GEOSPATIAL ANALYSIS OF CASSAVA COMMERCIALISATION IN TANZANIA

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Geospatial analysis of cassava commercialisation in Tanzania

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DECLARATION

This dissertation is my original work and has not been presented for a degree in any other university.

Signed: .... Date: ....

Elton Eric Chikondi Mgalamadzi

This dissertation has been submitted for examination with our approval as university supervisors

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DEDICATION

I dedicate this work to three women who made a difference in my life and these are; my grandmother Mrs Christina Mgalamadzi, my mum Mrs Evelyn Mgalamadzi and my lovely fiancé Loveness Msofi for being a source of hope and encouragement at different levels of my life in school.

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Above all I thank God for seeing me through this work.

ABSTRACT

Promoting cassava production and solving challenges that are associated with cassava processing and commercialisation has been a priority for government and non-governmental organisations in Tanzania. However, the commercialisation process is hindered by the bulkiness and natural occurrence of toxic substances (cyanogens) in cassava. The bulkiness in cassava raises transportation costs and occurrence of toxic substances poses health hazard to people consuming cassava.

The purpose of this study was to analyse distribution of cassava production in Tanzania in relation to number of cassava farmers, area under cassava, yield and production; examine spatial patterns of cassava production so as to identify areas of marked difference and finally, examine spatial relationships in cassava pricing in local markets so as to understand their implications to cassava commercialization process.

Through mapping, cassava distribution was analyzed. Moran's Index of global autocorrelation and local indicator of spatial autocorrelation were used to explore spatial patterns of farmers across the country. Hot spot analysis using Getis-ord GI* was conducted to identify areas with significantly high and low values of cassava yield figures. Price pattern of cassava was also examined using global indicator of autocorrelation (the Moran's Index).

The results revealed that cassava production in Tanzania is concentrated in the southern zone (Mtwara and Lindi regions), Lake Victoria zone (Mara, Kagera and Mwanza regions) and Indian Ocean coast. Each of these regions account for between 7% to 15% of total cassava farmers. Further, hot spot analysis identified 12 significant hot spots in five regions; Mtwara, Lindi, Mara, Mwanza and Pwani. Mtwara accounts for about 33% and Mwaza 25% of these hot spots. Finally, autocorrelation of prices in cassava were discovered implying that prices of cassava in neighbouring markets influence each other.

In principal, cassava commercialization can be effective if concentration can be in areas where more farmers, large proportions of land and higher production figures were observed.

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ACRONYMS

ASARECA	Association of Strengthening Agricultural Research in Eastern and Central Africa
GIS	Geographic Information System
GLCI	Great Lakes Cassava Initiative
GPS	Global Positioning System
FAO	Food and Agriculture Organisation
FAOSTAT	Food and Agriculture Organisation Statistics
FEWSNET	Famine Early Warning System Network
HQCF	High Quality Cassava Flour
JKUAT	Jomo Kenyatta University of Agriculture and Technology
LISA	Local Indicator of Spatial Autocorrelation
LSMS-ISA	Living Standards Measurement Study-Integrated Surveys on Agriculture
PRA	Participatory Rural Appraisal

CHAPTER ONE

INTRODUCTION

1.1 Background

Farmers, agricultural extension workers, agro-dealers, policy makers and researchers are facing an enormous challenge in their effort to promote cassava production and to solve challenges that are associated with cassava processing and commercialization in Tanzania. According to Silaya et al. (2007), cassava is a crop for improving livelihoods in Tanzania but has not been fully exploited partly due to limited use of appropriate technologies to produce value added products.

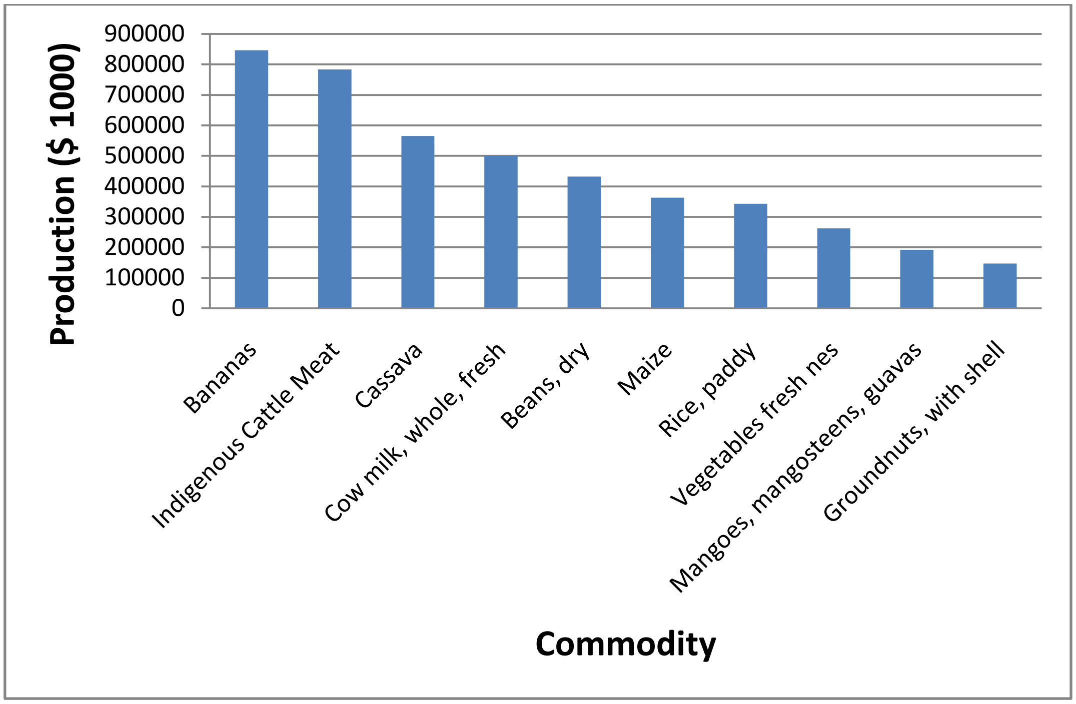
In terms of food security, cassava contributes an average of 15% of the total food requirements and is only second to maize as a staple crop in Tanzania (Mpagalile *et al*., 2008). Cassava plays an increasingly important food security role especially in areas which are prone to drought. Relatively cassava has advantages over other staple foods in that it is tolerant to water stress, has low demands on soil nutrients, and low requirements for chemical fertilizers.

The 2002-2003 National Sample Census of Agriculture indicated that about 24% of farmers in Tanzania grow cassava. Furthermore, cassava serves as a source of income for many farming families who produce and sell cassava locally and in urban markets. Cassava is mainly grown in the Coast region (along the Indian Ocean), areas around Lake Victoria, Lake Tanganyika and along the shores of Lake Nyasa (Mkamilo and Jeremiah, 2005). Figure 1-1 shows the main cassava growing zones in Tanzania.

Source: Mkamilo and Jeremiah, 2005

Figure 1-1: The main cassava growing areas of Tanzania

Economically, cassava is an important commodity and it ranks third in terms of monetary value after bananas and local cattle beef in Tanzania (FAO, 2009). Figure 1-2 depicts the economic value of various agricultural commodities in Tanzania.



Source: FAOSTAT (2009)

Figure 1-2: Top nine Agriculture commodities in Tanzania

The area under cassava production has been increasing over the period (Figure 1-4). Significant increases of about 20% have been observed from the period between 2005 and 2009. However, FAO reported no international trade for cassava. According to the National Sample Census of Agriculture (2002-2003), about 31% of cassava is marketed locally and the rest is retained for home consumption.

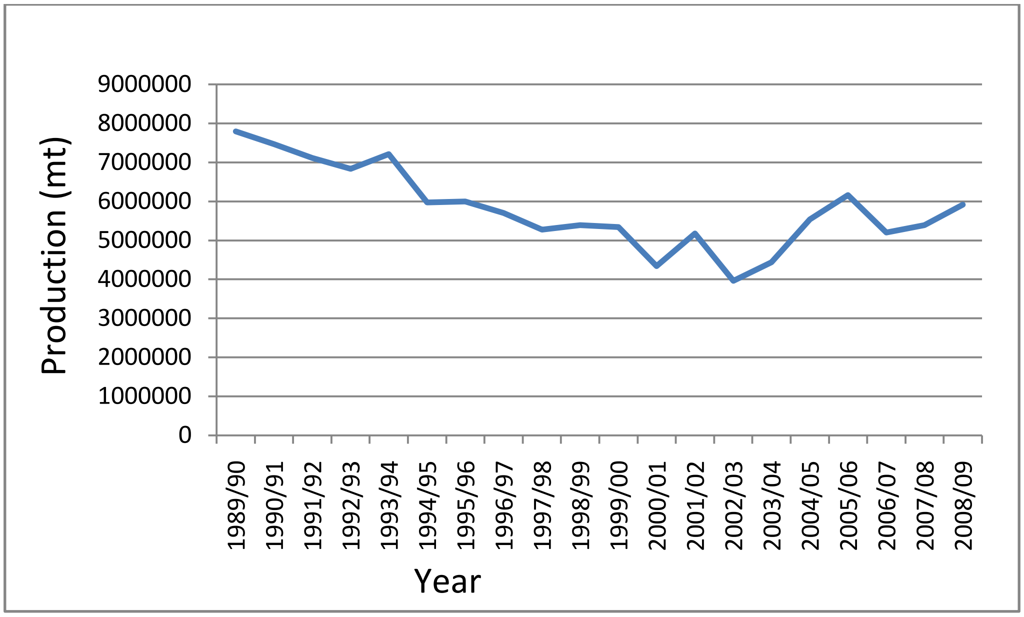


Figure 1-3: Cassava production trend in Tanzania over two decades period (FAOSTAT, 2010)

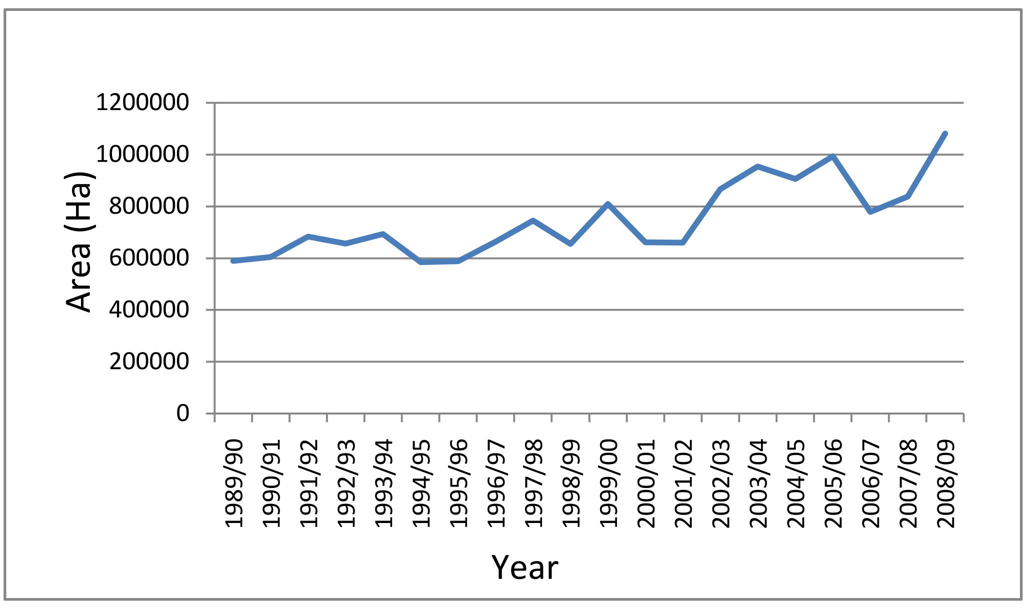


Figure 1-4: Area under cassava in Tanzania for a period of two decades (FAOSTAT, 2010)

Mkamilo and Jeremiah (2005) observed that poor processing technologies and limited cassava utilisation are the main problems that affect commercialisation of cassava in Tanzania.

1.2 Statement of the problem

Cassava is naturally bulky with very high water/moisture content of about 70%. It also contains cyanogens which often cause health problems to humans if not properly processed (Westby, 2002). Furthermore, cassava has a poor post-harvest life; it is highly perishable and can only be kept fresh for a period of between 24 and 72 hours (Alves, 2002).

The bulkiness of cassava raises transportation costs and thereby making it an uneconomical (low value) commodity in the market. In Tanzania the problems are exacerbated by the fact that cassava is produced in remote areas that are far from the markets. Producers or buyers face a challenge of transporting cassava to the market or point of consumption in time before it deteriorates as it is a short shelf life commodity. High tropical temperatures in Tanzania reduce even further the shelf life of cassava.

Commercialising cassava could be a solution to problems that are associated with the crop. This could bring facilities such as markets, storage equipment, and processing machinery to where they are needed most. However, spatial distribution of cassava in Tanzania need to be extensively studied and understood so as identify production trends and patterns. This will help to identify strategic positions with significant production to place such facilities and sustain them. Furthermore, as a marketing aspect, analysis of cassava prices in relation to production will help in decision making regarding any investment in promoting cassava.

This study strove to analyse cassava production patterns in Tanzania and expose business opportunities that exist to benefit local farmers as well as investors.

1.3 Study objectives

The main aim of this study is to explore existing and future opportunities in cassava production through understanding of geospatial patterns that exist about cassava and their implications to the cassava commercialisation process. This study therefore focuses much on application of geospatial statistical techniques such as mapping, hotspot and cluster outlier analysis to analyse the geography of cassava production and market price trends in Tanzania to benefit the cassava processing industry. The study has the following specific objectives:

1. To analyse the spatial distribution of cassava production in Tanzania in relation to farmers, area under production, yield and population.
2. To examine the spatial variations of cassava production and identify areas of marked differences.
3. To examine the spatial relationships in cassava prices from various local markets across the country

1.4 Hypothesis

The study was based on the following hypotheses:

1. Cassava production in Tanzania is randomly distributed across space such that it does not follow any pattern (no clusters of high or low values-hot and cold spots)
2. Prices of cassava in different local markets do not influence each other. There is no autocorrelation (no market integration) meaning no significant movement of the commodity on market. Market price serves as a proxy for a reason for commodity movement.

