Nutritional status in Tanzania

A regional comparison of the BMI and its determinants among adult women

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(21-08-2012)

Acknowledgements

This master thesis is the result of hard work and is the final piece of my path through the Master of Population Studies. Although I chose a topic and wrote research proposal in late 2010, the actual process started in September 2011. Now, a few struggles, even some topic changes and almost a year later, the process is finished with this thesis as the result. Sometimes it was hard and I lost motivation, but in the end I look back at it with satisfaction. There are several persons that I would like to thank who helped me through this process. First of all I warmly thank dr. ir. Hinke Haisma who was my supervisor for this thesis. She always showed interest in my progress, was constructively critical and monitored the scientific standard. She was always positive and always thought of solutions for my problems, I am thankful for that. I would also like to thank the rest of the PRC staff and especially Eva Kibele, who helped me with the multilevel analysis part. The questions of the PRC staff and their constructive criticism were helpful in improving my final product. Also, the courses I followed in the master were very helpful for writing my master thesis.
Finally, I would like to thank my friends and family who supported me throughout the process.

Thanks to you all, I finished this master thesis and I am proud of the result.

Melle Conradie

Abstract

Aims: To explain the regional patterns and differences in BMI among non-pregnant adult women in Tanzania by using determinants from the Tanzanian DHS. This is done by looking at the relation between BMI and the determinant variables from the Tanzanian DHS as well as by looking at the spread of BMI outcomes and determinants across the country.
Methods: A nationally representative survey of women aged 15-49 is used (n= 10,139), the pregnant and non-adult women are filtered out leaving 7746 women in the sample. Multilevel analysis was used to establish models at the national- and regional level with both region and individuals as a level.
Results: BMI is positively influenced on a national level by ‘current age’, ‘eligible women in household’, ‘time to get to water source’ and ‘wealth index factor score’. BMI is negatively influenced on a national level by line number of husband’. These relationships often differ on the regional level. In some cases, even the direction of the relation in the model is different. ‘Line number of husband’ has a negative coefficient in the national model in predicting BMI, whereas it is significantly positive for the model of Zanzibar South for example.
***Conclusions:* There are regional differences in BMI among non-pregnant adult women in Tanzania. Both underweight and overweight are heavily prevalent, which suggests that there might be a double burden of disease. The average BMI lies in the WHO normal weight range, which is also the biggest group for all regions. The regional models are probably better in predicting BMI at the regional level than the multilevel national model. Nutrition problems in Tanzania can be tackled by addressing the significant independent variables current age, line number of husband, wealth index factor score, time to get to water source and eligible women in household.**

*Keywords***:** BMI, Nutrition, Regions, Tanzania, DHS, Women.

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List of abbreviations

ANOVA	(Analysis of Variance)
BMI	(Body Mass Index = (weight in kilos/height in meters^2))
CIA	(Central Intelligence Agency)
DHS	(Demographic and Health Survey)
GDP	(Gross Domestic Product)
GIS	(Geographical Information Systems)
GPS	(Global Positioning System)
HIV/AIDS	(Human Immunodeficiency Virus/Acquired immune Deficiency Syndrome)
MEASURE DHS	(Monitoring and Evaluation to Asses and Use Results Demographic and Health Surveys)
MHC	(Major Histocompatibility Complex)
NR-NCD	(Nutrition-Related Noncommunicable Disease)
PRC	(Population Research Centre)
SPSS	(Statistical Package for the Social Sciences)
TFNC	(Tanzania Food and Nutrition Centre)
USAID	(United States Agency for International Development)
WHO	(World Health Organization)

1. Introduction

1.1. Background

This study will focus on the regional differences in BMI in Tanzania. The topic was chosen from a list of topics provided by the PRC. The reason why regional BMI differences interest me, is that they can be embedded in the wider framework of the *nutrition transition.* According to the literature (e.g. Caballero and Popkin, 2002), several developing countries are shifting from a stage with a lot of malnutrition to a stage with more overweight problems. During this shift, both patterns of both malnutrition and overweight can be seen. It would be interesting to see if the patterns seen in different regions correspond with this nutrition transition. As a result of restrictions of the used data, the focus of this study will be on non-pregnant females aged 18-49. It should be mentioned that BMI has some disadvantages in identifying body fat and obesity for people of certain stature, yet it is the most widely used indicator (Römling and Qaim, 2011) and the only one which is available in the data used.
Tanzania is a country in South-East Africa (Figure 1.1) and has great regional diversity. The climate varies from tropical along the coast to temperate in the highlands with about a quarter of the population living in urban areas (CIA World Factbook, 2011). These diverse circumstances make it more likely to see regional differences in BMI as well. Overweight problems are more associated with urban than rural lifestyle in developing countries for example (Caballero and Popkin, 2002).

Figure 1.1: The location of Tanzania in Africa.

1.2. Objective and research questions

This study aims to explain the patterns and differences in BMI between the regions (Figure 1.2) in Tanzania using independent variables selected from the Tanzanian DHS. The patterns will be described first, after this the patterns will be explained using the selected explaining variables from the Tanzanian DHS. Multi-level statistical analysis will be used to reach this goal.

For this, the following research question needs to be answered:

1. Are there regional differences in nutrition outcomes in Tanzania among non-pregnant 18-49 year old women?

2. How can the regional differences in nutrition outcomes in Tanzania among non-pregnant 18-49 year old women be explained?

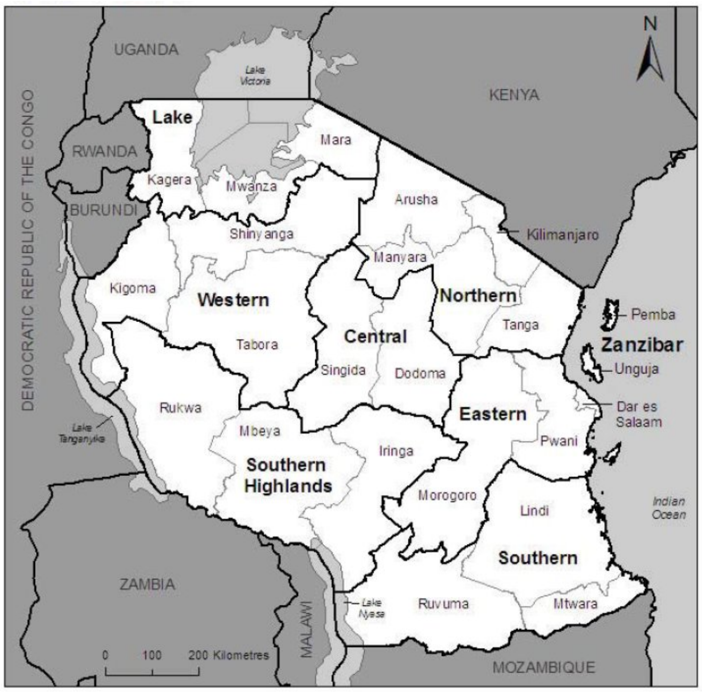


Figure 1.2 Map of Tanzania with the Tanzanian DHS regions (MEASURE DHS, 2008).

1.3. Relevance

This study is conducted by a master student from the master population studies in Groningen which is part of the PRC. The PRC works together on a project with the *Ifakara Health Institute* in Dar es Salaam, Tanzania. The program includes the development of a research master in public health research and a research synthesis in the area of the epidemiologic transition by four PhD students. This study supports the research of one PhD student in particular: Daniel Nyato and his research *Policy and community response to overweight in Tanzania*.
The outcomes of this study aim to provide information on regional differences in nutritional status and the determinants influencing this. In this way, it can help developing policies targeted towards these regional differences. The variables found to be influencing BMI can be addressed to tackle these nutrition problems with policies applicable to the local context.

2. Literature review

2.1. Introduction

This chapter will give an overview on the previous studies done on regional patterns in the nutrition outcomes, BMI in particular.
First, there will be a paragraph on the nutrition history of Tanzania. The second part will be about the previous studies done on determinants of BMI in general and the last part will focus on the previous studies done in Tanzania on BMI and its determinants.
The literature was found using the search engine of *Purplesearch.* Purplesearch searches for scientific articles and books in the following databases: Business Source Premier, PiCarta, Web of Science, PubMed, Historical Abstracts, MLA International Bibliography and University of Groningen Library Catalogue.
The following keywords were used in different combinations to find the relevant literature: Tanzania, region, nutrition, transition, age, ethnicity, religion, culture, wealth, obesity, BMI, determinants, factors, influence, women, Africa.

2.2 Nutrition history of Tanzania

This part of the chapter will briefly describe the history of Tanzania since, the beginning of the country in the early 1960s, to give a historical context for the current developments in Tanzania. The main focus in this summary will be the developments in the area of nutrition and the relating policies.
Dolan and Levinson (2000) also focused on the history of nutrition in Tanzania. According to them, efforts to address the nutrition problems of Tanzania date back to the late 1940s when a nutrition unit was formed under the Ministry of Health (Dolan and Levinson, 2000).
1962 is generally seen as the year when Tanzania was founded as this was the year when the first president, Julius Nyerere, was chosen (Kussendrager, 1996). This was followed by establishing the Tanganyika National Freedom from Hunger Committee, to lessen the reliance on food aid (Dolan and Levinson, 2000).
In 1967 the so-called declaration of Arusha was passed, this was a policy aimed at self-reliance and ujamaa (family sense). As a result of this declaration, ujamaa-villages were established. People could move to these villages, where they could live with the old Tanzanian family traditions (Kussendrager, 1996). One notable characteristic of the ujumaa-villages was that there were shared possessions. For example, if someone did not have enough food, he could get it from the ‘family’ (Kussendrager, 1996). The programme worked particularly well in remote agricultural areas, where the people had little to lose. In other areas however, people were reluctant to move to the new villages. Because of the slow development of the villages the government decided to force people to live in the villages (Kussendrager, 1996).
There were two main opinions about this policy. The one group thought the socialism failed in raising wealth, the other group thought that socialism was needed to decrease the gap between the rich and the poor (Konter, 1978). At first, the revenues from agriculture

rose. But after a while, the output dropped and as a result of incapable farming a lot of farmland became exhausted. Some land was not even suitable for farming. This resulted in food shortages in some areas and in an increase in corruption (Kussendrager, 1996). The rich farmers were also reluctant to move to the new villages as they thought it would not be profitable for them. The poor farmers also hesitated as they did not want to lose their family security of their own house (Konter, 1978). Another disadvantage of this policy was that the people in the villages were waiting passively for state initiatives where the state expected them to be more or less self-reliant (Konter, 1978).

In 1974, the Tanzania Food and Nutrition Centre (TFNC) was established to address the nutrition problems in Tanzania. Although it started under the Ministry of Agriculture, later it was put under the Ministry of health where it remains today (Dolan and Levinson, 2000). The focus of the TFNC was particularly to reduce food losses and malnutrition. In 1976, the TFNC created the first national food and nutrition policy. It took 15 years to implement it into politics because all the relevant ministries had to be involved in the policy negotiations however (Dolan and Levinson, 2000).

In the 1980s, the Tanzanian agriculture became more commercialized again; but at the cost of increasing regional differences (Kussendrager, 1996). This commercialization led to a renewed availability of goods, although they remained too expensive for most Tanzanians. It is due to this liberalization of agriculture that the revenues rose again in the 1980s. Next to the crops for own use, there is also an export of agriculture seen nowadays. Critics fear that these 'cash crops' will be cultivated at the expense of the food crops for the national market (Kussendrager, 1996).

One way to measure nutritional patterns is to look at the per capita food consumption in Tanzania. The food consumption per capita declined from 450 kg/person in 1983 to 330 kg/person in 1997. This is mainly due to a change in diet, particularly a decline in the consumption of cassava. There are some doubts about the correctness of this data however (World Bank, 2000). The adjusted numbers of the World Bank (2000) showed a food consumption falling from 300 kg/person in 1986 to 250kg/person in 1991.

There are three possible hypotheses for this decline. Since the income also rose during this period, there might have been a shift from staple food consumption to qualitatively higher food. A second explanation is a possible bias in the measurement. The initial high estimates were changed to more reasonable estimates. If these two hypotheses do not explain the fall in food consumption, then there must be an actual decline in the availability of food. Although this seems unrealistic as the average household income rose during this period (World Bank, 2000).

Since 1980, the Tanzanian ministry of health collects information from clinics and hospitals about nutrition. These data tend to be biased however since the hospital patients do not represent a random sample of the population (World Bank, 2000). In the period 1984-1993 the *Child Survival, Protection, and Development Survey* collected information about child malnutrition. The most adequate information is obtained by the Tanzanian DHS however. The trend seen in the period between 1991 and 1996 in the DHS is a slight improvement in nutritional status. The average BMI of mothers remains, according to the WHO guideline, low with a value of 18.5 (World Bank, 2000); which is the lower boundary for normal weight.

Another interesting remark made by the World Bank (2000) is that the status of child nutrition varies significantly with the characteristics of the household. Stunting among children under 5 is 40% more common in rural Tanzania than in urban Tanzania. This suggests that the advantages of urban residence (better health care, higher income, etc.) outweigh the disadvantages of urban residence (pollution, higher food costs, etc.) (World Bank, 2000).

Another striking pattern is that of the regions with the most stunting, there are two of the big four maize producing regions. This shows that per capita food production or per capita food availability is not a good measure for regional nutritional status (World Bank, 2000).

There is also a strong relationship seen between nutritional status of children and the level of education of the head of the household. This may also be correlated with the higher income earned by higher educated people though (World Bank, 2000).

Over the long term, Dolan and Levins (2000) state that although child malnutrition declined during the 1980s, it stagnated in the 1990s. A cause of this may be the slow agricultural growth, causing food supply problems (Dolan and Levins, 2000).

Concluding, there have been agriculture- and nutrition-related policies since the beginning of the country Tanzania. From the 1960s till the 1980s there is little factual information available however on nutrition patterns in Tanzania. From the 1980s onward, and the liberalization of agriculture, there is more information available. Most of this information is on malnutrition, and particularly on child malnutrition. Although this paper aims to explain nutrition pattern outcomes (not only malnutrition but also obesity) of adults, this gives a good insight in the nutrition patterns in the past. The next paragraphs will give an insight in the determinants of BMI in recent studies in both Tanzania and other countries.

2.3. Studies on determinants of BMI

This paragraph focuses on the variables that are found to be related to BMI outcomes in previous studies.

A study of Welch et al. (2009), in the Amazon region in Brazil, shows that there is a higher prevalence of obesity in societies that experience a greater involvement of market economy. This suggests that socioeconomic status has influence on the nutrition patterns of a population. Since these places differ in cultural- as well as in economic settings from the places that are less involved in market economy (Welch et al. 2009).

Tan et al. (2011) did a study on the determinants of body weight, measured in BMI, in Malaysia. A population aged 25-64 year old was used for this, both male and female. Several determinants turned out to be significant with body weight: age groups, education levels, income brackets, history of family illness and smoking status (Tan et al., 2011). These relations also turned out to be different for the different ethnic groups in Malaysia.

In Italy, a study on obesity was conducted by Banterle and Cavaliere (2009). The study population existed of 955 adult consumers in Lombardy, a region in northern Italy. The dependent variable was BMI in ordinal categories. As independent variables, socio-demographic variables like age and gender were used (Banterle and Cavaliere, 2009). The results showed a significant positive relation between age and obesity. The relation between gender and BMI was significantly negative, which showed that men are more likely to be obese than women. Furthermore, obesity was negatively related to education and fitness activity and positively to family size. This means that the higher educated one is and the more one does fitness, the lower the BMI is expected to be. People in bigger households tend to have a higher BMI on the other hand (Banterle and Cavaliere, 2009). Pieroni and Salmasi (2010) did an extensive study on the relationship between obesity measured in BMI and several socio-economic variables. The sample was composed of 5,500 households and 10,300 adults in the United Kingdom. It turned out that men working more than 30 hours a week are likely to have a higher BMI. This relation is not that clear for women. Just as in the Banterle and Cavaliere (2009) study, there is a big negative relation between BMI and physical activity for both men and women (Pieroni and Salmasi, 2010). Smoking also seemed to have a significant relation on obesity; the percentage of obesity among smokers was lower than the percentage of obesity among non-smokers. Another observation was that BMI was higher for black respondents than for white respondents, this suggests that ethnicity also has an influence on BMI but it is not sure whether this is due to cultural or genetic factors (Pieroni and Salmasi, 2009). A relation found as well was that people with higher education had a lower BMI. Income had no influence on the BMI of men but was negatively related to the BMI of women, the same was seen in a study on 9 European countries by Villar and Quintana-Domeque (2009). Interestingly, married respondents appeared to have a similar BMI to that of couples but higher than, divorced, separated and widowed people (Pieroni and Salmasi, 2009). External factors were also considered, the price of fruit has a positive effect on the BMI with the effect being bigger on women's BMI. The density of fast-food restaurants was also positively significant on BMI, especially for women. This relation also varies between the different income groups.

In the case of Germany, based on the 1998 National Health Survey, income tended to have a negative relation on BMI (Maennig et al., 2008). On the contrary, age had a positive effect on BMI. For smoking however, there did not appear to be a uniform relationship between the different groups. Physical activity was negatively related with BMI based on this study and marital status did not have any influence (Maennig et al., 2008).

A study in Russia by Huffman and Rizov (2007) was done on the increase in BMI after the shift from planned- to market economy. It is based on an annual household survey with data collected for more than 4,000 households and 10,000 individuals. In the period of 1994 to 2004 the average BMI increased significantly in Russia (Huffman and Rizov, 2007). It appeared that women are much more likely to be obese than men. Just as in other similar studies in developed countries, the same factors were found to be influencing BMI: dietary intake, income, age, smoking behavior, physical activity. The effects tend to be different by gender however (Huffman and Rizov, 2007).

Vernay et al. (2009) conducted a study in France on the association of socioeconomic status with overweight and obesity for both 18-74 year aged men and women. It turned out that both for men and women overweight was positively associated with socioeconomic status, the relations worked in a different way however. For men, occupation and the frequency of holiday trips were the main significant explaining variables. For women on the other hand, educational level and the frequency of holiday trips were most important (Vernay et al., 2009).

There have also been studies done on the determinants of BMI in developing countries. Römling and Qaim (2011) conducted a study on the nutrition transition and overweight in Indonesia. Indonesia faces overweight but there are still underweight problems as well, causing a double burden on the country's health system. The study focuses on the adult population between 20 and 75. A look at the BMI by gender shows that women have a higher BMI than men and that the difference increases over time. Rural/urban differences are also studied, with a higher BMI in the urban areas. This difference is decreasing over the past years however. An increase in BMI may either indicate an improvement or deterioration in nutrition status, depending on the starting point (Römling and Qaim, 2011). Although the prevalence of underweight seems to be equal by gender in Indonesia, overweight and obesity are significantly more prevalent in the female population. Living standards turned out to have a positive influence on BMI in this study. Per capita expenditure also had a positive relation with BMI, although this effect was bigger for men than for women. Education has a positive effect on BMI for men but no effect for women. A possible explanation for this is that men with a higher education tend to have jobs where they are more in a sedentary position, whereas this does not apply for women (Römling and Qaim, 2011). Age increases the BMI significantly. Being married increases the BMI especially for women, where the BMI is 1.4 higher for married women. This is probably mainly due to cultural factors and changing lifestyle (Römling and Qaim, 2011). Just as in other studies, smoking has a negative effect on BMI. The possession of a television increases the BMI for both men and women. This is related to a decrease in physical activity, where both work-related physical activity and physical activity in leisure time are related to a lower BMI for both men and women. The share of dairy and meat consumption also has a positive effect on BMI, this confirms the expectations that dietary changes related to the nutrition transition result in an increase in BMI (Römling and Qaim, 2011).

A study in sub-Saharan Africa was done by Ziraba et al. (2009). The aim of the study was to compare trends of overweight and obesity in urban Africa between the rich and the poor population. DHS data about women in seven countries for the period 1992-2005, one of them being Tanzania, was used for this. The prevalence of overweight/obesity was 2 to 8 times as high as in rural areas for the countries, with Tanzania showing a ratio of 3. The main conclusions were that the increase of overweight and obesity was significant and was higher among the poor urban population than the rich urban population; this difference was not significant however. What was significant, is the difference between the rise in overweight/obesity between the higher educated and the lower educated population. The rise in overweight/obesity increased significantly faster for the latter. The starting point of the measurement should not be forgotten however, as the higher educated population might have had a higher BMI already (Ziraba et al., 2009). One thing concluded by Ziraba et al. (2009) is that obesity is becoming an increasing problem in sub-Saharan Africa and might take epidemic proportions for urban women in developing countries. The chronic nature of obesity and its related diseases and its huge treatment costs will create a huge challenge for the healthcare system of these countries that already have to deal with existing epidemics like HIV/AIDS, tuberculosis and malaria (Ziraba et al., 2009).

In the same region, a comparison was made between the nutrition transition for South-Africa and Kenya. The study population consisted of 1008 and 4481 15-year and older women in Kenya and South-Africa respectively. The most interesting result was that in both countries the BMI was higher in the urban areas and for the older age-groups (Steyn et al., 2012).

