium can be used to block calcium channels in chicken neurons.

2.6.6.3 Cadmium source and exposure

In countries like Australia, cadmium in soils occurs at very low levels as they are present in some fertilisers and other products that are added to soils. Important sources are fertilizers containing phosphorus (P); by-product gypsum (phosphogypsum); certain zinc additives; biosolids (sewage sludge); manures and other organic wastes. Within the soil cadmium will be there for a very long time of almost 100 to 1000 years for the amount of cadmium in the soil to halve. Cadmium is more available to plants including vegetables that are grown in soils that are very sandy, acid and/or low in organic matter. (Taylor, 1997).

In order to reduce the risk of cadmium fertilizers in cadmium should be applied, over fertilization withheld, addition of lime to acid soils [pH($CaCl_2$) less than 6.0], keeping soil's zinc level up, plant varieties that take up less cadmium should be chosen. Also, soil organic matter levels should be increased and ensuring good irrigation water (Jarup, 1998).

Cadmium levels buildup in the water, air, and soil has been occurring particularly in industrial areas. In Japan environmental exposure to cadmium has been shown a troublesome where many people have consumed rice that was grown in cadmium contaminated irrigation water producing a disease called *itai-itai* (Taylor, 1997).

But greater levels accumulation may be found in adult animals' liver and kidneys (Jarup, 1998). However, cigarettes exhibit as a significant source of cadmium exposure. In tobacco there is less cadmium than in food, thus high risk of tobacco is due to the ability of the lungs to absorb cadmium more efficiently than food in the stomach (Taylor, 1997).

2.6.6.4 Toxicity of cadmium

The most dangerous form of occupational exposure to cadmium is inhalation of fine dust and fumes, or ingestion of highly soluble cadmium compounds (Kirk-Othmer, 2009). Inhalation of cadmium-containing fumes can result initially in metal fume fever but may progress to chemical pneumonitis, pulmonary edema, and death (Hayes, 2007).

2.6.6.5 Upper limit of cadmium

Cadmium in food is a potential threat to human health. For example, long-term accumulation in the body may lead to kidney damage. Health authorities have set an upper limit for cadmium in root, tuber and leafy vegetables. This is called the 'Maximum Permitted Concentration (MPC)' and is set at 0.1 milligrams per kilogram (mg/kg) of fresh weight (Bilczuk *et al*., 2009).

2.6.7 Iron

2.6.7.1 Role of iron in human metabolic processes

One of the major functions of iron in the body is to serve as a carrier of oxygen to the tissues from the lungs by red blood cell hemoglobin. It acts also as a transport medium for electron within cells, and as an integrated part of important enzyme systems in various tissues (WHO/FAO, 2004).

2.6.7.2 Population at risk for iron deficiency

Infants, children, adolescents women of childbearing age, especially pregnancy women are at higher risk for iron deficiency. Iron supplement in developing countries is still very critical in many groups especially infants in weaning period for brain development and muscle tissues (WHO/FAO, 2004).

In deeper clarification iron deficiency is defined as haemoglobin concentration below the optimum value in an individual, whereas ion deficiency anaemia implies that the haemoglobin concentration in a population (disregarding effects of attitude, age and sex etc) on haemoglobin concentrations. The confusion arises due to a very wide distribution of the haemaglobin concentration in healthy, fully iron-replete subjects (in women 120-160 g/l, in men 140-180 g/l) (Halloberg *et al*., 1993).

2.6.7.3 Prevalence and causes of iron deficiency

Iron deficiency probably is the most common nutritional deficiency disorder in the world. A recent estimate based on WHO criteria indicated that around 60 – 700 million people worldwide have marked iron deficiency anaemia (DeMaeyer *et al.*, 1985) most of them being in developing countries. But, in developed countries this is even lower and usually varies from 2% to 8%. In many tropical countries, infestations with hookworms lead to intestinal blood losses that in some individuals can be considerable. Egg count in stool can estimate the amount of blood loss, and the seriousness of infestation can vary depending on subjects and region (WHO/FAO, 2004).

2.6.7.4 Effects due to iron deficiency

Demonstration in animal has clearly shown that iron deficiency has several negative effects on important functions in the body (Dallman, 1986). There is an evidence of

reduced physical working capacity of rats due to states of iron deficiency especially during endurance activities (Finch *et al*., 1976; Edgerton, 1972). With iron deficiency in human there also reduced in working capacity with long standing iron deficiency (Scimshaw, 1984). Administration of iron normalizes these changes within 4-7 days. In a recent well-controlled study, administration of iron to non-anaemic but iron deficient adolescent girls improved verbal learning and memory (Bruner *et al.*, 1996).

2.6.7.5 Iron supplementation and fortification

Iron deficiency can generally be combated by one or more of the following three strategies; (i) Iron supplementation which means giving iron tablets to certain target groups such as a pregnant women and preschool children; (ii) Iron fortification of certain foods, such as flour, and (iii) Food and nutrition education on improving the amount of iron absorbed from diet by increasing the intake of iron and especially by improving the bioavailability of the dietary iron (WHO/FAO, 2004).

2.6.7.6 Recommendations for iron intake

It should be noted in Table 5 that there is no figures given for dietary iron requirements in pregnant women because the iron balance in pregnancy depends not only on the properties of the diet but also and especially on the stored irons (WHO/FAO, 2004).

Table 5: Recommended Nutrient Intakes (RNI) for iron for different dietary iron bioavailability (mg/day)

Group	Age	Mean body	Recommended nutrient intake (mg/day) for

	(years)	weight (Kg)	Dietary iron bioavailability of			
			15%	12%	10%	5%
Infants and	0.5-1	9	6.2[a]	7.7[a]	9.3[a]	18.6[a]
Children						
	1-3	13	3.9	4.8	5.8	11.6
	4-6	19	4.2	5.3	6.3	12.6
12.6	7-10	28	5.9	7.4	8.9	17.8
Males	11-14	45	9.7	12.2	14.6	29.2
	15-17	64	12.5	15.7	18.8	37.6
	18+	75	9.1	11.4	13.7	27.4
Females	11-4[b]	46	9.3	11.7	14.0	28.0
	11-14	46	21.8	27.7	32.7	65.4
	15-17	56	20.7	25.8	31.0	62.0
	18+	62	19.6	24.5	29.4	58.8
Post	-	62	7.5	9.4	11.3	22.6
Menopausal Lactating	-	62	10.0	12.5	15.0	30.0

Source: WHO/FAO (1988)

[a] Bioavailability of dietary iron during this period varies greatly
[b] Premenarche
[C] Part adapted in reference from FAO/WHO, 1988

2.6.8 An overall summary of tolerable upper limits for minerals in public health

Table 6 shows the acceptable tolerable upper limits for minerals in mg/kg/bwt

Table 6: Summary of tolerable upper limits for minerals as recommended daily allowances

Mineral	RDA (Recommended Daily Allowance)	TUL (Tolerated Upper Limit)
Calcium	1200 mg	2500 mg
Phosphorus	700 mg	4000 mg
Magnesium	320-420 mg	750 mg
Fluoride	3-4 mg	10 mg
Iron	15-10 mg	45 mg
Zinc	12-15 mg	40 mg
Iodine	150 mcg	1100 mcg
Selenium	55-70 mcg	400 mcg
Copper	0.9 mg	10 mg
Chromium	25-35 mcg	ND (not determined)
Manganese	1.8-2.3 mg	11 mg
Molybdenum	76-109 mcg	2000 mcg

Source**:** Frantz (2003)

2.7 Macronutrients

2.7.1 Chemistry of carbohydrates

This is the main source of energy and constitutes the greatest portion of their diet, as much as 80% in some cases (Latham, 1997). In contrast carbohydrates make up only 45 – 50% of diet of many people in industrialized countries. Carbohyrates are compounds containing carbon, hydrogen and oxygen (6:12:6). They are burned to produce energy, liberating CO_2 and Water. They are in form of starch and sugars. Three important groups of Carbohydrates are: -

a) Monosaccharides, e.g. Glucose, fructose and galactose.

b) Disaccharides, e.g. Sucrose (table sugar), lactose.

c) Polysacharides, e.g. Maltose, starch, glycogen (animal starch).

2.7.2 Carbohydrates and fibers

The value of carbohydrate content of foods given in compositional tables usually is "Carbohydrates by difference" that's the residual weight after subtracting amounts of water, protein, fat, and ash found by analysis; this moiety includes sugars, starches, fiber and small amounts of other organic compounds.

Digestible carbohydrates

About half of total digestible carbohydrates are made up of monosaccharides and disaccharides. These are found in fruits (sucrose, glucose, fructose and pentose) and milk (lactose). Sugars in soft drinks, candies, jams, jellies and sweet desserts are mainly sucrose and high fructose corn syrup. Complex carbohydrates which constitute the other half of digestible carbohydrate intake, are starches found predominantly in cereal grains and their products (flour, bread, rice, corn, oats and barley), potatoes, legumes and a few other vegetables (NRC, 1989).

Fructose product is formed by the enzymatic conversion of some of the glucose in cornstarch to fructose. Its fructose content ranges from 40% to almost 100%. In 1985, high-fructose corn syrup accounted for 30% of the total sweetener supply in the US (Glinsmann *et al.*, 1986).

2.7.3 Dietary fibers

Roles of dietary fibers

The roles of dietary fibers in human nutrition have attracted growing interest in recent years. Much research has been conducted on its physiological functions in the prevention of intestinal disorders in absorption of minerals, serum cholesterol and on their associated analytical methods (Mendeloff, 1984). The wheat fibers which consists only cellulose and Lignin, does not adequately express the nutritional role of sweet potato as a dietary fiber provider.

Fibers may also bind to mineral elements (NRC, 1989). It is recommended that the desirable fiber intake be achieved not by adding fiber concentrates to the diet, but by consumption of fruits, vegetables, legumes, and whole grain cereals, which also provide minerals and vitamins (DHHS, 1986; NRC, 1982).

2.7.4 Lipids/Fats

2.7.4.1 Dietary roles of fats

Fats are desirable dietary constituents for three main reasons. First, they supply on an average mixed diet slightly less than 9 available calories per gram, whereas carbohydrates or proteins supply about 4. Differences between animal and vegetable fats have slight variation. The study states that 8.95 g is supplied by animals and 8.35 vegetable. Secondly, fat increases the palatability of food, partly by its lubricating effect, and increases hunger between meals, since the maximum absorption is about 3.30 hours after ingestion. Thirdly, fats can be sources of the fat soluble vitamins (Beaton, 1969).

2.7.4.2 Chemistry of fat

Triglycerides

The abundant lipids in higher animals and plants are the substances generally called "Fats" these are glycerides, and if they are liquid in room temperatures they are referred as "oils" simple lipids.

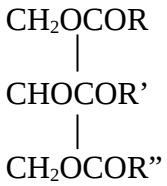

Figure 1: The structure of Triglycerides

2.7.4.3 Dietary sources of lipids

Animal products in particular red meat (beef, veal, pork, lamb), poultry, fish and shellfish, separated animal fats (such as tallow and lard), milk and milk products, and eggs contribute more than half of the total fat to US diets, three fourth of the saturated fat, and all the cholesterol (NRC, 1988).

2.7.4.4 Essential fat acids

The role of linoleic acid in human nutrition is becoming classified (Bivins *et al.*, 1983). Experiments in monkey and rats have shown visual impairment and behaviour differences after consumption of diets deficient in n – 3 fat acids (Neuringer and Connor, 1986).

2.7.4.5 Population at risk

In infants fed formulas deficient in linoleic acid, drying and flaking of the skin have been observed (Wiese *et al.*, 1958). Linoleic deficiency in adult humans was not reported until the early 1970s when several investigators described such deficiency was associated with scaly skin, hair loss and impaired wound healing in hospitalized patients fed exclusively

with intravenous fluids containing no fat (Collins *et al*., 1971; Paulsrud *et al.*, 1972; Richardson and Sgoutas, 1975). Further evidence has shown that the heated cotton seed oil can produce carcinoma of the fore stomach and hepatoma in mice (Peacock *et al.*, 1953).

2.7.4.6 Recommended intake of fat acid

Further recommended by Neuringer and Conner, (1986) the consumption of n-3 fatty acid in humans should be 10 to 25% that of linoleic acid, particularly during pregnancy, lactation and infancy. Also the ratio of dietary linoleic acid EPA and DHA can affect platelet function and inflammatory responses, and may thereby influence the development of certain chronic diseases such as coronary heart diseases and rheumatoid arthritis (Leaf and Weber, 1988).