CHAPTER TWO

LITERATURE REVIEW

2.1 Spatial variation theory

Spatial analysis recognises the fact that assumption about stationarity or independence or stability of a given variable under observation over space is highly unrealistic (Anselin, 1995). Anselin (1992) also observed that location in spatial data analysis plays a crucial role and gives rise to two classes of spatial effect: spatial dependence and spatial heterogeneity. The spatial dependence also referred to as spatial autocorrelation always exists and this follows directly from Tobler's first law of geography (1970) which states that "everything is related to everything else but near things are more related than distant things". As a consequence, similar values for a variable will tend to occur in nearby locations, leading to spatial clustering. Tobler's law also recognises a spatial distance decay function meaning that even though all observation have an influence on all other observations, after some distance threshold that influence becomes too small such that it can be neglected. Anselin (1992) reported that treatment of spatial data analysis from lattice (discrete variation over space) focuses on two main issues: estimation of regression models that incorporate spatial effects and testing of spatial association (autocorrelation). Autocorrelation can be measured either at global level or locally. Global spatial autocorrelation is a measure of overall clustering of data and it yields one statistic while assuming global homogeneity *(if the assumption is not holding then having one statistic is senseless)* where as local autocorrelation measures clustering in the individual spatial units thereby being able to evaluate clustering at the unit level.

Moran's *I* is a statistical measure of global autocorrelation and it is used to estimate the strength of correlation between observations as a function of distance separating them. Local Moran's index also known as Luc Anselin's Local Indicator of Spatial Autocorrelation (Oliveau *et al.*, 2004), decomposes the relationship and measures autocorrelation at local level (spatial unit) and evaluates statistical significance for each unit. Oliveau *et al.* (2004) noted that this index is fast becoming a standard tool to examine local autocorrelation. In this index, the sum of all local indices is proportional to the global value of Moran's statistic. Spatial autocorrelation tests whether or not observed value of a variable at one locality is independent of values of that variable at neighbouring localities.

According to Oliveau *et al*. (2004), for each local indicator spatial autocorrelation value allow for computation of its similarity with its neighbours and test its significance. In this test five scenarios may emerge as follows:

- Locations with high values with similar neighbours: high-high also called hot spots
- Locations with low values with similar neighbours: low-low also called cold spots
- Locations with high values with low-value neighbour: high-low which could be outliers
- Locations with low values with high-value neighbours low-high which could be outliers
- Locations with no significant local autocorrelation

Clustering of geographical units with similar values implies a positive autocorrelation as opposed to scattering of geographical units with similar values which implies negative autocorrelation. Random distribution of geographical units on a map indicates that there is no significant spatial autocorrelation.

According to Anselin (1992) relative positioning or spatial arrangement is an important determinant of the spatial interaction that is in addition to absolute spatial location (for example a coordinate point) of an observation. For each data point, a relevant neighbourhood is defined as those locations surrounding it that are considered to interact with it. The values at those locations/points thus expected to influence the observed values at the data point. Neighbours according to Anselin (1992) are defined as those data points that share a boarder or are within a given critical distance of each other. Membership of observations in the neighbourhood set for each location is expressed by means of a square matrix (W) of dimensions equal to number of observations (N); in which each row and matching column correspond to an observation pair $i.j$. In this weight matrix (W), elements Wij take on a non-zero value when observations i and j are considered to be neighbours and a zero value otherwise. Standardisation of the weight matrix is done for ease of interpretation such that the elements of a row sum up to one. This is done by diving each of the elements Wij of matrix W by its sum and yield values between 0 and 1.

2.2 Spatial data analysis application

Spatial data analysis distinguishes itself from classical data analysis in that it associates with each object the attribute under consideration including both non-spatial and spatial attributes. Spatial data analysis utilises geographically referenced data also called Geodata. Geodata describe both location and the characteristic of spatial features such as households, roads and water bodies and has two main components: spatial data representing its location, and attribute data representing its characteristics. Hintze *et al.,* (2009), indicated that using geographically referenced data allows one to expand the analysis of socio-economic data to incorporate a spatial dimension thereby allowing for addressing of several scientific questions by integrating socio-economic and geography. Further, he observed that households as well as environmental data can be linked to precise location in the real world and this allows for combining of different datasets via the spatial location. Indicators such as distance and accessibility can be included in analyses and models. Therefore, in this study factors that affect cassava production can be modelled while factoring in the spatial aspect. Systematic variation of values (spatial variation) which may be observed during analysis will not come about by chance alone and this may suggest variation due spatial effect.

Woodard (2010) used spatial panel econometric approach to estimate incidence of price shocks and government subsidies in the USA using farm level data from Illinois State. Dauda *et at.,* (2010) applied spatial analysis to assess spatial variations in experimental plots through global and local indicator of autocorrelation and results indicated that the selected spatial autocorrelation indicators were consistent with other spatial analytical tools. Mueller-Warrant *et al.,* (2008) used analysis of spatial clustering to analyse weeds severity in grass seed weeds in Oregon. It was concluded that clustering in the distribution of grass seed weeds occurred as a result of both cropping history and edaphic factors and was strong in some weed species than it was in others. The study further recommended publication of weed hot spots maps to help grass seed growers, production consultants, seed certification agencies and seed companies to monitor impact of weed severity. In a study to investigate regional development of agricultural production in Hungary, Balmann *et al.,* (2007) used Moran's Index of autocorrelation to investigate concentration of agricultural production in specific regions. The study aimed at establishing whether the regions with concentration of production were adjacent or spread across the country and to find out which regions have been able to grow their share of production and which regions had lost their positions.

2.3 Cassava production in Tanzania

In Tanzania, cassava is mostly grown by small scale farmers with land holding size ranging from 0.5 to 2 hectares. This is approximated to be one-third of the household farm size and 70% of total land under roots and tubers according to Nkuba *et al*. (2007). Cassava yields in Tanzania ranges from 1.5 metric tonnes per hectare in marginal areas with minimal use of improved technologies to 35 tonnes per hectare under favourable climatic conditions and use of improved technologies with an average of around 8 tonnes per hectare (FAO, 2001). A total of 655 700 hectares of land was being grown with cassava and realising 1, 795, 400 tons production (Sewando, 2012) making Tanzania the fourth largest producer of cassava in Africa behind Nigeria, Democratic Republic of Congo (DRC), and Ghana.

Cassava production in Tanzania has been increasing over the years. According to data obtained from FAO, cassava production has increased by about 20% in a period between 2005 and 2009 (FAOSTAT, 2009). The increase in cassava production could be attributed to increasing area that is put to cassava production which has also been increasing. It was estimated in the 2002/03 National Sample Census on Agriculture that about 24% of farmers in Tanzania grew cassava with Mtwara, Ruvuma, Kigoma, Mara and Lindi registering over 50% of farmers as cassava farmers.

Cassava production faces a number of challenges in Tanzania which have been summarised in a report by Match Maker Associates (2012), as being due to occurrence of pests and diseases, extremely low soil fertility, moisture stress, use of low yielding traditional planting materials, and poor farming practices.

2.4 Small scale cassava processing industry in Tanzania

Cassava processing is done mostly to increase shelf life, facilitate transportation and reduce cyanogens level. Processing reduces transportation costs by reducing high water content and bulkiness. Cassava processing also helps to reduce post harvest losses. Processing and packaging cassava helps to increase its availability, add value, stabilise prices and facilitate export. Efficient utilisation of processing technologies will play a significant role in increasing the scope of cassava commercialisation and in turn stimulate production. The extent to which potential markets of cassava may be expanded depends largely on the degree to which the quality of various processed products can be improved to make them attractive to consumers and various markets without increasing costs of production significantly (ASARECA).

Cassava processing in Tanzania like in many other countries in Africa is mostly done using traditional methods and the products are mostly for home consumption. Oirschot *et al.*

(2004) reported that these traditional processing methods are too labour intensive such that they cannot be used for commercial purposes and also that cassava flour produced is usually not of a high enough quality. Mkamilo and Jeremiah (2005), observed that poor (traditional) processing is one of the major constraints of cassava commercialisation in Tanzania and he attributed the poor quality products and safety of cassava products to the poor processing techniques which he further argued that they are a draw back to the exploitation of market opportunities. A study conducted by Ministry of Agriculture (Promar Consulting, 2011) revealed that cassava product demand for human consumption is most pressing but the problem is that most cassava processing is done using traditional techniques which requires large amount of labour and time and still results in low quality products with low food safety standards. The study observed that urban Tanzanians are unlikely to consume more cassava unless is in the form of a convenient processed product easy for cooking like maize flour and rice. Furthermore, the same study established that Tanzania's distribution lacks a cold chain and thus there is no way to preserve cassava beyond two days without processing which is the only alternative available in Tanzania.

To increase demand for cassava in Tanzania, expansion of modern technologies and greater supply of high-quality cassava flour is needed (Promar Consulting, 2011). The report indicated inconsistent supply of raw cassava as a major challenge that contributed to failure of large scale cassava processing factories that were initiated and the currently promoted small scale cassava processing plants in Tanzania hence a recommendation to expand and stabilise the supply of cassava raw materials. This report concurs with another report by match Maker Associate (2007), which indicated a particular case of failure of cassava processing industry in the Lake zone region. The failure was to due to inconsistent supply of raw cassava to a processing group that was organised with assistance from Ukuriguru Agricultural Research Institute with some machinery like a greater and a chipper to produce high quality cassava flour. These findings are similar to the situation in West Africa where cassava based industries were also closed in Nigeria and in Ghana because farmers were unable to meet the export market demand for dried cassava roots (Nweke, 2004). On the other hand, establishment of the processing plants in within cassava producing areas might act as a motivating factor for farmers to produce more cassava and supply the plants. Access to urban markets is an essential factor that can increase the probability of farmers to take the risk to produce cassava or marketing (Sewendo *et al.*, 2011). Nweke (2004) argues that mechanisation of cassava production, harvesting and processing will shift the supply curve to the right and lead to expansion in cassava production and decline in cassava prices to the consumers, livestock and industrial users. He further observed that the need to mechanise cassava harvesting and processing increases with the adoption of high yielding cassava varieties that are being promoted.

2.5 Cassava marketing in Tanzania

In Tanzania, cassava is hardly produced for the market. An estimated 84% of the national production is for own consumption (Match maker associate, 2007). The remaining portion is put on the market that is mostly domestic. Cassava trade in Tanzania is virtually local as indicated by FAO statistics (2009). There is little international trade even cross border trade against what has been reported for other food crops like maize which is mostly exported to southern neighbouring countries of Malawi and Zambia. This is the case despite liberalised food policy which according to Minot (2010), saw most of the state owned enterprises and cooperatives created in 1960s and 1970s either reduced in size and mandate or dismantled completely. Under the new policy, private traders are now free to buy and sell any crop anywhere and the consumer and producer food prices are determined by market forces of demand and supply. Furthermore, the cassava marketing that take place in local markets is mostly for fresh cassava (Sewando *et al*., 2011), or locally processed grits without much value addition despite availability of marketing opportunities for value added products such as cassava flour (HQCF) and cassava chips for animal feed. Famers sell their fresh cassava either per ridge or acre to rural vendors or traders. The vendors sale their cassava along the road sides or rural markets either directly to consumers or to middle men who then transport the cassava to some urban markets. Cassava marketing also involves some big traders who usually buy fresh cassava or dried cassava chips and transport to other regions or in a few cases and in small quantities export to Kenya, Rwanda, DR Congo or Uganda as it is the case with traders from Geita district markets (Match Maker associates, 2007).

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study was conducted in Tanzania, an Eastern Africa country that is found 6^{o} south of equator and 35^{o} east of Greenwich meridian. Tanzania share borders with Mozambique, Malawi, Zambia, DR Congo, Burundi, Rwanda, Uganda and Kenya and Indian Ocean to the east.

The study covered all the regions; Dodoma, Arusha, Kilimanjaro, Tanga, Morogoro, Pwani, Dar es Salaam, Lindi, Mtwara, Ruvuma, Iringa, Mbeya, Singida, Tabora, Rukwa, Kigoma, Shinyanga, Kagera, Mwanza, Mara, Manyara, Kaskazini, Kusini, Mjini Magharibi, Kaskazini Pemba and Kusini Pemba (Figure 3-1).

Figure 3-1: The regions that constituted Tanzania where the study was conducted

3.2 Data Sources

The study utilised data from various sources (databases) to achieve its objectives as follows;

1. Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) data
2. Tanzanian population data of 2002 and 2008 projection
3. Local market price data
4. Famine Early Warning System Network (FEWSNET) data
5. Great Lakes Cassava Initiative (GLCI) data

Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) data

This study utilised Living Standards Measurement Study data which was collected and archived by Tanzania National Bureau of Statistics over a period of twelve months from October 2008 to October 2009. Living Standards Measurement Surveys are multi-topic household surveys that use questionnaires designed to assess household welfare, understand household behaviour and evaluate effects of various interventions on the livelihood of the population (Pica-Ciamarra *et al.,* 2011). The questionnaires were in three categories which are household questionnaire, an agriculture questionnaire and a community questionnaire. This study utilised the agriculture component and its questionnaire contained 13 sections that relate to agriculture activities such as crops, livestock, fisheries, agricultural marketing and agricultural inputs acquisition. Appendix1 depicts a sample of the data from the agricultural component.

The first Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) thus the agriculture section described above was designed to produce a nationally representative estimates and it consisted 3280 households. Agricultural households completed an additional questionnaire in which 2474 indicated involvement in agricultural activities (crop production, livestock production or fisheries).

Using this data, which was already referenced geographically, intensity of cassava production per region (proportion of cassava farmers per region) was mapped and spatial autocorrelation models run to test whether clustering of cassava production in specific regions of the country is significant.

Tanzanian population data of 2002 and 2008 projection

The study also utilised population data from the Tanzania National Bureau of Statistics to map population densities across the different regions. National census data of 2002 and 2008 projection were chosen so that the data should correspond to the other data sets that were used in the analyses. The data was geographically referenced per region.

Appendix 2 shows an extract of the population data and it includes region code, name of the region, regional capital, regional total land area in km^2, population as recorded in 1988 and 2002 census, as well as projected population for 2008. Spatial distribution of population across the country was examined for the purpose of comparing it with cassava distribution trend as it is commonly understood that cassava is a food security crop and therefore with growing population there could be a need for more food supply.

Local market price data

Local market price data was obtained from the Ministry of Industries and Trade Tanzania and it include prices for various crops in 55 markets across main land Tanzania. Cassava price data was extracted for analysis to determine relationships in the pricing of cassava across the country. The data includes recorded average monthly and annual prices of fresh and dried cassava in the listed markets for two years (2007 and 2008). Annex 3 is the sample of the market price data. This data was used to examine spatial relationship in cassava prices across neighbouring markets as price is taken as a proxy measure for market stability and determines flow and availability of cassava in the local markets. This is important in deciding commercialisation initiatives in the cassava industry. Coordinates points for the district centres which are also positions for the markets were traced to geographically reference the data.