As this paragraph shows, there have been several studies done on BMI in both globally and in Africa. Most studies result in the same variables influencing BMI, both in the world and in Africa. Socioeconomic status, age, smoking habits, gender, marital status, type of place of residence, physical activity and education were often mentioned as to be significant to BMI. These variables will also be considered in this study on BMI, as they are expected to be related to BMI. The next paragraph will show the existing studies on BMI for Tanzania.

2.4. Studies on determinants in BMI in Tanzania

There are few studies done on the distribution of BMI among adults in Tanzania. Shayo and Mugushi (2011) did a study on obesity (with BMI as the dependent variable) in the Kinondoni district in Dar es Salaam, the biggest city in Tanzania. Since this study is only in this district, it is not nationally representative for Tanzania. Of the sample of 1,249 adults, 65.2% were females and pregnant women were excluded. The prevalence of obesity appeared to be significantly higher for females than for males. As in other studies, BMI seemed to increase significantly with age as well. BMI was also negatively related to educational level in this study. Increasing parity and socioeconomic status seemed to have a significantly positive effect on BMI. Furthermore, obesity was significantly higher for people who only experienced moderate physical activity (Shayo and Mugushi, 2011). Marital status also seemed to have a significant influence, whereas cohabiting and married couples had a significant higher BMI than single respondents (Shayo and Mugushi, 2011).

Another study on BMI in Tanzania was done in the Dar es Salaam region as well. Bovet et al. (2002) conducted a study on the relation of blood pressure, BMI and smoking habits with socioeconomic status. For this, 9254 men and women were questioned. The main results regarding BMI were that BMI has a significant positive relation with socioeconomic status and that BMI has a significant positive relation with blood pressure. The main concern of the authors is that the increasing affluence of the urban Tanzanian population will cause a rise in blood pressure and cardiovascular diseases through a rise in BMI (Bovet et al., 2002).

Keding et al. (2011) studied the relationship between BMI, socioeconomic status and dietary patterns in Tanzania. The population studied for this cause was 252 women between 16 and 45 in rural areas in the Northeast and Central area of Tanzania. It was found that BMI was significantly related to the difference between traditional and modern nutrition patterns. This may suggest evidence of early stages of the nutrition transition in Tanzania (Keding et al., 2011).

Bengtsson (2010) has studied the relationship between body weight and income changes in rural Tanzania. He found that the relationship is positive on average: when income increases, bodyweight also increases. The impact turned to be the highest for female children and lower for adults (Bengtsson, 2010). The reason for this relationship remains unclear however. It is not known whether this is because children, and especially female children, do not get enough food when there is little money; or that it is because the parents spent their additional income on the children first, rather than on themselves (Bengtsson, 2010).

Unwin et al. (2010) conducted a study on the differences in cardiovascular risk factors in rural to urban migrants in Tanzania. Some interesting results were found. First of all, the migrants showed less physical activity after moving to the city. In particular males showed an increase in alcohol consumption. There were also increases in vegetable and fruit consumption and the consumption of saturated fat for both men and women (Unwin et al., 2010). Weight- and waist circumference as well as BMI also increased for both men and women who moved to urban areas. There were different outcomes for blood pressure: both systolic as diastolic blood pressure fell among the migrants but there was a rise in mean triglycerides and mean cholesterol level (Unwin et al., 2010). Unwin et al. (2010) conclude that living in urban areas is likely to increase the risk of cardiovascular diseases and diabetes. This is yet another study that shows that type of place of residence can influence nutrition patterns and health outcomes.
Figure 2.1 shows that there might be a relationship between the GDP and nutrition outcomes in Tanzania. The high logs of per capita expenditure clearly have higher logs in per capita daily caloric availability (Figure 2.1). This implies that a higher GDP also has a positive effect on energy intake. This again, can result in higher average BMI levels if low per capita energy expenditure is the cause of a low BMI.

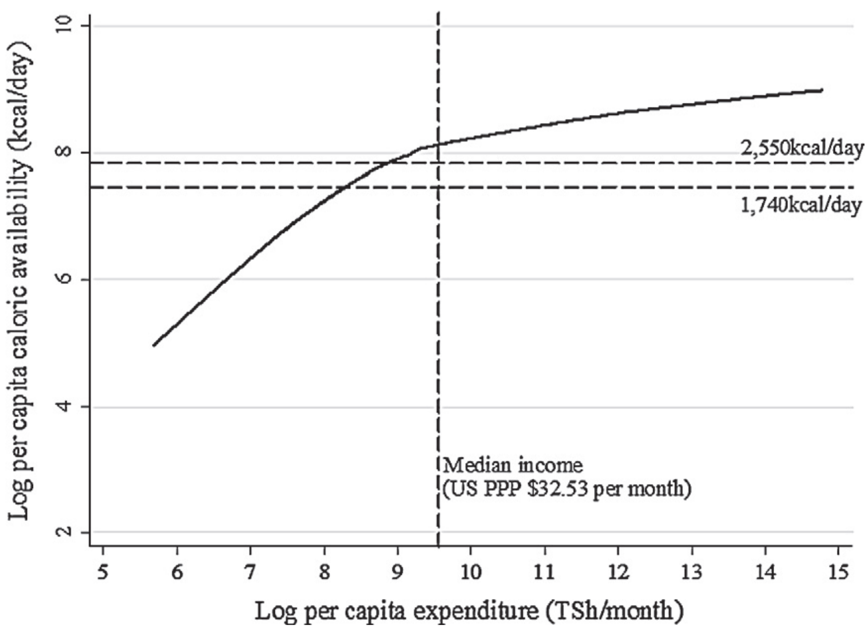


Figure 2.1: The relationship between per capita GDP expenditure and per capita caloric availability (Pauw and Thurlow, 2011).

2.5 Regional differences in BMI in Tanzania

This paragraph will summarize the studies done on the nutrition outcomes and their indicators between the regions in Tanzania. There are few studies done in Tanzania on nutrition outcomes on women in Tanzania. Therefore, some studies do not have the same study population as this study (adult non-pregnant women), but they give a good insight in the existing nutrition patterns and problems of Tanzania

Pauw and Thurlow (2011) have looked at the relationship between agricultural growth, poverty and nutrition in Tanzania. It turns out that despite a constant increase of the GDP during the period 1998-2007, the population consuming insufficient calories only fell from 25% to 23.5% (Pauw and Thurlow, 2011). Although economic growth in general is a good thing for the poor population, only a small amount of the poor population has profited from this economic growth. The economic growth consists for a large part of the growth in agriculture. The agriculture of Tanzania is mainly controlled by large-scaled farmers, so the rich farmers are the ones who profit the most from this growth in agriculture (Pauw and Thurlow, 2011). This is a process of increasing inequality due to (unequal) technological development.
Simler (2006) studied undernutrition (low weight-for-age) and stunting (low height-for-age) among children under 5 in Tanzania. The regional prevalence of stunting for the different regions of Tanzania is shown in figure 2.2.

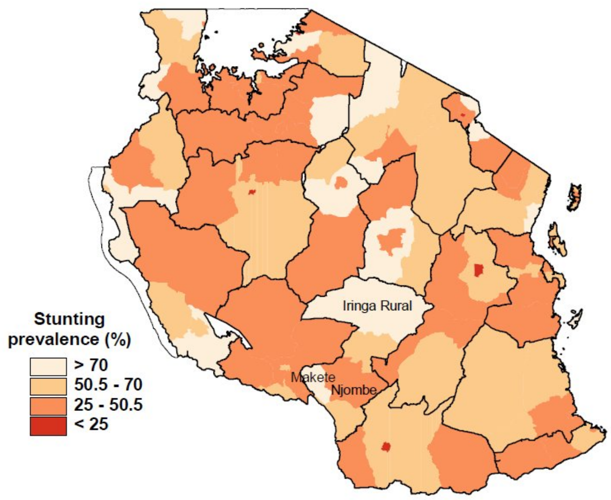


Figure 2.2: Estimated stunting of children under 5 in Tanzania by district (Simler, 2006).

It turns out that there is a significantly higher undernutrition for rural regions compared to urban regions, even for the small urban centers (Simler, 2006). This supports the hypothesis that type of place of residence is also an important factor in explaining nutrition intake patterns in Tanzania.

The regional patterns of underweight among children under 5 can be found in figure 2.3. Although most regions tend to show the same trends in both stunting and underweight, it is interesting to see that the Northern Mwanza region shows a very low underweight percentage. Simler (2006) does not explain this however.
Since both stunting (Sebanjo et al, 2011) and underweight (Khan and Kraemer, 2009) are a result of a low energy intake, the same patterns in underweight are expected to be seen for adult women.

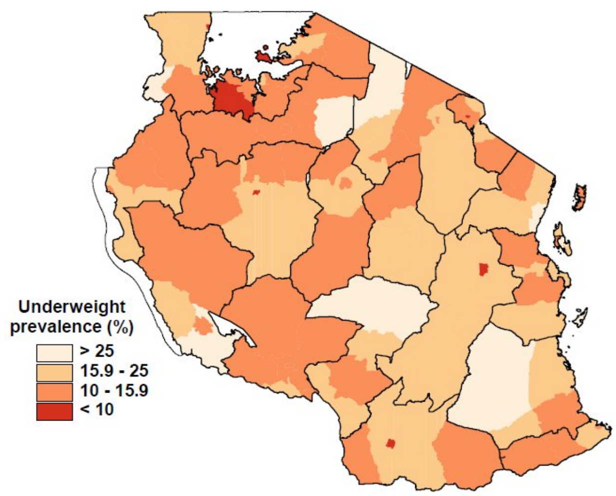


Figure 2.3 Estimated underweight of children under 5 in Tanzania by district (Simler, 2006).

The encyclopedia of population (2003) provides an article about famine in Africa. According to the article from Hill (2003), there were no major famines in Tanzania since the 1960's (von Braun, Teklu and Webb, 1999). Figure 2.4 makes a comparison of African countries on based on the indicators of undernutrition. The figure shows that a quarter of the children in Tanzania under age three is two standard deviations below the weight/age standard. Women of reproductive age have a Body Mass Index (BMI) of less than 18.5 (which is the WHO classification for underweight (World Bank, 2000)) in about 10% of the cases. This contradicts to the linear line seen in figure 2.4 and the earlier statement that patterns for adult women and children are expected to be the same. Where children are relatively malnourished compared to the other African countries in the study, the women population has relatively few malnourishment (Tanzania lies above the line in figure 2.4). In general, there is not a high prevalence of undernutrition in the higher ages but there is in the lower ages, compared to the other African countries (Figure 2.4). It should be taken in account however that the data used for Tanzania in this figure is from 1992, circumstances may have changed since then.

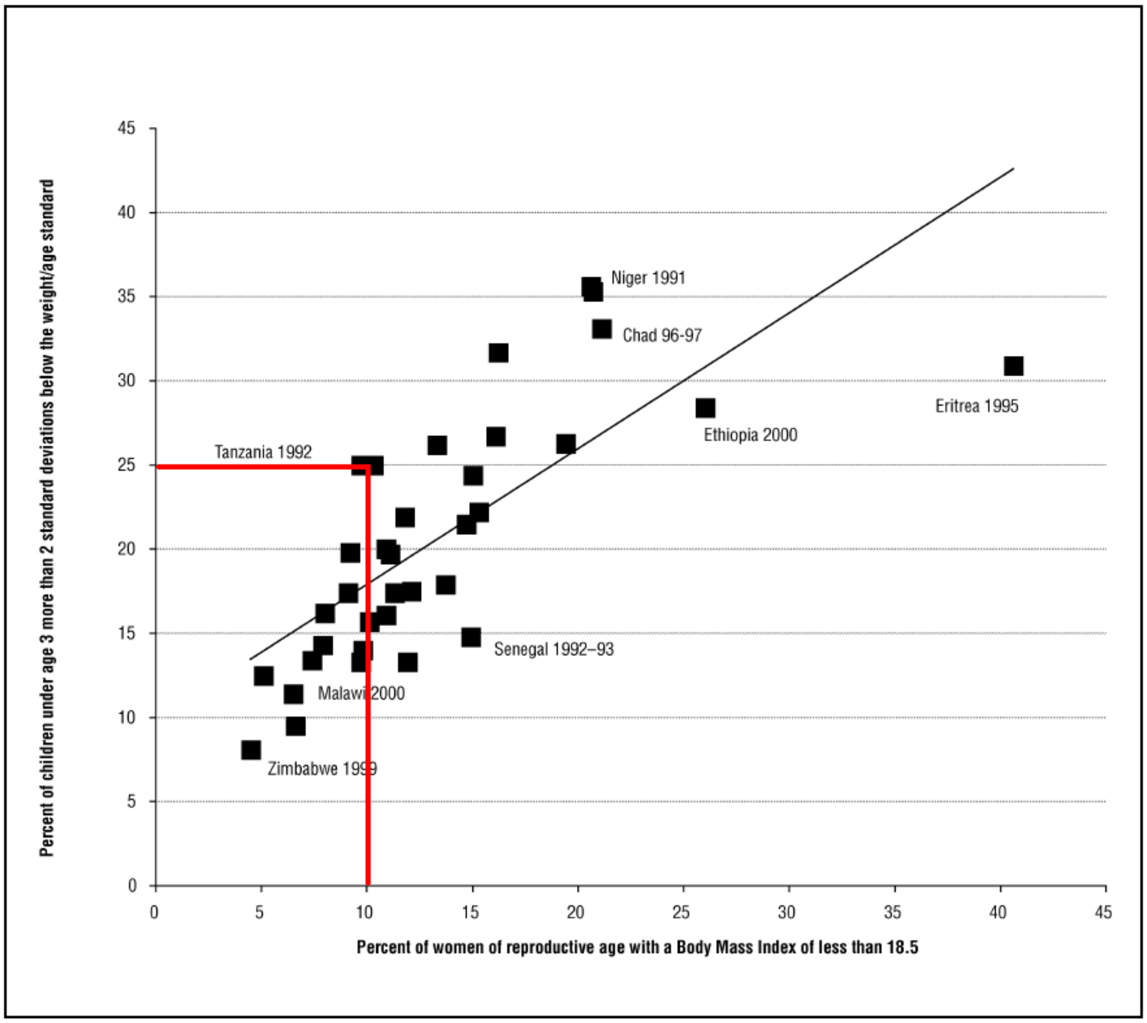


Figure 2.4: Indicators of undernutrition among children and women in Tanzania and other selected African countries (Hill, 2003).

As can be seen in this literature review there are several studies done on the relationship between nutrition status and its determinants. In Tanzania there were few studies done on the determinants of BMI for adult women however. Studies on other populations, like children, gave an insight that there are regional differences in nutrition outcomes however. In most cases, a significant relationship between these variables and nutrition is found. This makes it interesting study the relationship between nutrition and these variables.

3. Theoretical framework

This chapter will be about the underlying theory used to explain the outcomes of the study. The main topic will be the nutrition transition theory, which is the macro context in which the study takes place.

The nutrition transition is a transition theory that is linked to the demographic transition and the epidemiologic transition (Figure 3.1). It does not focus solely on diet but recognizes that most of the health effects of diets in human population are also a result of lifestyle and physical activity (Caballero and Popkin, 2002). Generally there are five stages recognized in the nutrition transition: collecting food, famine, receding famine, degenerative disease and behavioral change (Caballero and Popkin, 2002).

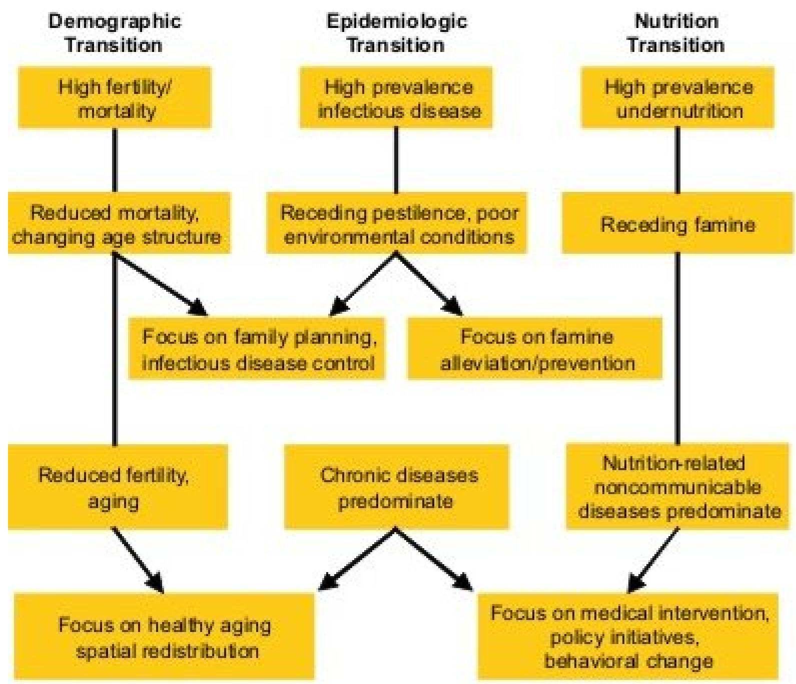


Figure 3.1: Stages of health, nutrition and demographic change.

The stage of collecting food is the stage of the first two- to three million years of human existence in which humans were hunters and gatherers. Caballero and Popkin (2002) say that about 50-80% of food came from plant and that 20-50% of food came from animals in that period. The general diet of these people was assumed to be varied (Truswell, 1977; cited by Caballero and Popkin, 2002) and the fat-intake was low. The most common diseases were infectious diseases and chronic diseases were absent (Cavalli-Sforza, 1981; Eaton et al., 1988; cited by Caballero and Popkin, 2002). Researchers agree that this has to do with their living patterns rather than their short average life-expectancy. Obesity was also absent but malnourishment may have existed (Caballero and Popkin, 2002).

As humans developed a sedentary lifestyle, the age of famine started. The development of agriculture made the sedentary lifestyle possible with the production of food. The protein- and fat consumption decreased notably (Trowell and Burkett, 1981; cited by Caballero and Popkin, 2002). In most communities, plants and vegetables made up a large part of the diet. The dependence on agriculture led to a less-varied diet and the increase of diseases related to this lack in variation (Yudkin, 1969; cited by Caballero and Popkin, 2002).

In the 18th and 19th century, modern technology was first applied in agriculture and led to the age of receding famine. Natural fertilizers, crop rotation systems and transportation helped to reduce the effect of climatic fluctuations (Caballero and Popkin, 2002). The diet also changed significantly in this period: there was a decrease in intake of starchy foods and an increased intake of sugar, vegetables and fruits (Caballero and Popkin, 2002). There were fewer famines but because poor people tended to live together, there was an increase in the prevalence of infectious diseases (Caballero and Popkin, 2002).
The age of degenerative disease started with a rapid growth in animal husbandry, urbanization and economic change. The nutrition intake shifted towards a diet with excessively high saturated fat and refined sugar intake (Caballero and Popkin, 2002). Most meat eaten is from domesticated animals. These animals contain more fat than wild game and their fat is less likely to be polyunsaturated. This might explain why the human body provides little protection against high (polyunsatured) fat-intake (Caballero and Popkin, 2002).
The final stage in this theory is the age of behavioral change. In this agem, there is a change in diet to reduce degenerative diseases and to prolong health. People are starting to become more aware of what they eat and what the results of their diets are. There is a desire seen to prevent degenerative diseases. Whether these changes are sufficient to result in a large-scale transition remains to be seen (Caballero and Popkin, 2002). Some researchers have shown however, that these behavioral changes will extend the period of healthful living (Manton and Soldo, 1985; Rogers and Hackenberg, 1987; cited by Caballero and Popkin, 2002).
There is a clear distinction between the first three stages of the nutrition transition and the last two stages. In the former, the main food problems are undernutrition and famine; whereas in the latter, the main food problems are overweight and obesity (Caballero and Popkin, 2002). The contemporary world faces both overnutrition and undernutrition (Steckel, 2003). This is also the case for Tanzania (Villamor et al., 2006).
Steckel (2003) states that undernutrition is mainly a problem of low-income countries and that the largest regions of undernutrition are found in Africa and Asia. Obesity however, is more a problem of wealthy countries (Steckel, 2003). Because the price of food has fallen relatively to income as a result of agricultural innovations since the 1950's, people tempt to consume more (Steckel, 2003). The growing use of cars replaced walking or cycling. The diminishing demand for manual labor makes people use less energy. These two factors are possible explanations for the increase of obesity in first-world countries. An argument against this may be the increased use of fitness gyms and the growing number of people doing recreational sports. This results in a sharp division on the base of weight and physique in a lot of industrialized countries (Steckel, 2003).
A problem that is commonly faced in the transition from the third to the fourth stage is a double burden of disease. This is the case when both infectious as non-communicable diseases occur at the same place at the same time. This is also related to under- and overnutrition problems that take place at the same place at the same time (Custudio et al., 2009). Custudio et al. (2009) studied this phenomenon in Equatorial Guinea. The most important findings of this study are that in general, the prevalence of overweight increased and the prevalence of stunting decreased although it remained very high. This is an example of a country in transition, suffering both nutrition problems from the 'old' stage as well as from the 'new' stage. Often, a division can be seen between urban and

rural regions as well as between the richer and the poorer population groups (Caballero and Popkin, 2002).