2.7.4.7 Side effects of fat consumption

It is experienced that the amount of nature of fat ingested affects plasma cholesterol concentration, and that high blood cholesterol levels are strongly related to the incidence and risk of atherosclerotic vascular diseases, especially coronary heart diseases (NRC, 1989).

2.7.5 Protein

2.7.5.1 Roles of protein

The protein molecules are made up of 20 amino acids from which different proteins are made from and arranged in different patterns. The digested proteins become broken and pass through the gut into the blood. Then the amino acids are carried into cells by blood, which are rebuilt them into new protein (King and Burgess, 1996).

The demonstrated functions of proteins in the body are to build new tissues and fluids, replacing the amino acids, help body cell work, protecting the body against infections and act as fuel for energy (King and Burgess, 1996).

2.7.5.2 Dietary sources and absorption

Most animal proteins contain almost the same proportion of each essential amino acid and human proteins. Thus eggs, milk, meat and fish are sometimes called complete proteins. Proteins in plants often contain much smaller amounts of one or more essential amino acids than animal and human proteins, for example maize and beans protein. The bean protein has *methionine*, and maize protein has less *lysine* than eggs (King and Burgess, 1996).

2.7.5.3 Protein requirements

Protein needs for different kinds of people depends on persons size, age, and sex, and for women, or whether they are pregnant or breast feeding. The type of protein and amount of fibers are also very important. However, the following criterions are very important: -

(i) People needs less protein if they eat complete proteins (with a high amino acid score) than if they eat complete proteins (with a lower amino acid score).

(ii) The amount of fiber in a meal affects the amount of protein which is digested into amino acids and absorbed. If a meal contains only a little fiber, more protein is digested, if a meal contains a lot of fiber more protein is digested.

2.7.5.4 Population at risk

For most adults, an even nitrogen balance is ideal, meaning that the amount of nitrogen provided in the diet is equivalent to the amount of nitrogen excreted. In contrast, children

require a positive nitrogen balance to support growth and development, meaning that more nitrogen is supplied by the diet (as protein) than is eliminated. Pregnant and lactating women also require a positive nitrogen balance (The George Mateljan Foundation, 2001-2011). The level of protein intake is presented in Table 7.

2.7.6 Human macronutrient set requirements

The human percentages requirements of micronutrients are based on different sources although the WHO set limits are also available (FAO/WHO, 2004). Generally protein accounts for 16.6%, fat/oils 14.9%, nitrogen 3.3% and moistures (61.8%) (Leaf and Weber, 1988). Other established limits are Crude fibres (1.5-2.0) (Warren and Siciliano, 2010)), and Bregendahl *et al*. (2002) for Ash (3%).

Table 7: Daily protein needs for different sex, weight and age groups

Age	Weight (Kg)	Protein
Children of both sexes		
0 - 1 years	7.3	12
1 – 3 years	11.9	23
3 – 5 years	15.9	26
5 – 7 years	19.6	30
7 – 10 years	25.9	38
Boys		
10 – 12 years	34.0	50
12 – 14 years	43.2	64
14 – 16 years	54.5	75
16 – 18 years	63.6	84
Girls		
10 – 12 years	35.4	52
12 – 14 years	44.2	62
14 - 16 years	51.5	69
16 – 18 years	54.6	66
If pregnant		77
Men – active age		
18 – 60 years	65.0	57
> 60 years	65.0	57
Women - active		
Child bearing age	55.0	48
Pregnant	55.0	55
Lactating	55.0	68
> 60 years	55.0	48

Source: King and Burgess (1996)

All quantities assume large amount of fibers against little amount of protein (except 0-1)

2.8 Food Insecurity Policy

Food insecurity results in substantial productivity losses in both the shorter and long term runs because of reduced work performance, lowered cognitive ability and school performance, and inefficiency or ineffective income-earning decision designed to hedge against food availability and access constraints. Food insecurity thus can lead to a misallocation of scarce resources and loss through sale of productive assets. Food security is essential and people are more emotionally secure and better off psychologically when they have food security.

2.8.1 Population susceptible to food insecurity

Depending on factors such as agro-ecological characteristics, access to land, diversity of income sources and states of development of the economy, food insecure households can be members of different socio-economic and demographic groups in different areas. Nevertheless, some common characteristics of food insecure people emerge, of which poverty is a central one.

A number of common sociodemographic characteristics emerged from a recent cooperative study that looked at income source patterns of malnourished rural poor in 13 survey areas in Africa, Asia and Latin America (Von Braun and Pandya-Lorch, 1991).

The research suggested that: -

1. Food insecure households tend to be larger and to have higher number of dependants and a young age composition.
2. Ownership of land or access to even small pieces of land for farming has a substantial effect on the food security of rural households, even when income level is controlled for the prevalence of food insecurity tends to be higher among landless or quasi-landless households, who are much more dependent on riskier source of income than farm income and diversification of rural economy (Von Braun and Pandya-Lorch, 1991).

2.8.2 Improving food insecurity

Technological innovation and commercialization in agriculture induce economic gain by stimulating agricultural growth, improving employment opportunities, and expanding food supplies, all of which involve and benefit the poor and help to alleviate poverty. (Lipton and Longurst, 1989; Von Braun *et al.*, 1992). A policy of self-sufficiency in food production or adoption of a “Food first” policy that food crops to the exclusion of cash

crops is not necessarily desirable or crucial for alleviation of hunger and undernutrition when market infrastructure and policies do not impair trade (Lipton and Longurst, 1989).

A has been defined by CGP (1999), food preservation is the process of treating and handling food to stop or slow down spoilage (loss of quality, edibility or nutritional value) and thus allow for longer storage. The process usually involves preventing the growth of bacteria, yeasts, fungi, and other micro-organisms (although some methods work by introducing benign bacteria, or fungi to the food), as well as retarding the oxidation of fats which cause rancidity.

2.8.3 Food choice, preference and selection

Eating is a discrete behaviuoral event and the quantity and the quality of child's diet depends upon meal frequency, the amount of food consumed at each meal (meal size) and which food is mostly being preferred and selected for consumption. Possibly, that variation in one of a combination of these parameters can dramatically alter food intake and dietary quality (Meiselman and MacFie, 1996).

2.8.4 Food preservation

Many processes designed to preserve food will involve a number of food preservation methods. Preserving fruit, by turning it into jam, for example, involves boiling (to reduce the fruit's moisture content and to kill bacteria, yeasts, etc), sugaring (to prevent their re-growth) and sealing within an airtight jar (to prevent recontamination) (CGP, 1999).

Traditional food preservation methods

Drying is one of the oldest methods of food preservation which reduces water activity sufficiently to delay or prevent bacterial growth. Other method of Food preservation is

smoking which is mostly used to preserve and give flavour meat, fish and some other foods through the use of smoke, typically in a smoke-house. The combination of heat to dry the food without cooking it, and the addition of the aromatic hydrocarbons from the smoke preserves the food. Vacuum packing, sugaring, salting and pickling are extensively traditionally used from ages (CGP, 1999).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Location

This study was conducted in Meatu and Karatu districts that are located in Shinyanga and Arusha regions respectively. They are both in northern part of Tanzania across the border of Mwanza within Lake Zone. The districts lie between 3º and 4º South and, 34º and 35º East.

3.2 Study Design

A cross-sectional study design was used to collect data from two groups located in Karatu and Meatu districts. Structured and semi-structured questionnaires were used to investigate the temporal patterns for availability patterns of food types consumed. Characterization of food types was determined using several methods shown in the Appendix 4. Macronutrients in particular carbohydrates, proteins, fats and fiber were analysed in most consumed indigenous foods. Analysis was also performed for the following metals Cd, Cu, Cr, Fe, Ca, Zn and Mg from *Shumugo, Magharitako* and *Ekwa* those of which the scientific names were not found. In SUA, inclusive particular macronutrients analysed were carbohydrates, proteins, fats and fiber.

3.3 Sampling and Data Collection

3.3.1 Study area and population

In this study data were collected in Iramba Ndogo village at Sungu hamlet in Meatu district and three hamlets of Qangdend, Mchangani and Mbuyuni nearby Meatu in Karatu district. A total of 259 respondents were involved and included both male and female

adults. Samples of three common roots from Mchangani and Mbuyuni hamlets of Karatu including Sungu hamlet of Meatu district were collected and submitted to SEAMIC for analysis for analyses of Cu(mg/l), Cr(mg/l), Fe(mg/l), Zn(mg/l), Mg(mg/l), Cd (mg/l) and Ca%.

3.3.2 Selection of cases and study villages

Systematic sampling was applied to purposively select villages and subjects. The selected villages were the only places with nomads. Every 'n^{th}' (number of target cases) consecutive subject was drawn starting with a randomly selected number between one and 'n'.

3.3.3 Sample size determination

Sample size determination calculation

The sample size was determined using the formula

$$N = \frac{Z^2pq}{d^2} \quad \text{.....} \quad \mathbf{1}$$

$$N = \frac{(1.96)^2 \times (0.5)(0.5)}{0.05^2} \quad \text{.....} \quad \mathbf{2}$$

where:

N = The desired sample size (when the population is greater than 10,000)

Z = The standard normal deviate, usually set at 1.96 which corresponds to 95 percent confidence level

p = The proportion in the target population estimated to have a particular characteristic. As there is no reasonable estimate then 50 percent (0.50) was used

q = 1.0 – p

d = Degree of accuracy desired, usually set at 0.05 The more convenient standard error (SE) of 1.96 for the Z statistics will be targeted, and thus, a sample size accounted for 384. But then for practical application only 259 subjects were obtained.

3.3.4 Structured interview

A structured interview was conducted to respondents using pretested structured questionnaires (Appendix 1). Pretesting was done to 30 participants outside study villages with field supervisors/interviewers in order for them to clearly understand the study objectives and to ensure that the respondents were able to understand the questions and estimate the time limit expected. The use of other field interviewers fluent in the local language enabled sufficient collection of reliable information from the study subjects.

3.3.5 Secondary sources

Secondary data were obtained from official statistics and reports from previous surveys. Other service statistics included the Health Management Information Systems (HMIS) that assisted in defining the parameters of the problem under the study.

3.3.6 Qualitative data

Reconnaissance or Sondeo methods were applied that accompanied with no guide theme and sample size. Focus Group Discussions (FGDs) with accompanied theme enabled the researcher to shorten the time and reduce the number of personnel required for conducting and analyzing data. An in-depth interview also was organized through unstructured interview that probed to gather in-depth information.

3.4 Chemical Analyses

The chemical analyses carried in this study used analytical grade reagents for both proximate and mineral anayses. These analyses were done at SUA in the Department of Food Science and Technology (proximate) and SEAMIC – Dar es Salaam (mineral analysis).

3.5 Methods for Sample Preparation and Analyses

3.5.1 Sample preparation

The mature and freshly washed but not peeled *shumugo, magharitako* and *Ekwa* roots were dried in oven 105ºC at SUA laboratory in the Department of Food Science and Technology and SEAMIC laboratory where they were labeled, milled to a mesh of 0.15 millimetre sieve size, stored in air tight containers in freezers and analysed at respective centres.

3.5.2 Proximate analyses

The proximate analyses of the three roots (*Ekwa, Magharitako and Shumugo*) were determined according to the Standard Methods of Analysis of AOAC (AOAC, 1995). The samples were analysed in three replicates for crude protein, moisture, crude fats, ash and crude fibre contents using dried samples.

3.5.2.1 Determination of protein

Determination of crude protein was done using Kjeldahl's method (AOAC, 1995 method number 990.03).