FEWSNET data

Cassava production time series data for Tanzania for several decades compiled and archived by the Famine Early Warning System Network (FEWSNET) sourced from the Ministry of Agriculture has been utilized in this study. The data included variables such as area grown to cassava, yield and production per year per region. The regions were used in this study as reference points. Appendix 4 shows sample of this data.

Great Lakes Cassava Initiative (GLCI) data

This was a four year project/initiative jointly implemented by Catholic Relief Services and International Institute of Tropical Agriculture in six great lakes countries of DR Congo, Rwanda, Kenya, Burundi, Uganda and Tanzania in a period between 2007 and 2011. The project was funded by Bill and Melinda Gates Foundation to strengthen capacity of partners to prepare for and respond to the cassava mosaic disease and emerging cassava brown streak disease pandemics that threaten food security and incomes of cassava dependent farm families in six Great Lake countries. At the end of the project, data was collected to help in evaluating the project and eventually a data base was created. The data included variables such as plot yield, plot harvest (plot production), plot size and crop variety and contained coordinate points for the individual respondents. The data was obtained from International Institute of Tropical Agriculture archive (Tanzania office). Specifically, this study utilised yield variable from that database to analyse spatial relationships of cassava production within Tanzania in hot spot analysis. Appendix 5 shows a sample of this data.

3.3 Research Framework

This study adopted geospatial analysis and spatial models to explore spatial distribution of cassava, identify spatial patterns of cassava production and examine spatial relationships in cassava prices. Chrolepth maps were used to identify distribution of cassava farmers, distribution of cassava growing area, cassava production and yield trends and population densities across the regions in Tanzania. Population distribution was examined and compared to cassava distribution as it is argued that decisions to grow more cassava could be influenced by the growing population for food security purposes.

Moran's Index of global autocorrelation and Local Indicator of Spatial Autocorrelation (LISA) models were adopted to establish existence of autocorrelation and identify clusters of cassava farmers. These models were originally constructed by Luc Anselin in 1992 and revised in 1995. Getis-Ord Gi^* model which was developed by Getis and Ord in 1992 (Lentz, 2009) was used to examine spatial patterns of cassava production and identify specific locations with significantly high cassava yield figures as cassava hot spots which could be potential target locations for commercialisation initiatives. Moran's Index of global autocorrelation model was also used to identify spatial relationship in cassava prices across the country. Price serves as a proxy measure of stability in flow of commodities (market integration) within neighbouring markets. Finally, correlation analysis was conducted to establish spatial correlation between cassava prices and cassava production as illustrated in figure 3-2.

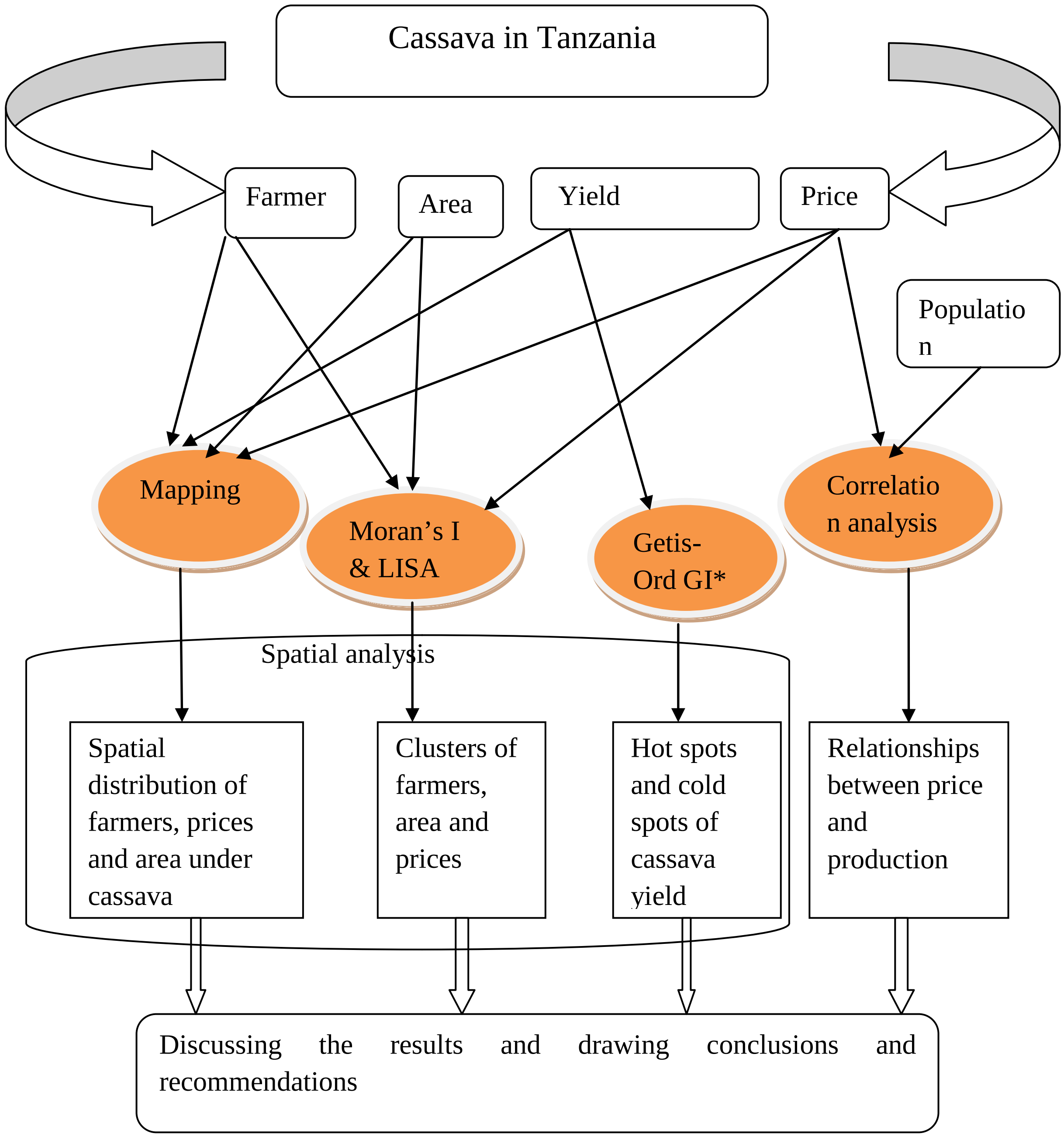


Figure 3-2: Research Frame work

3.4 Data analysis

Data analysis was performed in Microsoft Excel, SPSS and the two Geographical Information Systems (GIS) platforms; ArcGIS version 10.0 and GeoDa version 1.0.1. ArcGIS is licensed software while GeoDa is open source software.

Data files in Microsoft excel and access sheets extracted from the various databases described above was imported into ArcGIS using add data tool and converted into shapefiles (digital format for storing location and associated attribute information for GIS analysis) by using data-export tool. These shapefiles were constructed in WGS1984 projection.

Vector GIS data in shapefile format for Tanzanian maps were downloaded online with regional, district and village boundaries and were constructed on arc 1960 projection. These shapefiles were created and had built in data for population census of 2002 and the regional, district and village boundaries included all the changes before then.

The shapefiles constructed in Long/Lat decimal degree projection WGS1984 were reprojected to match the arc 1960 projection of the Tanzanian map shapefiles. All the maps that were produced in Arc Map were saved as jpeg files for easy importation in word document. The maps produced in GeoDa were directly copied and pasted on the word document.

3.4.1 Mapping cassava growing areas in Tanzania

Two different maps were produced depicting cassava production in Tanzania. The first map is showing proportions of cassava farmers in different regions in the country. This map was produced using the LSMS-ISA (Appendix 1). The data was summarised in Microsoft excel and proportions of cassava farmers per region as a fraction of the total number of cassava farmers in Tanzania were calculated and imported in ArcGIS for mapping. The output to this analysis is a chrolepth map with different colours depicting concentration of cassava farmers in the regions as proportions of the total cassava farmers in the country. The lighter colours depict areas with relatively smaller proportions of cassava farmers and the dip dark colours depict areas with relatively larger proportion of cassava farmers.

The second map showed proportions of area under cassava. This map was also produced using production data obtained from FEWSNET database (Appendix 4). Microsoft excel data files containing amount of cassava production per region was imported into ArcGIS for mapping. A choropleth map was produced showing the variations in area committed to cassava production. Colour progression from light to dark indicates intensity of production per region.

Both data sets were converted into shape files with respect to their regions. In ArcMap, the created shapefiles were joined to the original Tanzania shapefiles with the regions as the key variable (area) using join-relate tool in ArcGIS. The join resulted in a table that had fields (columns) from both shapefiles and was saved as a new shapefile for analysis and map production.

3.4.2 Mapping population in Tanzania

Using population data for 2008, population density data in Microsoft excel presented per region was converted into a shapefile with arc 1960 projection. This shapefile was then joined to the Tanzanian map shapefiles that were also constructed in arc 1960 projection to create a joined table using join-relate tool in arcMap. The joined table was then converted to a new shapefile which was used to map out population densities. The coloured map shows systematic colour progression indicating different population densities for the regions with lighter colours depicting regions with less population density and the dark colour depicting heaving populated regions.

3.4.3 Spatial Clustering of cassava farmers

Moran's Index of global autocorrelation

Using LSMS-ISA data, spatial autocorrelation analysis was conducted to explore spatial patterning of cassava farmers across the country. In ArcGIS, the tool is located in Arctoolbox-Spatial statistics-Analysing patterns- Spatial autocorrelation (Moran's I). This analysis uses global Moran's Index by Luc Anselin (1995) which is expressed as;

$$I = \frac{n}{S_O} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} \ z_i z_j}{\sum_{i=1}^{n} z_i^2} \qquad (1)$$

Where z_i is the deviation of an attribute for the feature i (number of farmers in a particular region) from a mean regional farmer population (x-$\bar{x}$), $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of feature (region) and S_O is the aggregate of all the spatial weights given as:

$$S_O = \sum_{i=1}^{n} \sum_{i=1}^{n} w_{i,j} \qquad (2)$$

Using the Moran' Index, global spatial autocorrelation was measured and its significance tested. The tool described above calculates the Moran's Index value, a Z score and a p-value that evaluates the significance of that index. The Moran's Index measures spatial autocorrelation which is feature similarity based on both feature locations and feature values simultaneously (Lentz, 2009). In this analysis, the null hypothesis states that "there is no spatial clustering associated with geographical features in the study area". When the p-value is small (less than 0.05) and the absolute value of the Z score is large enough (greater than 1.96 standard deviation) that it falls outside the desired confidence level the null hypothesis is rejected. In general, a Moran's index near +1.0 indicates clustering while an index near -1.0 indicates dispersion however Lentz (2009), argued that without looking at statistical significance there is no basis of knowing that the observed pattern could be random.

Local Indicators of Spatial Autocorrelation

As presented above, Moran's Index measures autocorrelation or detect presence of clustering at global level. This means that it can only detect presence of autocorrelation but it cannot locate the actual area where features are correlated significantly. To address that issue, Local Moran's I statistic which is a local indicator of spatial autocorrelation (LISA) also by Luc Anselin (1995) was used to identify local clustering. This tool in ArcGIS is located in Arctoolbox - Spatial statistics – mapping clusters – cluster and outlier analysis (Anselin Local Moran's I). LISA is formally expressed as:

$$I_i = \frac{(x_i - x)}{m_o} \sum \mathrm{w}_{ij} \ (x_i - x) \text{ with } m_o = \sum (x_i - x)^2/n \qquad (3)$$

Where *n* is the number of regions under study, x_i is the regional attribute values (number of cassava farmers in a particular region), x is the national mean of cassava farmers per region *n* regions and w_{ij} is the spatial weight matrix.

3.5 Cassava production hotspots (Getis-Ord Gi*)

Determination of hot spots for cassava production was conducted in ArcGIS 10.0 using spatial statistics tools (Arc toolbox-- spatial statistics tools-- mapping clusters-- hot spot analysis, Getis-Ord Gi*). Shapefile of the cassava production data with WGS9184 projection obtained from GLCI database was uploaded in the Arc GIS 10.0 for analysis and cassava yield was the input feature. The data was plotted on world base map that is built in ArcGIS.

The Getis-Ord Index (Getis-Ord, 1992) is a local statistic of autocorrelation and it measures how concentrated are the low and high values for a given study area and it is presented as:

$$G_i^* = \frac{n \sum_{i=1}^{n} w_{i,j} \ x_j - \bar{x} \sum_{i=1}^{n} w_{i,j}}{\mathrm{s} \frac{\sqrt{\left[n \sum_{i=1}^{n} w_{i,j} \ x_j - \left(\sum_{i=1}^{n} \ w_{i,j} \ \right)^2\right]}}{\mathrm{n}-1}} \qquad (4)$$

Where x_j is the attribute value for feature j (cassava yield in a particular location), $w_{i,j}$ is the spatial weight between features $i \; and \; j$, n is equal to the total number of features (total number of sampled farmers) and;

$$\bar{x} = \frac{\sum_{i=1}^{n} x_j}{n} \tag{5}$$

$$S = \frac{\sqrt{\sum_{i=1}^{n} x_j^2}}{n} - (\bar{x})^2 \tag{6}$$

The null hypothesis of the Getis-Ord Index is that "there is no spatial clustering of the values or there is complete spatial randomness". In this case there is no spatial clustering of cassava yield values across the study area. The resultant Index is a z-score and it tells where features either with a low value of high value cluster spatially. Occurrence of a high value feature is interesting according to Lentz (2009), but it may not be a statistically significant hot spot. To be a statistically significant hot spot, a feature has to have high value and be surrounded by features with high vales as well.

3.5.1 Interpretation of Getis-ord statistics (Gi*)

The Gi* statistic returned in data set is a z-score. For statistically significant positive Z scores, the larger the Z score is the more intense the clustering of high values (hot spot). For statistically significant negative Z scores, the smaller the Z score is, the more intense the clustering of low values (cold spot) (Lentz, 2009). For this study, the hypothesis was tested at 95% confidence level which implies a standard deviation of 1.96 and above for hot spots and -1.96 and below for cold spots.

3.6 Spatial relationships in cassava prices from various local markets

3.6.1 Moran's Index of global autocorrelation

Using cassava price data, spatial autocorrelation analysis was conducted to examine spatial relationships or autocorrelation of the prices across the country. In ArcGIS, the tool is located Arctoolbox-Spatial statistics-Analysing patterns- Spatial autocorrelation (Moran's I). This analysis uses global Moran's Index as expressed in equation 1 and 2.