Although the data set of the Tanzanian DHS has little information available on lifestyle changes and dietary patterns, there is information on nutrition outcomes in Tanzania. It will be interesting to see whether there will be a difference between the regions for the stages of the nutrition transition. The expectation based on the literature is that most of the country will still experience the age of famine. There may also be some signs of the age of noncommunicable diseases however. This could result in a double burden of disease for Tanzania. The actual results can be seen in chapter 6.

4. Conceptual model

This study focuses on the regional differences in the outcomes of nutrition patterns. At the international level, a great part of Africa is currently in the stage of receding famine or the age of degenerative diseases (Popkin et al., 2012). The theoretical framework of the nutrition transition can be fit into a conceptual model. Figure 4.1 shows the stage of receding famine and the stage of noncommunicable diseases and all their characteristics, this is the macro context in which this study is embedded. This study aims at exploring and explaining the differences between the regions. The regions are expected to fit the nutrition outcomes for the different stages of the nutrition transition described by Caballero and Popkin (2002).

The regional differences will be studied using BMI as outcome variable. The explanatory variables come from the DHS dataset. The variables are chosen based on the literature review (chapter 2) and the theoretical framework (chapter 3). In this conceptual model, only the variables implemented in the final model of analysis are shown. There were more variables considered but they could not explain the differences between the regions. A list of all the variables considered and the criteria for selection can be found in the results chapter (chapter 6). The resulting conceptual model can be seen in figure 4.1.

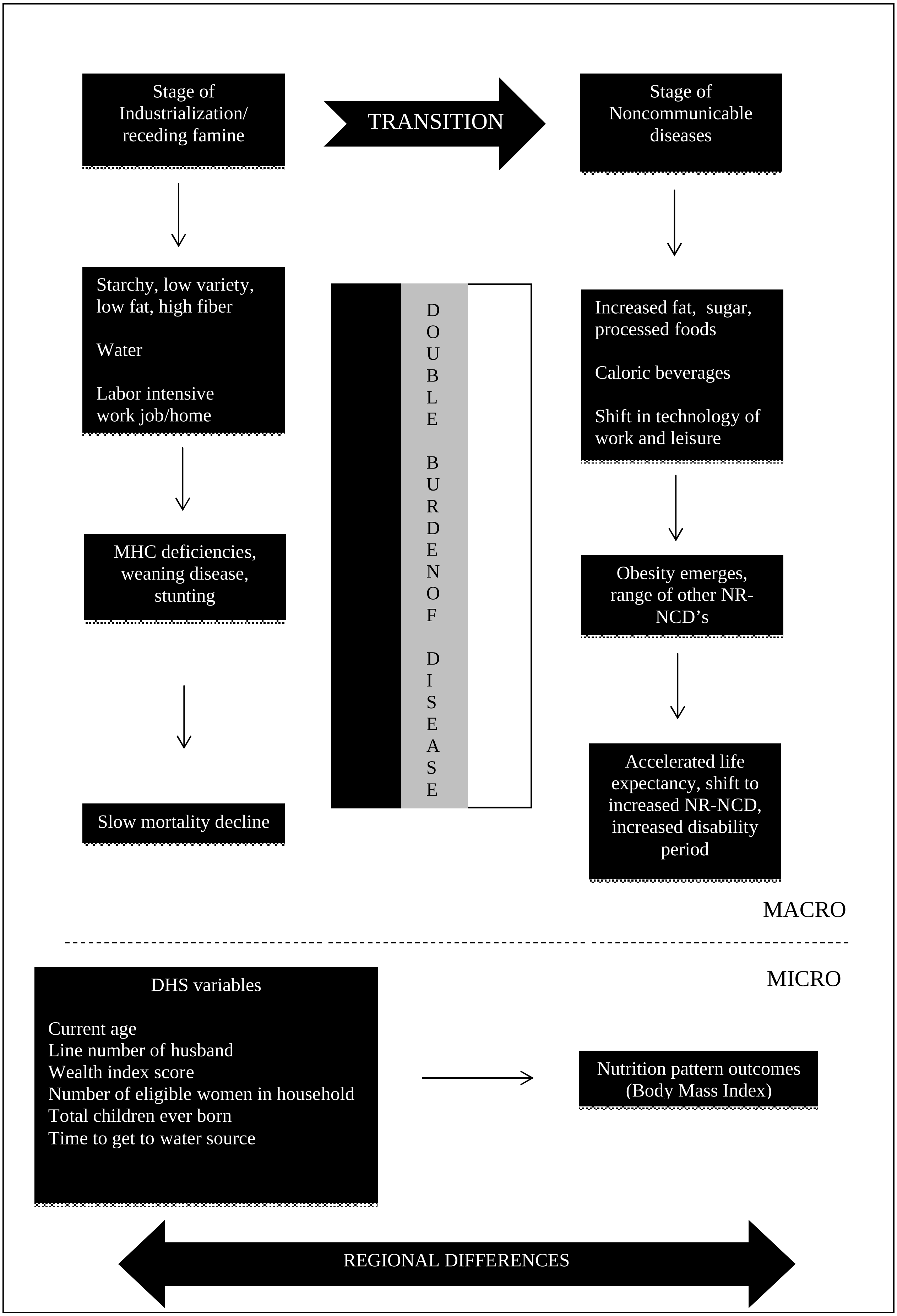


Figure 4.1: Conceptual model of nutrition pattern outcomes in Tanzania (Caballero and Popkin, 2002; modified).

5. Methods

5.1. Introduction

Before the actual research questions will be answered, first there will be a brief consideration on the data used in the research. This chapter will take both the quality of the data as the structure of the data into account. The data will be processed using the computer statistical computer programs SPSS 16 and STATA 11 and the GIS computer program ArcGIS 10. It will be mentioned in the text which computer program is used for each step.

5.2. Quality of the data

The data source used for the actual calculations in this paper is the database of the 2010 DHS for Tanzania, which is the most recent DHS available for Tanzania. The first DHS taken in Tanzania was in 1991-1992.
Since 1984, the MEASURE DHS project has provided technical assistance to more than 260 surveys in over 90 countries (MEASURE DHS, 2012). The DHS collects nationally representative data on fertility, family planning, maternal and child health, gender, HIV/AIDS, malaria and nutrition (MEASURE DHS, 2012).
The project is financed by the USAID and, although there are sometimes some biases in the data, is widely recognized as a reliable and national representative source for the topics it addresses (Stanton et al., 2000).

5.3. Structure of the data

The data used in this study exists of a survey- and a GPS dataset. The first contains all the survey results whereas the latter has the geographical coordinates for the places where the survey was taken. Both can be combined using GIS to analyse the spatial relationships in the data.
The data is obtained using three questionnaires: the household questionnaire which is about all the household members, the women's questionnaire which only questions females, and the men's questionnaire which only questions males.
The survey data again exists of seven different recodes: the births-, couples'-, household-, individual-, children's-, male- and household member recode. Each dataset has the general information of the respondents from the survey from which it was derived, as well as specific health information for each group (MEASURE DHS, 2012).
The recode used in this paper is the individual recode. One of the reasons to choose this recode is because it is the only recode available with information on both height and weight, which is needed to calculate BMI. This individual recode only has information about 15-49 year old women, that is the reason why this study is only on women and not on the total Tanzanian population. It is a disadvantage that there are no men in this recode, but there is no data on height and weight available for men in the 2010 Tanzanian DHS.

Another advantage of this recode is the sample size, as this recode is the biggest of all recodes. The recode consists of 10,139 women. If the pregnant and non-adult women are taken out, there are 7,746 women left. The pregnant and non-adult women will be filtered out for the rest of the analysis because they tend to have a BMI which is not representative for the general population (Gigante et al., 2005; Hedley et al., 2005) which may lead to misinterpretations.

5.4. Statistical methods

In this paragraph, the steps taken in SPSS, STATA and ArcGIS will be described. The choices made will be explained, the results are in the results chapter however. All the exact syntax commands can be found in the appendix.
First, the SPSS file of the individual recode is used. In SPSS, the pregnant and non-adult women are filtered out using the function: data → select cases → if condition is satisfied. The unselected cases are deleted using the 'delete unselected cases' function in the 'select cases' window. The pregnant and non-adult women are filtered out because they do not represent the general population in BMI (Gigante et al., 2005; Hedley et al., 2005).
Since the study focuses on BMI as an outcome variable, this variable has to be created. This was done by making a variable for weight in kilos and height in meters first using the function: transform → compute variable. These variables are needed to create the BMI variable. BMI is weight in kilos/ (height in meters^2). This variable can be created using the same 'compute variable' command.
The first step in exploring the data will be to see whether the chosen independent variables are significant with the exposing variable 'region' and the outcome variable 'BMI'. In this way, it can be seen whether there is difference of the independent variables between the regions and whether the variables relate to BMI. This is the first selection to see which variables relate to regional BMI differences. The significance level chosen for this was 0.1. This value was chosen to not to disregard variables from the analysis too quickly. The variables for which the relation with BMI and region was tested, are the following: current age – respondent, type of place of residence, de facto place of residence, line number of husband, highest educational level, highest year of education, source of drinking water, time to get to water source, type of toilet facility, has electricity, has radio, has refrigerator, has bicycle, has motorcycle/scooter, has car/truck, main floor material, main wall material, main roof material, number of children 5 and under, number of eligible women in hh, educational attainment, sex of HOUSEHOLD head, age of HOUSEHOLD head, has a landline telephone, literacy, type of cooking fuel, toilet facilities shared, wealth index, type of bednet(s) slept under last night, total children ever born, age of respondent at 1st birth, smokes cigarettes, smokes pipe, uses snuff, chewing tobacco, current marital status, currently/formerly/never marr. These variables were selected mostly based on the literature review and the theoretical framework. A lot of variables were selected because it is quite easy to do analysis on all of these variables, whereas when a variable is not included it will never be known whether it is significant or not.
It might not be clear what all variables mean at first, a short explanation of the possibly unclear variables will be given. The line number of number of husband variable registers what place the husband of the respondent has based on age (if the husband is the oldest in

the household, this value will be 0). The number of eligible women in the household measures the number of women in the household that are eligible (aged between 15-49) to take the questionnaire.

To look into this relation between the independent variables and region and BMI, crosstabs will be made for the categorical independent variables by region. The Chi-square test is used to look at the significance between the variables. This is done by the command analyze → descriptive statistics → crosstabs. The chi-square option can be found when clicking on the statistics button in the crosstabs window. Besides the 0.1 significance level, the chi-square tests also have to satisfy the chi-square requirements of a maximum of 20% of the cells with an expected value below 5 and no expected values below 1 (Norušis, 2006). The variables that do not match these conditions will be recoded, if possible, into variables with less categories and the test will be run again.

For the ratio variables ANOVAs will be computed by region. This will be done by the SPSS function: analyze → compare means → One-Way ANOVA. ANOVAs will also be made for the categorical independent variables by BMI using the same method. Finally the independent ratio variables are tested on linearity with BMI by using the SPSS function: analyze → regression → linear. This tells whether BMI has a linear relation with the independent ratio variable.

Comparing these variables by BMI and region tells whether there are relations between the independent variables and region and BMI, so whether each variable varies between the regions and across the BMI curve. Only if the variable is significantly related to both BMI and region, the variable will be selected for further analysis. The remaining categorical variables will be recoded into dummies for this analysis. This will be done by the function transform → recode into different variables in SPSS. The values given will be 0 or 1 for no and yes for each category of the variable respectively. There is one reference category that is not made into a variable for each categorical variable; a variable with four categories will thus be made into three new dummies.

After the variables are selected, the actual statistical analysis can take place. The focus of this study is on regional differences in BMI. The structure of the DHS data is on the individual level however. To make sure that the dependence of individuals is considered in the model, a multilevel model might be necessary because this takes into account that cases from the same region are not independent from each other.

To see whether the cases at the same level can be seen as independent from each other first, two empty models with only the different 'spatial level' variables are built. The region variable is in both models because it is the goal of this study to explain the regional differences in Tanzania. It should be noted that the individual level is always present in the model as the data is on the individual level. Respectively, the cluster number and the household number make up the rest of the two models. In the model with the cluster variable in it; 87% of the variability in BMI is explained within the clusters, 6.4% between clusters within regions and 6.3% between regions (Table 5.1). These models were made using the function Analyze → mixed models → linear in SPSS.

Parameter	Estimate	% of total variance
Residual	16.691830	87.3%
Intercept [subject= region]	1.208543	6.3%
Cluster number [subject= region]	1.218122	6.4%

Table 5.1: Distribution of variance in a model with region- and cluster-level.

The other model results in an explained variability in BMI of 90.2% within households, 3.3% between the households within the regions and 6.5% between the regions (Table 5.2).

Parameter	Estimate	% of total variance
Residual	17.207901	90.2%
Intercept [subject= region]	1.245626	6.5%
Household number [subject= region]	0.623726	3.3%

Table 5.2: Distribution of variance in a model with region- and household-level.

After considering these percentages, both household number and cluster number are disregarded from the final model. Household number is disregarded from the model since only a small part of the variance is explained between the households. Cluster number is disregarded because it is too abstract to draw valuable conclusions from it. It is easier to explain the differences between 26 regions and make policies based on that than on the differences between 475 clusters. But it should be noted that observations from the same clusters also influences the independence of the cases. In the model with only regional- and individual level in it, 93.4% of the variability in BMI is explained by differences within regions and the remaining 6.6% is explained by differences between regions (Table 5.3). This will be the level of analysis for the final model.

Parameter	Estimate	% of total variance
Residual	17.834281	93.4%
Intercept [subject= region]	1.260819	6.6%

Table 5.3: Distribution of variance in a model with region-level.

After the empty model with region and individuals is chosen as the model for further analysis, the explaining variables can be implemented in the model. These procedures will be done using the function Statistics → multilevel mixed-effects models → mixed effects linear regression in STATA after the SPSS file is converted to a STATA file. It was chosen to do the analysis in STATA because there appeared to be more options for comparison between the regions than in SPSS. First, all the variables related to BMI and region were put into the model with region and individual level. After that, the most insignificant variable will be removed, again using a significance level of 0.1 to be conservative. This is the so-called *backwards* procedure and will be repeated till there are no insignificant variables left. Then, possible interaction effects will be considered. Again, the most insignificant interactions will be removed until there are no insignificant interactions left.

To support the interpretation of the results, the results will be visualized using maps made in ArcGIS. It is possible to do this because the DHS dataset has a GPS component which makes it possible to link it with the SPSS data and point the data on location in the map. Unfortunately however, the dataset only contains information for the location of the clusters and not for the regional and national boundaries.

Therefore, a *shapefile* with the coordinates of regional and national boundaries was downloaded from an external source: DIVA-GIS (2012). Although DIVA-GIS (2012) does not provide the source for the data, the projection seems right when compared to a map of the regions shown in the report 'Tanzania in Figures 2010' by the Tanzanian National Bureau of Statistics (2011). One disadvantage of using these regions is that they are not exactly (but almost) the same regions as used in the DHS. It is possible to visualize the regional differences in the maps but it is not possible to project it directly to the DHS regions.

With both the layer file of the regions and the layer file of the clusters separate, it is only possible to show the clusters as points (and colored by values) in the regions. To make the maps easier to interpret, average values for the variables are calculated for each cluster (there are more measurements per cluster) and region using Excel. After this, the layers are joined using the function *spatial join*. The new layer's output not only contains information of the points but also has the information of the region layer in its attribute table. This table can be exported to Excel; the previously calculated averages can be added to the table here. This table again can be linked to the region layer. Now the region layer contains the average values of the variables and the differences by regions can be projected in a map. All maps showing regional differences are produced using this technique. The maps of cluster differences are produced using the same method, but instead of working with the region layer, the cluster layer will be used.

The categories used in the maps are made using the method *natural breaks (Jenks)*. This method picks the category breaks, using the existing values of the variables, which best group similar values and maximize the difference between the groups (Webhelp ESRI, 2007). In this way, there is a clear distinction between the groups and it is easier to see the differences between the regions. The categories used in the maps are, if not mentioned, created using the natural breaks (Jenks) method. The distribution of the variables and the break variables can be found in the appendix.

6. Results

6.1 Introduction

In this chapter, a model explaining BMI for Tanzania will be established using the methods described in the methods chapter. A model will be made for both the whole country as well as for each different region. The regional variation of the variables will be implemented in maps made using GIS and tables using Excel.
Since the model that will be established in this chapter aims to predict BMI, it is good to take a brief look at the distribution of BMI in Tanzania; this can be seen in figure 6.1.

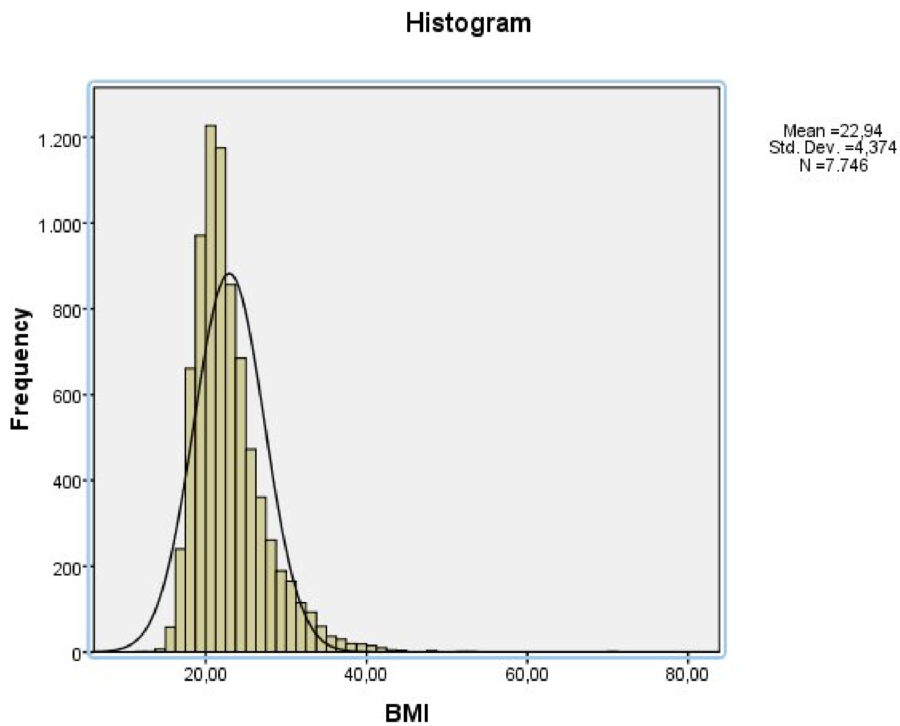


Figure 6.1: Distribution of BMI across adult non-pregnant Tanzanian women.

As can be seen in the histogram, the average BMI lies around 23. This is in the normal weight range defined by the WHO (which is between 18.5 and 25.0 (World Bank, 2000)). The lowest BMI lies around 12 and the highest around 50. These values are extreme outliers and possibly wrong (but not certainly), but they are kept in the dataset because they are only a few of these outliers that do not have a big influence on the results. It can be seen that although the average is in the normal range, there also is a lot of underweight (below 18.5) and overweight (above 25; obesity is above 30) (World Bank, 2000).

6.2 Selection of variables

In this part of the chapter, a selection of the variables will be made. This is done as described in the methods chapter (chapter 5). For the significance, there is a significance level chosen of 0.1. This is to avoid throwing relevant variables out of the analysis too quickly. The variables that have a significance of higher than 0.1 will be taken out of the further analysis.

The tables 6.1 and 6.2 show all the variables that were tested; the bold values are significant at the 0.1 level. The variables that are both significant for region and BMI are taken into account for further analysis. The variables ‘type of toilet facilities’ and ‘literacy’ were recoded into variables with less categories because they did not match the conditions for the chi-square test at first. The exact procedure can be found in the methods section and the SPSS syntax commands can be found in the appendix.