Principle

1. Organic compound containing Nitrogen + H_2O_4+ $\xrightarrow[\text{digest}]{Cu^{2+}}$ $(NH_4)_2SO_4$ ……..... 3

2. $2(NH_4)\,SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O + 2NH_3$ ……. 4

3. $NH_3 + HCl \rightarrow NH_4Cl$ ……5

4. Titration of HCL versus NaOH ……. 6

5. Then Final Calculation $M_1V_1 = M_2V_2$ ……. 7

$$\%\text{Nitrogen} = (V_1 - V_2) \times N \times F \times 0.014 \times \frac{100}{V} \times \frac{100}{S} \quad \text{.....8}$$

where

V_1 = Titre for sample (ml)

V_2 = Titre for blank (ml)

N = Nomality of standard HCl solution (0.02)

F = Factor of standard HCl

V = Volume of diluted digest taken for distillation (10ml)

S = Weight of sample taken (g)

The protein content was calculated from the relationship

%Crude protein = %N x 6.25 ……... 9

3.5.2.2 Determination of moisture content

The fresh plants of *Ekwa*, *Magharitako* and *Shumugo* were analyzed for moisture according to standard methods outlined by AOAC (1995), method number 945.38F, 920.39C. The samples were first weighed (W_1) and put in pre-weighed crucibles (W_2) and were oven dried at 105ºC for 24 hours. The crucibles with contents were then cooled in desiccator and reweighed (W_3) until attained constant weight. The amount of moisture in

percentages was calculated as follows:

$$\% \text{ moisture content (fresh weight basis)} = \frac{W_1 - (W_3 - W_2) \times 100}{W_1} \ldots\ldots\ldots\ldots 10$$

3.5.2.3 Determination of fat content

The determination of fat content was performed using soxhlet extraction method (AOAC, 1995 method number 945.38F; 920.39C). The pre-dried 2 g of samples was weighed into extraction thimble and covered with defatted cotton wool. The thimble was placed in an extraction chamber which was suspended above a flask containing the solvent (petroleum ether) and below a condenser then extracted for 16 hours by heating solvent in the flask. The flask containing extracted fat was dried in an oven at 100°C for 30 minutes, cooled in desiccators and weighed. The percentage fat was determined using the following formula.

$$\% \text{ Fat} = \frac{\text{Weight of fat (g)}}{\text{Weight of the sample (g)}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 11$$

3.5.2.4 Determination of ash

Ash content of samples was determined by heating in a muffle furnace as described in standard method (AOAC, 1995 method number 923.03). About 5 g of sample was weghed in a pre-weighed crucible and put in a furnace at 550°C for 3 hours until it established constant weight. The ash was then weighed and expressed as percentage of the original sample weight on dry weight basis. Percentage ash was calculated using relationship:

$$\% \text{ Ash} = \frac{\text{Weight of the ash (g)}}{\text{Weight of the dry sample (g)}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 12$$

3.5.2.5 Determination of crude fibre

Determination of crude fibre was performed using dilute acids and alkali hydrolysis as described by AOAC (1995) method number 994.13 whereby 2 g of the sample was accurately weighed into a 500 ml conical flask and 200 ml of boiled 1.25% H_2SO_4 was poured into the flask and the mixture boiled for exactly 30 minutes under reflux condenser. The digest was filtered through a whatman paper number 54 grade paper held in a funnel and the insoluble matter was washed by boiling water until washing was free from acid. The residue was washed back to the original flask by means of wash-bottle containing 200 ml of 1.25% boiling sodium hydroxide solution heated for 30 minutes under reflux condenser. The residues were filtered, washed with boiling water followed by 1% HCl and finally with boiling water until it was free from acids. The residue was washed twice with alcohol and three times with diethyl ether. After digestion, the residues were dried with glass filter at 100^{o}C for 1 hour, cooled to room temperature to a constant weight and subsequently weighed. The residues were incinerated in the crucible in an electric furnace at 450 – 500^{o}C for about 1 hour until all carbonaceous matters were burnt. The temperature was decreased from 500–200^{o}C and crucible transferred to the desiccators, cooled to room temperatures and weighed. The percentage fibre was calculated using the following formula:

$$\%\ \text{Crude fibre} = \frac{B - C \times 100}{A} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots ...\ 13$$

Where: A = Weight of the sample (g)

B = Weight of the crucible with dried residue after digestion (g)

C = Weight of crucible with ash (g)

3.5.2.6 Determination of carbohydrate content

The carbohydrate content of the samples was determined by difference as described in AOAC (1995) official method described in CAC/VOL IX-Ed.1, and expressed as seen in the following formula:

% Carbohydrates =

100 – (% moisture + % protein + %crude fibre + crude % fat + % ash ash) ……14

3.5.3 Chemical analyses of metals

Determination of metals/mineral content

The ash content was used for analysis for the minerals according to the AOAC (1995) methods (method number 994.02). The ash was dissolved in 20 ml of 1 N HCl and heated for 5 minutes at 80–90^{o}C. The solute was then transferred quantitatively to a 100 ml volumetric flask and made to level with distilled water. Mg, Ca, Cu, Fe, Zn, Cd and Cr were both determined using Flame Atomic Absorption Spectrophotometry (FAAS) at SEAMIC in Dar-es- Salaam (Tanzania) with air acetylene flame at 722 nm. Each sample was analysed in three replicates. The quantification was then accomplished by comparison with standard curve drawn using standard solution of known concentration at 0.5, 1.00, 1.5 and 2.5 ppm. The results were expresses using the following formula:

$$\% \text{ Mineral content (mg/100g)} = \frac{R \times 100 \times DF \times 100}{S \times 1000} \quad \text{……...15}$$

where:

R = Reading value (in p.p.m)

DF = Dilution Factor

S = Sampe weight (g)

(i) Comparison of the Detected (analysed) Means with Tolerable Daily Intakes

Assumption: Roots consumption pattern was 0.2kg (200g) fresh weight root/60kg/day.

The MARL = $\frac{\text{TDI (mg/kg bodyweight) x body weight (60kg)}}{\text{Amount of roots consumed per day (kg)}}$ …….... 16 (Mdegela *et al*., 2008)

The MARL obtained was then compared with the Maximum concentration of heavymetals that were detected in the sample (Table 17).

3.6 Ethical Considerations

Confidentiality of the collected information was strictly maintained. To achieve this, initially, list of names of interviewees was used and later during analysis, codes instead of names of persons were also adopted. For those respondents who did not want to be interviewed their decisions were respected.

3.7 Data Analysis

Data analyses were performed through EPI Info 6.0 of WHO versions and Excel statistical packages. All the data collected through questionnaires were initially coded and summarized in tables. The descriptive statistics such as frequencies means and standard deviations were useful parameters of interest under this study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

Fruits, tubers, roots and vegetables are important component sources of vitamin and mineral (micronutrients) for proper functioning of body systems (WHO/FAO, 2004). Prevention of occurrence of most diseases caused by deficit or excess might be one role performed by these nutrients (WHO/FAO, 2004). This can be further supplemented by proteins and fats as crucial macronutrients for body cells synthesis and somatic heat production respectively, derived from food of animal origin. In order to ensure a complete balanced diet on daily basis, temporal availability patterns of foraged food in nomadic community was critically assessed. Furthermore, additional laboratory analyses for micronutrients together with proximate composition determination in certain common roots/tubers used were carried out.

4.1 Descriptions of key Informants

4.1.1 Common foods eaten by *Hadzabe* nomads

An in-depth interview was conducted with key informants to establish common foods eaten by *Hadzabe* tribe. Lameck Moses Baradesh says, “Many different wild food varieties are consumed by *Hadzabe* that include wild roots/tubers, wild animals and tree leaves as vegetables. Tree leaves such as *Ngobabe or Mibuyu (Adansonia digitata)* are crushed in mortar and boiled before eaten. Roots/tubers are also eaten either being raw or ripe depending on types of wild roots. For instance, *Miswaki* or *Tafabe (Salvadora persia*) and *Shumugo* are eaten raw while *Ekwa* and *Magharitako* are roasted in advance before consumption. *Shumugo* tubers mostly contain water which renders them preferable

due to their quick quench of thirsty and relief for abdominal discomfort after eating. Wild Potatoes (*Ipomoea cairica var)* and *Shukwaayabe* or *Karanga mwitu* (*Alsodeiopsis schumannii)* are sometimes eaten raw.

Ruth Bulugu continues to state that, "for fruits such as *Ngobabe* known scientifically as *Adansonia digitata*, *Midabi/Undushibi/Mpelemese (Grewia platyclada)*, *Tafabe (Salvadora persia), Mbawepi*, *Embelebe/Ntagwasa (Grewia similes), Ngwilabe/Bumende, Kongolobe/Bukoma(Grewia bicolar) Ntobo/Mathakai (Azanza garckeana), Mwipe/ukwaju (Tamarindus indica), Ntundwa (Ximenia americana), Untuwago/Nyuguyu (Balanites aegyptica) and Ngubalu (Athium burtii)* are eaten at the collection sites but also brought home for use by children."

Foods of animal origin are major foods of interest by *Hadzabe* nomads included Chatu/Kidinga (Python), Simba/Seseme (Lion), Chui/Janjai (Leopard), Nyani/Neego (Monkey), Tumbili/Numbiliya (Baboon). Other animals used were Ng'anako/Tandala (Rain deer), Nkanga (Dik dik), Swala/Popoako (Antelope), Kobe/Goloako (Tortoise), Pofu/Komatia (Gnu), Punda/Dongowako (Donkey). Birds eaten were Djago/Kanga (Foul), Kuku/Igongoda (Chicken), Twiga/Dhoganago (Giraffe), Tembo/Deghawago (Elephant), Pundamilia/Dongowako (Zebra), Ng'ombe/Achagiago (Cow) and Mbuzi/Alako (Goat).

4.1.2 Gender roles in collection of foods

Food for family use such as wild roots, fruits, *Manunuako* (fungi) and leaves were commonly collected by women and brought home for use by children and other family members. In rare circumstances men and young children collected *Ngobabe (Adansonia digitata)* and *Mwipe (Tamarindus indica)* and eat fruits at place of harvest. Selectively,

men hunted many types of wild animals excluding hyenas. Ruth Bulugu from Nyerere camp says that, “Hyenas are not interested for consumption due to the reason that its meat contains a lot of fibers that render it unsuitable to eat. All other tamed animals were eaten in case such meat was offered by neighbour *Iraqw* people but such meat is not good due to unequal odour sensed during eating. Eggs of wild birds were also collected and eaten raw and sometimes roasted and boiled”.

4.1.3 Eating habits

Hadzabe tribe eats collectively with their children at home. Male adults do mostly eat roots during hunting or at collection sites except for killed animals, which are brought home for skinning, roasting/cooking, preservation and consumption by family members.

4.1.4 Seasonal acquisition of foods

Many wild root plants were collected almost in the entire season of a year but fruits were sometimes foraged early during dry season and entirely vanish in wet season. Similarly, animals migrated far during dry season due to lack of green pastures and became very difficult to trace and hunt them.

4.1.5 *Hadzabe* views on their future lives

The nomadic lives of *Hadzabe* are funny and interesting. They do not own properties such as cow; goat and hen except that only dogs were used as for hunting purpose. They spend in whole day hunting, collecting fruits/roots and participating in occasional ceremony. They did not own land for farming and housing. Whenever they find a loose and free forests may settle and establish residences. The residences of *Hadzabe* in Karatu

district are now being divided into almost 8 camps in Qangdend village which are accommodated within 6 hamlets meanwhile in Meatu they are found at Irambandogo village in *Sungu* hamlet with established family residences.

Kampala Magandula of Karatu says, "*we are living awkwardly now due to many areas being encroached by other tribes. Hunting areas are diminishing and animals are disappearing. He continues saying, we shall be more interested if the government will opt to reserve our own land for hunting but there is no need of land for tilling since the work is difficult and we are accustomed to hunting for many years. We are interested living in our own huts and when rains come we migrate in caves for safety." Living in corrugated iron sheets normally is a problem because when raining start it hits above and provokes to anger our ancestors. Generally we are not supposed to live in such houses"*. Figure 2 describes of the *Hadzabe* residence underneath the big tree.

Figure 2: The researcher and family members in their residence area

Figure 3: The researcher, research assistant and family members of Shadrack in their residence (cave) in Karatu district

4.1.6 Reaction of living together with other tribes

Living together with other tribes is difficult because other tribes kill *Hadzabe* tribe. Kampala says, “In the earlier time we tried to live together but our children died, that forced us to return back into our forests. Also, we fail to join due to the fact that our ancestors’ night dance (*epeme*) will fail”

4.1.7 Care of children

Children in *Hadzabe* nomads are cared normally as other tribes’ children are cared. For sick children, local herbs are used to treat them whereas attendances to clinics for immunization are a rare instance.

4.1.8 Cultural ceremonies

Cultural ceremonies in *Hadzabe* tribes are held when a big animal like a giraffe or elephant is killed where they come together and establish a temporary settlement near the killed animal. This ceremony is held until the eating of the animal is entirely exhausted,

and then moves to another settlement. Other ceremonies are wedding and *epeme* ‘ancestral dances done during the midnight’ that involve all family members.

4.1.9 Marriage rituals

Marriage rituals in *Hadzabe* nomads are performed by dowry payment as other tribes do. Geofrey Sambega of Mbuyuni hamlet is a leader (Lalai) of the cave/camp. He says that, “When a young boy wants to marry a young girl, a ceremony is held (*Hunanigo waah gwachita akwitiko)*, boy elopes the girl then information is sent to parents of a girl by an elder brother to narrate about the event. An agreeable bride dowry is then paid, which is male Gnu *(Komatia yagamba)*, male Warthorg *(Kwani yagamba*) and then alcohol made from *Adansonia digitata* fruits is prepared, means *(Ndulibii guyipi ambalako Ngobabe)*. Also, honey, beads, Marijuana and a killed monkey are offered as dowry to parents in law. They make sure that marriage ritual is conducted within indigenous and not outside the fellow tribe members. After child birth a ceremony is held with relatives concurrently with cooked meat, which is eaten whilst dressed in beads.