Where z_i is the deviation of an attribute for the feature i (cassava market price in a particular market/region) from a regional mean price (x-$\bar{x}$), $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of feature (markets) and S_0 is the aggregate of all the spatial weights:

3.6.2 Correlation between cassava production and cassava prices

Cassava price and production density data for 2007 and 2008 per region were tested for correlation in SPSS using Pearson's correlation coefficient of correlation (r) and scatter plots. Data in Microsoft excel files were imported in SPSS using read text data tool and subjected to the test.

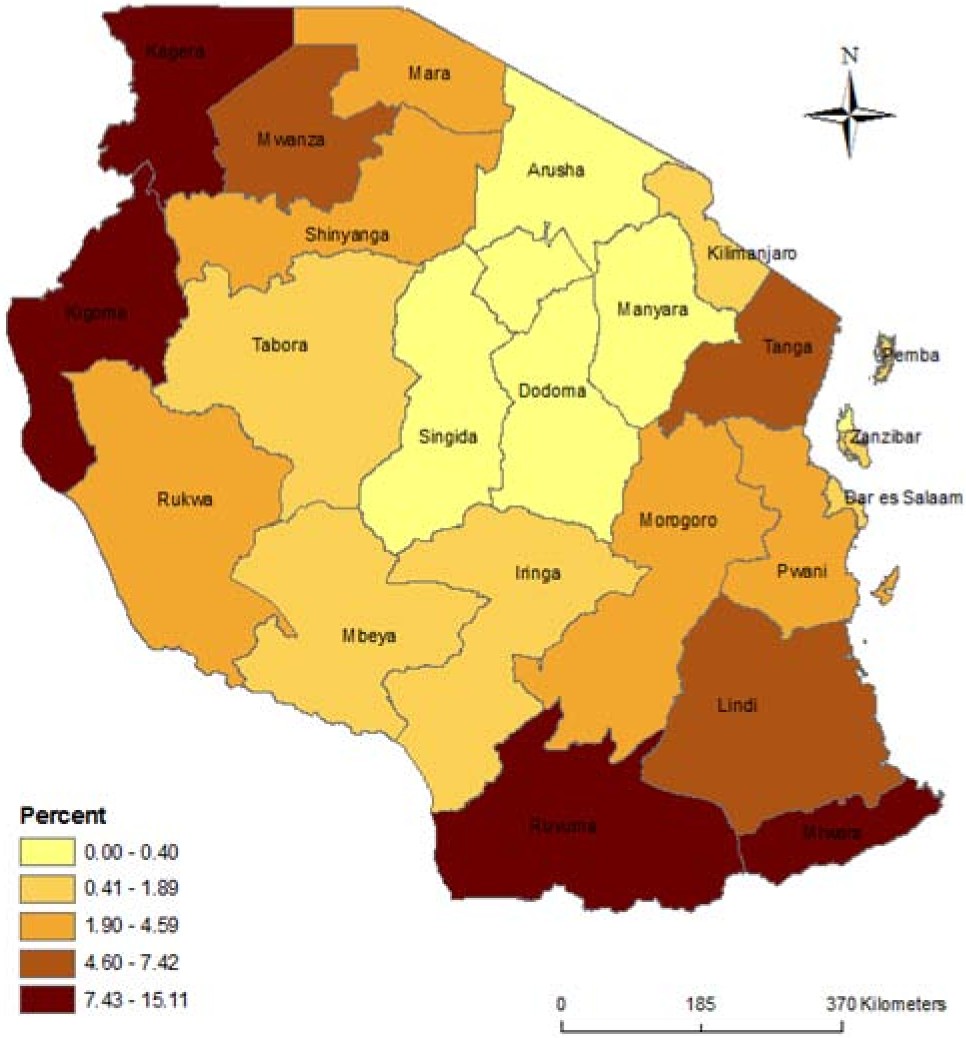
CHAPTER FOUR

RESULTS

4. 1 Spatial distribution analysis of cassava in Tanzania

4.1.1 Distribution of cassava farmers across the country

From the LSMS-ISA data, 2474 households out of the total survey sample of 3280 indicated that they are involved in at least one agricultural activity thereby qualifying as an agricultural household. This represents 75% of the total. From the 2474 household who indicated to be agricultural households, 741 of them reported having grown cassava within the period of data collection which was between 2008 and 2009 representing about 30% of the agricultural households and about 23% of the whole population. Those households which indicated having grown cassava during the survey period were distributed across the country in different proportions.



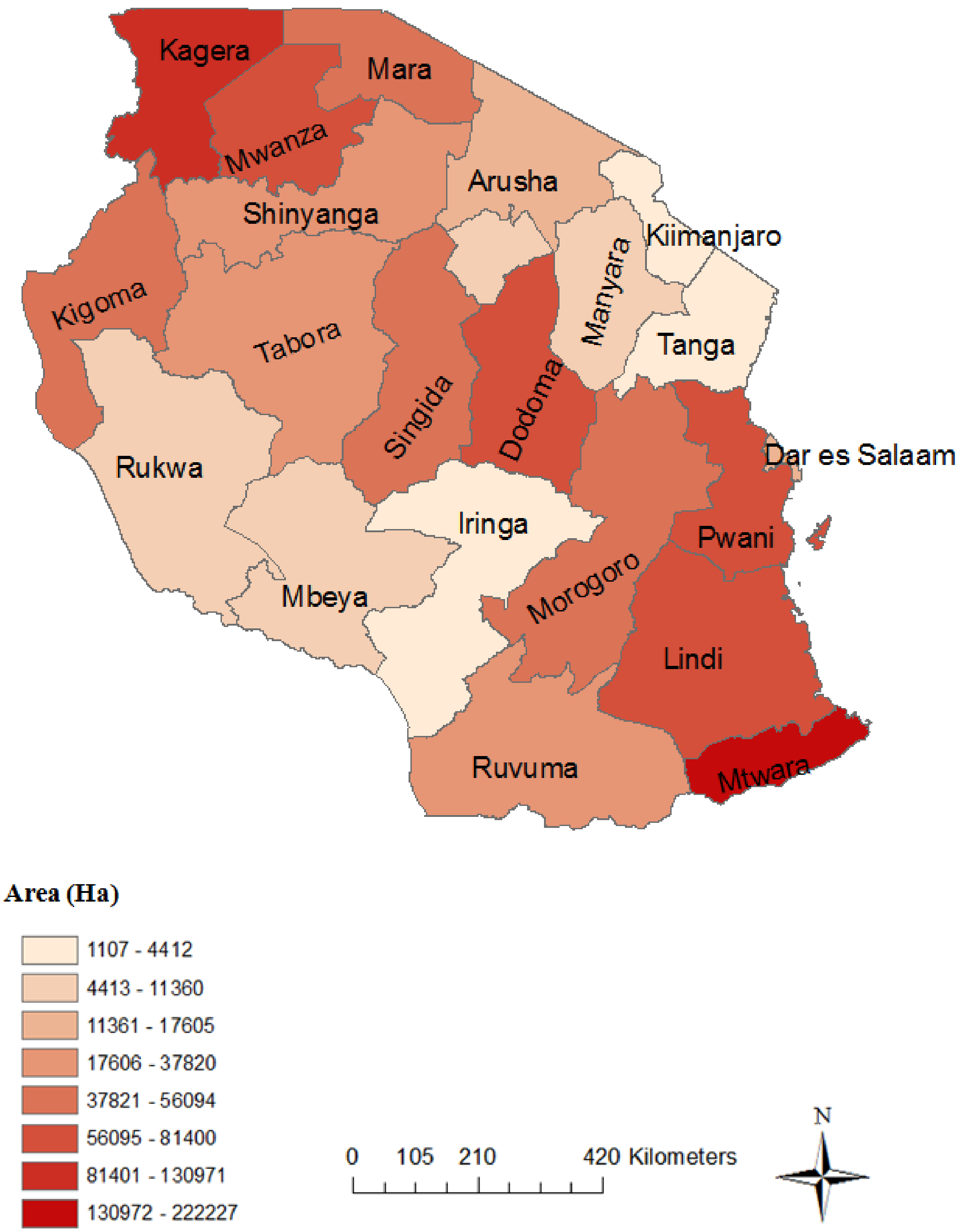
Data source: LSMS-ISA

Figure 4-1: Spatial distribution of proportions of farmers growing cassava per region in Tanzania for 2008-2009 season

Figure 4-1 shows distribution of cassava farmers across the country. In general, it has been observed that cassava farmers are more concentrated in the Lake Victoria zone, Tanga and southern regions of the country. The Southern zone includes Mtwara, Lindi and Ruvuma regions and the Lake Victoria zone includes Kagera, Kigoma and Mwanza regions. Each of these regions had about 7% to 15% of the cassava growing households in the country. Regions in the central part of the country (Tabora, Singida and Dodoma) indicated relatively much lower proportions of households growing cassava with at least less than 1% of the cassava farmers in the country in each of these regions.

4.1.2 Area under cassava per region

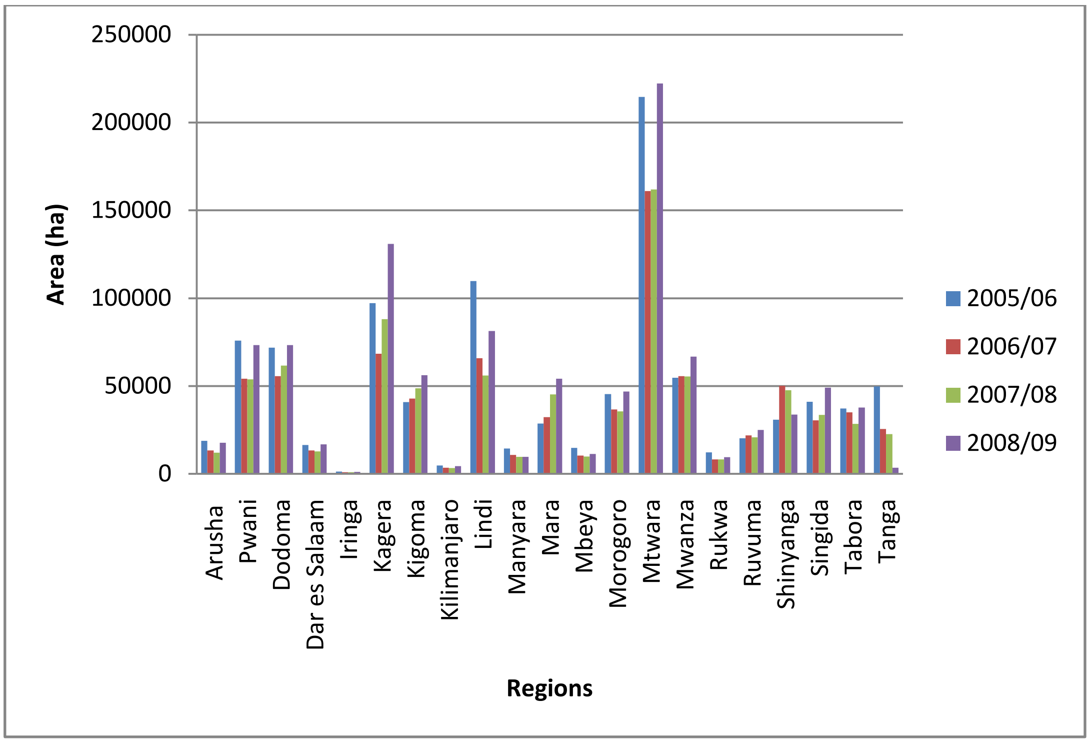
During the data collection (2008-2009), area under cassava indicates that Mtwara and Kagera regions had the highest proportion of area under cassava each recording above 81,400 hectares of land. Iringa, Tanga, Kilimanjaro and Mbeya regions were the least with each of them recording less than 4500 hectares of land grown to cassava. Figure 4-2 shows variations in area under cassava per region.



Data source: FEWSNET

Figure 4-2: Spatial distribution of area under cassava production in Tanzania in 2008-2009 growing season

Figure 4-3 depicts trends of area that is reserved for cassava per region for a period of four years starting from 2005/06 season through 2008/09. In all the years, Mtwara region has been the highest with at least area of about 150,000 hectares or more each year. Regions of Pwani, Dodoma, Kagera, Lindi, and Mwanza have had area of above 50,000 hectares grown to cassava in each of the years. Iringa, Kilimanjaro, Mbeya and Rukwa are among the regions with the least hectarage grown to cassava.

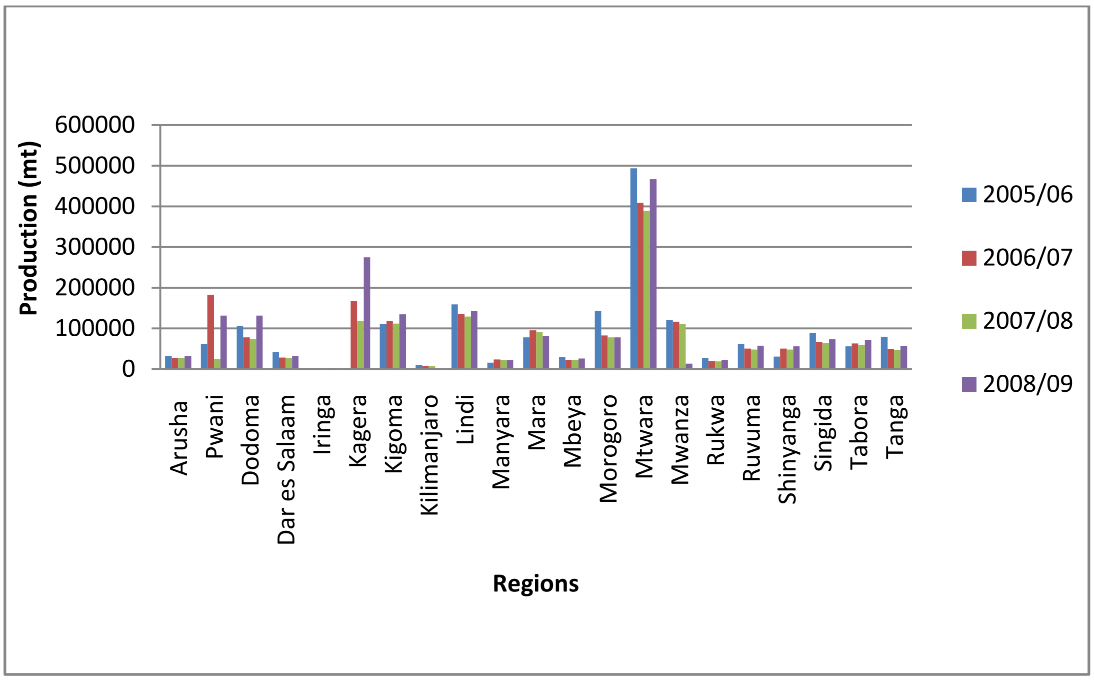


Data source: FEWSNET

Figure 4-3: Area under cassava in four growing seasons (2005-2009)