Variables	Chi-square conditions	Relation with Region	Relation with BMI	Variable in model?
Type of place of residence	Satisfied	0.000	0.0010	Yes
De facto place of residence	Satisfied	0.000	0.0200	Yes
Highest educational level	Not satisfied	0.000	0.2350	No
Source of drinking water	Not satisfied	0.000	0.6460	No
Type of toilet facility	Not satisfied	0.000	0.5980	No
Has electricity	Satisfied	0.000	0.2320	No
Has radio	Satisfied	0.000	0.4120	No
Has television	Satisfied	0.000	0.2910	No
Has refrigerator	Satisfied	0.000	0.2670	No
Has Bicycle	Satisfied	0.000	0.3760	No
Has motorcycle/scooter	Satisfied	0.000	0.4630	No
Has car/truck	Satisfied	0.000	0.3640	No
Main floor material	Not satisfied	0.000	0.2330	No
Main wall material	Not satisfied	0.000	0.8590	No
Main roof material	Not satisfied	0.000	0.5150	No
Educational attainment	Satisfied	0.000	0.1220	No
Sex of HOUSEHOLD head	Satisfied	0.000	0.2780	No
Has a landline telephone	Satisfied	0.000	0.4280	No
Literacy	Not satisfied	0.000	0.0970	No
Toilet facilities shared	Satisfied	0.000	0.9610	No
Type of cooking fuel	Not satisfied	0.000	0.3640	No
Wealth index	Satisfied	0.000	0.0280	Yes
Type of bednet(s) slept under last night	Satisfied	0.000	0.1420	No
Smokes cigarettes	Not satisfied	0.015	1.0000	No
Smokes pipe	Not satisfied	0.000	1.0000	No
Chewing tobacco	Not satisfied	0.011	1.0000	No
Uses snuff	Not satisfied	0.000	0.0170	No
Current marital status	Satisfied	0.000	0.0030	Yes
Currently/formerly/never marr.	Satisfied	0.000	0.0730	Yes
Toilet facilities in categories	Satisfied	0.000	0.4160	No
Literacy in categories	Not satisfied	0.000	0.0820	No

Table 6.1: List of categorical variables tested with on the relation with BMI and region (bold values are significant).

Variables	Relation with Region	BMI	Variable in model?
Current age - respondent	0.000	0.000	Yes
Line number of husband	0.000	0.000	Yes
Highest year of education	0.000	0.855	No
Time to get to water source	0.000	0.000	Yes
Number of children 5 and under	0.000	0.000	Yes
Number of eligible women in hh	0.000	0.000	Yes
Age of HOUSEHOLD head	0.000	0.645	No
Total children ever born	0.000	0.000	Yes
Age of respondent at 1st birth	0.000	0.138	No

Table 6.2: List of ratio/interval variables tested with on the relation with BMI and region (bold values are significant).

The variables that were both significant with BMI and region are:

- Type of place of residence
- De facto place of residence
- Wealth index
- Current marital status
- Currently/formerly/never marr.
- Current age - respondent
- Line number of husband
- Time to get to water source
- Number of children 5 and under
- Number of eligible women in hh
- Total children ever born

Interestingly, most variables are also determinants of BMI found in the literature. In most studies, there was a relation between BMI and rural/urban residence, socioeconomic status, marital status and age as well. In a lot of studies there was also a relation found between education and BMI, this relation is not found here. The relation with smoking behavior is also not proven here because the data did not satisfy the conditions for the test. In previous studies, smoking behavior was often seen to be significantly related to BMI.

6.3 Estimating a national multilevel model explaining BMI

The distribution of BMI in Tanzania was shown in figure 6.1. In this paragraph, the selected variables will be implemented in a model with the region and individual level. The most insignificant variable will be removed from the model and the model will be re-estimated again. To do this however, the variables marital status and de facto type of place of residence were recoded into dummy variables first. The removed variables can be seen in table 6.3.

Never married	(Omitted)
Living Together	0.857
Widowed	(Omitted)
Divorced	(Omitted)
Separated	(Omitted)
Largecity	0.731
Smallcity	0.009
Town	0.681
Total children ever born	0.323
Number of children 5 and under	0.202

Table 6.3: Disregarded variables from the multilevel model.

First, the variable of marital status was removed. Most of the categories were omitted because almost all respondents were married (which was the baseline category) and there were few cases in the other categories. For 'de facto type of place of residence', where countryside was taken as the baseline category, only 'smallcity' was significant. Because these three dummy variables are actually one categorical variable, all three dummy variables were removed. The last two variables that were removed were: 'total children ever born' and 'number of children 5 and under'. After that, there were no insignificant variables left.

The remaining significant variables and their coefficients can be seen in table 6.4.

Parameter	Coefficient	P-value
Current age- respondent	0.0503162	0.000
Line number of husband	-0.1067388	0.012
Wealth index factor score (5 decimals)	0.0000178	0.000
Time to get to water source	0.001747	0.096
Number of eligible women in hh	0.1083339	0.087
Constant	21.27377	0.000

Table 6.4: Coefficients for the variables explaining BMI among adult non-pregnant women in Tanzania.

This results in the following model for BMI in Tanzania if interactions are not considered:

BMI

=

21.27377
+ 0.0503162(Current age)
- 0.1067388(Line number of husband)
+ 0.0000178(Wealth index factor score)
+ 0.001747 (Time to get to water source)
+ 0.1083339(Eligible women in household)

Now that the influence of the dependent variables on BMI is studied, the effects of possible interactions will also be taken into account. Only interactions with the variables that are currently in the model are considered. There were no interactions found between these selected variables in the literature and the theoretical framework. It seems logical however that ‘time to get to water source’ and ‘wealth index factor score’ might have an interaction. As wealthier people may have a water source in their own home.
This is the only interaction studied in this model. Unfortunately, STATA could not calculate the significance of this interaction as wealth index factor score had negative values. This results in the model described earlier in this paragraph, a model without interactions. This is the model for BMI in Tanzania when it is taken into account that observations from the same region cannot be treated as independent from each other.

6.4 Visualizing the results using GIS

This paragraph will visualize the results, using ArcGis. The first map (figure 6.2) shows the regions of Tanzania. This map was made, using the regional borders of DIVA-GIS (2012). The same regions will be used to link to the DHS data in the other maps.

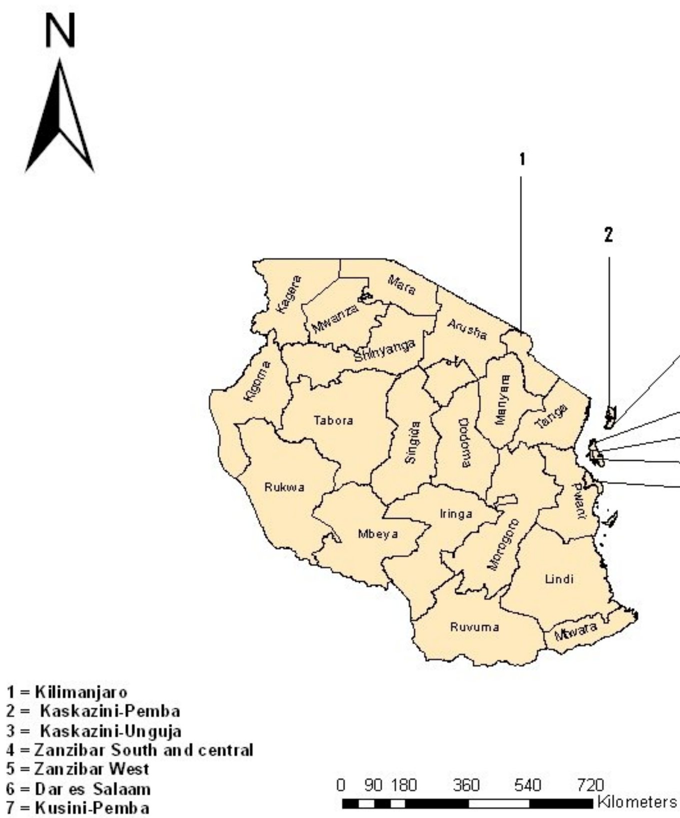


Figure 6.2: The regions of Tanzania.

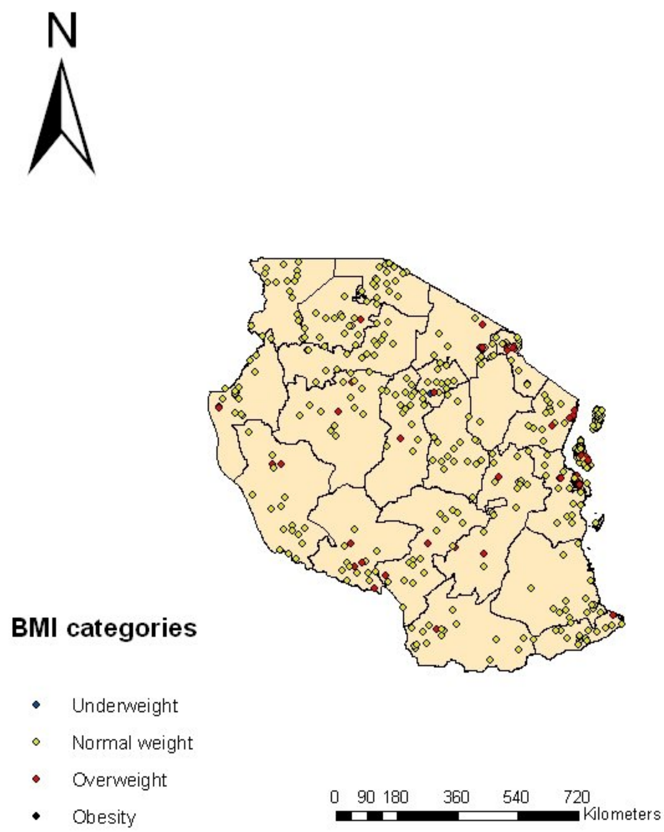


Figure 6.3: WHO BMI category per cluster in Tanzania among adult non-pregnant women.

Figure 6.3 shows the average BMI for the clusters. The clusters are categorized using the BMI categories provided by the WHO (lower than 18.5 is underweight, 18.5-25.0 is normal weight, 25.0-30.0 is overweight and >30.0 is obesity (World Bank, 2000)). It can be seen that most clusters are either average normal weight or average overweight, although there are slightly more clusters having average normal weight. There seems to be only one cluster measured with average underweight, north of the centre of the country in Manyara.

The variation of BMI observed at the regional level is found in figure 6.4, which shows a clearer pattern for BMI differences. It can be seen that the regions with the highest BMI are in the Northeast, around Dar es Salaam and Zanzibar. The lowest BMI averages are in Southeast and Central Tanzania. It is interesting to see that almost all regions are in the normal range for BMI, whereas there were a lot of clusters facing overweight. This also corresponds with the values seen in figure 6.1, where it was seen that the average national BMI lies in the normal range (18.5-25.0).

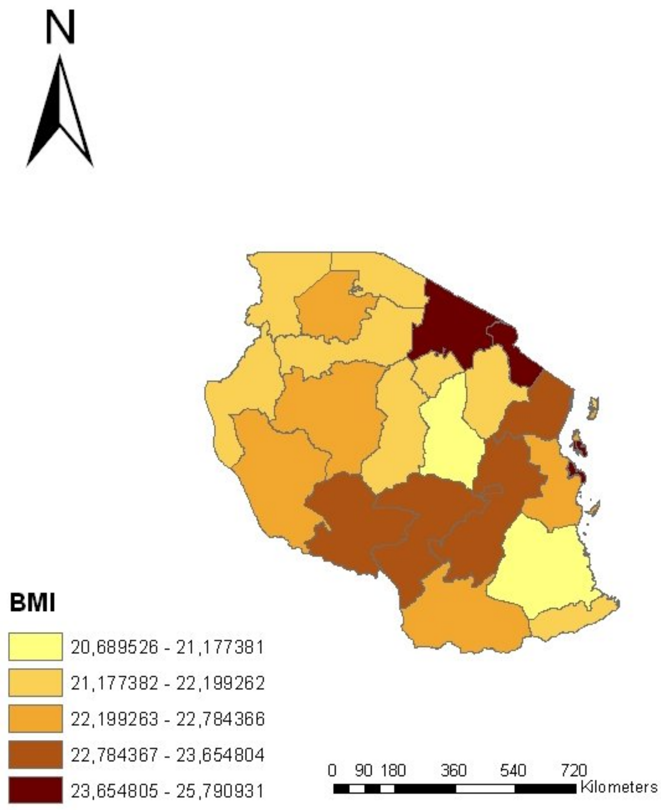


Figure 6.4: Average BMI per region in Tanzania among adult non-pregnant women from DHS (2010) data (categories chosen using Jenks break values).

Figure 6.5 provides the BMI as it is estimated from the initial model. It should be noted that the constant from the model was used to make the predications for all regions; the average values for the variables were filled in, in the model.

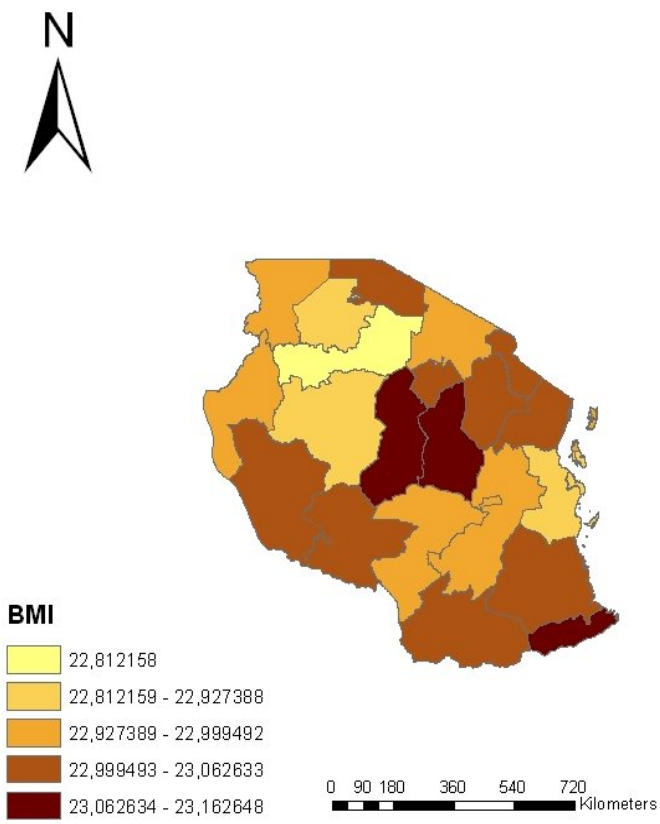


Figure 6.5: Average BMI per region in Tanzania among adult non-pregnant women predicted from the model (categories chosen using Jenks break values).

This gives quite another figure than the BMI observed from the DHS. Therefore the constants should be different for each region. These constants were obtained by the function: Statistics → post-estimation → predictions, residuals, etc. → fitted values in STATA.

The values gotten from this procedure were calculated back to the constants, using the regional averages for the other variables. The constants can be seen in table 6.5.

Region	Constant
Dodoma	20.129265
Lindi	20.641552
Mara	20.710292
Pemba North	20.753105
Mtwara	20.827588
Kigoma	20.935554
Kagera	20.936128
Ruvuma	20.986653
Shinyanga	21.004166
Singida	21.011426
Mwanza	21.025837
Pemba South	21.04739
Manyara	21.087928
Pwani	21.270973
Rukwa	21.331337
Town West	21.39027
Zanzibar North	21.437403
Arusha	21.494788
Iringi	21.546443
Tanga	21.617302
Tabora	21.682
Dar es Salaam	21.852716
Mbeya	21.857739
Kilimanjaro	21.874417
Morogoro	22.062989
Zanzibar South	22.598014

Table 6.5 Regional constants for the national level model.

These are the BMI levels that the regions would have based on the model if all the coefficients were set to the value 0. This better reflects the data observed in the DHS, as Arusha, Kilimanjaro, Mbeya and Zanzibar South were all regions with a high BMI average in the DHS as well. If the coefficients from the model would be used in combination with these constants, the regional predicted BMI averages should be the same as the predicted BMI averages from the DHS data.

Besides maps on BMI, there are maps made for the other variables in the model as well. This shows whether the patterns of these variables correspond to what would be expected based on the national model and the regional distribution in average BMI in the DHS seen in figure 6.4.

But it should be noted that although figures 6.3 till 6.5 are mostly in the normal range, underweight and overweight also occur in Tanzania. Figure 6.1 already showed the BMI distribution for Tanzania in total. This gives a good view of the fact that there is also a big share of the women population facing underweight or overweight/obesity.

Figure 6.6 gives the cumulative curves of BMI for each region in Tanzania. As can be seen in the figure, the cumulative curves for the regions vary quite a lot. The steeper the line is in the beginning, the more underweight there is. If the line is steep at the end, then there is a substantial share of overweight in the region.

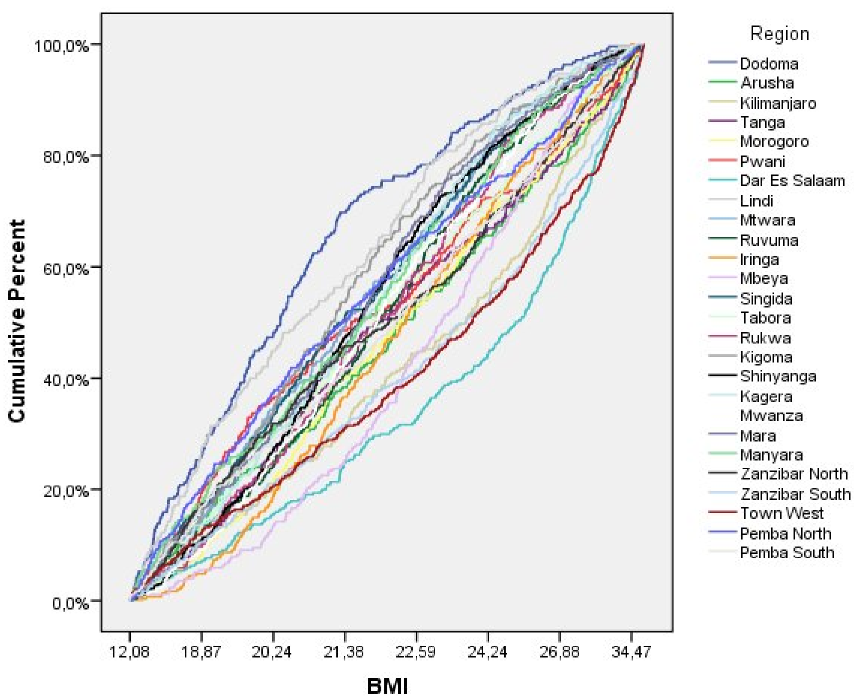


Figure 6.6 Cumulative curves of BMI for adult women for every region of the Tanzania DHS based on DHS data.

Figure 6.6 is somewhat difficult to read because there are 26 regions in the figure. Figure 6.7 shows the same relation but with only six regions in it: Dar es Salaam, Pemba North, Pwani, Lindi, Iringa and Morogoro. These regions were chosen as an example because there is a great distinction between these curves. As said before, the steepness of the curves determines the distribution of the cases as the curves are cumulative. In this way, it can be seen that Lindi faces the most underweight as they have the biggest proportion with a BMI of under 18.5 (the WHO classification for underweight; World Bank, 2000). Dar es Salaam on the other hand, has the biggest problem of overweight as they have the lowest cumulative percentage at a BMI of 25 (the WHO classification for overweight). This makes sense since Dar es Salaam is a predominantly urban region, which was seen to have higher BMI outcomes in the literature.
The other curves are in between the curves of Lindi and Dar es Salaam. This shows that the distribution of BMI can differ greatly among the regions although there might not be much difference in the average BMI.

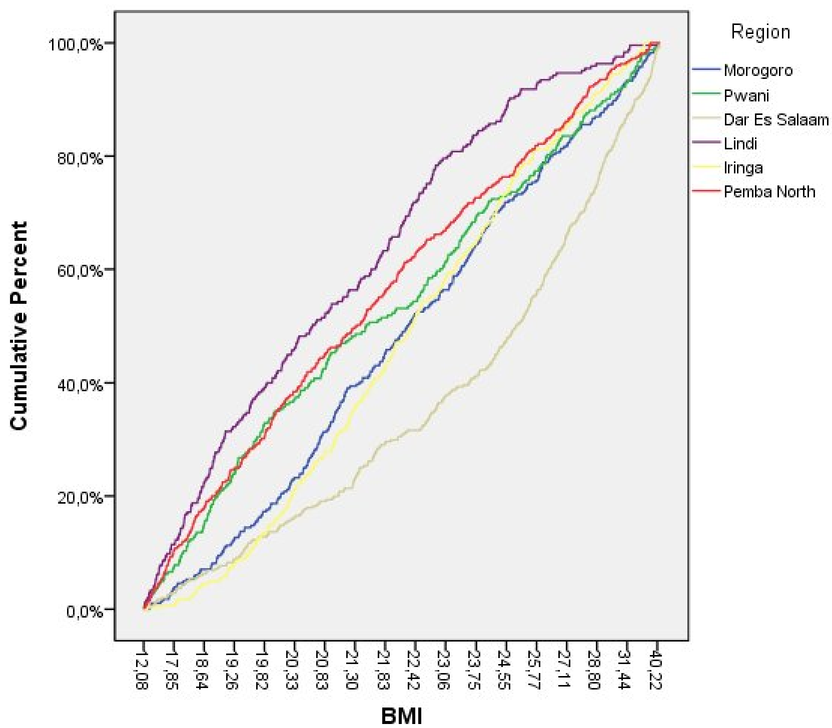


Figure 6.7 Cumulative curves for BMI among adult women for 6 Tanzanian regions based on DHS data.