4.1.10 Household leader

The family leaders of *Hadzabe* nomads were formerly selected at a certain rendezvous of cultural ceremony after killing a large animal like an elephant or giraffe. A wise elder person is elected from the kinship and appointed to be a leader. Presently a group leader from respective camp may be selected to be a leader.

4.1.11 Socialization of *Hadzabe* children

Hadzabe children normally have their own roles in the family. They spend a day with grandmothers at home while other family members are in collection of foods. They learn

how to make small weapons such as arrows and playing games and at some other time accompany their parents to alcohol club.

4.1.12 *Hadzabe* history

Kampala Magandula says,"through narration the history of our tribe starts long time ago. Our parents originated in South Africa where they travelled and reached Tanzania, then widely distributed in the regions of Mbeya, Shinyanga, Arusha and Manyara". From his own knowledge Magandula says, "they migrated from Dilodabe in Hanang where they travelled to Yaeda Chini – Mbulu and later to Qangdend village in Karatu'.

4.1.13 Illness and death

Whenever a person fall sick, a patient is always treated by different plant roots known to cure certain kind of diseases. Wild roots which are used include *Tafabe* (*Salvadora persia*) for treating Sexual transmitted Infections (STI), *Kerangei* (*Aloe vera*) which are intermingled with other cobwebs to develop a local vaccine termed as '*Lukagoako'* for prevention of bewitched illnesses. *Puthuputhu* is an herb used to treat dysentery.

When unfortunately, a person dies, few people are selected to carry the corpse into Aadverk animal dug hole (*Shimo la Muhanga*) for burial. In case there is no hole exist they try to borrow a hoe from the neighbouring *Iraqw* tribe and make a tomb. Death to *Hadzabe* nomads is threatening event. In the earlier when a person died they moved from the former temporary camp or residence then killed a large animal which was placed aside the corpse covered with animal skin so that when carnivores such as hyena comes can eat the animal together with the corpse. Later when they come to check and find the

corpse disappeared they become reassured that their relative has been taken by God "*Haine*". In case burial ceremony is finished normally they move to other places '*abasaota ihuaka icheyamua haama kweshaata dusaga*'

4.2 Strategies Done by Government Leaders to Supply food to *Hadzabe*

4.2.1 Water supply

Philipo Nducha, the District Administrative Secretary of Karatu states that, 'water supply to the *Hadzabe* nomads is a major problem. Since most of them do not have a permanent place to settle, it becomes very difficult for the government to provide water for household use. At the mean time they use water from the rivers and naturally occurring dumps/depressions. Although the water used is not safe they normally adapt to the existing situations and no diarrhea diseases from *Hadzabe* are reported to hospitals'. Figure 4 shows the main water source used by both human and animals of all kind.

Figure 4: The main source of water supply used by hunter-gatherer nomads shared with animals in Karatu district

4.2.2 Housing

In the past, the government tried to bring together the *Hadzabe* nomads by constructing houses for their living but later the *Hadzabe* left such houses and went back to their former residences for easy search of food meaning that they do not require such houses.

4.2.3 Food supply

Hadzabe nomads depend primarily on wild animals, wild plant roots, wild fruits and honey from the forests. However, additional supply of food by the government has been done since July 2010. Food is supplied on weekly basis to all *Hadzabe* households.

4.2.4 Health services

Health services delivery to *Hadzabe* is a major problem. They do not depend on public health services for their ill health. Tree herbs are normally used to treat different diseases such as Sexually Transmitted Infections (STI), pneumonia, dysentery and malaria. Although the government has provided the *Hadzabe* people with the Lutheran Health Centre at Mang'ola (Karatu) and Sungu dispensary at Meatu district only a few of them can attend the health services.

For preventive services such as immunization for outreach campaign, the government tries to reach the remote areas monthly through routine mobile services although such services cannot guarantee coverage to the entire community. All types of immunization of major preventable diseases are offered by the government.

4.2.5 Education

The government in Karatu and Meatu districts has constructed boarding schools as for accommodation of nomadic children. Despite of school provision, food is also supplied

relative to the allocated budget by the departments of concern including all the essential needs at school. Inclusively with the World Food Programme (WFP), the government has achieved to bring together the nomadic children of Longido district at Qangdend village (Karatu) where food is supplied regardless of their inequality in ecological zones. At least 150 children are being admitted to such school. Indicated in Figure 5 are the two *Hadzabe* children who has desserted the tendency of skin wearing.

Figure 5: Nkamba Tunya (left) and Hollo Tunya (right) the *Hadzabe* children schooling at Sungu Primary School at Meatu District

4.2.6 Successes of the government support to nomads

The governments in both districts of Karatu and Meatu have succeeded to adequately supply education and educational essential needs. Also, food availability and demand to nomads has been met. Health services in particular, immunization has been delivered successfully to nomadic children although the overall total figure is not known.

4.2.7 Constraints

The effort to bring together the nomads has become a major problem. Also, many bandits are being involved in nomadic community. There are other people from outside the tribe

who are normally against the law who find the way to intermingle with *Hadzabe* livings. Provision of specific reserved area for their future survival is yet to be realized apart from the failure of provision of safe water supply. Finally, the Wildlife Management Areas (WMA) is not specifically allocated with boundaries the reason of which the *Hadzabe* tribe presses a demand to have own rights on wild animals to kill.

4.3 Focus Group Discussion (FGD) in Meatu

FGD was conducted to both districts of Meatu and Karatu. Major themes under discussion regarded the types of indigenous foods consumed by *Hadzabe* tribe and the patterns of foods relative to seasonal availability.

A group of at least 12 people from the 3 groups in Sungu village participated in this discussion. One group consisted of male and female adults while the other two groups were composed of males and females alone (Meatu).

It was discovered that different wild foods were eaten by tribe. Those included wild fruits, wild animals, roots and honey. Some animals were not eaten due to the fact that they were important in ancestral ceremony *'mitambiko'* such as gnu, giraffe and monkey for a woman who requires restoration of birth.

Also as has been said by the group, the availability of wild foods such as animal meat, fruits and roots were difficult due to the game reserves encroachment by Coalman wildlife within WMA at Makao, Ngorongoro and Serengeti reserves. At that time there was no specific area to hunt. Their husbands have been held in custody due to illegal hunting. Indicated in Figure 6 is a meeting as for FGD held in Sungu, Meatu. Worn in

clothes (not skin), are *Hadzabe* that has undergone transformation (acculturization) occurring in Meatu rather than in Karatu.

Figure 6: Members of a Focus Group Discussion at Sungu Meatu district

4.4 Focus Group Discussions (FGDs) in Karatu

The meeting was held at Nyerere Camp at Qangdend village at Eyasi division with 8 individuals in a group of mixed gender. The main theme was to investigate the patterns of seasonal availability of Food. They said that the availability of food to *Hadzabe* especially wild animals were a major problem during dry season. Weakly distribution of food by government was done but still the food was insufficient.

Also they said, assistance from the government is required to allocate them with their own specific areas of hunting ever since animals migrate far into game reserves during the time of dry season. They were not allowed to hunt into reserved areas.

4.5 Socio-Demographic Characteristics of Respondents

Table 8: Socio-demographic characteristics of respondents

Item	Distribution of Respondents	
	Frequency (n)	Percent
Age Group (years)		
15 - 24	71	27.4
25 - 34	92	35.5
35 - 44	48	18.5
45 - 54	34	13.2
>55	14	5.4
Total	**259**	**100.0**
Gender		
Female	127	49.0
Male	132	51.0
Total	**159**	**100.0**
Level of Education		
Attended	63	24.0
Not attended	196	75.7
Total	**259**	**100.0**
Marital Status		
Married	200	77.2
Devorced	11	4.2
Unmarried	46	17.8
No Answer	2	0.8
Total	**259**	**100.0**
Religion		
Traditional	232	87.6
Christian	25	9.6
Islamic	0	0.0
No answer	2	0.8
Total	**259**	**100.0**
Occupation	259	100.0
Hunter-gatherers	250	96.5
Businessmen/hunter gatherers	1	0.4
Others	8	3.1
Total	**259**	**100.0**

From the findings and Table 8, the overall 92 (35.5%) interviewees were at the age of 25 – 34 while 14 (5.4%) were at the age of 55 and above. Female subjects were 127 (49%) compared to 132 (51%) male who resided in eight hamlets of Qangdend village of Karatu district and one hamlet of Sungu at Iramba ndogo village of Meatu district. Of all interviewees 63 (24.3%) of them had primary school or ordinary level education. The rest, 196 (75.7%) had no formal eduction.

Regarding marital status, 200 (77.2%) of them were married while fewer 11 (4.2%) were divorced. Most of them 232 (87.6%) had traditional religion versus 25 (9.7%) who believed in Christianity. Islamic religion accounted for nil believers. Most nomads 250 (96.5%) were hunter-gatherers and only few 1 (0.4%) were either business or hunter-gatherers.

4.6 Assessment of Baseline Information of Common Wild Foods Consumed

A study was conducted to ascertain different types of fruits, vegetables and roots foraged by *Hadzabe* nomads. The results of common wild foods consumed were as summarized in Table 9.

Table 9: Types of fruits, vegetables and roots collected and foraged by *Hadzabe*

S/N	Indigeneous/Swahili names	Scientific names[a]	Part of tree used		
			Leaves	Underground parts (roots)	Seeds/fruits
1	Shandeyeko	—	√		
2	Ngwilabe	—	√	√	√
3	Shukwaayabe	—	√	√	√
4	Undushibi/Mkole	*Grewia platyclada*	√		√
5	Ngobabe/Mibuyu	*Adansonia digitata*	√		√
6	Doiako	—	√	√	√
7	Tafabe/Mswaki	*Salvadora persia*	√	√	√
8	Embelebe/Mkole	*Grewia similes*	√		√
9	Wild Nuts/Karanga pori	*Alsodeiopsis schumanii*	√	√	
10	Ng'ang'a	—	√		
11	Ekwa	—	√	√	√
12	Ngwingwila	—	√		
13	Kapuloko	—	√		
14	Mkokoma	—	√		
15	Sonodaro	—	√		
16	Kuchukuchu	—	√		
17	Kyubu	—	√		
18	Tloboko	—	√		
19	Ngwabi	—	√		
20	Wild potato/Viazi mwitu	(*Ipomoea cairica var)*	√	√	
21	Mbigiriko/Mbigiri	*Tribulustrrestris*	√		
22	Nate	—	√		

Table 9: (Contd).

23	Lutendi/Mrenda	—	√		
24	Watsenabe	—	√		
25	Meshalobe	—	√		
26	Kombiabe	—	√		
27	Mogapi	—	√		
28	Songapi	—	√		
29	Ngubalu	*Athium burtii*	√	√	
30	Mathakai/Mnduwe	*Azanza garckeana*	√		

31	Ntundwa/Mpingi	*Ximenia americana*	√	√		
32	Shumugo	—	√	√		
33	Shakiago	—		√		
34	Komokoko	—		√		
35	Ndundu	—		√		
36	Magharitako	—		√		
37	Panjugo	—		√		
38	Mwatugwako	—		√		
39	Nyuguyu	*Balanites aegyptica*				√
40	Kongolobe/Mkole	*Grewia bicolar*				√
41	Kondola	—				√
42	Meselekwape	—				√
43	Kalaige	—				√
44	Mwipe/Ukwaju	*Tamarindus indica*				√
45	Panjugo	—				√
46	Ngoka	—				√
47	Sogosogopi	—				√

(√) Indicates that scientific names unavailable

[a] Source: Ruffo *et al*. (2002)

From Table 9, types of fruits and berries identified were 17 while, 16 root types (underground parts) and 28 leaves that were customarily consumed as food were identified. Within the identified categories, 5 types of plants of leaves, fruits and roots were eaten as food.

The data of cross-sectional assessment of food profile based on fruits/berries, vegetables/leaves and roots foraged by hunter-gatherer nomads showed identical consumption of both products within the sampled districts. Only 15 scientific names of plant species were identified from a list of 47 product species. The existence of many different varieties of tree species implies sustainable continuity in collection and use of such foods, if the seasonal pattern of its availability and preference is kept into little consideration (Meiselman and MacFie, 1996). On the other hand, much reliability of food which only focuses its growth during rainy seasons may lead to serious deficiency to the oncoming season, if storage and preservation tendencies are disregarded (CGP, 1999).