4.1.3 Cassava yield and production trends

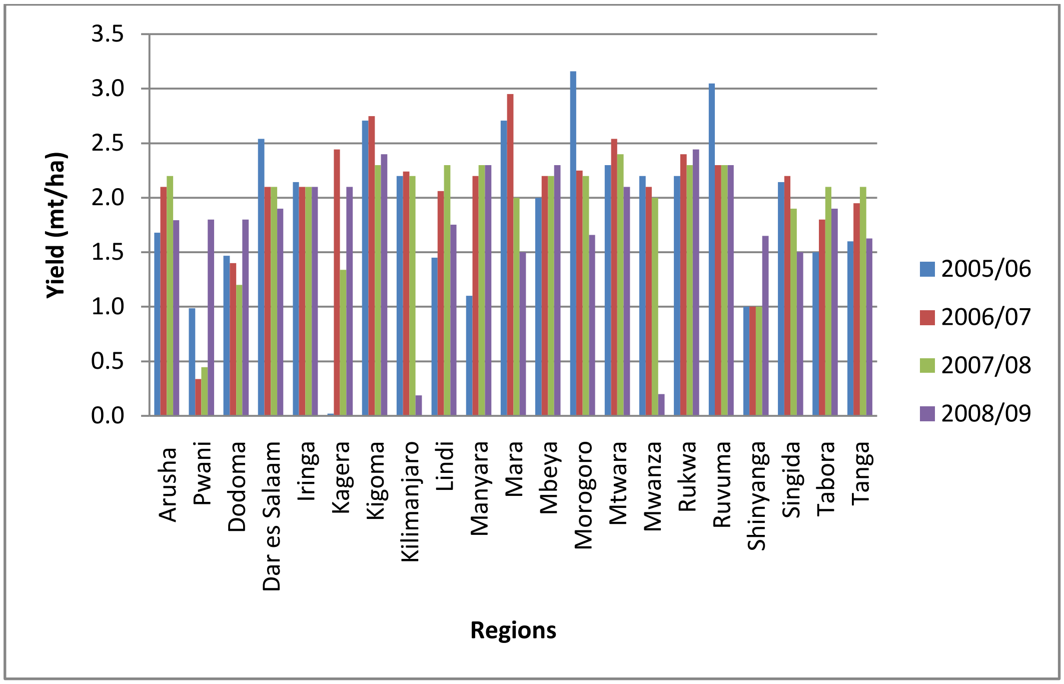
The amount of cassava produced in different regions in the country varies. Figure 4-4 shows cassava production trends in a four year period between 2005/06 and 2008/09. In all the years, Mtwara recorded production of about 400,000 metric tonnes of cassava consistently far more than the other regions. Regions of Kagera, Lindi and Mwanza had also recorded higher production of about 100,000 of cassava; however the trend was not very consistent. Iringa, Kilimanjaro, Mbeya and Rukwa had recorded the least cassava production figures over the period.



Data source: FEWSNET

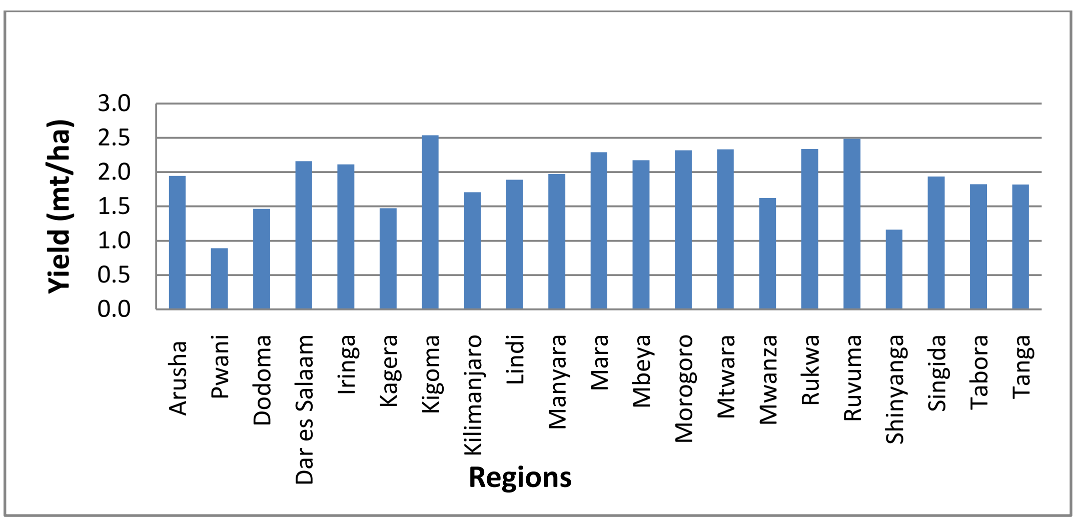
Figure 4-4: Cassava production in Tanzania for four growing seasons (2005-2009)

Figures 4-5 and 4-6 show cassava yields and average yield for the four seasons 2005/06, 2006/07, 2007/08 and 2008/09, respectively. Ruvuma and Kigoma regions recorded the highest yields over the period with average of about 2.5 mt/ha. Pwani, Shinyanga, Dodoma and Kagera recorded averages of less than 1.5 mt/ha.



Data source: FEWSNET

Figure 4-5: Cassava yields in Tanzanian regions for four growing seasons (2005-2009)



Data source: FEWSNET

Figure 4-6: Cassava average yield in Tanzania regions for the four growing seasons (2005-2009)

4.1.4 Spatial clustering of cassava farmers

Farmer preference of cassava production in specific regions of the country could be influenced by various factors such as food security, and culture. These factors may cause natural clusters of farmers in a specific enterprise like cassava. However, these clusters may exist but may not be significant enough to arouse attention and interventions. Identification of significant clusters could be important in policy decision making. Table 4-1 is ArcGIS output testing global autocorrelation and figure 4-7 and 4-8 are GeoDa output testing local autocorrelation of cassava farmers in the country.

Table 4-1: Results of global autocorrelation analysis of cassava producers

Global Moran's I Summary	
Moran's Index:	0.366731
Expected Index:	-0.040000
Variance:	0.012926
Z-Score:	3.577447
p-value:	0.000347

Distribution of cassava producers in the country indicates presence of global autocorrelation with a z-score of 3.577447, p-value of 0.000347, and Moran's Index of 0.366731. This test was against a null hypothesis of randomness of cassava producers across the country. With a p-value of 0.00347 which is less than 0.05, the null hypothesis is rejected implying that the clustering of cassava farmers in the country exists and distribution is not by random chance. LISA significance and cluster maps (figure 4-7 and 4-

8) (GeoDa output) helped to identify the actual areas where clustering of cassava farmers occur and the type of clusters.

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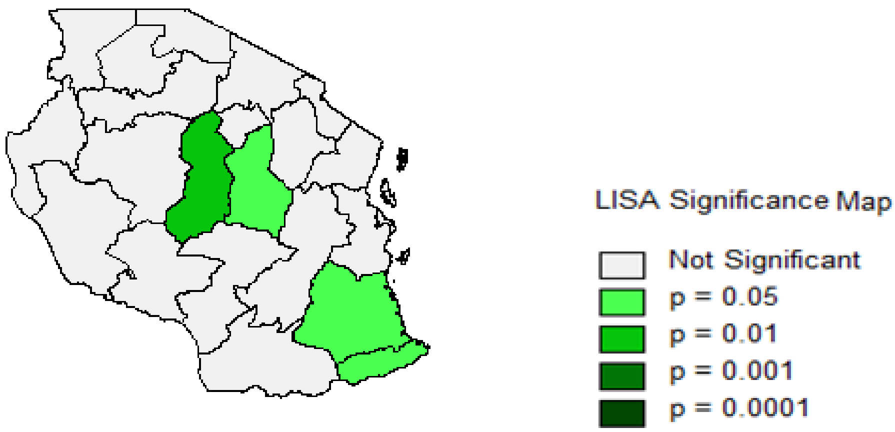


Figure 4-7: LISA significance map of cassava producers

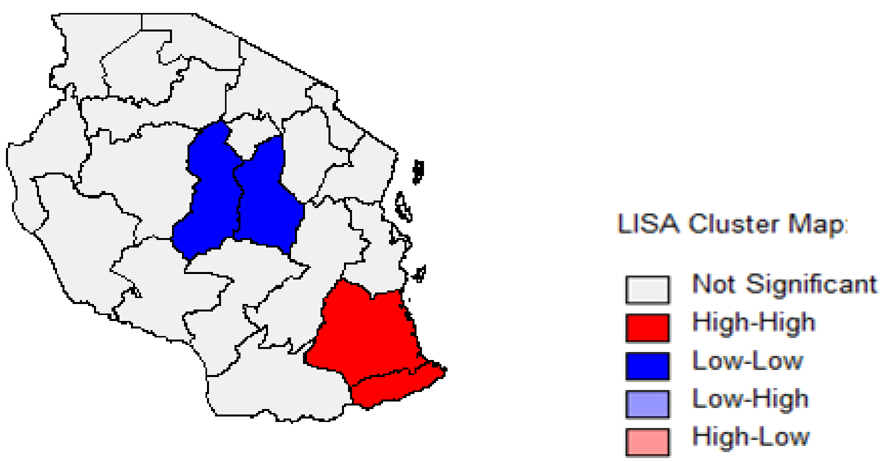
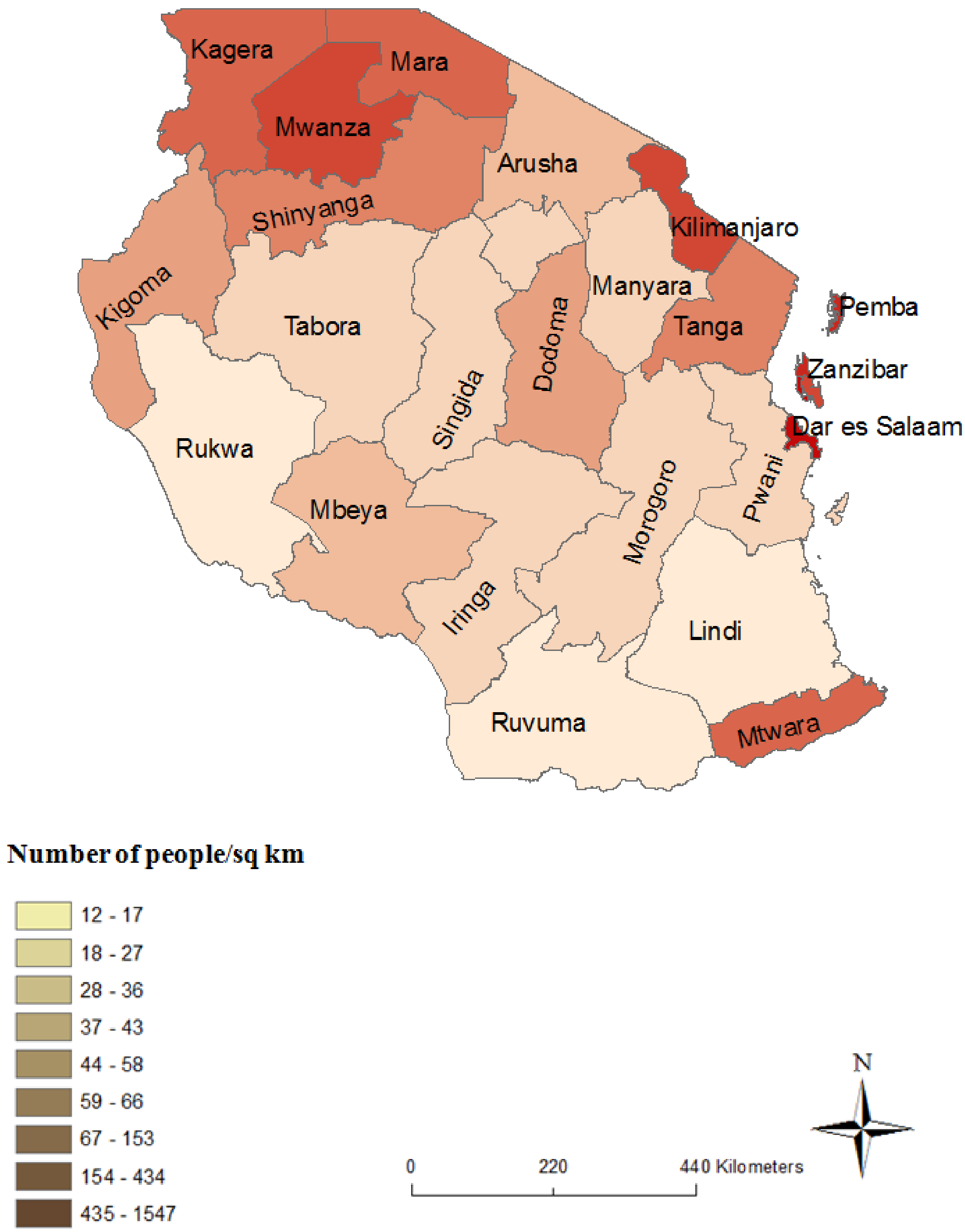


Figure 4-8: LISA cluster map of cassava producers.

LISA significance map of cassava producers has shown two clusters of producers (GeoDa output). The LISA cluster map indicates that one of the clusters is a cluster of low values (Singida and Dodoma) in the central regions of the country while the other in Mtwara and Lindi in the southern regions of the country is a cluster of high values. The regions of Singida and Dodoma forms a cluster of fewer number of cassava producers in the country while the regions of Mtwara and Lindi forms a cluster of higher number of producers in the country. Otherwise clustering is not significant in the rest of the regions in the country.

4.1.5 Population of Tanzania

Figure 4-9 is a population density map of Tanzania per region using the population census data of 2002 from the Tanzania Bureau of statistics. The northern regions of Kagera, Mara, Mwanza and southern region of Mtwara had higher population densities (above 59 people per square kilometre) as compared to central regions of Tabora, Singida, Morogoro, Iringa, Mbeya and Pwani with less than 27 people per square kilometre. Lindi, Rukwa and Ruvuma are the regions with least population densities of less than 17 people per square kilometre. Dar es Salaam is the region with highest population of about 435- 1547 people per square kilometre.