Figure 6.8 shows the average current age of the respondents for the different regions in Tanzania. Although there are some relatively 'old' regions with age averages of about 31-33, these regions do not have the highest BMI quintiles. This is different than what would be expected based on the model (where age has a positive association with BMI). But it should be kept in mind that BMI relates to a lot of different variables. For one region, other variables may be more important than for another region.

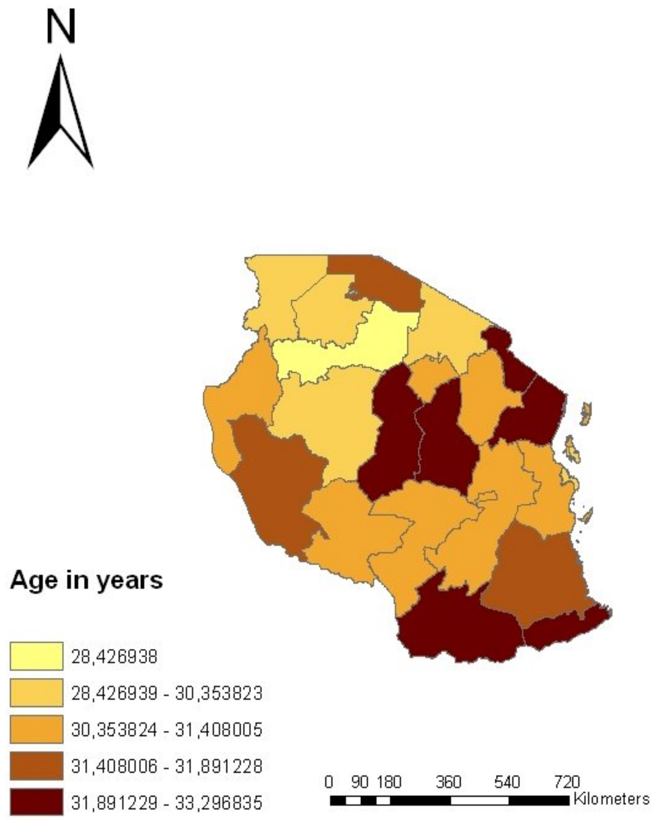


Figure 6.8: Average age per region among adult non-pregnant women in Tanzania (categories chosen using Jenks break values)

The results of the regional spread in line number of husband can be seen in figure 6.9. What strikes about the figure is that the average line number of husband is highest at the East coast and some parts of Zanzibar as well as in the Central-West. According to the model this should lead to a small decrease in BMI in these regions, but of course every region has on average a decrease in BMI based on the line number of husband when using the national model; since the average line number of husband is always positive. It should be noted however that the differences based on this variable will not big because the differences between the averages are not big either.

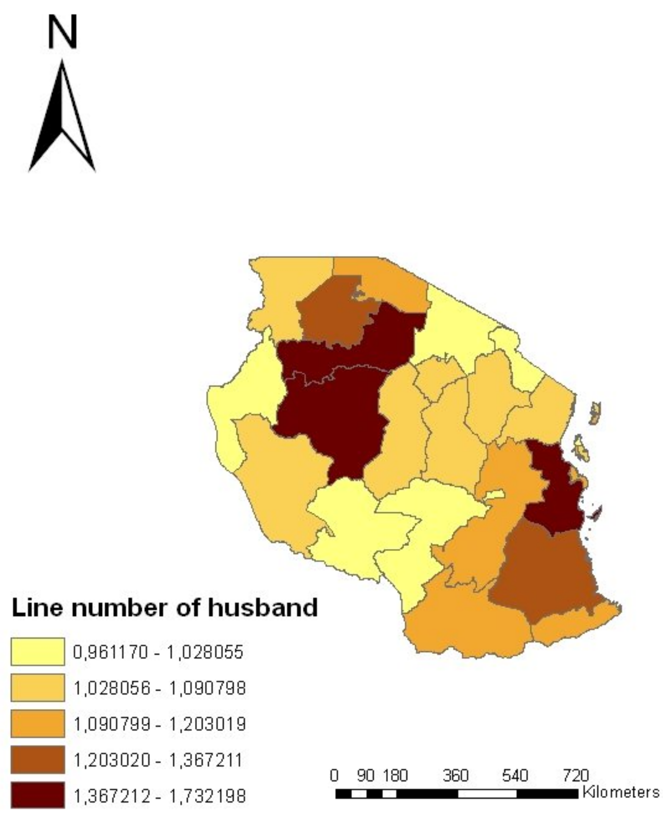


Figure 6.9: Average line number of husband per region (categories chosen using Jenks break values).

A variable found to be significant in both earlier studies as well as in this study is wealth. In the Tanzanian DHS it is measured as a wealth index score. The regional variation of this variable can be found in figure 6.10.

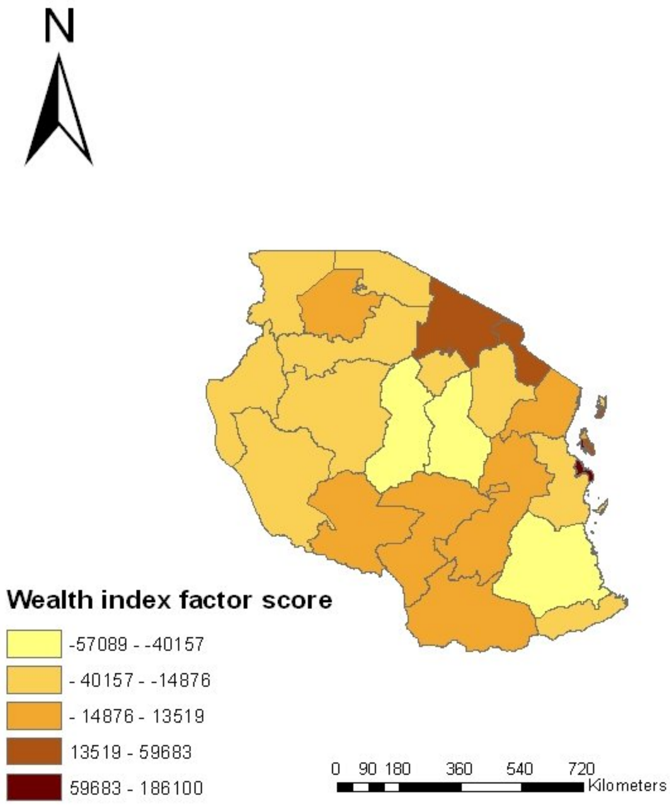


Figure 6.10: Average wealth index factor score per region (categories chosen using Jenks break values).

The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household’s ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities (MEASURE DHS, 2012).
It is interesting to see that the highest wealthiest region seen is around Dar es Salaam and the least wealthy regions are found in the interior of the country. In the model, wealth index factor score was positively related to BMI. The figures that seem to have a high factor score also seem to be in the highest BMI categories (Figure 6.4).

Figure 6.11 shows the average time to get to the water source per region (which is not included in the wealth factor index). The regions with the highest time to get to the water source are in the interior of the country. The model showed a positive relation between this variable and BMI. If looked at the both maps, the pattern seems less clear however.

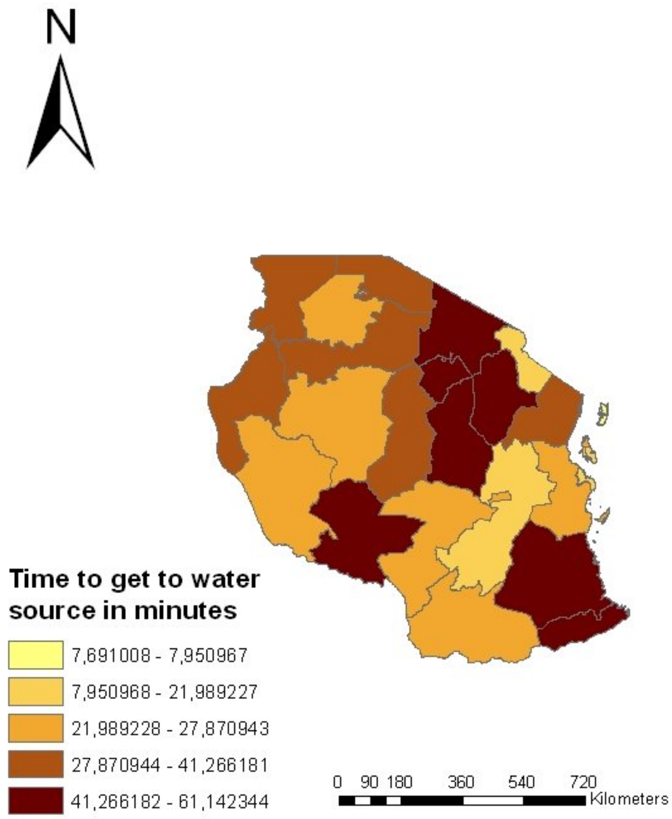


Figure 6.11: Average time to get to water source per region (categories chosen using Jenks break values).

The last variable that was included, is the number of eligible women in the household. These are the women eligible for an interview, usually the women between 15 and 49 that slept in the household the night before the survey (Rutstein and Rojas, 2006). Figure 6.12 shows the regional variation for this variable. What is interesting is that there is very little variation in this variable when looked at the categories. The number of eligible women per household has a positive relation with BMI, but because most regions are in the range of 1.6-1.75 women per household, these differences will be very small.

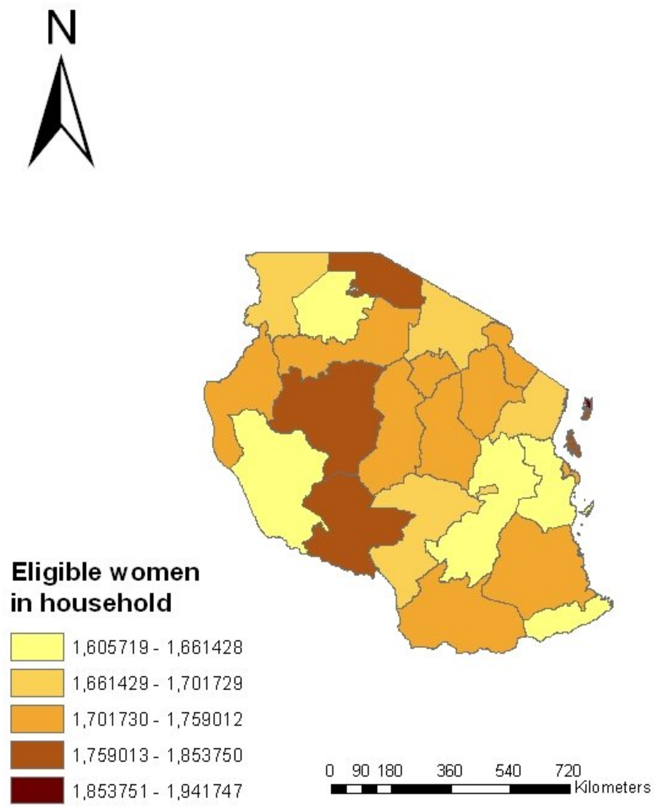


Figure 6.12: Average number of eligible women per household per region in Tanzania (categories chosen using Jenks break values).

The relations studied in this paragraph were mainly on the relationship of the explaining variables with the regional averages of BMI. Figures 6.5 and 6.6 showed however that although the averages may be close to each other, the distribution of values can be quite different. Therefore, there will also be looked at the share of each BMI category determined by the WHO per region. The results can be seen in the maps in figures 6.13-6.16.

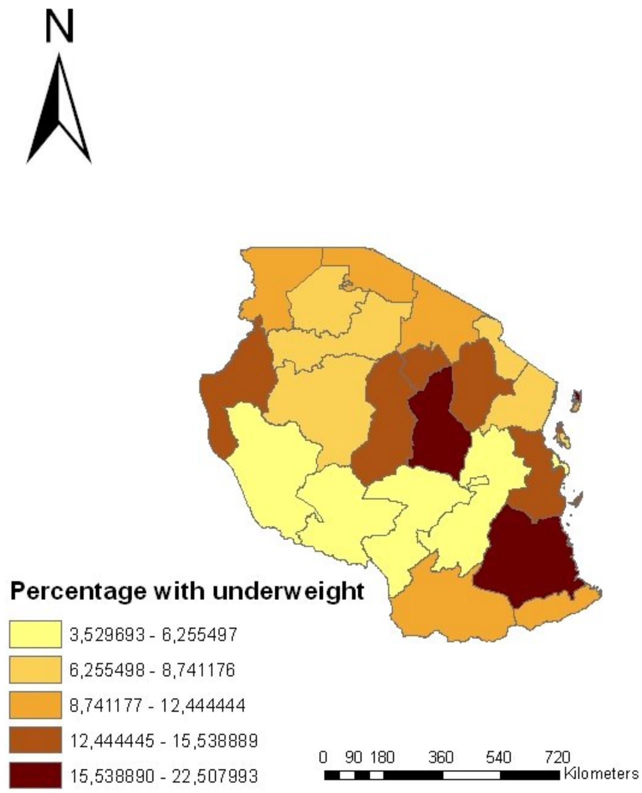


Figure 6.13: Percentage of the female adult population with underweight per region in Tanzania (categories chosen using Jenks break values).

In figure 6.13, it is striking to see that there is a belt from East to West in the south with relatively little underweight. Dar es Salaam also has little underweight in the contrary to Dodoma and Lindi where the underweight is the highest.

Figure 6.14 shows the share of the normal weight category of BMI within the adult female population. The regions with the highest share of the normal category of BMI are in the West of the country. Most regions here have about 75% of their population in the normal BMI category. In the Northeast and at the East coast, there are some regions with the lowest share of people in the normal range of BMI. It should be noted that the lower limit for the normal range is about 42%. This is higher than the highest limit of each of the other BMI categories which means that the group of people in the normal range of BMI is the biggest group in each region.

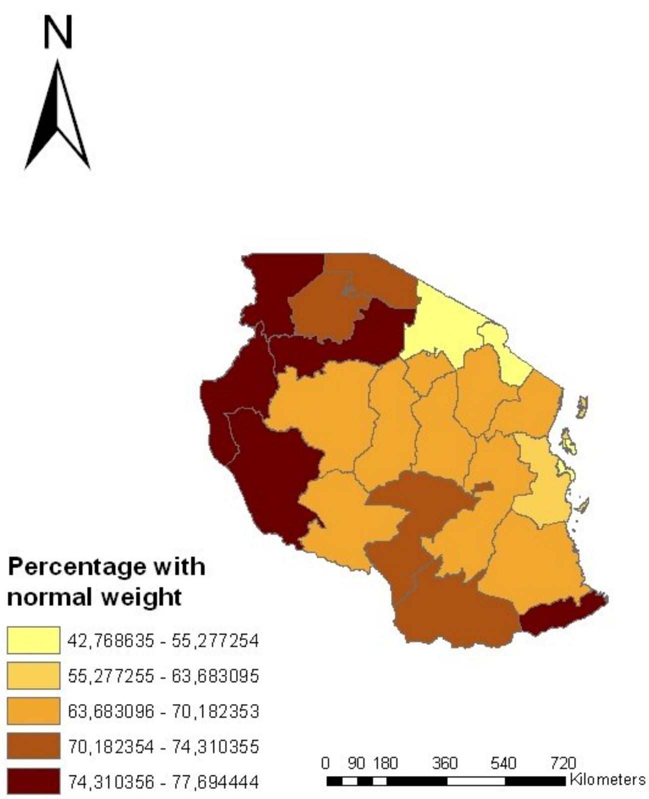


Figure 6.14: Percentage of the female adult population with normal weight per region in Tanzania (categories chosen using Jenks break values).

It can be seen in figure 6.15 that there are only a few regions in the highest category of share of overweight. These are the regions of Mbeya, Kilimanjaro, Dar es Salaam en Zanzibar South and Central. This category has quite a bigger share than the other categories with about 22-32% of the people in it (Figure 6.15). There seems to be no spatial relationship for the overweight categories, as they are all spread over the whole country. There are more regions in the categories with a lower share of overweight than regions in the categories with a higher share of overweight.

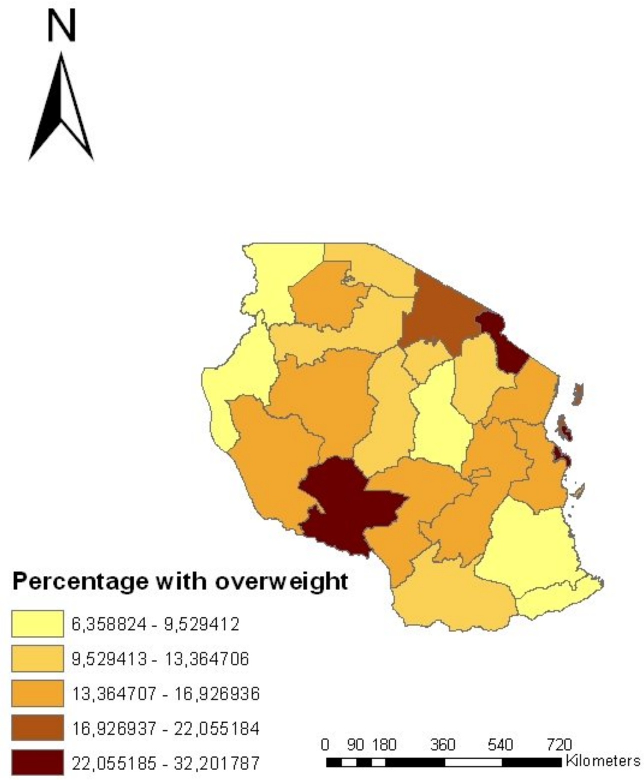


Figure 6.15: Percentage of the female adult population with overweight per region in Tanzania (categories chosen using Jenks break values).

Finally, figure 6.16 shows the percentage of obesity for each region. Although most regions have a share of less than 7.7%, the highest category is between 14.5% and 19.4% which is a substantial share. All regions in the highest two categories are in the east of the country with the regions in the highest categories being coastal Dar es Salaam and the island regions of Zanzibar South and Central and Zanzibar West. Most regions; in particular in the Southeast, Central, West and Northwest, have a substantial lower share of obese people in their population.

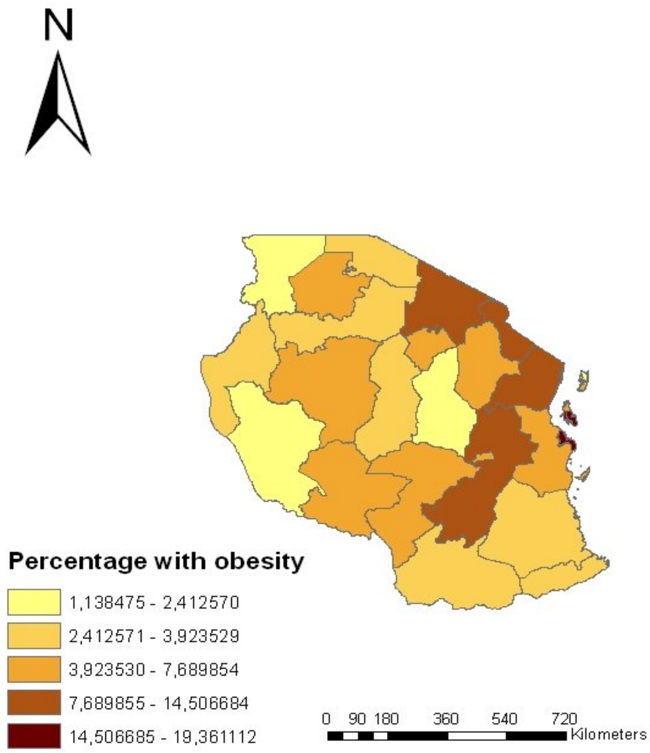


Figure 6.16: Percentage of the female adult population with obesity per region in Tanzania (categories chosen using Jenks break values).

Concluding, figures 6.12-6.15 give a totally different picture of the prevalence of overweight than the figures on BMI averages. Based on the latter, one would think that there are not much regional weight problems in Tanzania. Based on the share of the population in each BMI category however, one can see that there are several regions in Tanzania with a substantial problem of under- and/or overweight. The fact that both problems occur in Tanzania at the same time may be evidence of the double burden of disease explained in the theoretical framework (Caballero and Popkin, 2002).

6.5 Estimating regional models

It was seen in the previous paragraph that the relations in the regions are not always the same as expected from the national model. Therefore a separate model will be established for each region.

The national model established in paragraph 6.2 will be used in this chapter to describe the differences in BMI between the regions in Tanzania. The previous model calculates BMI for Tanzania in total, taken into account that cases from the same region cannot be treated as independent. It was seen that when looked at the variables separately in the maps, it was difficult to see the relation between each variable and BMI. Therefore, in this paragraph, a separate model will be established for each region. Both the coefficients and the constants will differ for each region. It will be shown which variables are significant in the regional model for BMI.

The maps shown in previous paragraph provide an insight in the spatial variability of the studied phenomena. When looking at these variables, it is still not clear what the most important variables are for each separate region in explaining the BMI outcomes. Therefore, the results will be supported using tables. For each region, it is estimated what the influence of these variables are for the concerning region. The results can be seen in table 6.5 and 6.6.