The common wild animals which are consumed by *Hadzabe* tribe were assessed and the results were as indicated in Table 10:

Table 10: Common wild animals and food types identified that were eaten by *Hadzabe* nomads

S/n	Indigenous/Swahili names	English name	Scientific name[a]	Food eater
1	Sungura	Hare	*Lagomorpha lepridae*	Herbivorous
2	Chui/Janjai	Leopard	*Panthera pardus*	Carnivorous
3	Simba/Seseme	Lion	*Panthera leo*	Carnivorous
4	Nguruwe mwitu	Pigs	*Suidae suinae*	Herbivorous
5	Faru	Black Rhinoceros	*Diceros bicornis*	Herbivorous
6	Swala/Popoako	Antelope	*Alcelaphus buselaphus*	Herbivorous
7	Nja	Gazelle	*GAZELLE gazelles*	Herbivorous
8	Fisi	Hyenae	*Crocuta crocuta*	Omnivorous
9	Twiga/Dhoganago	Giraffe	*Giraffa camelapardalis*	Herbivorous
10	Tembo/Deghawago	Elephant	*Lexadanta africana*	Herbivorous
11	Pundamilia/Dongowako	Zebra	*Equus burchellii*	Herbivorous
12	Mbogo/Nyati	Buffalo	*Syncerus caffer*	Herbivorous
13	Digidigi/Nkanga	Dik-Dik	*Madoqua kirkii*	Herbivorous
14	Nyani/Neego	All Monkeys	*Macaca fascicularis*	Herbivorous
15	Pofu/Komatia	Gnu	*Connochaetes taurinus*	Herbivorous
16	Chatu/Kidinga	Snake/Python	*Antaresia stimsoni*	Omnivorous
17	Fungo	Polecat	*Mustela putorius*	Carnivorous
18	Panya	Rats	*Ratus norvegicus*	Herbivorous
19	Tumbili/Numbiliya.	Baboon	*Papiocynocephalus*	Herbivorous
20	Nungunungu	Porcupines	*Erythizon dorsatum*	Herbivorous
21	Sindi/Kindi	Squirrel	*Sciurus calolinis*	Herbivorous
22	Nguchiro	Mangoose	*Helogale parvula*	Carnivorous
23	Kongoni	Hartebeest	*Alcelaphus buselaphus*	Herbivorous
24	Paa	Topi	*Damaliscus lunatus*	Herbivorous
25	Ngiri	Warthog	*Phacochoerus africanus*	Herbivorous
26	Pimbi	Skunks	*Mephitis mephitis*	Herbivorous
27	Kobe/Goloako	Tortoises/Turtles	*Chelonial tytonidae*	Herbivorous
28	Muhanga	Aadvark	*Orycteropus affer*	Herbivorous
29	Nyumbu	Wildbeest	*Taurotrogus oryx*	Herbivorous
30	Punda/Dongowako	Donkey	*Equus asinus*	Herbivorous

[a] Sources: Klappenbarch (2011)

Table 10 shows that there are almost 29 types of wild animals consumed as food of animal origin by hunter-gatherer nomads from districts of Meatu and Karatu. An additional tamed animal called donkey (*Equus asinus)*, which is not consumed by neighbouring *Iraqw* tribe was also consumed.

Foods of animal origin were assessed due to the fact that they immensely contribute to protein, fats and energy in a meagre state. At least each animal that got into *Hadzabe* sight and boundary was killed for food. However, this applicability of wild meat food in the purposively sampled districts seemed equally distributed except for the fewer inhabitants of Sungu hamlet in Meatu who were debarred of wild meat use by law enforcement. Precise dependability on wild meat has been rather seen projected to *Hadzabe* than the use of tamed animals as they generally did not possess any property of their own (Jones *et al.*, 2002). It is important that, the extensive use of meat alone can result into some deficiencies or protein toxicity if consideration to sufficient starchy food supplements is simply overlooked (WHO/FAO, 2004)

4.7 Seasonal Availability Patterns of Food Consumed by *Hadzabe*

4.7.1 Workload to women

Table 11 indicates workload distribution in the studied community:

Table 11: Roles of family members in collection of food by *Hadzabe* nomads (N=259)

Responsible person	Distribution of respondents			
	Leaves	**Roots/tubers**	**Fruits**	**Animal hunting**
1. Women	236(91.1)	245(94.6)	254(98.1)	5(1.9)
2. Men	4(1.5)	11(4.2)	2(0.8)	252(97.3)
3. Children	1(0.4)	0(0.0)	0(0.0)	0(0.0)
4. All the above	1(0.4)	1(0.4)	0(0.0)	0(0.0)
5. No response	17(6.6)	2(0.8)	3(1.2)	2(0.8)
Total	**259(100.0)**	**259(100.0)**	**259(100.0)**	**259(100.0)**

( ) Numbers in parentheses are percentages.

Table 11, indicates that women played a big role in collection of leaves 236 (91.1%), roots/tubers 245 (94.6%), fruits 254 (98.1%) and men participated fully in hunting activities 252 (97.3%).

In addition, caring of children at home and during food gathering were also tasks that women performed. However, the observed differences might be the reason as to why many children suffered malnutrition and deaths (Hill and Hurtado, 1989; Pointing, 1995).

4.7.2 Food availability patterns

Food availability patterns were investigated and the results were as indicated in Table 12:

Table 12: Distribution of respondents on availability and durability patterns of certain honey, milk and money for commodity purchase (N = 259)

Item	Distribution	
	Frequency (n)	Percent
Honey availability		
Hives	1	0.4
Caves	218	84.2
Caves and anthills pits	9	3.4
Anthills pits	30	11.6
No response	1	0.4
Total	**259**	**100.0**
Honey Durability		
0 – 6	54	20.8
7 – 12	10	3.9
13 and above	192	74.1
No response	3	1.2
Total	**259**	**100.0**
Milk availability		
Buying	78	30.1
Milking of Cow	5	1.9
Don’t know/No response	176	68.0
Total	259	100.0
Money availability		
Sale of Honey/Wild Meat	65	25.1
From tourists	14	5.4
Herdsmen	3	1.2
No response	177	68.3
Total	**259**	**100.0**

Indicated in Table 12, honey was always collected by the majority from caves 218 (84.2%) while the minority 1 (0.4%) obtained their honey through hives. Durability of the collected honey was more than a year at home as was responded by 192 (74.1%) interviewees. Milk as well was purchased by 78 (30.1%) nomad respondents through money that was obtained from sale of honey and meat 65 (25.1%) with the fewer 3 (1.2%) who purchased honey through money received from herdsmen.

The findings were discussed relative to availability and accessibility of certain food such as honey, milk and meat. Caves were the main home of bee breeding. At least more than 80% respondents received most of the honey from caves with the minority (1%) from hives. Honey was one of the food products persistently availed for more than 12 months. The milk which was entirely unavailable was rarely obtained through purchase with money that was generated from sale of honey and wild meat from neighbouring tribes. The availability of honey was hardly harvested traditionally by chance from caves to the community as they lacked awareness on appropriate technological means in hives designing and installing such technology. The tendencies observed implied that, disappearence of bushes will automatically cause disappearance of honey and hence lack of income from honey for other purchases.

Similarly, wild meat was the major raw food materials used for sale to obtain other household commodities. The disappearing of bushes and wild animals may result in lack of meat and consequently lack of income diversity in this community. The combination of the factors may lead to impaired food productivity, susceptibility to hunger and malnutrition problem (Lipton and Longurst, 1989).

Table 13 indicates the methods of preparation of certain foods to nomads.

Table 13: Methods of preparation of certain foods from meat, roots/tubers and mushrooms before being eaten by respondents (N = 259)

Item	Distribution	
	Frequency (n)	Percent
Meat		
Slaughtering then cook	44	17.0
Roasting	186	71.8
Eaten raw	28	10.8
No response	1	0.4
Total	**259**	**100.0**
Roots/tubers		
Cooked and Eaten	31	12.0
Cooked also eaten raw	1	0.4
Eaten raw but also roasted	207	79.9
Burnt on open fire	8	3.1
Don't know/No response	9	3.5
Total	**259**	**100.0**
Mushrooms		
Cooked and eaten	85	32.8
No response	174	67.2
Total	**259**	**100.0**

As shown in Table 13 the majority 186 (71.8%) of all respondents roasted the meat before consumption while 28 (10.8%) it raw. For roots and tubers 207 (79.9%) on *Hadzabe* nomads such products were eaten raw at site of collection but also roasted them at home. At least 85 (32.8%) ate cooked mushrooms while most (67.2%) of them did not use mushrooms.

Meat was generally leading among the wild collected foods. Prior to consumption, preparation and preservation means adopted, normally determined the extent of its safety and durability patterns. Roasting the meat on an open furnace was among the habits of food preparation, whereas eating it while raw influenced only by the delicacy of certain internal organs such as a liver, kidney and stomach. Apart from internal organs, other

tough meat was roasted to easy digestibility and prevent early perishability but not for the sake of killing the microorganisms (CGP, 1999). Similarly, tubers/roots were eaten raw while other roots were roasted to ease digestibility. Fewer (0.4%) respondents ate raw roots without subjecting them to heat. Also, mushrooms were prepared and eaten at low frequency whereas the other majorities were neither aware nor interested in the food type (Meiselman and MacFie, 1996).

However, the methods employed in meat usability did not absolutely observe the desired requirements of traditional means of preparation and preservation of food (CGP, 1999; http://agriculture.indiabizclub.com/info/coperates, 2011). It is very potential that the use of the remote means of food preparation and preservation be kept into consideration, since this may lead to meat borne diseases such as cystercosis, tuberculosis and other disease.

Food availability patterns were investigated to assertain the chronological application and the results were given as indicated in Table 14:

Table 14: Frequency distribution of respondents on food patterns availability of *Hadzabe* nomads (N = 259)

S/n	Food types	Season for availability			
		Dry	Rainy	All (Rainy & Dry)	No response
1	Roots/tubers	18(6.9)	30(11.6)	210(81.1)	1(0.4)
2	Tree barks	1(0.4)	20(7.7)	74(28.6)	164(63.3)
3	Leaves/Vegetables	5(1.9)	183(70.7)	64(24.7)	7(2.7)
4	Wild fruits	59(22.8)	95(36.7)	105(40.5)	0(0.0)
5	Wild meat	14(5.4)	2(0.8)	241(93.0)	2(0.8)
6	Animal Blood	0(0.0)	0(0.0)	9(3.5)	250(96.5)
7	Milk	0(0.0)	39(15.1)	47(18.1)	173(66.8)
8	Eggs	16(6.2)	156(60.2)	85(32.8)	2(0.8)
9	Fishes	31(12.0)	61(23.5)	10(3.9)	157(60.6)
10	Honey	24(9.3)	140(54.0)	94(36.3)	1(0.4)
11	Termites	0(0.0)	9(3.5)	3(1.1)	247(95.4)
12	Fungi	0(0.0)	102(39.4)	5(1.9)	152(58.7)

Numbers in parentheses are percentages

As indicated in Table 14 roots and tubers 210 (81.1%), wild fruits 105 (40.5%), wild meat 241 (93.0%), were both of them collected during both rainy and dry seasons. Meanwhile leaves 183 (70.7%), honey 140 (54.0) and eggs 156 (60.2%) were selectively found during rainy season. Tree barks 164 (63.3%), animal blood 250 (96.5%), Milk 173 (66.8%), fish 157(60.6), termites 247 (95.4) and Fungi 152 (58.7%) were mostly not used by respondents.

Over half of the hunter-gatherer respondents in Karatu and Meatu had full availability and existence of roots and wild meat during both rainy and dry seasons. Barks, animal blood,

milk, fish, termites and fungi were invariably not used by the majority of respondents. Although honey was the only product being preserved for a prolonged period, its prevalence was high during rainy season. Eggs and leaves prevailed only during rainy season. There was no food product that seemed to be more prevalent during dry saeson. Based on the data collected, fully life dependency of nomadic society was based on roots/tubers and meat. Honey was food supplement preserved that reinforced life stability as a cash crop.