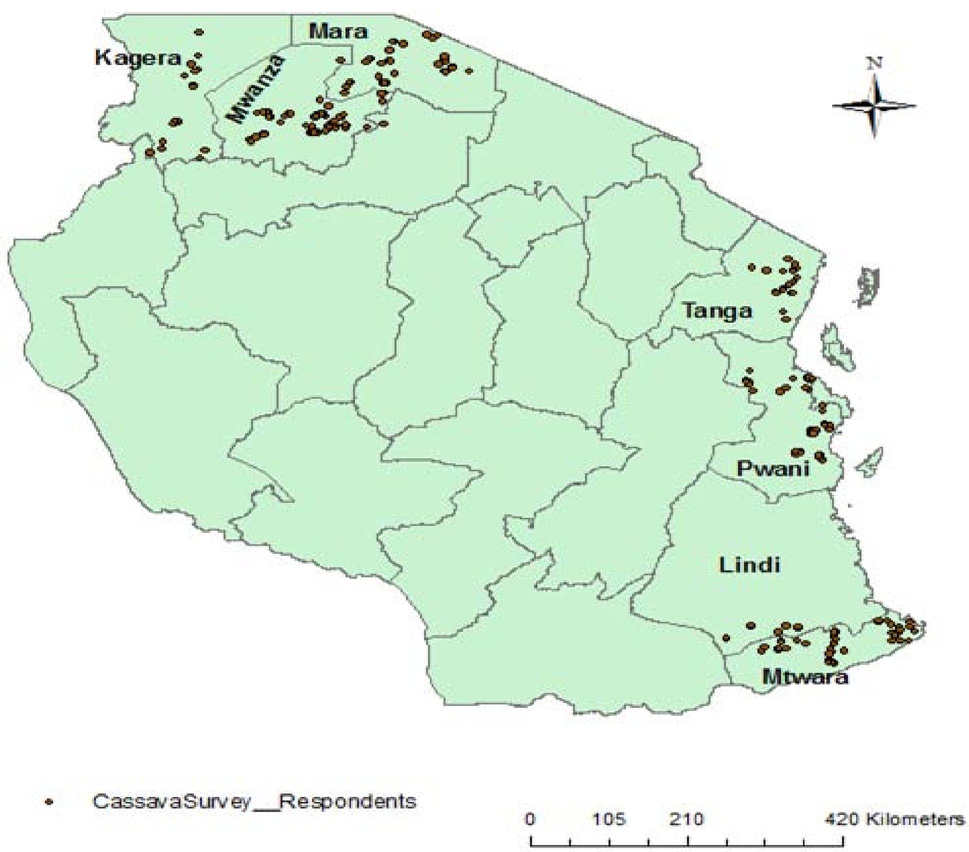
Data source: Tanzanian National Bureau of Statistics

Figure 4-9: Spatial distribution of population in Tanzania as of 2002

4.2 Spatial patterns of cassava production in Tanzania

4.2.1 Spatial clustering of production

Using cassava yield data, hot spot analysis was conducted in ArcGIS. Figure 4-10 shows spatial distribution of respondents who were involved in the survey in the seven regions of Kagera, Mara, Mwanza, Tanga, Pwani, Lindi and Mtwara. A total of 1385 respondents were involved from these regions as follows: 92 from Kagera, 55 from Lindi, 228 from Mtwara, 297 from Mwanaza, 311 from Pwani and 122 from Tanga.



Data source: GLCI

Figure 4-10: Spatial distribution of respondents for cassava yield survey.