Constants		Current age of respondent		Line number of husband		Time to get to water source		Number of eligible women in hh		Wealth index factor score	
Arusha	18.39908	Kagera	-0.14%	Kagera	**-2.87%**	Pwani	-0.09%	Morogoro	-2.20%	Zanzibar South	0.000002%
Kilimanjaro	19.39362	Ruvuma	-0.03%	Arusha	-2.77%	Mwanza	-0.06%	Mtwara	-2.07%	Mwanza	**0.000050%**
Town West	19.45049	Kigoma	0.01%	Kilimanjaro	-2.77%	Iringa	-0.06%	Lindi	-2.01%	Kagera	**0.000051%**
Dar es Salaam	19.71088	Mtwara	0.01%	Tanga	**-2.22%**	Manyara	-0.04%	Tanga	-1.74%	Shinyanga	**0.000052%**
Manyara	20.00728	Iringa	0.05%	Manyara	-1.79%	Kagera	-0.04%	Pemba North	-1.51%	Town West	**0.000064%**
Rukwa	20.42121	Dodoma	0.09%	Iringa	-1.65%	Singida	-0.03%	Zanzibar North	-1.05%	Mbeya	**0.000064%**
Zanzibar South	20.48354	Tanga	0.11%	Mara	-1.59%	Arusha	-0.01%	Tabora	-0.58%	Iringa	**0.000064%**
Pemba North	20.54075	Lindi	0.11%	Singida	-1.35%	Mara	-0.01%	Shinyanga	-0.48%	Pwani	**0.000066%**
Dodoma	20.74998	Singida	0.12%	Town West	-1.35%	Lindi	0.00%	Mbeya	-0.29%	Mara	**0.000068%**
Shinyanga	20.76781	Zanzibar North	0.13%	Dodoma	-1.33%	Zanzibar South	0.00%	Ruvuma	-0.19%	Tabora	**0.000068%**
Mara	20.80136	Pemba South	0.13%	Dar es Salaam	-1.26%	Tanga	0.00%	Kagera	0.43%	Zanzibar North	**0.000069%**
Mwanza	20.84634	Mara	0.21%	Pwani	**-1.25%**	Tabora	0.01%	Mwanza	0.44%	Pemba North	**0.000071%**
Tanzania	21.27377	Pwani	0.23%	Kigoma	-1.19%	**Tanzania**	**0.01%**	**Tanzania**	**0.51%**	Rukwa	**0.000074%**
Pemba South	21.33002	**Tanzania**	**0.25%**	Pemba South	-0.87%	Pemba South	0.01%	Dar es Salaam	0.52%	Dar es Salaam	**0.000076%**
Pwani	21.3665	Rukwa	**0.26%**	Zanzibar North	-0.79%	Zanzibar North	0.01%	Rukwa	1.05%	Mtwara	**0.000077%**
Singida	21.53677	Mwanza	**0.27%**	**Tanzania**	**-0.50%**	Mbeya	0.01%	Manyara	1.13%	Pemba South	**0.000081%**
Mbeya	21.58987	Shinyanga	**0.28%**	Lindi	-0.31%	Dar es Salaam	0.02%	Town West	1.17%	**Tanzania**	**0.000084%**
Tabora	21.70015	Tabora	**0.28%**	Morogoro	-0.23%	Shinyanga	0.02%	Mara	1.54%	Morogoro	**0.000098%**
Kigoma	21.85811	Pemba North	0.28%	Tabora	-0.16%	Dodoma	0.02%	Zanzibar South	1.59%	Singida	**0.000098%**
Morogoro	22.11211	Mbeya	**0.29%**	Shinyanga	-0.11%	Kilimanjaro	0.02%	Pemba South	2.17%	Manyara	**0.000098%**
Iringa	22.29301	Morogoro	**0.34%**	Rukwa	0.10%	Morogoro	0.02%	Pwani	2.69%	Kigoma	**0.000111%**
Mtwara	22.58571	Zanzibar South	**0.40%**	Ruvuma	0.14%	Kigoma	0.03%	**Kigoma**	3.12%	Ruvuma	**0.000111%**
Lindi	22.67703	Kilimanjaro	**0.50%**	Mbeya	0.34%	Mtwara	**0.04%**	**Dodoma**	3.16%	Tanga	**0.000114%**
Ruvuma	22.78207	Manyara	**0.50%**	Mwanza	0.36%	Ruvuma	0.05%	**Singida**	3.74%	Lindi	**0.000123%**
Zanzibar North	22.78928	Town West	**0.63%**	Mtwara	0.81%	Pemba North	0.07%	Kilimanjaro	4.40%	Dodoma	**0.000131%**
Tanga	23.60392	Arusha	**0.66%**	Pemba North	1.19%	Rukwa	**0.10%**	**Iringa**	4.73%	Kilimanjaro	**0.000139%**
Kagera	24.35142	Dar es Salaam	**0.70%**	Zanzibar South	**6.85%**	Town West	0.11%	**Arusha**	5.52%	Arusha	**0.000142%**

Table 6.6: Influence of the variables on the regional model constants.

In table 6.6, there are a lot of regions where the influence of the variables is different from the influence that the variables have on the national level. It should be noted that these differences are relative to the constant of the regional model. In the ascended lists, the constant and influences of variables on the constant for Tanzania are around the middle. Interestingly wealth index factor score is significant for the model of all regions except for the model of Zanzibar South. The current age of the respondent is also significant for a lot of regions. The other variables are less often significant in the regional models.
It can be seen that some variables have up to ten times a bigger influence on the constant at the regional level than at the national level (e.g. time to get to water source has an influence of 0.1% on the constant of the region in Iringa whereas it is 1% at the national level). It should be noted that a variable can still have a higher coefficient but have less influence on the constant in that region if the constant is also lower than on the national level.
Figure 6.7 illustrates the reversal of relations between the national model and the regional model. Whereas for most variables there is only a decrease or increase seen in the regional model compared to the national model; in some cases, the relation moves from positive to negative or the other way around.

	Eligible women in household		**Time to get to water source**		**Line number of husband**		**Current age**
Tanzania	**0.51%**	Tanzania	**0.01%**	Tanzania	**-0.50%**	Tanzania	**0.25%**
Morogoro	-2.20%	Pwani	-0.09%	Rukwa	0.10%	Kagera	-0.14%
Mtwara	-2.07%	Mwanza	-0.06%	Ruvuma	0.14%	Ruvuma	-0.03%
Lindi	-2.01%	Iringi	-0.06%	Mbeya	0.34%		
Tanga	-1.74%	Manyara	-0.04%	Mwanza	0.36%		
Pemba North	-1.51%	Kagera	-0.04%	Mtwara	0.81%		
Zanzibar South	-1.05%	Singida	-0.03%	Pemba North	1.19%		
Tabora	-0.58%	Arusha	-0.01%	Zanzibar South	**6.85%**		
Shinyanga	-0.48%	Mara	-0.01%				
Mbeya	-0.29%						
Ruvuma	-0.19%						

Table 6.7: Regions with an opposite relation between the national and the regional model.

This is interesting because this shows that the relations between BMI and the explaining variables do not work the same way in all regions. For example, on the national level, there is a positive relation between current age and BMI. But in the regions of Kagera and Ruvuma; this relation is negative in the regional model. Most reversed relations are not significant however, only the variable line number of husband in Zanzibar South is (Table 6.7). For the wealth index factor score, no reversed relations were found.
This does show however, that there are different relations considering BMI on the regional level than on the national level. It might even be the case that when a model is

constructed from the start, with all variables considered again, different variables would be in the model at the regional level than in the model at the national level.

This chapter showed that the relationship between BMI and the explaining variables is not an easy one to understand. A model was established to predict someone's BMI based on determinant factors. It turned out that these variables were different for the different regions however, some relations were even opposite between the regional- and the national level. This also shows that it matters quite a lot what population is used when making a predictive model. Another population may yield other results. The national model however, gives a good view on what variables influence the BMI in Tanzania and in which direction on average. The relationship seems to make even more sense however when looked at the share of each WHO BMI group per region. The differences between the national and the regional level might suggest that the differences in independent variables and relations are great and that a regional model fits better than the national model. If a specific model for a region was established from the beginning, it is likely that there would be other variables in the model.

7. Conclusions and recommendations

This chapter will draw conclusions based on the results found in this study. First the main findings will be compared to the existing literature, the theoretical framework and the conceptual model. After that, a main conclusion will be stated. The chapter will end with policy recommendations and recommendations for further research.

7.1 Main findings

The aim of this study was to explain the regional differences in nutrition outcomes among 18-49 year old women in Tanzania. This was done by looking at the regional variation of BMI and its determinants.

The average BMI of the total population studied in Tanzania lies around 23, which is in the normal weight range of between 18.5 and 25.0 defined by the WHO (World Bank, 2000); the averages of the regions also tend to be in this range. At the cluster level, the clusters with average overweight and average normal weight seem to be most prevalent, with a little bit more clusters with normal weight. What strikes is the almost absolute absence of average underweight and average obesity in the clusters.

The cumulative distribution and the share of underweight and overweight in the population show a different pattern however. There are regions with 15-22% underweight (Dodoma and Lindi), 22-32% overweight (Kilimanjaro, Arusha, Dar es Salaam and Zanzibar West) and 14-19% obesity (Dar es Salaam and Zanzibar West). It should be noted that the group in the normal weight range is the biggest group in all the regions with a share of 42-78%. This supports the hypothesis that there are problems of both underweight and overweight. This relates to the country 'being in a shift' between the stage of epidemiologic diseases and the stage of non-communicable nutrition related diseases as described in the theoretical framework of the nutrition transition of Caballero and Popkin (2002).

This shift may be very costly, as the country's health system has to deal with both the overweight and the underweight related problems and diseases at the same time, this is called the double burden of disease (Caballero and Popkin, 2002) and is also found in the macro part of the conceptual model used in this study.

To find the determinants of the regional variation in BMI, a list of variables selected from the literature was tested on both their relation with the BMI variable and their relation with the region variable. The following factors that were found to be significant with both BMI and region were also found to be significant in the literature: type of place of residence, wealth, age and marital status. The variables that were found to be significant with both region and BMI that were not found in the literature are: line number of husband, time to get to water source, number of children of 5 and under, number of eligible women in household and age at first birth. Variables that were not related to BMI and region in this study but were related to BMI in previous studies are education and smoking behavior.

The remaining variables that were found to be related with both BMI and region in this study were implemented in a multivariate multilevel model. This resulted in the following variables being in the model that could predict the value of BMI in this study: current age (positive relation), line number of husband (negative relation), wealth index

factor score (positive relation), time to get to water source (positive relation) and number of eligible women in the household (positive relation).
This model can predict the BMI value of a particular case, based on the values of these variables and a given constant. It was interesting to see the different constants for the different regions. These gave the BMI values for the regions if all parameters were set to 0. These constants varied between 20.1 in Dodoma and 22.6 in Zanzibar South.
In addition to the national multivariate multilevel model, a separate model was made for each of the 26 regions found in the DHS; the same determinants as in the national model were used for this. The variables were not always significant in predicting BMI at a regional level however. The current age was significant in 12 out of 26 regional models, line number of husband in 4 out of 26, time to get to water source in 2 out of 26, number of eligible women in the household in no region and wealth index factor score in all regions but Zanzibar South. In some regional models, the direction of the relation in the model was reversed as compared to the national model. Number of eligible women in the household was negative in the model of 10 of 26 models, time to get to water source was negative in 8 of 26 models, line number of husband was positive in 7 models, current age negative in 2 and wealth index factor score showed no reversal in any region. The negative relation between time to get to water source and BMI was the only significant reversed relation however.

7.2 Main conclusions

It can be concluded that there are differences in nutritional status outcomes between the regions. The average values of BMI and the relative size of WHO (2000) BMI groups were seen to be varying between the regions. Another thing that can be concluded is that there are some regions in the country facing overweight and some regions facing underweight, suggesting an existing double burden of disease.
These differences were investigated by making both national models and regional models for BMI. The variables in the national model were seen to vary between the regions as well, causing regional BMI differences in the model. The best model of predicting BMI at the national level (taken into account that cases from the same region are not independent from each other) is with the variables current age, line number of husband, wealth index factor score, time to get to water source and number of eligible women in the household in it.
Although only the variables that were tested in the national model were tested in the regional models, it can be said that different variables are important in predicting BMI in different regions. This is because the influence, direction and significance of a variable often differ in the regional model as compared to the national model with the differences in current age being the biggest and the differences in wealth index factor score being the smallest.

7.3 Discussion

In this study, the study population was non-pregnant women aged 18-49 in Tanzania. It would have been better if men were also included in the study population but this was not possible due to constraints of the data. In this way, only conclusions can be made about the non-pregnant adult women population.
Another limitation of this study is that the nutrition outcomes are measured in BMI. Of course, this is a nutrition outcome but it is not the only nutrition outcome and arguably not the best measure. Römling and Qaim (2011) state that it should be mentioned that the BMI has some disadvantages in identifying body fat and obesity for people of certain stature; yet it is the most widely used indicator.
The fact that it was chosen to look into the differences between regions also influences the results. If another level of analysis, e.g. cluster, was chosen; the results could be quite different. The reason to choose this level was because most policy implications are made at either regional or national level and not on the local level (Jørgensen, 2012).
An additional point of concern is that variables selected in predicting BMI in this study, were obtained by making a national model. Although it was seen that this model can predict the regional differences in BMI, the relations tend to be different at the regional level. In this way it might be possible that variables that are important in predicting BMI in a particular regional model are not considered in the analysis. The relations between the determinants are also not explained. Explanations can be taken from previous studies, but to actually see whether these assumptions are true for Tanzania, another (qualitative) study has to be done.
All in all, there are some limitations to this study that could be improved in further studies. These recommendations will be given in the next paragraph.

7.4 Recommendations

The main recommendation for further research is that a model should be made at the level the research takes place. If BMI in Dar es Salaam needs to be predicted, it is best to make a model for Dar es Salaam. This probably has other determinants in it than the national model has.
Another thing that should be focused on is the reason why certain relations exist. A qualitative study should be done to reach this goal. If the reasons are known, then it's also easier to use the results of this study for policy implications.
The existing overweight and underweight problems can be dealt with by addressing the explaining variables. Some demographic variables like 'current age' and 'line number of husband' are hard to address by policies however. But variables like 'time to get to water source' and 'wealth index factor score' can be addressed by policies at both the national and the regional level. By redistributing wealth to families with a low wealth factor index score underweight problems can be addressed. By making more wells, overweight problems can be addressed as a shorter time to get to the water source gives a lower BMI according to the model. There should be looked at the underlying reasons for these relations however as there could be confounding factors explaining this relation between time to get to water source and BMI for example.

Although a higher time to get to the water source and a lower wealth index factor score will be good for regions facing underweight and overweight according to the model, that is not recommended here. Since that results in a diminished quality of life in another way. In particular for obesity it would be recommended to address it by policies focused on relations that were not investigated in this study and that were found to be successful in other countries in the past, like nutrition education and the promotion of physical activity (Caballero and Popkin, 2002).

I. Appendix

A. Syntax commands and explanation (SPSS)

```
FILTER OFF.
USE ALL.
SELECT IF (V012 >= 18 and V213 = 0).
EXECUTE.
```

*** Filter out the pregnant and non-adult women**

```
COMPUTE WeightKilo=V437/10.
EXECUTE.

COMPUTE HeightMeter=V438/1000.
EXECUTE.

COMPUTE BMI=WeightKilo/(HeightMeter*HeightMeter).
EXECUTE.
```

*** Create a new variable of BMI by using the variables ‘respondent’s weight (kilos-1d)’ and ‘respondent’s height (cms- 1d)’**

```
FREQUENCIES VARIABLES=BMI
  /HISTOGRAM NORMAL
  /ORDER=ANALYSIS.
```

*** Make a histogram for the distribution of BMI**

```
RECODE V115 (996=1) (997=SYSMIS).
```

*** Change the values for ‘missing’and water source on own property for the ‘time to get to water source variable’**

```
CROSSTABS
  /TABLES=V025 V026 V106 V113 V116 V119 V120 V121 V122 V123 V124 V125
V127 V128 V129  V149 V151 V153 V155 V160 V161 V190 ML101 V457 V463A
V463B V463C V463D V501 V502 BY V024
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.
```

*** Make crosstabs of the ordinal variables by region and BMI. Also do a chi-square test for each ordinal variable with region**

```
RECODE V116 (10 thru 14=1) (20 thru 23=2) (30 thru 31=3) (32 thru Highest=4) INTO
Toiletfacil2.
VARIABLE LABELS  Toiletfacil2 'Toilet facility in categories'.
EXECUTE.

RECODE V155 (0=1) (1 thru 2=2) (3 thru 4=3) INTO Literacycat.
VARIABLE LABELS  Literacycat 'Literacy in categories'.
EXECUTE.
```

*** Recode the variables ‘type of toilet facility’ and ‘literacy’ into new variables with less categories to fit the requirements for chi-square testing**

```
CROSSTABS
  /TABLES= Toiletfacil2 Literacycat BY
   V024
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.
```

*** Make crosstabs for the new variables by region and chi-square test the relationship between the variables**

```
ONEWAY V025  BY BMI
  /MISSING ANALYSIS.

ONEWAY V026  BY BMI
  /MISSING ANALYSIS.

ONEWAY V106  BY BMI
  /MISSING ANALYSIS.

ONEWAY V113  BY BMI
  /MISSING ANALYSIS.

ONEWAY V116  BY BMI
  /MISSING ANALYSIS.

ONEWAY V119  BY BMI
  /MISSING ANALYSIS.

ONEWAY V120  BY BMI
  /MISSING ANALYSIS.

ONEWAY V121 BY BMI
```

```
  /MISSING ANALYSIS.

ONEWAY V122  BY BMI
  /MISSING ANALYSIS.

ONEWAY V123  BY BMI
  /MISSING ANALYSIS.

ONEWAY V124  BY BMI
  /MISSING ANALYSIS.

ONEWAY V125  BY BMI
  /MISSING ANALYSIS.

ONEWAY V127  BY BMI
  /MISSING ANALYSIS.

ONEWAY V128  BY BMI
  /MISSING ANALYSIS.

ONEWAY V129 BY BMI
  /MISSING ANALYSIS.

ONEWAY V149  BY BMI
  /MISSING ANALYSIS.

ONEWAY V151  BY BMI
  /MISSING ANALYSIS.

ONEWAY V153  BY BMI
  /MISSING ANALYSIS.

ONEWAY V155  BY BMI
  /MISSING ANALYSIS.

ONEWAY V160  BY BMI
  /MISSING ANALYSIS.

ONEWAY V161  BY BMI
  /MISSING ANALYSIS.

ONEWAY ML101  BY BMI
  /MISSING ANALYSIS.

ONEWAY V457  BY BMI
  /MISSING ANALYSIS.
```

```
ONEWAY V463A  BY BMI
  /MISSING ANALYSIS.

ONEWAY V463B BY BMI
  /MISSING ANALYSIS.

ONEWAY V463C  BY BMI
  /MISSING ANALYSIS.

ONEWAY V463D  BY BMI
  /MISSING ANALYSIS.

ONEWAY V501  BY BMI
  /MISSING ANALYSIS.

ONEWAY V502  BY BMI
  /MISSING ANALYSIS.

ONEWAY Toiletfacil2  BY BMI
  /MISSING ANALYSIS.

ONEWAY Literacycat  BY BMI
  /MISSING ANALYSIS.
```

*** Make an one-way ANOVA for categorical variables by BMI**

```
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V012.

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V034.

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
```

```
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V107.

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V115.

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V137.

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V138.

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V152.

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V191.
```

```
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V201.

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT BMI
  /METHOD=ENTER V212.
```

* **Make a linear regression for ratio variables with BMI**

```
ONEWAY V012 BY V024
  /MISSING ANALYSIS.

ONEWAY V034 BY V024
  /MISSING ANALYSIS.

ONEWAY V107 BY V024
  /MISSING ANALYSIS.

ONEWAY V115 BY V024
  /MISSING ANALYSIS.

ONEWAY V137 BY V024
  /MISSING ANALYSIS.

ONEWAY V138 BY V024
  /MISSING ANALYSIS.

ONEWAY V152 BY V024
  /MISSING ANALYSIS.

ONEWAY V191 BY V024
  /MISSING ANALYSIS.

ONEWAY V201 BY V024
  /MISSING ANALYSIS.

ONEWAY V212 BY V024
```

```
  /MISSING ANALYSIS.
```