Table 14 shows the frequencies of food types: -

Table 15: Frequencies of food types by likerd method of ratings (N = 259)

S/N	Food types	Like most (1)	Like (2)	Undecided (3)	Don't like (4)	Don't l. most (5)	Total Resp
1	Roots/tubers	198(76.4)	52(20.1)	0(0.0)	9(3.5)	0(0.0)	259(100)
2	Tree barks	1(0.4)	15(5.8)	35(13.5)	107(41.3)	101(39.0)	259(100)
3	Leaves/Veg	75(29.0)	151(58.3)	13(5.0)	18(6.9)	2(0.8)	259(100)
4	Wild Fruits	225(86.9)	33(12.7)	1(0.4)	0(0.0)	0(0.0)	259(100)
5	Wild Meat	238(91.9)	16(6.2)	1(0.4)	3(1.1)	1(0.4)	259(100)
6	Animal Blood	1(0.4)	8(3.1)	40(15.4)	118(45.6)	92(35.5)	259(100)
7	Milk	24(9.3)	56(21.6)	57(22.0)	69(26.6)	53(20.5)	259(100)
8	Eggs	94(36.3)	146(56.3)	8(3.1)	9(3.5)	2(0.8)	259(100)
9	Fishes	50(19.3)	39(15.0)	53(20.5)	60(23.2)	57(22.0)	259(100)
10	Honey	250(96.5)	3(1.1)	2(0.8)	2(0.8)	2(0.8)	259(100)
11	Termites	0(0.0)	5(1.9)	45(17.4)	150(57.9)	59(22.8)	259(100)
12	Fungi	5(1.9)	89(34.4)	34(13.1)	54(20.9)	77(29.7)	259(100)

Numbers in parentheses are percentages

As has been shown in Table 15, honey was the most preferable food (96.5%) and the second was meat (91.9%). Other food products in decreasing order were fruits (86.9%). Around 76.4% of respondents liked most fruits and 58.3% liked vegetables.

Data with food preference ranking shows that honey was one of the most prefered foods in *Hadzabe* community, followed by meat. Others in decreasing order were fruits/berries and roots. Vegetables/leaves were just liked for more than half of the respondents whereas products such as blood and tree barks were among the least of the foods consumed by *Hadzabe* nomads. The results suggest that the main foods used by the *Hadzabe* were honey, meat and roots (Jones *et al*., 2002; Lowenbergy *et al.*, 1968; Mottram *et al.*, 1974). However, energy intakes are derived mainly from meat (80%), starch (10%) and honey (10%) nutrients. Energy intakes from fruits accounted for only 1% as was suggested by Jones *et al*. (2002). Relative to the minority use of blood was probably due to fear of poisoned arrows applied to kill the animals, as the poisons may still be circulating and harmful to meet eaters.

Food preservation and storage were investigated as shown in Table 16:

Table 16: Preservation and storage of common wild roots, leaves, fruits, meat and honey

Food variables	**Distribution of respondents (n = 259)**				
	Leaves	**Roots/tubers**	**Fruits**	**Meat**	**Honey**
Preserved/Stored	33(12.7)	15(5.8)	23(8.9)	4(1.5)	258(96.6)
Didn't preserve	210(81.1)	242 (93.4)	231(89.2)	82(66.8)	1(0.4)
No response	16(6.2)	2(0.8)	5(1.9)	173(31.7)	0(0.0)
Total	**259(100.0)**	**259(100.0)**	**259(100.0)**	**259(100.0)**	**259(100.0)**

Numbers in parentheses are percentages

Most foods foraged as leaves (81.1%), roots/tubers (93.4%), fruits (89.2%) and meat (66.8%) were customarily not preserved except for honey (96.6%), which was kept longer for more than 12 months (see also Table 12 and 15).

More than 80% of *Hadzabe* respondents had most of common foraged foods not customarily preserved exept for honey which could be kept for more than 12 months. The obtained findings portrayed that over half of the entire hunter-gatherer nomads in Meatu and Karatu districts were severely insecure as most foraged foods became unprereserveable. This situation made the community inaccessible to diversity of income sources, poor states of development and economy as has been suggested by Von Braun *et al.* (1992). They were also highly susceptible and vulnerable to food insecurity, and hence, prone to severe malnutrition (Von Braun – Lorch, 1991).

The long time preservation of honey might probably be exaggerated by the naturally occurring antimicrobials and low water activities present in honey due to high sugar content (Lee *et al.*, 2008) but not due to the concept of use of *Sharoda* (Gourd) and *Mishon* (Skin folder) that were observed by the researcher during field work.

4.8 Levels of Macronutrients and Micromolecules in Roots and Tubers

The common foods consumed by nomads are root types as shown in shown by Figure 7.

4.8.1 Levels of Minerals from *Shumugo, Magharitako* and *Ekwa* Roots/tubers Consumed by *Hadzabe* Nomads

Figure 7: Roots/tubers mostly consumed by *Hadzabe* (From left are *Ekwa,* center are *Magharitako* and right side are *Shumugo*)

4.8.2 Micronutrients in roots/tubers

Table 17 summarises the results of three root samples from different three locations as has been compared with WHO safety level:

Table 17: Micronutrient contents in *Ekwa, Magharitako* and *Shumugo* roots collected from three hamlets in Meatu and Karatu districts

Minerals	Sample	Location									Standard Limit		Sources
		Sungu			Mbuyuni			Mchangani					
		mg/l	TDI (mg/kgbwt/d)	Factor	mg/l	TDI (mg/kgbwt/d)	Factor	mg/l	TDI (mg/kgbwt/d)	Factor	TDI (Unit/ kgbwt/d)	MARL (Unit/day)	
Cu	R1	65.04	0.22	4	16.64	0.05	1	18.00	0.06	1.2	0.05	15mg	FAO/WHO (1971)
	R2	5.68	0.02	0.4	13.60	0.04	0.8	12.72	0.04	0.8			
	R3	18.16	0.06	1	10.96	0.04	0.8	16.88	0.06	1.2			
Cr	R1	62.40	0.21	362	14.40	0.05	86	21.60	0.07	120	0.58µg	175µg	Food &Nutrition
	R2	13.60	0.04	68	30.40	0.10	172	24.80	0.08	137			Board (1997)
	R3	24.00	0.08	137	11.20	0.04	69	26.40	0.09	155			
Fe	R1	300.80	1.00	4	2156.00	7.17	28.5	3943.20	13.14	52	0.25mg	75mg	Food &Nutrition
	R2	712.00	2.37	9.5	2328.80	7.76	31	2720.00	9.07	36			Board (1997)
	R3	1948.00	6.49	26	300.00	1.00	4	2545.60	8.48	34			
Zn	R1	230.40	0.77	0.4	218.40	0.73	0.4	208.00	0.69	0.3	2mg	600mg	Food &Nutrition
	R2	198.40	0.66	0.3	247.20	0.82	0.4	212.00	0.71	0.3			Board (1997)
	R3	209.60	0.70	0.4	214.40	0.71	0.3	224.80	0.75	0.4			
Mg	R1	6208.00	20.69	2	336.00	1.12	0.1	4496.00	14.99	1.5	10mg	3000mg/day	Food &Nutrition
	R2	2405.60	48.02	5	4848.00	16.16	1.6	5175.20	17.25	2			Board (1997)
	R3	5120.00	17.07	2	3912.00	13.04	1	4600.80	15.34	1.5			
Ca%	R1	82.00	0.27	1	4.17	0.01	0.06	1.22	0.004	0.02	0.16%	48%	WHO/FAO(2004)
	R2	5.06	0.07	0.4	1.49	0.004	0.02	4.62	0.02	0.1			
	R3	0.82	0.002	0.01	1.19	0.004	0.02	4.19	0.01	0.06			
Cd	R1	<0.01	BDL	-	<0.01	BDL	-	<0.01	BDL	-	0.001mg	0.3mg	Mdegela *et al*,
	R2	<0.01	BDL	-	<0.01	BDL	-	<0.01	BDL	-			(2008)
	R3	<0.01	BDL	-	<0.01	BDL	-	<0.01	BDL	-			

Source: SEAMIC laboratory data (2010), R1 = *Ekwa*, R2 = *Magharitako*, R3 = *Shumugo*, BDL = Below Detectable Limit, d = day

As demonstrated in Table 17, the excess amount Chromium and Copper in roots indicated the possibility of toxicity that was predisposed by the consumption of more than 300 times and 0.05 mg/kgbwt/day respectively, although this has been experienced a rare case in the US population (NRC, 1977). Ferrous on the other hand have been found abnormally high in root. This excess is suggested higher toxicity if the consumption exceeds more than 40 mg/day MARL intake (FAO/WHO, 1971; Frantz, 2003). The marked increase in Mg in roots is also extremely higher as compared to the WHO recommended MARL intake (FNB, 1997). But then it has reported that magnesium excess from dietary sources (142 mg/day) is relatively harmless because the optimal presence of zinc in roots may deactivate/decrease the absorption of Mg in the body (Greger *at el.,* 1981). However the presence of inadequate increase amount of Chromium in roots might probably be caused by the Rift Valley causing a risk of reducing blood sugar, build muscle, reducing body weight and stimulating production of insulin (FNB, 1997).

Based on the comparison of set requirement values of micronutrients as stated by WHO/FAO (2004), from the three important foraged roots (*Ekwa, Magharitako* and *Shumugo*), it showed that except for Ca%, Cd, Zn mg/l other micronutrients (Cu, Fe, Cr and Mg) exceeded the WHO recommended MARL intake. This can be justified using a calculated amount of 2 roots eaten per day. Possibly, not more than 200 g was consumed per person per day, the amount of which was greater if compared to normal recommended intakes.

However, the upper limits of Cr, Fe, Mg and Cu micronutrient (mg/l) values from each of the three roots/tubers examined, exhibited an abnormally higher level compared to the WHO set limit of safety values. Only Cu and Cr would have exceeded the recommended

intake if each individual person would be able to eat a single root (100 mg/day) (Frantz, 2003; WHO/FAO, 2004).

Based on examination of tolerable upper limit and toxicity of minerals in roots it inapparently rules out the exact causes. Probably, the increase of copper might be subjected by extensively use of fertizers used in onions plantations in Mang'ola.This clearly give us evidence that the observed amount of nutrients are high in Fe and Cr and slight higher in Cu and Mg if compared with the WHO recommended Maximum Acceptable Residual Level intake (WHO/FAO, 2004). It can then be adhered to the ideas that the newly unknown wild root species are probably toxic in Cr, Fe and Cu to public health requirements.

4.9 Characterization of proximate composition of shumugo roots consumed by *Hadzabe* nomads

The only investigation of Shumugo roots was performed to see whether the proximate composition of same differed significantly relative to location. The results are shown in

Table 18: Proximate composition (Mean± SD) of *Shumugo* root from three sites in Karatu and Meatu (n = 3)

Compos	Sungu	Mbuyuni	Mchangani	Standard Limit%	Source
CHO%	1.93±0.16	2.46±2.08	3.99±1.16	50	Lanthan (1997)
Oil/Fat%	1.62±0.12	1.52±0.11	1.81±0.01	14.9	Leaf and Weber (1988)
C.Fiber%	1.84±0.12	1.56±0.09	1.03±0.04	2.7	Warren and Siciliano (2010)
C.Protein%	2.11±0.11	2.73±0.09	2.36±0.20	16.6	Warren and Siciliano (2010)
Ash%	2.3±0.05	1.83±1.12	1.76±0.14	3	Bregendahl *et al.* (2002)
Moisture%	90.2±0.005	89.88±1.85	89.41±1.4	61.8	Bregendahl *et al.* (2002)

As indicated in Table 18 the moisture contents of *Shumugo* roots was higher (90%) than the set limit of human (61.8%) requirement (Bregendahl *et al.*, 2002). With Carbohydrates data, although the amount analyzed was lower than normal, it showed some variations of its replicates probably due to analysis errors, location, and age of the tree root or pH values of individual soil and spacing. Based upon proximate composition of other macronutrients, the percentage values were detected being suboptimal of the standard set limit as has explained in Bregendahl *et al.* (2002)

Shumugo roots were deemed by *Hadzabe* tribe to treat abdominal pains and exhibited rapid quench of thirst immediately after eating. Probably, this might be due to the fact that they contain almost 90% of water thus supplying substantial amount to quench thirst and relieve abdominal discomfort. Figure 8 are the species of *Shumugo* roots.

Figure 8: *Shumugo* roots extracted from Mbuyuni hamlet in Qangdend village

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study has investigated the types of food and subsequent characterization of the prospective nutrients contained in the commonly consumed indigenous wild plant roots in nomadic hunter-gatherer community, northern Tanzania.

It is concluded that there are many food types consumed by *Hadzabe* hunter-gatherer nomads including roots, tubers, tree leaves, fruits/berries, wild animals and honey. Patterns of food availability to the identified depended on seasonal influence preferably during rainy season. Assessment relative to nutritive values suggest that the explored level of micronutrients in roots such as Cr, Cu, Fe and Mg exeeds the WHO intake requirements and the toxicity limit. In contrast, Ca%, Cd and Zn has been found to meet with the WHO established level of intakes.