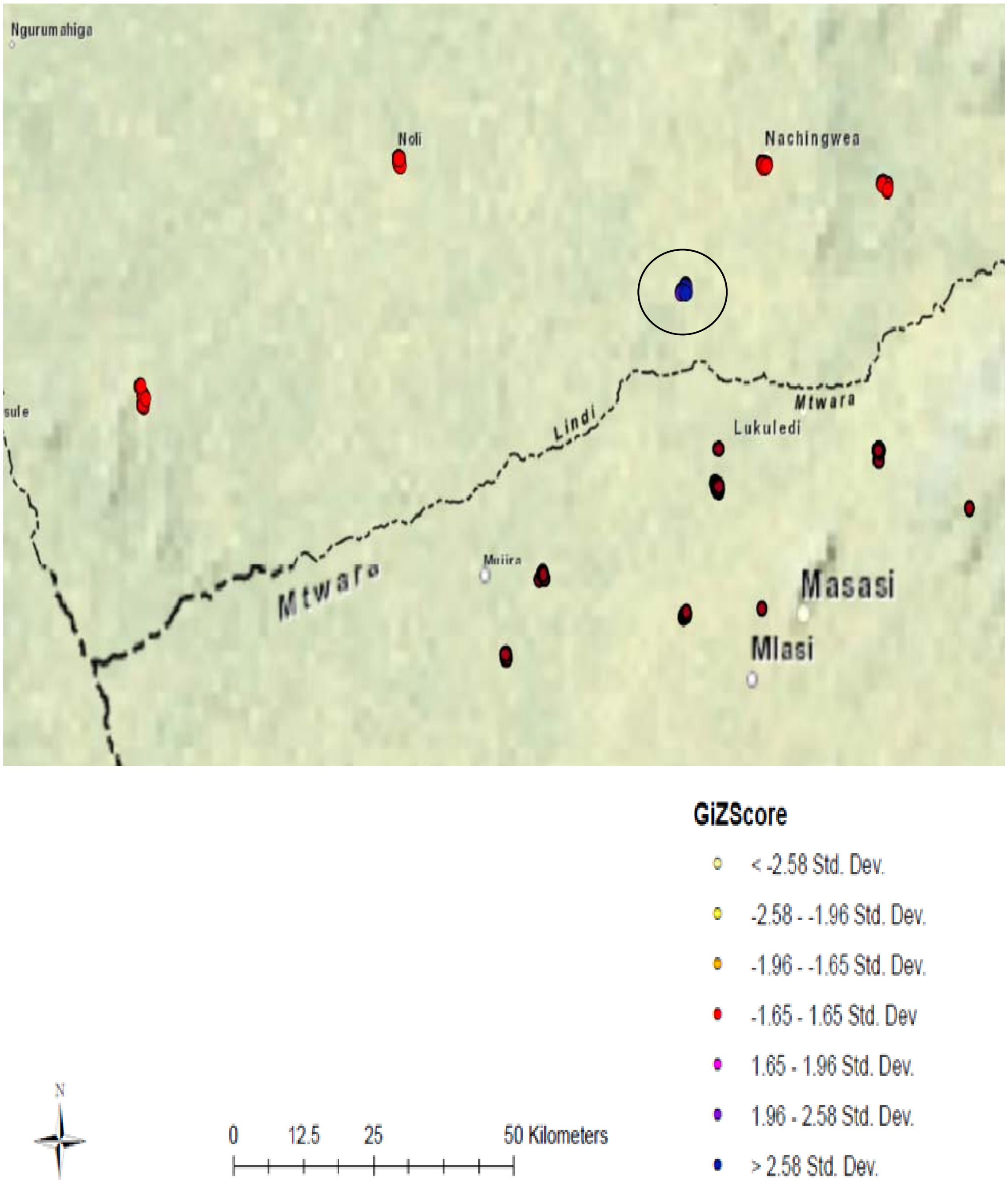


Figure 4-11: Cassava yield hotspot map for Lindi region in 2008-2009 season

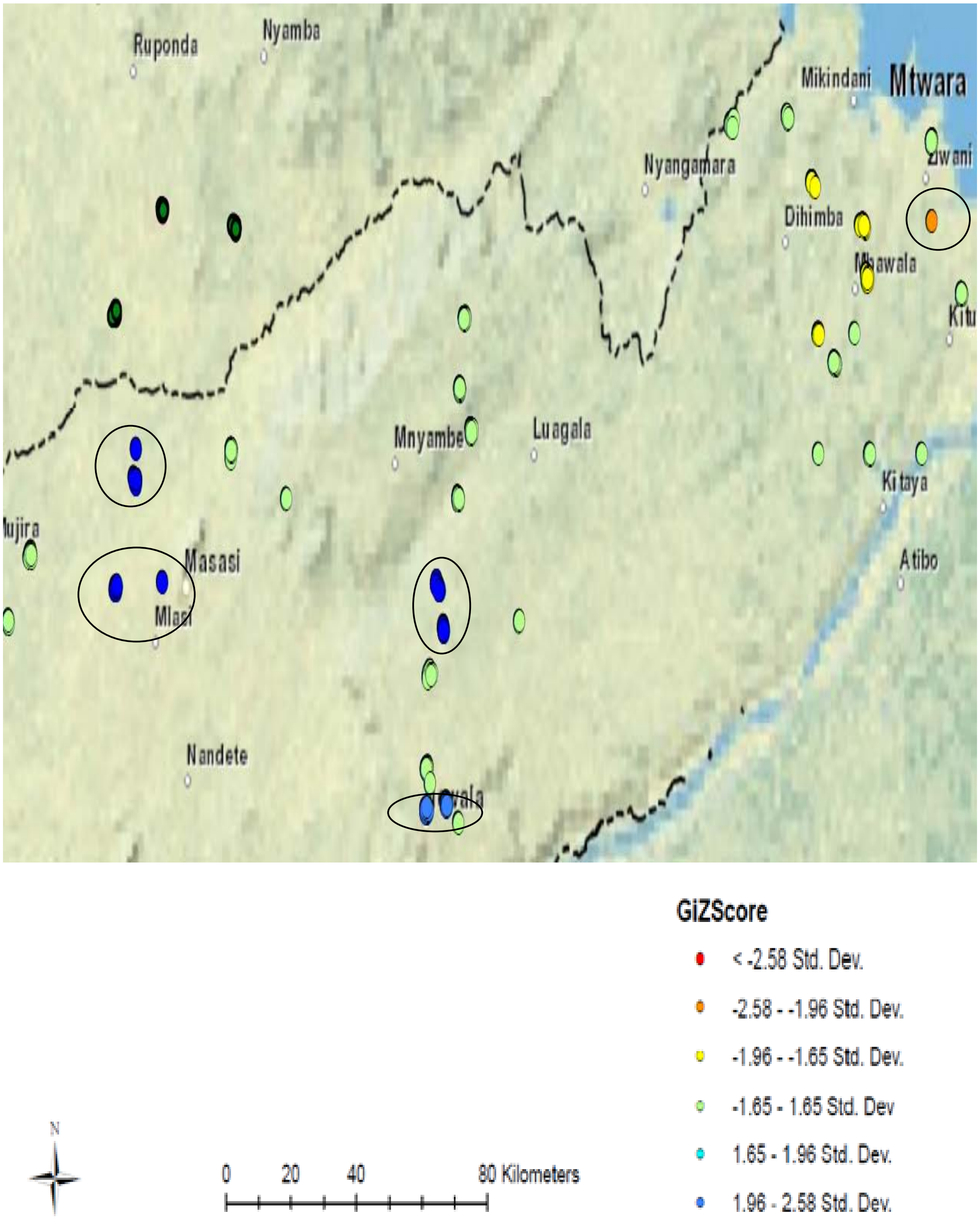


Figure 4-12: Cassava yield hotspot map for Mtwara region in 2008-2009 season

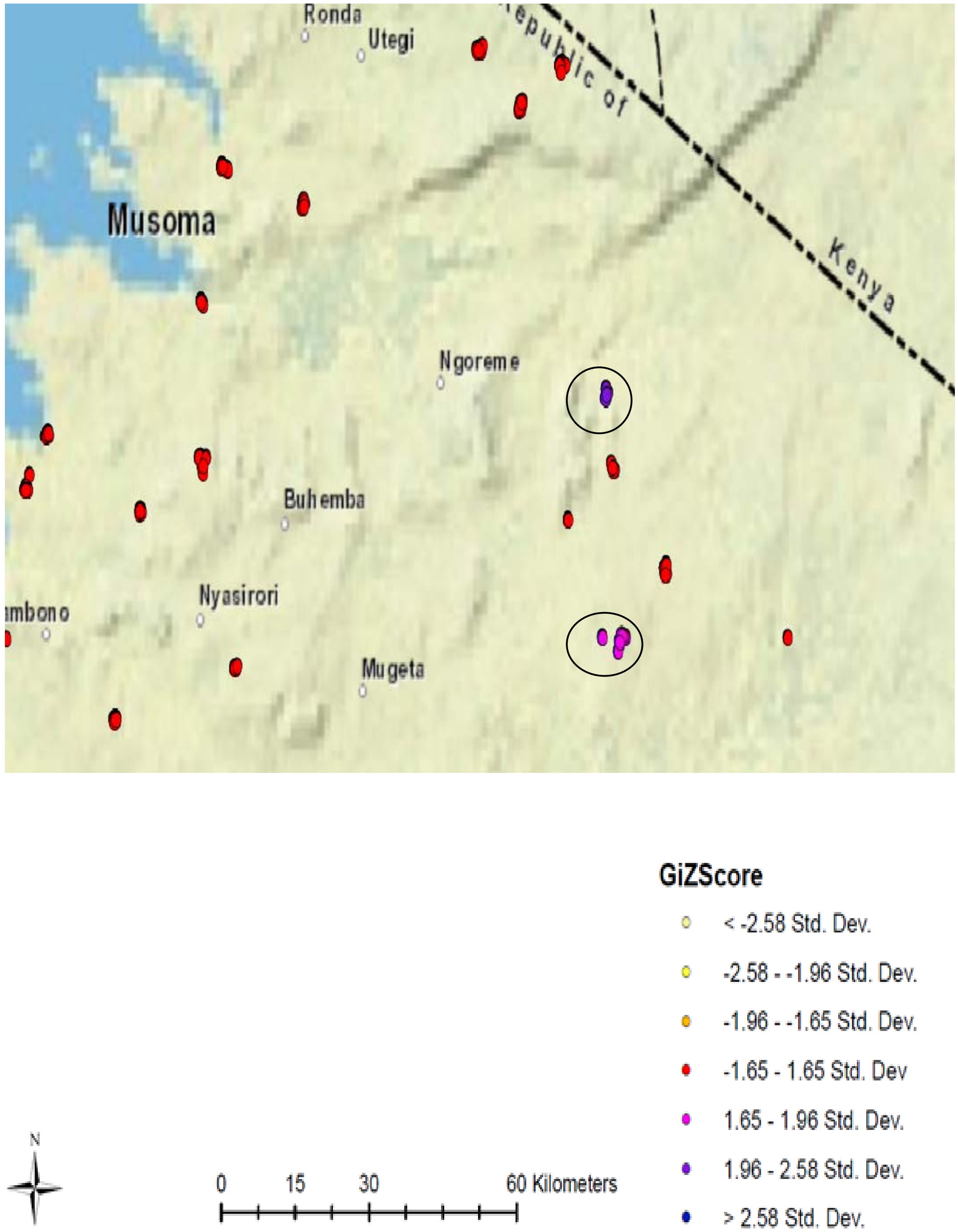


Figure 4-13: Cassava yield hotspot map for Mara region in 2008-2009 season

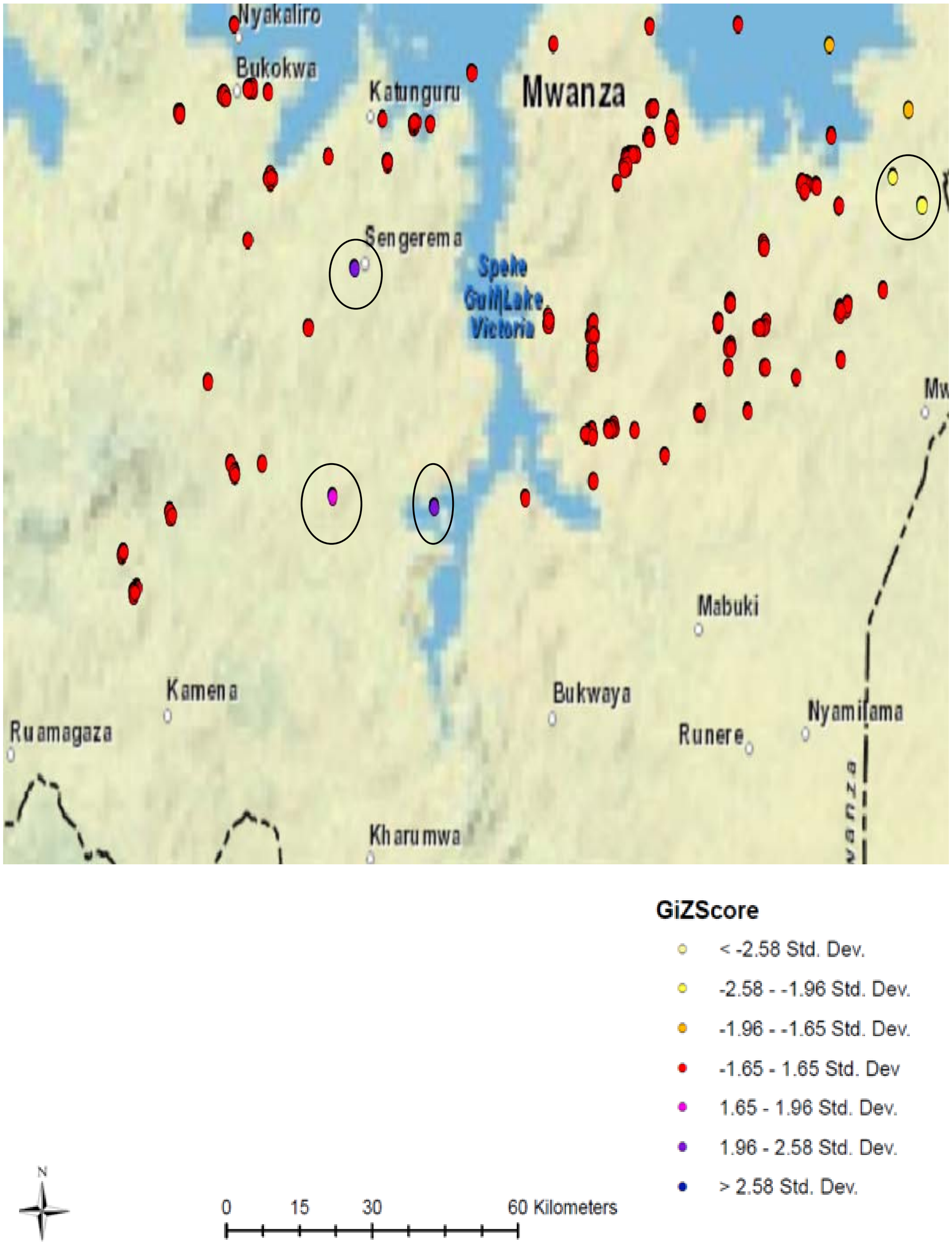


Figure 4-14: Cassava yield hotspot map for Mwanza region in 2008-2009 season

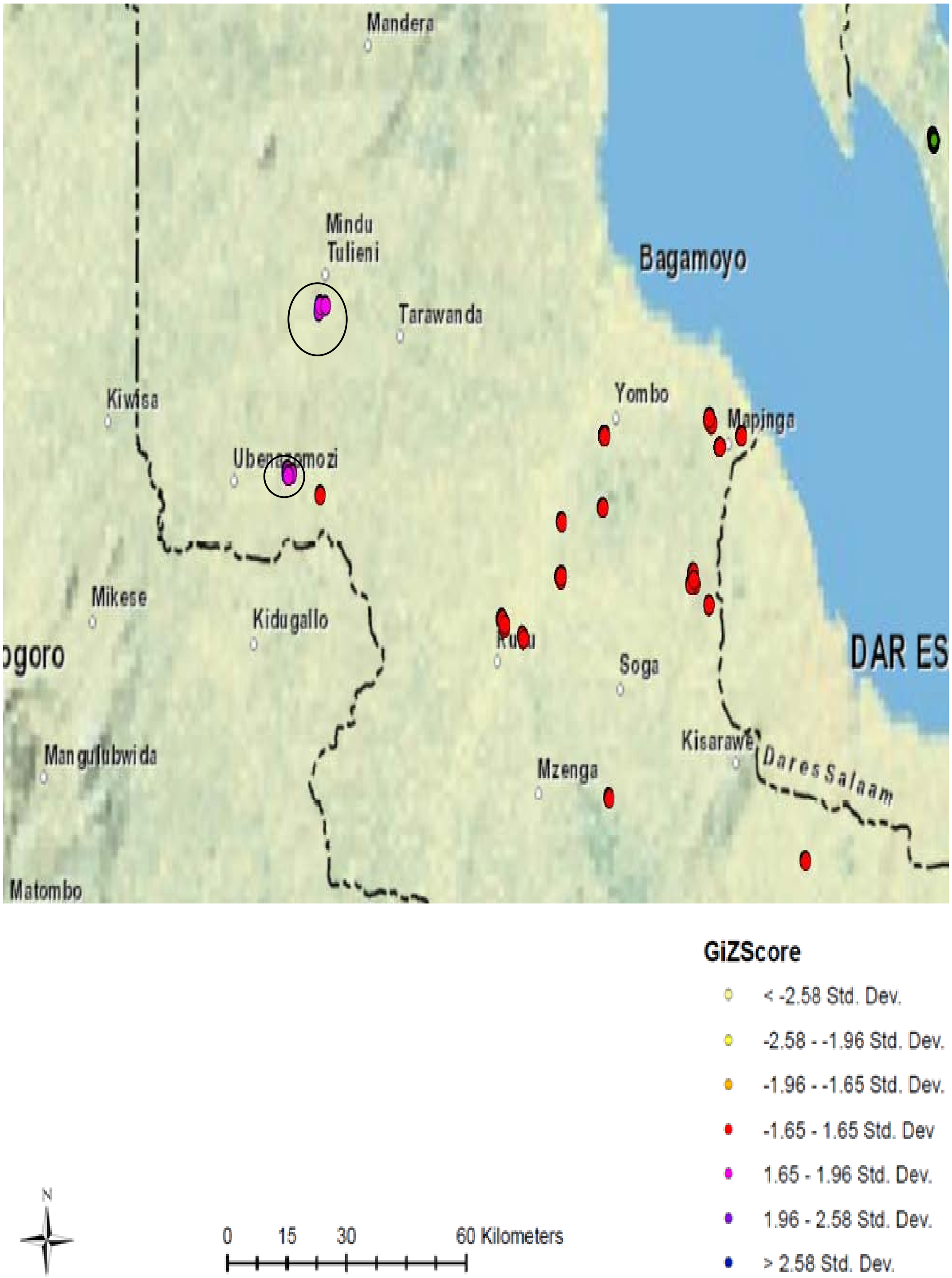


Figure 4-15: Cassava yield hotspot map for Pwani region in 2008-2009 season

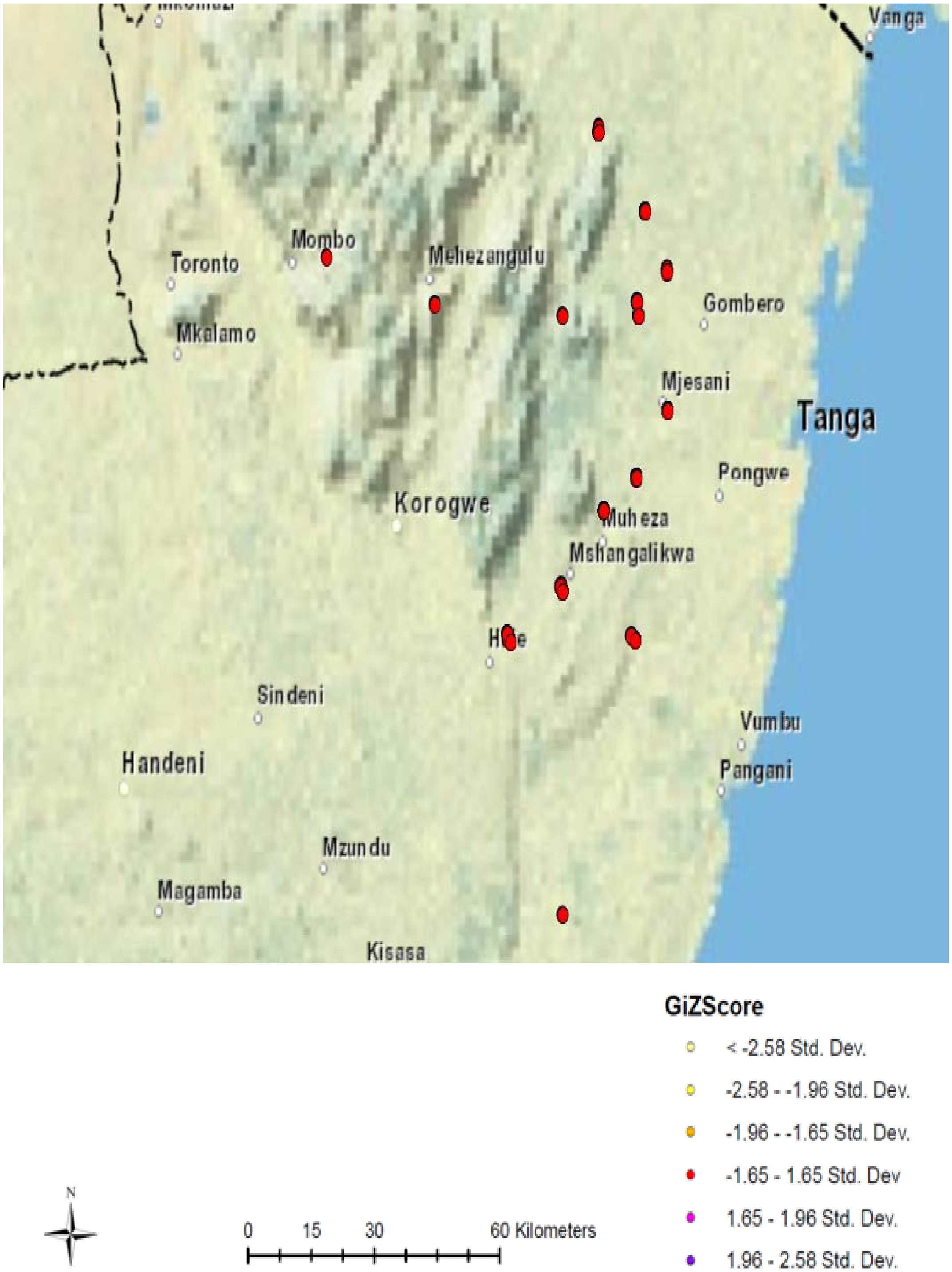


Figure 4-16: Cassava yield hotspot map for Tanga region in 2008-2009 season

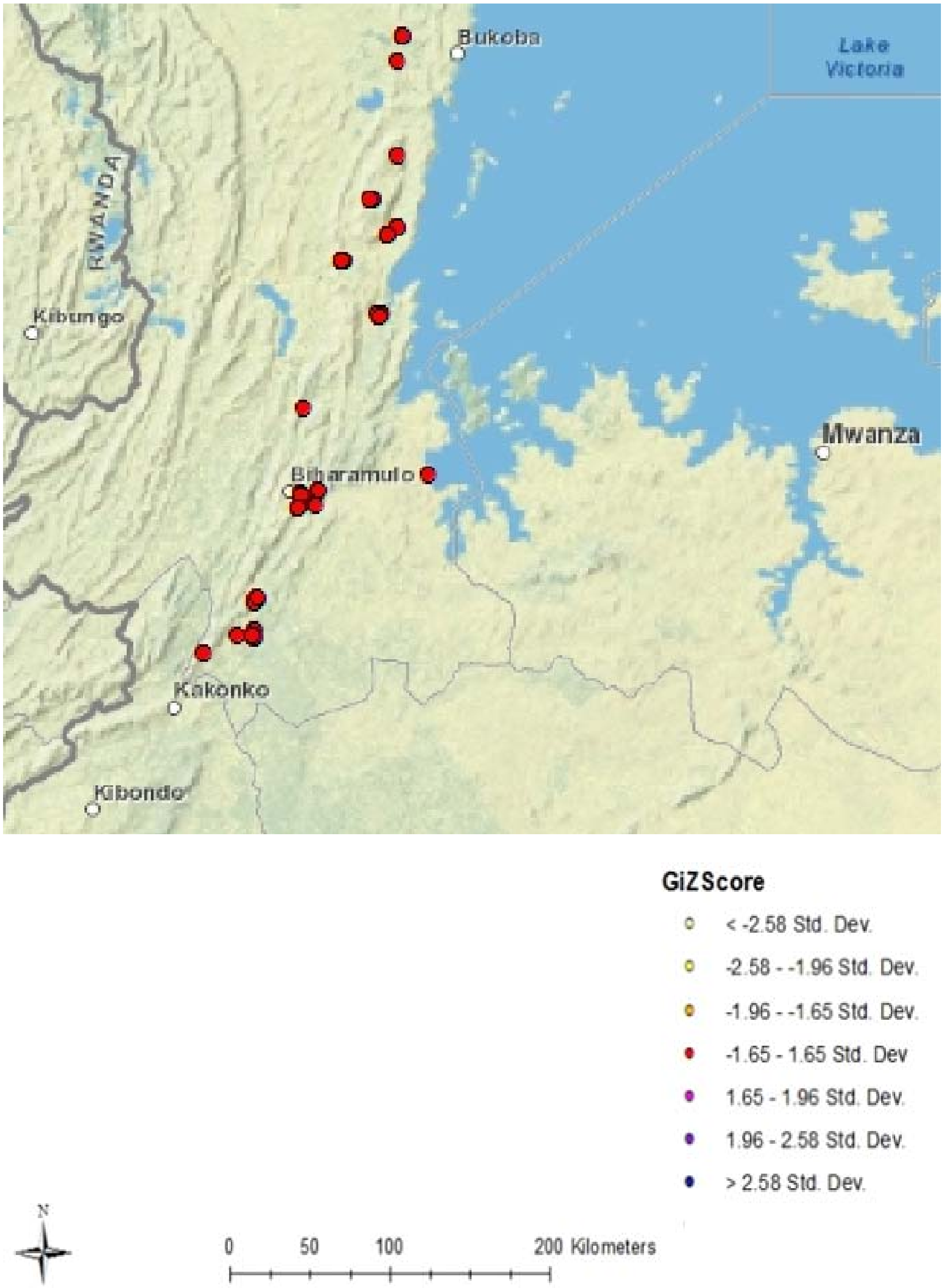


Figure 4-17: Cassava yield hotspot map for Kagera region in 2008-2009 season

Figures 4-11, 4-12, 4-13, 4-14, 4-15, 4-16 and 4-17 are outputs from ArcGIS for hot spot analysis. The figures have been presented per region to ease presentation (scaling the map) and for comparison. In each of the regions, at least one hot spot or cold spot has been identified except for Tanga and Kagera regions where there is none implying that any existence of high or low value of cassava yields in these regions is merely as a result of random chance. In the rest of the regions presented above, at least one hot spot was identified and marked by a circle.