* **Make an one-way ANOVA for ratio variables with Region**

```
RECODE V501 (0=1) (ELSE=0) INTO NeverMarried.
VARIABLE LABELS  NeverMarried 'Never married yes/no'.
EXECUTE.

RECODE V501 (2=1) (ELSE=0) INTO Livingtogether.
VARIABLE LABELS  Livingtogether 'Living together yes/no'.
EXECUTE.

RECODE V501 (3=1) (ELSE=0) INTO Widowed.
VARIABLE LABELS  Widowed 'Widowed yes/no'.
EXECUTE.

RECODE V501 (4=1) (ELSE=0) INTO Diforced.
VARIABLE LABELS  Diforced 'Diforced yes/no'.
EXECUTE.

RECODE V501 (5=1) (ELSE=0) INTO Seperated.
VARIABLE LABELS  Seperated 'Seperated yes/no'.
EXECUTE.

RECODE V025 (1=0) (2=1).
EXECUTE.

RECODE ML101 (1=1) (ELSE=0) INTO Treatedbednets.
VARIABLE LABELS  Treatedbednets 'Dummy for no bednets'.
EXECUTE.

RECODE ML101 (1=2) (ELSE=0) INTO Treateduntreatedbednets.
VARIABLE LABELS  Treateduntreatedbednets 'Dummy for either bednet'.
EXECUTE.

RECODE ML101 (1=3) (ELSE=0) INTO Untreatedbednets.
VARIABLE LABELS  Untreatedbednets 'Dummy for untreated  bednet'.
EXECUTE.
```

*** Recode the categorical variables for the multilevel mixed model (dummies)**

```
GRAPH
  /LINE(MULTIPLE)=CUPCT BY BMI BY V024.
```

*** Make a cumulative line graph for BMI per region**

```
USE ALL.
COMPUTE filter_$=(V024 = 6 OR V024 = 7 OR V024 = 8 OR V024 = 11 OR V024 =
54 OR V024 = 5).
VARIABLE LABEL filter_$ 'V024 = 6 OR V024 = 7 OR V024 = 8 OR V024 = 11 OR
V024 = 54 OR V024 = 5 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.
```

*** Select the regions of Dar es Salaam, Pemba North, Pwani, Lindi, Iringa an Morogoro**

```
GRAPH
  /LINE(MULTIPLE)=CUPCT BY BMI BY V024.
```

*** Make a cumulative line graph for BMI per region**

```
RECODE BMI (Lowest thru 18.5=1) (18.5 thru 25=2) (25 thru 30=3) (30 thru
Highest=4) INTO BMICat.
VARIABLE LABELS  BMICat 'BMI in categories'.
EXECUTE.
```

*** Recode the BMI variables in the WHO categories**

B. Syntax commands and explanation (Stata)

xtmixed BMI V012 V034 V191 V115 V137 V138 V201 Largecity Smallcity Town, || V024:, covariance(independent)

xtmixed BMI V012 V034 V191 V115 V137 V138 V201 , || V024:, covariance(independent)

xtmixed BMI V012 V034 V191 V115 V137 V138 , || V024:,

xtmixed BMI V012 V034 V191 V115 V138 , || V024:, covariance(independent)

*** Make a national model using all the variables at first and excluding the insignificant variables stepwise.**

xtmixed BMI V012 V034 V115 V138 V191 V115#V191, || V024:, covariance(independent)

*** Test the interaction between 'time to get to water source' and 'wealth index factor score' in the model.**

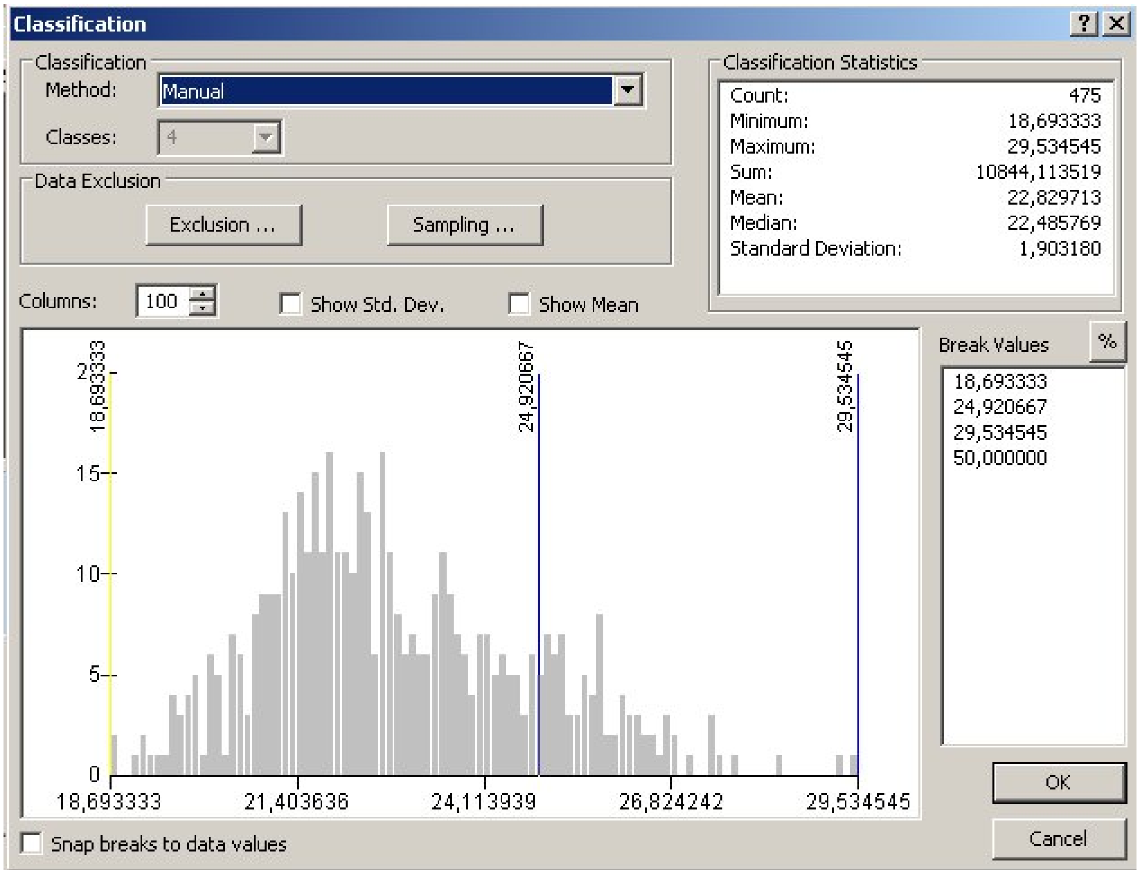
predict Constant, fitted level(V024)

*** Predict the constant using post-estimation.**

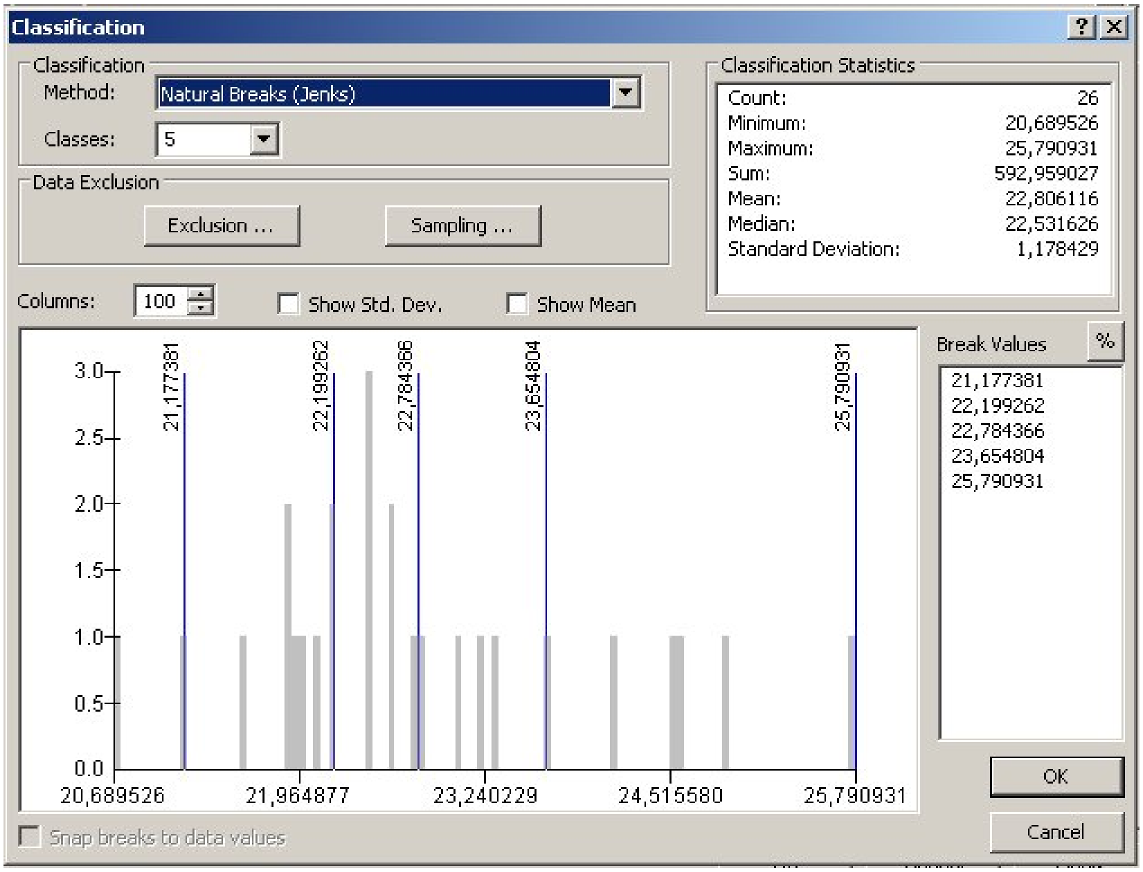
by V024, sort : xtmixed BMI V012 V034 V191 V115 V138, || V024:, covariance(independent)

*** Calculate a separate model for each region.**

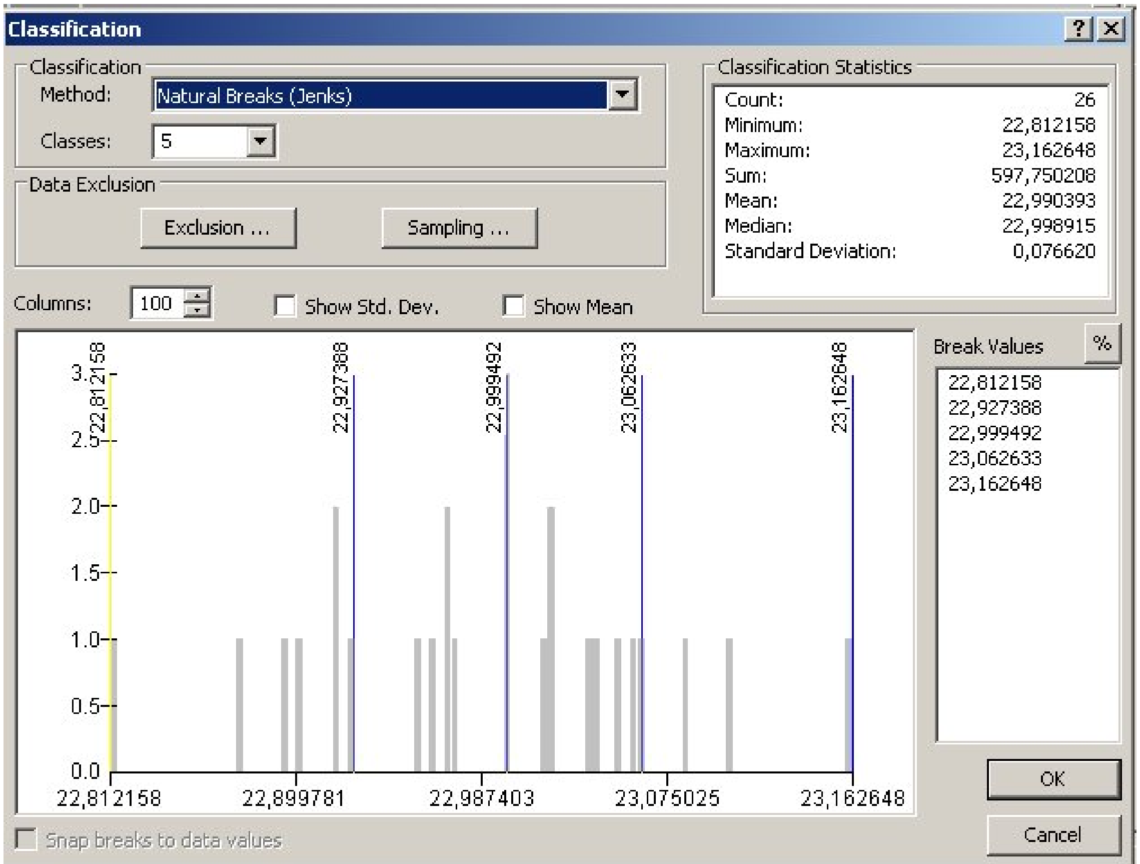
C. Distribution of variables and chosen break values in ArcGis



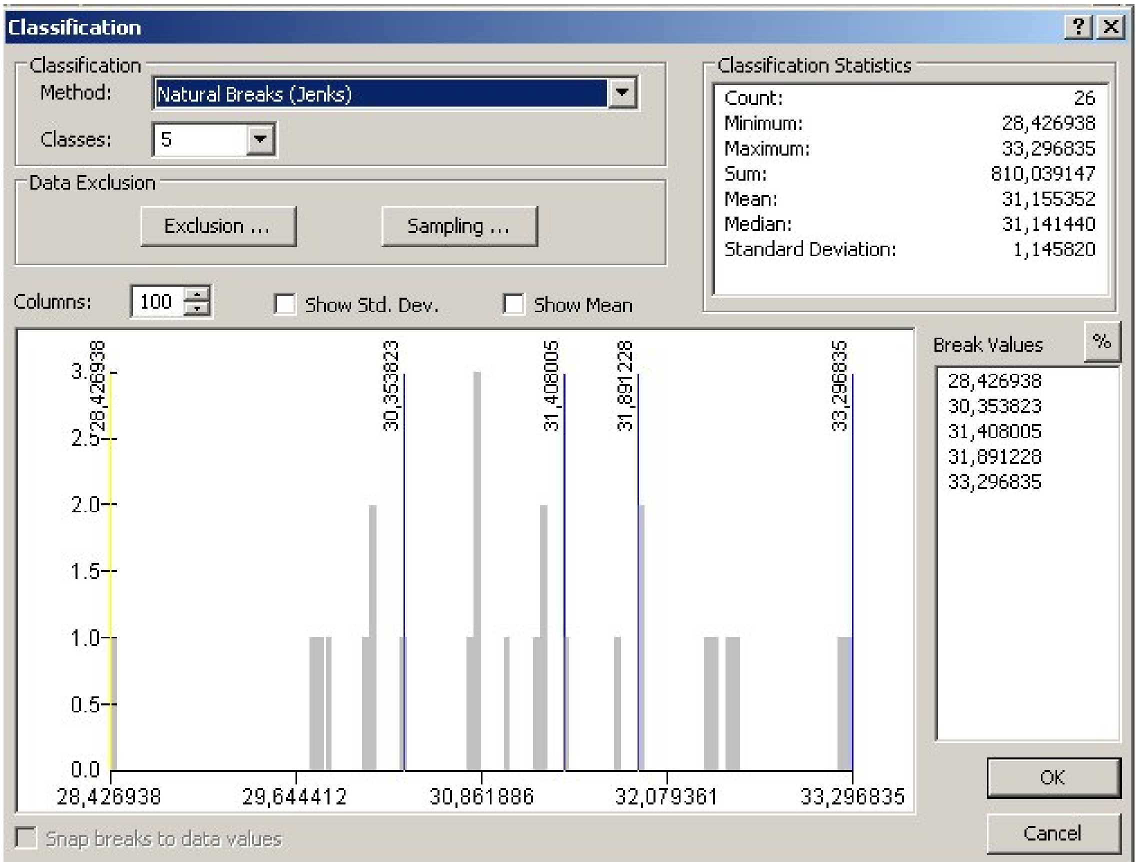
*** Distribution and break values for BMI clusters WHO**



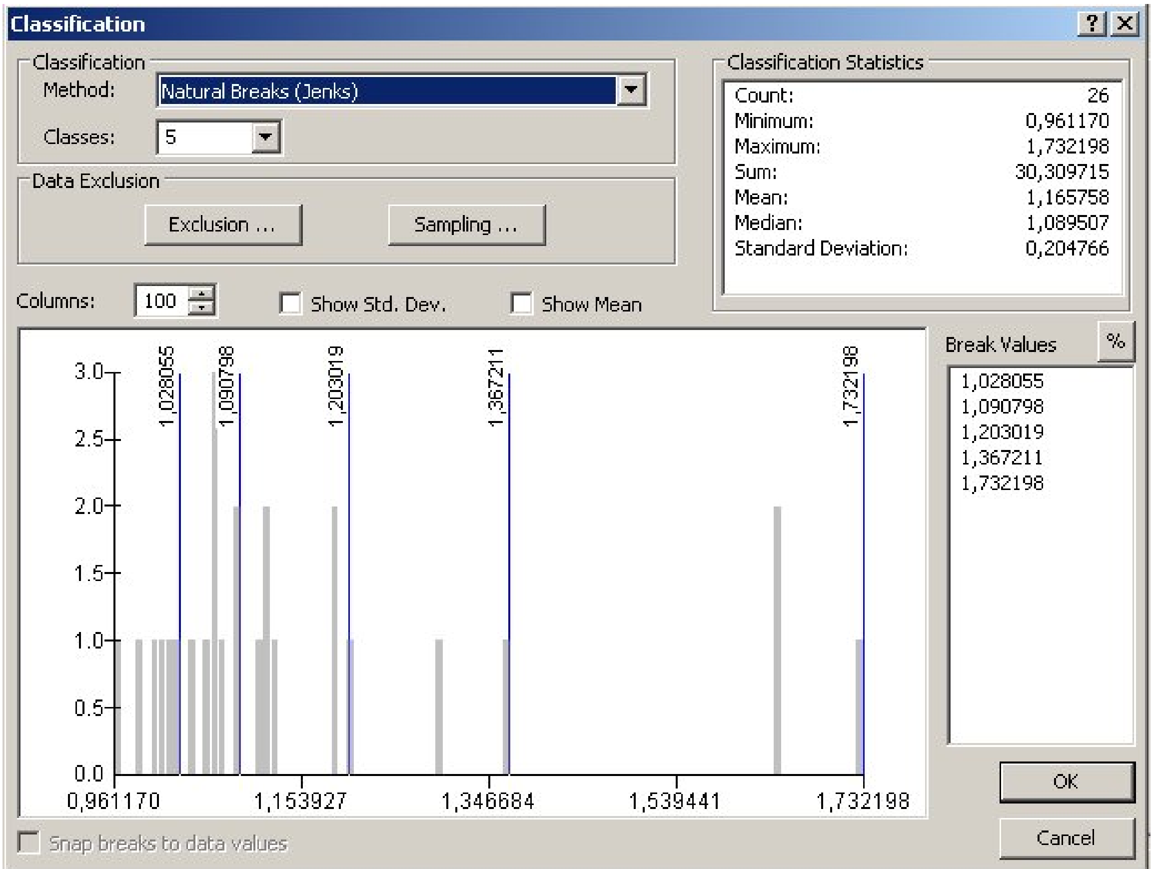
*** Distribution and break values for BMI (DHS)**



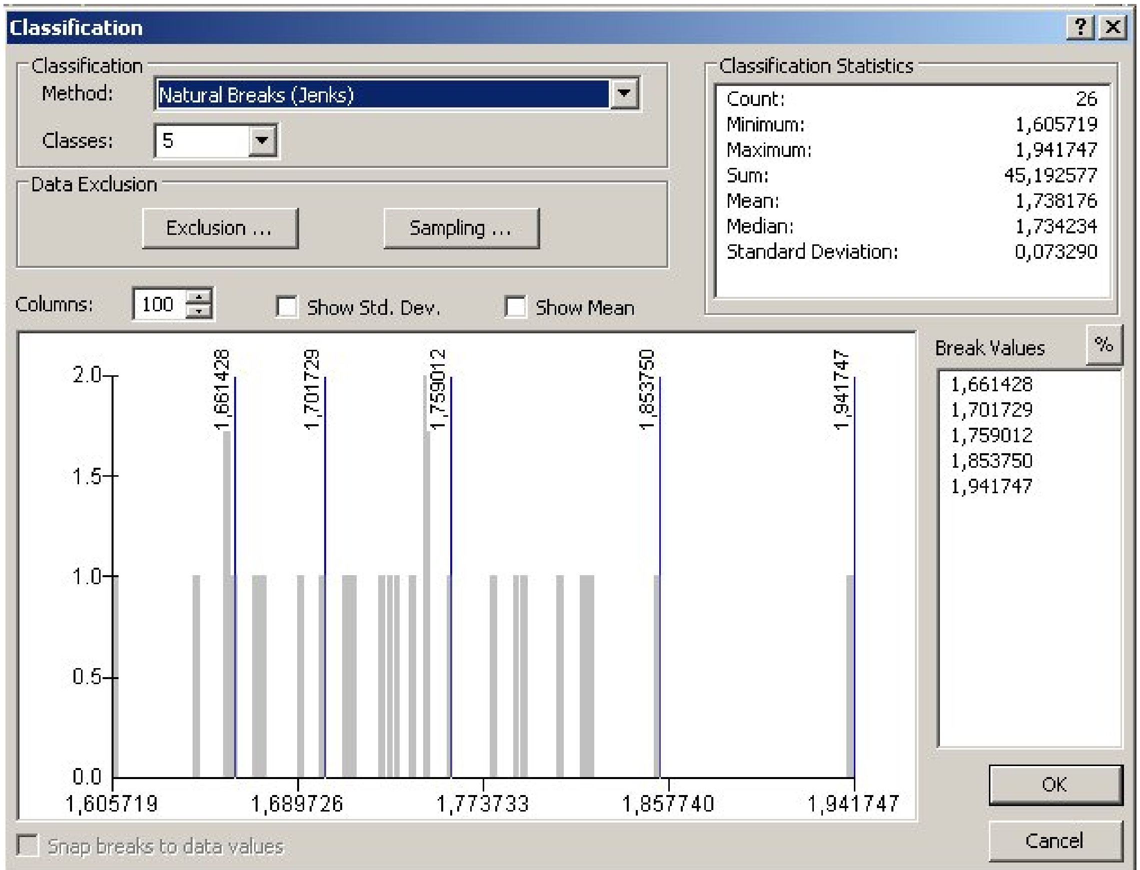
*** Distribution and break values for BMI (predicted)**