5.2 Recommendations

From this study there are only few outcomes that have been established with the most of the remainder being obscure. Based on the findings, the following are the recommendations: -

i) Further research on toxicity and antimicrobial factors of roots including the presence phylates, aflatoxins and phenolic compounds from *Ekwa, Magharitako, Shumugo, Doiako* and *Shukwaayabe.*

ii) Further studies on common roots declared by the indigenous people (*Hadzabe*) to treat STI and other diseases for instance *Magaritako and Ekwa.*

iii) The *Hadzabe* nomads are at high risk of developing severe malnutrition attributed by wildlife encroachment and susceptible to lack of indigenous foods. The government should strive hard to allocate them with specific areas through “Land tenure schedule”

iv) The *Hadzabe* people are faced by lack of knowledge caused by low level of education. The eligible authorities are advised to raise awareness about the dangers associated by their nomadism, lack of housing skills and the resulting risks that may be exaggerated such as malnutrition and the future survival dilemmas.

v) The *Hadzabe* people are inadequately supplied with essential health services. The authority of concern should enforce extra energetic struggle to extend mobile served clinics, health education campaign, provision of water supply regardless of their nomadism, house to house community routine survey campaigns in order to ensure the availability of health baseline information.

vi) Preprimary and the school enrolling children of hunter-gatherers should as much recruited, admitted and monitored at available schools to prevent high number of drop out, as early childhood behavioural mobilization effects the change of culture of whole generation. Forget about forcibly bringing (the *Hadzabe*) together to live with other tribes.

vii) Establish a special program aimed at food and nutrition including workload to women reduction interventions for rescuing hunter-gatherer nomads from malnutrition.

viii) Historians are suggested to safeguard the cultural heritage and language since the *Hadzabe* nomads are rapidly disappearing.

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APPENDICES

Appendix 1: Questionnaires (English Version)

HADZABE COMMUNITY BASELINE INFORMATION SURVEY QUESTIONNARES

1. **QUESTIONNAIRE IDENTIFICATION NUMBER _____**
2. **DISTRICT _____**
3. **DIVISION _____**
4. **VILLAGE _____**
5. **HAMLET _____**

Introduction: My name is … I am working for … We are interviewing people here in [name of village] in order to find out about [describe purpose of study]. Tell them you cannot interview them a second time. Thank them and end the interview. If they have been interviewed before continue.

Confidentiality and Consent: I am going to interview you some very questions that some people find difficult to answer. Your answers are completely confidential and your name will not be written in this form, and will never be used in connection with any of the information you tell me. You do not have to answer any question that you do not want to answer, and you may end this interview at any time you want to. However your honest answer to these questions will help us better understand, what people think, say and do certain kind of practices. We would greatly appreciate your help in responding to this survey. The survey will take about half an hour.

6. **INTERVIEWER: NAME _____ DATE: _____**
7. **CHECKED BY SUPERVISOR: SIGNATURE _____ DATE_____**

Section 1: Socio Demographic Characteristics [Cycle only one correct answer]

No.	Questions and Filters	Coding Categories	Skip to
01	Record sex of the respondent	Male 1 Female 2	
02	How old are you? [Estimate the best answer]	Age in Completed years Don't Know 1 No Response 2	
03	Have you ever been to school	Yes 1 No 2 No Response 3	
04	What is the highest level of education you completed? [**CYCLE ONE**]	Primary 1 Secondary 2 'A' Level 3 Diploma 4 University 5 No Response 6	
05	What is your current marital status?	Married 1 Single 2 Divorced 3 Widowed 4 No response 4	
06	What is your religion?	Christian 1 Moslem 2 Traditionalist 3 Don't know 4	
07	What is your current occupation?	Hunter-gatherer 1 Farmer 2 Government Employee 3 Herder 4 Business 5	

Section 2: Indigenous Food Baseline Information

No.	Questions and Filters	Coding Categories	Skip to
08	What kind of tree leaves do you use as food or vegetables [mention]	i) _____ ii) _____ iii) _____ iv) _____	
09	What do you think among the mentioned leaves you best prefer? [Mention 1)	i) _____	
10	Do the leaves harvested being preserved?	Yes 1 No 2	
11	Who does among community members collect the leaves? [CHOOSE ONE]	Women 1 Men 2 Children 3 Both the above 4	
12	What are the common roots eaten by your tribe? [Mention]	i) _____ ii) _____ iii) _____ iv) _____ v) _____	
13	Who among the community members of your tribe collect the roots? [Select One]	Women 1 Men 2 Children 3 Both of the above 4	
14	How does the roots being collected prepared when you want to eat?	Mashed/crushed and eaten 1 Cooked and eaten 2 Eaten raw once after harvest 3 Don't know 4	
15	Are the roots harvested being stored?	Yes 1 No 2 Don't know 3	
16	If yes in the question above, show where the roots are stored.	i) _____	
17	Are the roots collected by individuals eaten together in a family? [Choose one]	Yes 1 No 2	
18	Among the roots collected which one is believed to cure diseases?	i) _____	
19	Which type of disease cured?	i) _____	
20	Is the bark/stem of tree used as food?	Yes 1 No 2	
21	Are the wild fruits being eaten?	Yes 1 No 2 Don't know 3	

22	If yes as in question 20 name them	i) _____ ii) _____ iii) _____ iv) _____	
23	Who collects the fruits?	Women 1 Men 2 Children 3 Both the above 3	
24	Are the fruits being collected become preserved?	Yes 1 No 2 Don't know 3	
25	If yes how are they preserved? [Explain]	i) _____	
26	Is also Meat commonly eaten in this village?	Yes 1 No 2 Don't know 3	
27	If yes which kind of meat being used?	i) Wild animals (mention them) _____ _____ _____ _____ ii) Termed animals (mention them) _____ _____ _____	
28	Who hunt the animals if the wild animals are common?	Women 1 Men 2 Children 3 Both the mentioned 4	
29	Which kinds of tools are used to hunt the animals? (show them)	i) _____ ii) _____ iii) _____ iv) _____	
30	How do the meat being prepared for dish?	Slaughter and cook 1 Burning on open fire 2 Eating raw 3	
31	Is the meat being preserved?	Yes 1 No 2	
32	How does this meat being preserved? Explain	_____	
33	Apart from eating meat, are the animal blood also used as food?	Yes 1 No 2	

34	Is Milk also being used as food?	Yes 1 No 2	
35	If yes where do you get them?	Purchasing 1 Milking our cow 2 Don't know 3	
36	If purchasing where you do get the money? (state)	i) _____ _____	
37	Do you also collect egg as for food?	Yes 1 No 2	
38	Which type of egg do you collect? [Cycle One]	Wild birds 1 Domestic birds 2 All types of birds 3	
39	Do you eat fish	Yes 1 No 2	
40	How do you get fish	In River 1 Purchasing 2	
41	If yes which tools do you use?	_____ _____ _____	
42	How do you catch fish? [Show]	_____ _____	
43	Do you always use honey as food?	Yes 1 No 2	
44	If yes where do you get such Honey?	Hive 1 Cave 2 Anti hills 3 Other place (mention)	
45	How do you store/preserve such honey	_____ _____ _____	
46	How long does it take to preserve such honey before being rotten?	1 – 6 months 1 6 – 12 Months 2 More than 6 months 3	
47	Do you use mushrooms as part of meal?	Yes 1 No 2	
48	If yes how do these mushrooms prepared/preserved?	_____ _____ _____	

Section 3 (I): Availability Patterns of Food Consumed

Indicate by placing a tick on the most appropriate answer you think suitable for seasonal availability of food.

Origin of Food	Food	Only Dry Season (Rank 1)	Only Rain Season (Rank 2)	All the time (Rank 3)
Trees	Roots/Tubers			
	Stem/barks			
	Leaves			
	Fruits			
Animal & Birds	Meat (Wild)			
	Blood			
	Milk			
	Eggs			
	Fish			
Insects	Honey			
	Termites			
Fungi	Mushrooms			

Section 3 (II): Patterns of Food Preference

Origin of Food	Food Type	Preference Summated Ratings Rank				
		Like most	Like	Undecided	Unlike	Don't Like most
		1	2	3	4	5
Trees	Roots/Tubers					
	Stem/barks					
	Leaves					
	Fruits					
Animal & Birds	Meat (Wild)					
	Blood					
	Milk					
	Eggs					
	Fish					
Insects	Honey					
	Termites					
Fungi	Mushrooms					

Thank you for the good corporation

Appendix 2: Questionnares (Swahili version)

DODOSO KWA AJILI YA UTAFITI KWENYE JAMII YA HADZABE KARATU NA MEATU

1. **NAMBA YA ANAYOHOJIWA _____**
2. **WILAYA _____**
3. **TARAFA _____**
4. **KIJIJI _____**
5. **KITONGOJI _____**

Utangulizi: Jina langu ni …… nafanya shughuli za …… tunafanya mahojiano na watu katika [jina la kijiji] ili kupata habari juu ya [elezea madhumuni ya kufanya utafiti]. Watahadhalishe kuwa hutaweza kuwahoji tea mara ya pili. Washukuru na uhitimishe mahojiano. Au kama walishawahi kuhojiwa kabla ya hapo endelea nao.

Usiri na ukubali wa muhojiwa: Nitakuhoji maswali ambayo kwako utaona ni magumu kuyajibu. Hata hivyo majibu utakayoyatoa yatakuwa ni siri na hakuna jina la mtu yeyote litakaloonekana wakati wa uchambuzi wa habari uzisemazo. Si lazima ujibu kila swali ambalo hutataka kulijibu na kama utaona ni vigumu kuendelea na mahojiano haya unaweza ukaamua kujitoa wakati wowote. Hata hivyo majibu yako ya upole yatokanayo na maswali haya yatatusaidiwa kutupa ufahamu bora wa jinsi watu wafikirivyo, wasemavyo na matendo yafanywayo. Tutakuwa na shukrani kubwa kwa kusaidia kujibu vyema maswali juu ya Uchunguzi huu. Uchunguzi huu utachukua muda wa Saa 1.

6. **JINA LA ANAYEHOJI _____TAREHE _____**
7. **IMEHAKIKIWANA MSIMAMIZI _____SAHIHI _____**

Sehemu ya Kwanza: Habari za Watu na Mahusano

NA.	MASWALI	UFUPISHO	BILA JIBU
01	Jinsia ya mhojiwa	Mme 1 Mke 2	
02	Umri wa mhojiwa [Kadiria jibu sahihi]	Miaka Kamili_____ Sifahamu 1 Hakuna Jibu 2	
03	Umeshawahi kusoma shule?	Ndiyo 1 Hapana 2 Hakuna jibu 3	
04	Umesoma hadi darasa la ngapi?	Msingi 1 Kidato ca Nne 2 Kidato cha Sita 3 Stahahada 4 Chuo Kikuu 5 Hakuna jibu 6	
05	Hali ya ndoa	Nimeoa/olewa 1 Sijaoa/olewa 2 Nimeachika 3 Mjane 4 Hakuna jibu 5	
06	Dini	Mkristu 1 Muislam 2 Sina dini/Jadi 3 Sijui 4	
07	Kazi yako	Mwindaji 1 Mkulima 2 Mwajiriwa Serikalini 3 Mchungaji wa mifugo 4 Biashara 5	

Sehemu ya Pili: Uchunguzi wa Vyakula Asilia

08	Ni majani gani yatokanayo na majani ya miti hula kama mboga [Taja]	I] ……. Ii] …… Iii] …….. Iv] ……..	
09	Unafikiria ni majani yapi yanafa zaidi [Taja moja]	_____	
10	Majani yavunwapo huhifadhiwa?	Ndiyo 1 Hapana2	
11	Ni nani kati yenu katika familia huweza kuvuna majani/mboga?	Wanawake 1 Wanaume 2 Watoto 3 Wote waliotajwa 4	