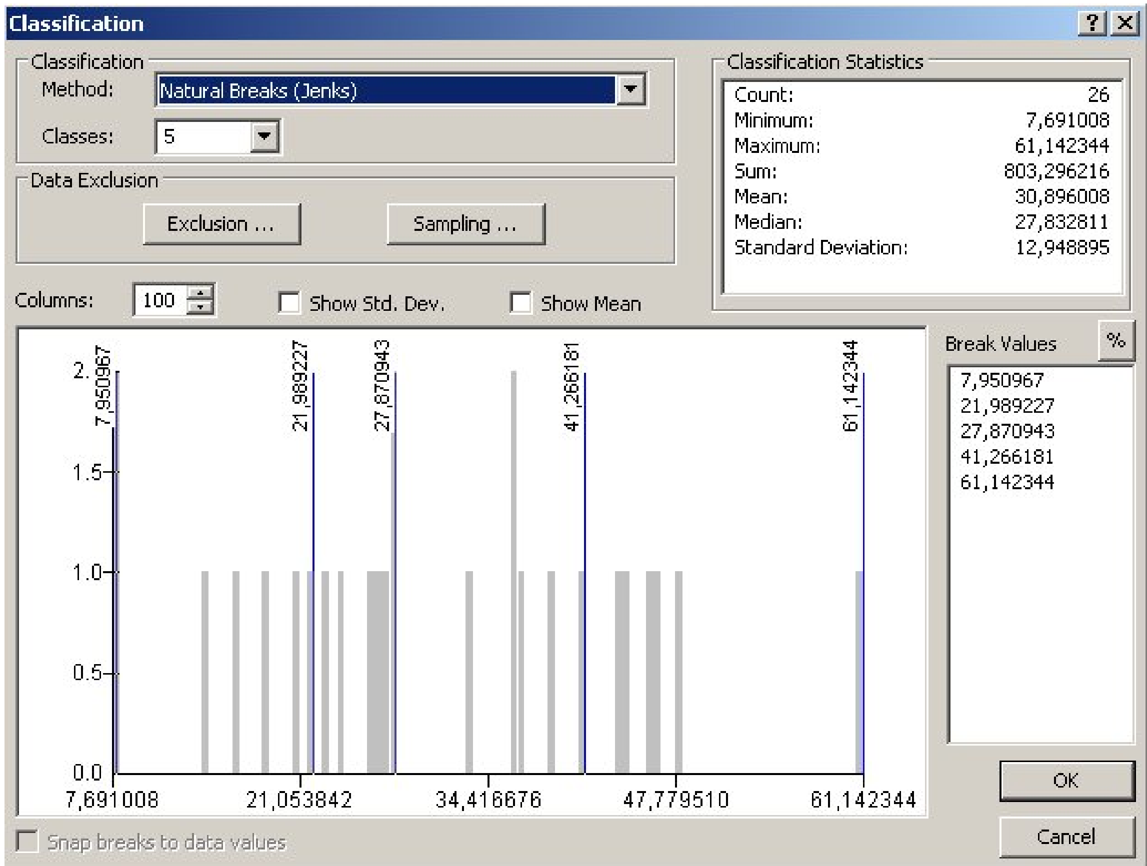
*** Distribution and break values for current age**



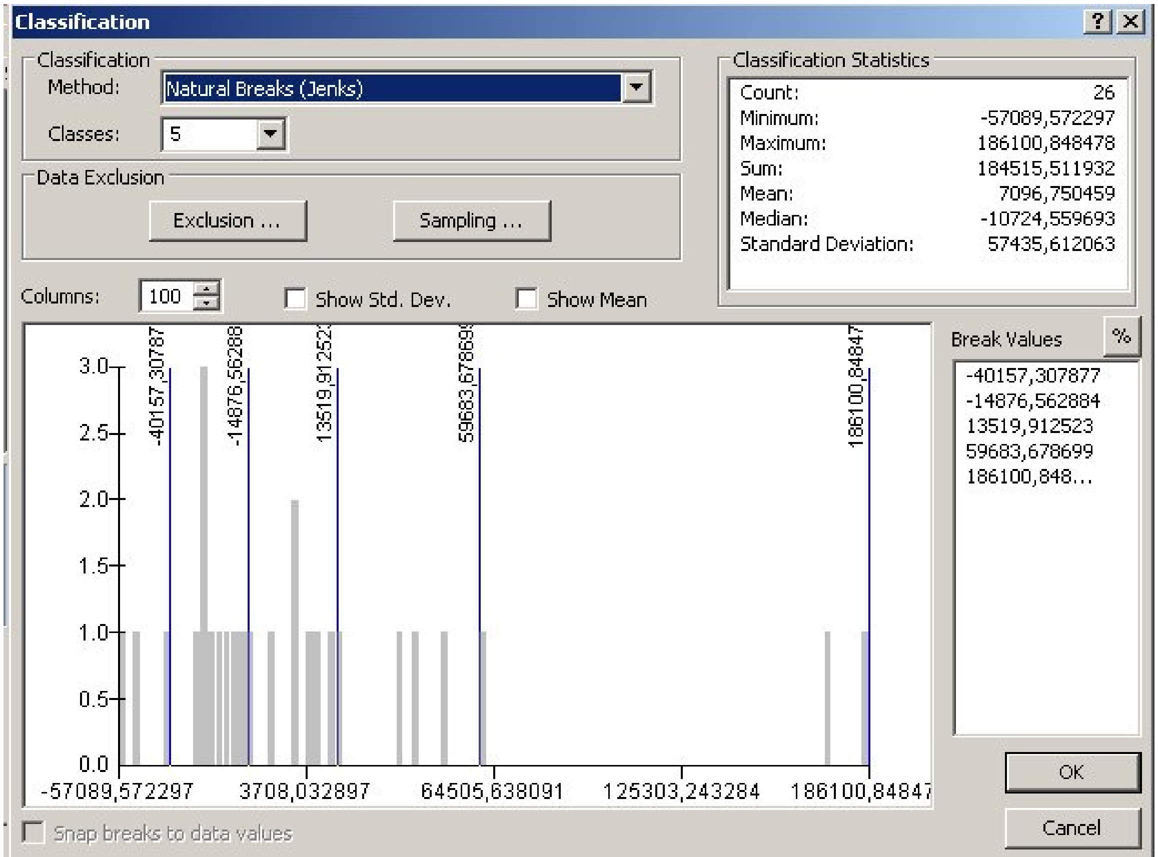
*** Distribution and break values for line number of husband**



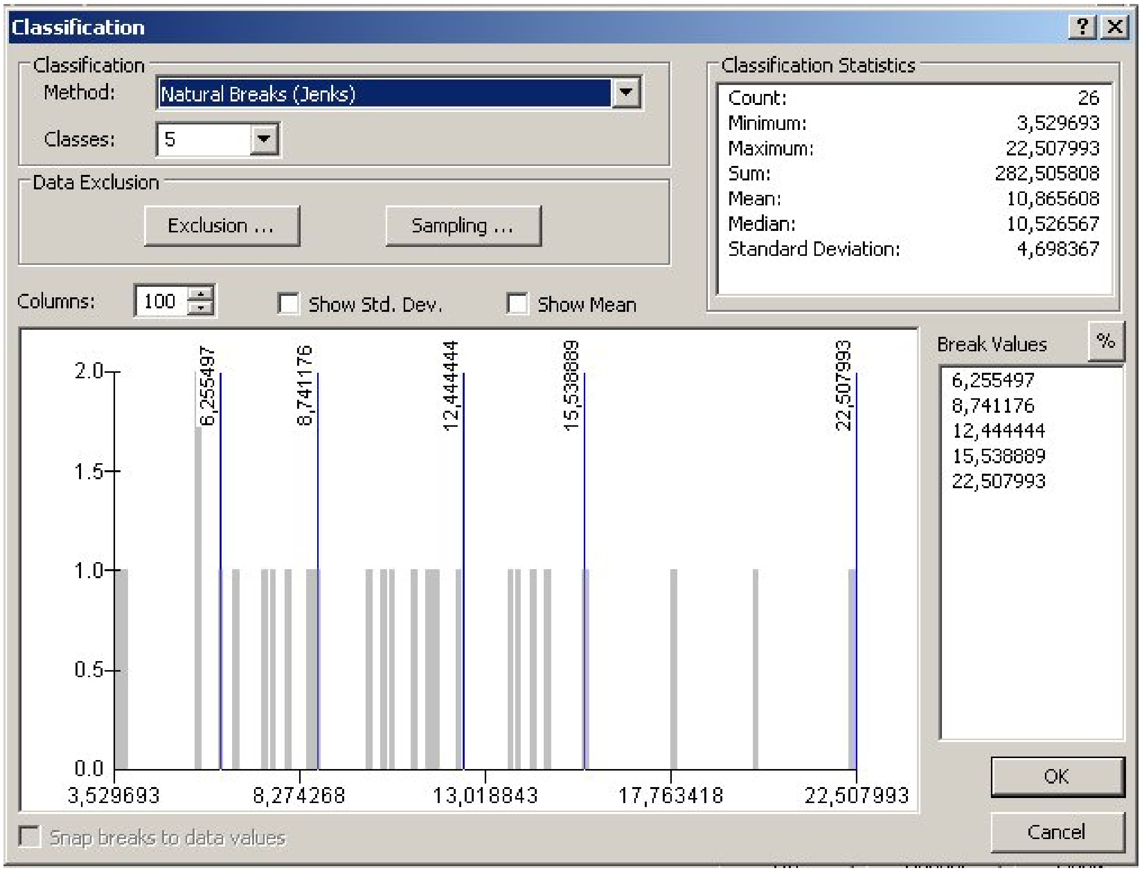
*** Distribution and break values for number of eligible women in the household**



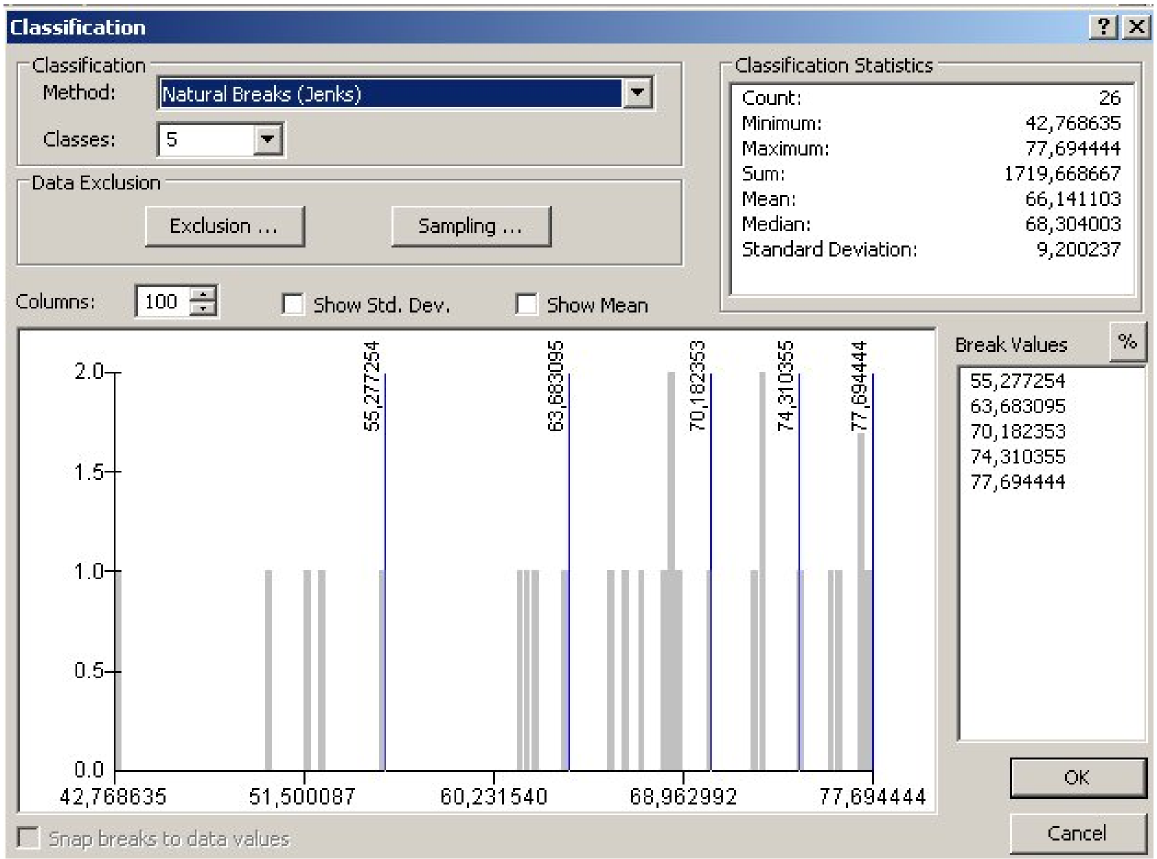
*** Distribution and break values for time to get to water source**



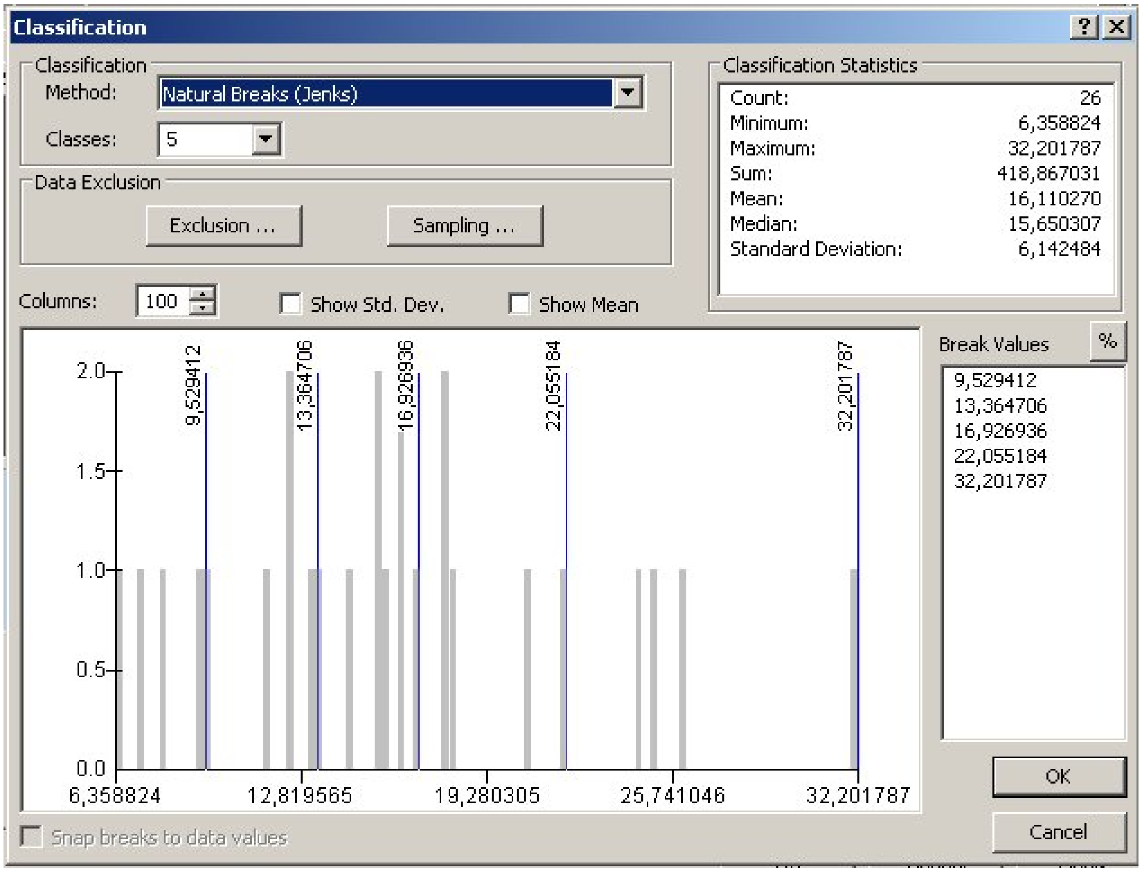
*** Distribution and break values for wealth factor index score**



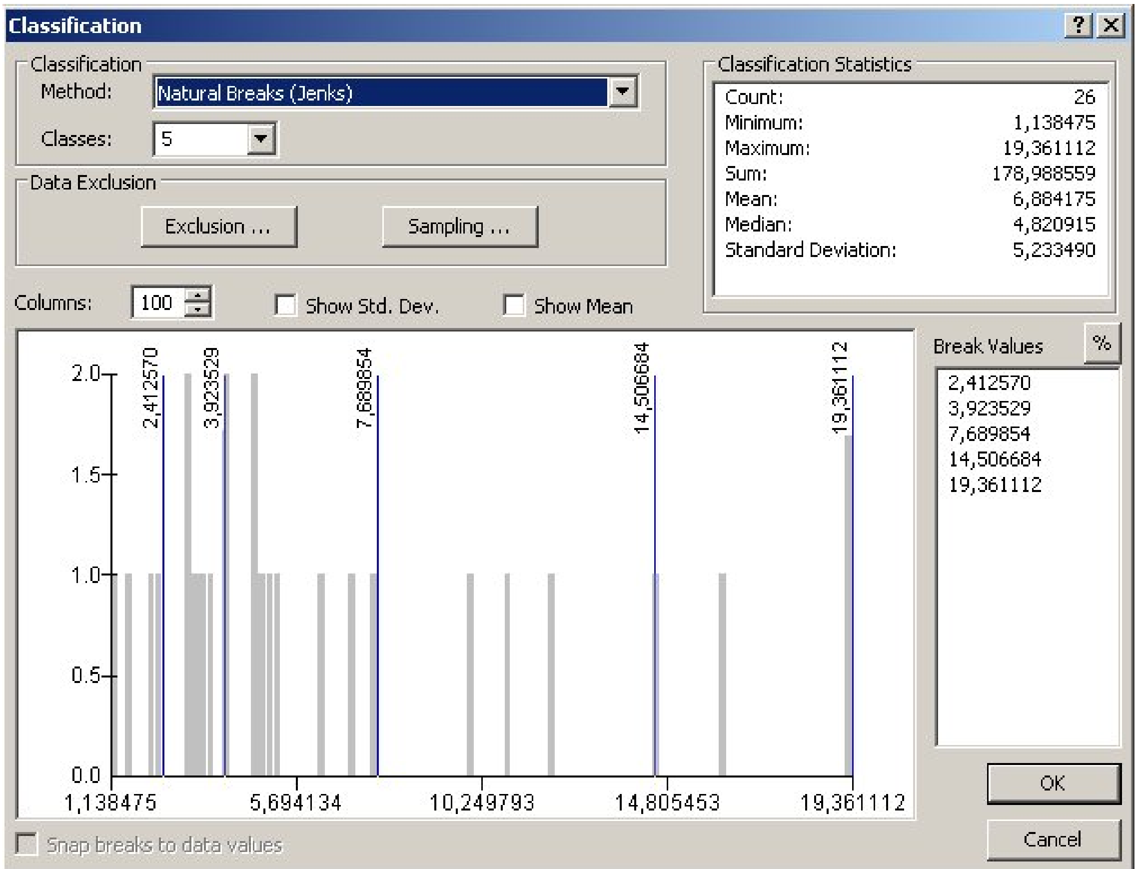
*** Distribution and break values for percentage of underweight**



*** Distribution and break values for percentage of normal weight**



*** Distribution and break values for percentage of overweight**



*** Distribution and break values for percentage of obesity**

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