12	Ni mizizi gani muhimu huliwa na kabila lenu?	I] …… Ii] ……... Iii] …….. Iv] …….	
13	Ni nani katika familia hufanya kazi ya kutafuta chakula cha mizizi?	Wanawake 1 Wanaume 2 Watoto 3 Wote walotajwa 4	
14	Ni kwa jinsi gani mizizi iliyokusanywa huandaliwa?	Husagwa na kupondwa pondwa 1 Hupikwa na kuliwa 2 Huliwa mibichi baada ya kuvunwa 3 Sifahamu 4	
15	Mizizi hiyo baada ya kuvunwa huhifadhiwa stoo?	Ndiyo 1 Hapana 2	
16	Kama ni ndiyo kutokana na swali lilioulizwa onyesha stoo ilipo.	Ipo 1 Hakuna 2	
17	Miziziiliyokusanywa huliwa kwa pamaja ndani ya familia?	Ndiyo 1 Hapana 2	
18	Katika mizizi ikusanywayo ni upi mojawapo huponya magonjwa	Upo (taja)_____ Hakuna	
19	Ni aina gaini ya ugonjwa huponyesha?	i) _____ _ ii) _____ _	
20	Je! Magome ya miti huliwa pia kama chakula?	Ndiyo1 Hapana 2	
21	Matunda mwitu pia yaliwa kama chakula?	Ndiyo 1 Hapana 2	
22	Kama jibu ni ndiyo ni matunda yapi?	i] …… ii] …….. iii] ……. Iv] ……. V] …….	
23	Ni nani katika familia hufanya kazi ya kukusanya matunda?	I] Wanawake 1 Wanaume 2 Watoto 3 Wote waliotajwa 4	
24	Matunda yakusanywayo huhifadhiwa?	Ndiyo 1 Hapana 2	
25	Kama ni ndiyo ni kwa jinsi gani huhifadhiwa	I] …… …… ……. ……	
26	Je! Nyama katika kijiji hiki huliwa	Ndiyo 1	

		Hapaa 2 Sijui 3	
27	Kama ni ndiyo ni aina gani ya nyama huliwa?	I] Wanyama mwitu [Wataje] …… …… …… …… Ii] Wanyama wafugwao [Taja] …….. …… …… ……	
28	Ni nani katika familia huwinda wanyama pori kama ni muhimu?	Wanawake 1 Wanaume 2 Watoto 3 Wote waliotajwa 4	
29	Ni silaha gani hutumika kuwinda wanyma? [Onyesha]	I] …… Ii] ……... Iii] …….. V] ……	
30	Ni jinsi gani nyama huandaliwa kwa kula?	I] kuchinja na kula 1 Kuchoma hadharani 2 Kula ikiwa mbichi 3	
31	Nyama mnayokula huhifadhiwa inapobidi?	Ndiyo 1 Hapana 2	
32	Ni kwa namna ipi nyama hiyo huhifadhiwa?	_____	
33	Licha ya kutumia nyama, je! Damu yake huliwa pia?	Ndiyo 1 Hapana 2	
34	Je! Maziwa hutumika pia kama chakula?	Ndiyo 1 Hapana 2	
35	Kama jibu ni ndiyo, mnayapata wapi?	Kununua 1 Kukamua mifugo yetu 2 Sijui 3	
36	Kama jibu ni kununua, mnapata wapi pesa?	_____ _____ _____	
37	Je! hula mayai pia?	Ndiyo 1 Hapana 2	
38	Aina gani ya mayai Hula kama chakula?	Ndege pori 1 Ndege wa nyumbani 2 Aina zote za ndege 3	
39	Je! mnakula Samaki?	Ndiyo 1 Hapana 2	
40	Mnawapateje Samaki?	Mtoni 1	

		Kununu 2	
41	Kama ni kuvua mtoni, ni aina gani ya vifaa hutumia? (Eleza)	_____ _____ _____	
42	Ni jinsi gani huvua samaki? (Elezea)	_____ _____ _____	
43	Je! Mnatuma asali kama chakula?	Ndiyo 1 Hapana 2	
44	Kama ni ndiyo huwa mnapata wapi asali hiyo?	Katika Mzinga 1 Mapangoni 2 Vichuguuni 3 Sehemu nyinginezo (taja)	
45	Ni kwa jinsi gani huhifadhi hiyo asali		
46	Ni kwa muda gani huchukua kuhifadhi asali mpaka iharibike?	Miezi 1 – 6 1 Miezi 6 -12 2 Zaidi ya Miezi 12 3	
47	Je! Mnatumia uyoga kama chakula	Ndiyo 1 Hapana 2	
48	Kama ni ndiyo, ni kwa jinsi gani uyoga huo huandaliwa?		

Sehemu ya Tatu (I): Mifano Hai ya Upatikanaji wa Vyakula

Asili ya Chakula	Chakula	Wakati wa kiangazi (1)	Wakati wa masika (2)	Nyakati zote (3)
Miti	Mizizi			
	Magamba ya miti			
	Majani			
	Matunda			
Wanyama na Ndege	Nyama pori			
	Damu			
	Maziwa			
	Mayai			
	Samaki			
Insects	Asali			
	Mchwa			
Fungi	Uyoga			

Sehemu ya 3 (II): Mifano ya Upendeleo Maalum ya Vyakula

Asili ya	Aina ya	Upendeleo maalum wa chakula

chakula	chakula	Napendelea sana	Napenda	Sina uamuzi	Sipendelei	Sipendelei Mno
		1	2	3	4	5
Miti	Mizizi					
	Magamba ya miti					
	Majani					
	Matunda					
Wanyama na Ndege	Nyama pori					
	Damu					
	Maziwa					
	Mayai					
	Samaki					
Insects	Asali					
	Mchwa					
Fungi	Uyoga					

Ahsanteni Sana!!!

Appendix 3: Indepth Interview Guide to Key Infomants

In-depth Interview Guide with Key Informants on Indigenous Foods

1. What are the common foods that are eaten by *Hadzabe* tribe?
2. What are the common characteristics attached to male/female roles in collection of foods
3. What are the eating habits used by the *Hadzabe* tribe in eating foods?
4. What are the food acquisition patterns relative to seasonal food availability?
5. What views the community intends for future lives? (including owning households' resources such as land, farming implements etc)
6. What is the community reaction on joining with other community members of tribes living collectively in villages?
7. How does the children underfive years of age cared to prevent malnutrition?

Other social cultural practice for discussion will involve:

1. Cultural ceremonies
2. Marriage rituals
3. Household leaders
4. Socialization of *Hadzabe* children
5. *Hadzabe* history
6. Illness and deaths.

In-depth Interview to Government Leaders on Strategies for Rescuing the *Hadzabe* Tribe Relative to Food (Karatu & Meatu)

1. Are there strategies being done by the government to supply the *Hadzabe* people with essential service?
2. If so how was the intervention designed.
3. What methods did the government employ to make sure that the *Hadzabe* community is saved with food?
4. What were the strengths and pitfalls of the strategies used?
5. what are some of the known results

Section 4: Focus Group Discussion (FGDs)

Essentially to be conducted to Youths, Women & Men to respective villages of Iramba ndogo, Makao and two villages of Karatu district. The respective names of respondents should be mentioned. The following themes guided the interviewer

1. What are the types of indigenous foods consumed by the *Hadzabe* tribe?
2. What are the patterns of foods relative to seasonal availability to the same community?

Section 5: Research Tools

A SONY Camera with high resolution output 10.1Megapixel will be used during data collection.

Appendix 4: Summary Methods of Different Macromolecules and Metals in Plants

Determination Methods of Different Macromolecules and Metals in Plants Used

S/N	Type of macromolecules/ Metals	Analytical method/equipment	Status of the sample before analysis	Place of analysis
1	Protein %	Kjeldahl's/Chemical/Titrimetry	Crushed	Dept of Animal Science (SUA)
2	Fat %	Soxhlet/Gravimetry/Ether extraction	Chemical Extraction	Dept of FST (SUA
3	Starch %	Titration/Calorimetric	Liquefied	Dept of FST (SUA)
4	Fibers %	Southgate's/Ceramic fiber filtration	Ground and Sieved in 0.15-mesh	Dept of FST (SUA)
5	Moisture %	Vacuum oven/Gravimetry	Crushed	Dept of FST (SUA)
6	Total Carbohydrates	Calculation	Liquified in clear Soln	Dept of FST (SUA)
7	Ash	Bulky density/Furnace	Liquified	DEPT. FST (SUA)
8	Cd, Cu, Cr, Fe, Zn, Ca. and Mg	Atomic Absorption Spectroscopy (AAS)	Liquidified	SEAMIC - DAR

Source: AOAC international (1995) in Codex STAN 234 -1999

Appendix 4: Property Calculation, Principles and Methods of Analysis

Property calculation, principles and methods of analysis

S/N	Property	Calculation	Principle	Method
1	Ash (%)	Mass(Wet ash)/Mass(dry ash) x 100	Gravimetry	AOAC 950.49
2	Moisture (%)	Mass(initial) – Mass(final)/Mass (Initial) x 100	Gravimetry (vacuum oven)	ISO 662: 1998 AOAC 934.06
3	Fat, Crude (%)	(W2–W1)x 100/Sample(W)	Ether extraction/Soxhlet/Gravimetry	AOAC 945.38F; 920.39C
4	Protein (%)	%N x 6.25 Digest, Dist, Tirat & Calcul.	Kjeldahls/Titrimetry	ICC Method No 105/1 (1986)
5	Heavy Metals	Absorption of light against Concentration (PPm/PPb/PPt	FAAS (Most efficient & reliable)	AOAC 994.02 ; or ISO 12193: 2004; or

Appendix 5: Raw Data of Micronutrients as has been Examined from SEAMIC

Mineral/micronutrient values in mg/l extracted from [1]*Ekwa*, [2]*Magharitako*, and [3]*Shumugo* that were sampled from three hamlets

S/N	Sample ID	Cd mg/l	Cu mg/l	Cr mg/l	Fe mg/l	Zn mg/l	Mg mg/l	Ca %
1	SUNGU 1	<0.01	65.04	62.40	300.8	230.40	6208.0	0.82
2	SUNGU 2	<0.01	5.68	13.60	712.0	198.40	2405.6	5.06
3	SUNGU 3	<0.01	18.16	24.00	1948.0	209.60	5120.0	0.82
4	MBUYUNI 1	<0.01	16.64	14.40	2156.0	218.40	336.0	4.17
5	MBUYUNI 2	<0.01	13.60	30.40	2328.8	247.20	4848.0	1.49
6	MBUYUNI 3	<0.01	10.96	11.20	300.0	214.40	3912.0	1.19
7	MCHANGANI 1	<0.01	18.00	21.60	3943.2	208.00	4496.0	1.22
8	MCHANGANI 2	<0.01	12.72	24.80	2720.0	212.00	5175.2	4.62
9	MCHANGANI 3	<0.01	16.88	26.40	2545.6	224.80	4600.8	4.19

[1] Root sample of *Ekwa*

[2] Root sample of *Magharitako*

[3] Root sample of *Shumugo*

Appendix 6: Raw Data of Proximate Composition as has been Examined from SUA Laboratory

Analytical results of percentage proximate composition of *Shumugo* tubers examined at SUA laboratories

S/N	Sample ID	District	Village	Hamlet	Moisture	Ash	C. Protein	C. fibre	Oil/Fat	Carbohy
1	MT 'A' N	Meatu	I. Ndogo	Sungu	90.19	2.35	2.23	1.72	1.75	1.93
	Replicate1	Meatu	I. Ndogo	Sungu	90.20	2.25	2.00	1.96	1.50	1.77
	Replicate2	Meatu	I. Ndogo	Sungu	90.20	2.30	2.10	1.84	1.62	2.09
2.	KRT 'A' N	Karatu	Qangdend	Mbuyuni	88.05	1.74	2.83	1.49	1.42	2.46
	Replicate1	Karatu	Qangdend	Mbuyuni	91.76	1.92	2.64	1.67	1.64	4.54
	Replicate2	Karatu	Qangdend	Mbuyuni	89.82	1.83	2.72	1.58	1.53	0.37
3	KRT 'B' N	Karatu	Qangdend	Mchangani	90.80	1.63	2.57	1.07	1.82	3.99
	Replicate1	Karatu	Qangdend	Mchangani	88.00	1.91	2.16	0.99	1.80	2.83
	Replicate2	Karatu	Qangdend	Mchangani	89.43	1.77	2.35	1.03	1.81	5.16

Table 24 shows the three samples with their replicates profile of individual shumugo root species extracted from three different locations in Karatu and Meatu.

Methods Employed:

Crude Protein – Kijeltec system

Crude Fat – Soxhlet extraction

Ash – Maffle furnace

Moisture – Oven drying method

Crude fibre – Fibre tech.

Appendix 7: Laboratory results of proximate composition of *Shumugo* root

Value and significance levels of percentage proximate composition from Shumugo root

Macronutrient level	**Location**			**Level of significance**
	Sungu	**Mbuyuni**	**Mchangani**	
Moisture	90.20[a]	89.88[a]	89.41[a]	P> 0.05
Ash	2.30[a]	1.83[b]	1.76[b]	P> 0.05
Crude protein	2.11[b]	2.73[a]	2.36[b]	P< 0.05
Crude fibre	1.84[a]	1.56[b]	1.03[c]	P< 0.05
Crude Fat	1.62[a]	1.52[a]	1.81[a]	P> 0.05
Carbohydrate	1.96[c]	2.46[b]	3.99[a]	P< 0.05

Source Appendix 8