Hot spot locations

In Lindi, one hot spot was identified near the region boarder with Mtwara north of Masasi district. In Mtwara, several hot spots with different levels of significance were identified and circled. The most notable ones are around Masasi district and some in the south east of Masasi district. In Mara, two hot spots were highlighted in the central part of the region north of a place called Igomo and east of Ngoreme. In Mwanza, three hot spots were identified in the central part of the region. One is at Sengerema and others are south of Sengerema. In Pwani, two hot spots were identified at Ubenazomozi and close to Tulieni.

Cold spots locations

From figures (4-11, 4-12, 4-13, 4-14, 4-15, 4-16 and 4-17) presented above, only two regions have produced significant cold spots. There is a cold spot in the north eastern part of Mwanza region near Lake Victoria. The second cold spot with a significant Z-score (1.96) has been identified in Mtwara region near the Indian Ocean cost and the rest within the region are less significant.

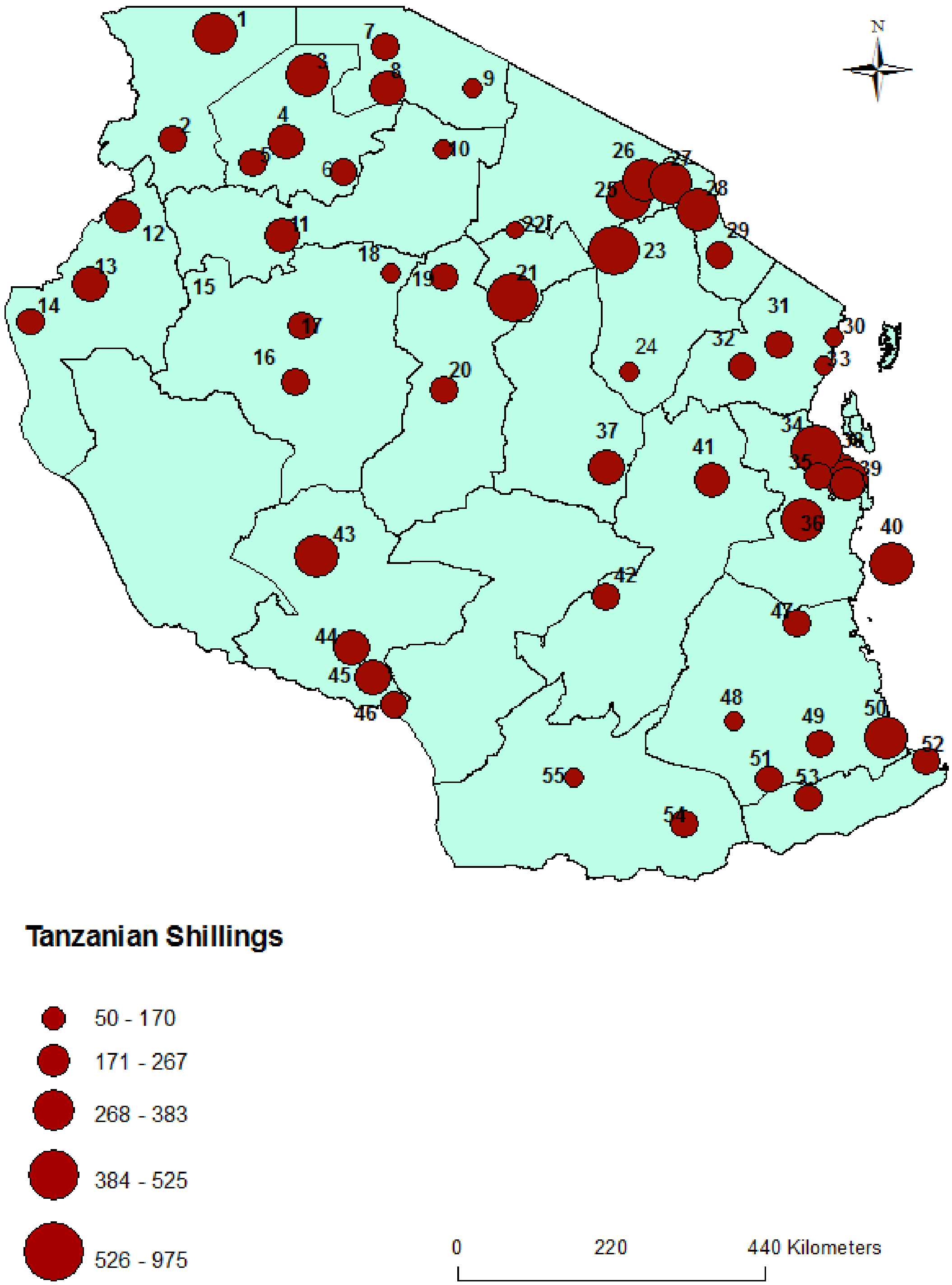
Table 4-2: Hot spot analysis summary

Region	No. of hot spots	No. of cold spots	Z-score
Lindi	1	0	> 1.96
Mtwara	4	1	>1.96
Mara	2	0	>1.96
Mwaza	3	1	>1.96
Pwani	2	0	>1.96
Tanga	0	0	>1.96
Kagera	0	0	>1.96

4.3 Spatial relationships in cassava prices

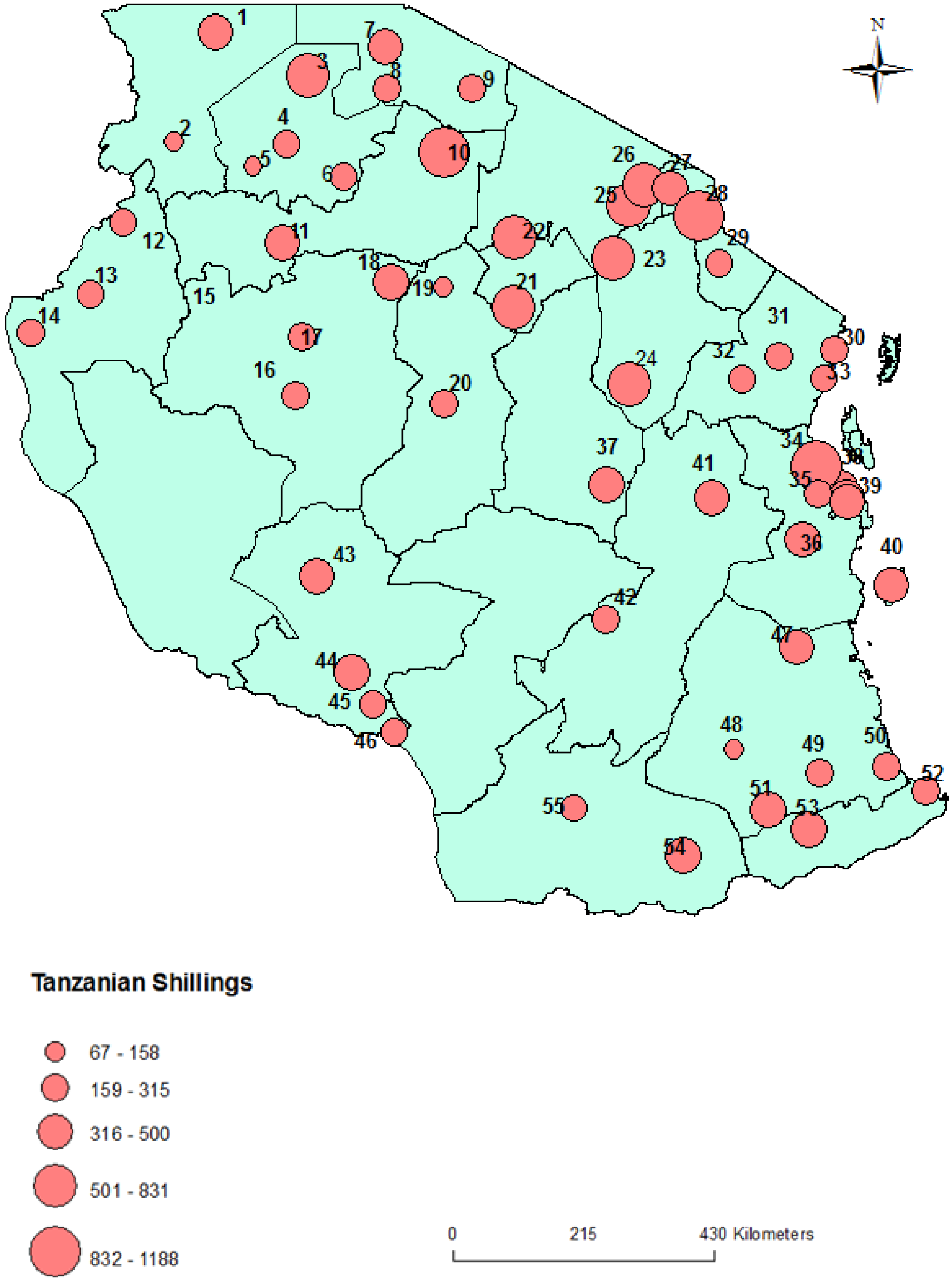
4.3.1 Cassava prices in various markets across the country

Cassava prices in various markets of the country varied from one market to another and in different seasons. Annual average prices were mapped and tested for autocorrelation. The data was collected from 55 district markets (Figure 4-18 and 4-19).



Data sources: Ministry of industries and trade Tanzania

Figure 4-18: Average cassava prices for 2007 season in various markets in Tanzania



Data sources: Ministry of industries and trade Tanzania

Figure 4-19: Average cassava prices for 2008 season in various markets in Tanzania

Figure 4-18 and 4-19 shows locations of the markets where cassava price data was collected for 2007 and 2008. The varying size of the solid circles for each market indicates cassava price ranges in the markets across the country.

Testing autocorrelation for 2007 price data

Table 4-3: Results of global autocorrelation analysis of cassava prices for 2007

Global Moran's I Summary	
Moran's Index:	0.210572
Expected Index:	-0.014286
Variance:	0.005508
Z-Score:	3.029750
p-value:	0.002448

Table 4-2 is an output from ArcGIS on global autocorrelation of cassava prices. Average cassava prices for the year 2007 indicated a strong positive autocorrelation with a z-score of 3.03, p-value 0.002448 which is less than 0.05 and the Moran's Index is 0.2106. This test was against a null hypothesis of randomness amongst cassava prices across the country. The null hypothesis is therefore rejected and this implies that cassava prices from different markets in the country were significantly correlated.

Testing autocorrelation for 2008 data

Using 2008 cassava price data, the autocorrelation test was repeated in ArcGIS, the results indicated strong autocorrelation as well with a z-score of 2.882, a p-value of 0.003955 and the Moran's Index was 0.2100. The results are presented in Table 4-3 which is ArcGIS output.

Table 4-4: Results of global autocorrelation analysis of cassava prices for 2008

Global Moran's I Summary	
Moran's Index:	0.210048
Expected Index:	-0.016393
Variance:	0.006175
Z-Score:	2.881714
p-value:	0.003955

Relationship between cassava prices and production

Correlation analysis to establish existence of linear relationship between cassava production and cassava price trends in the regions across Tanzania was conducted using data for 2007 and 2008. Figures 4-23 and 4-24 are output from SPSS.

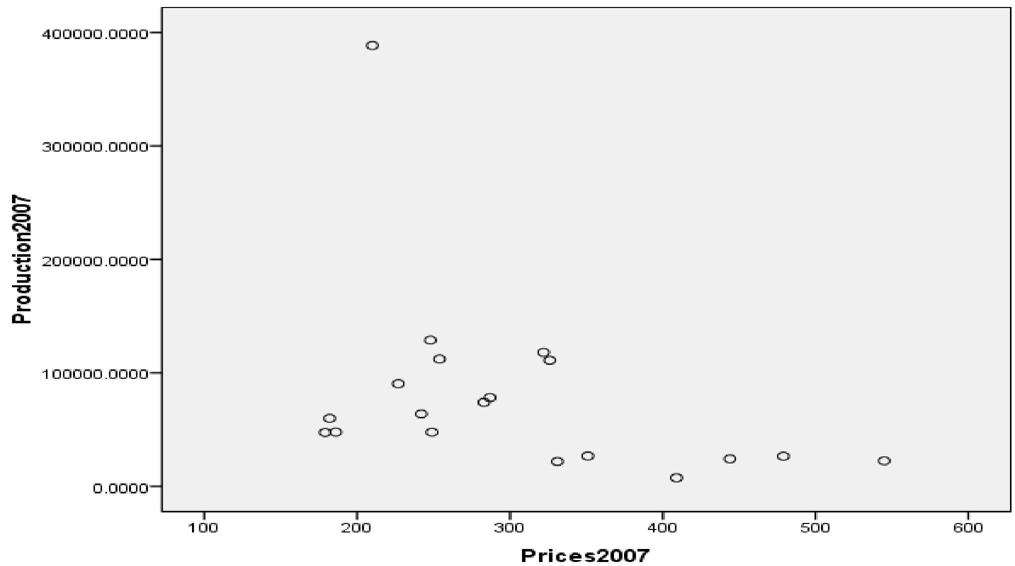


Figure 4-20: Scatter plot for cassava production and prices in 2007

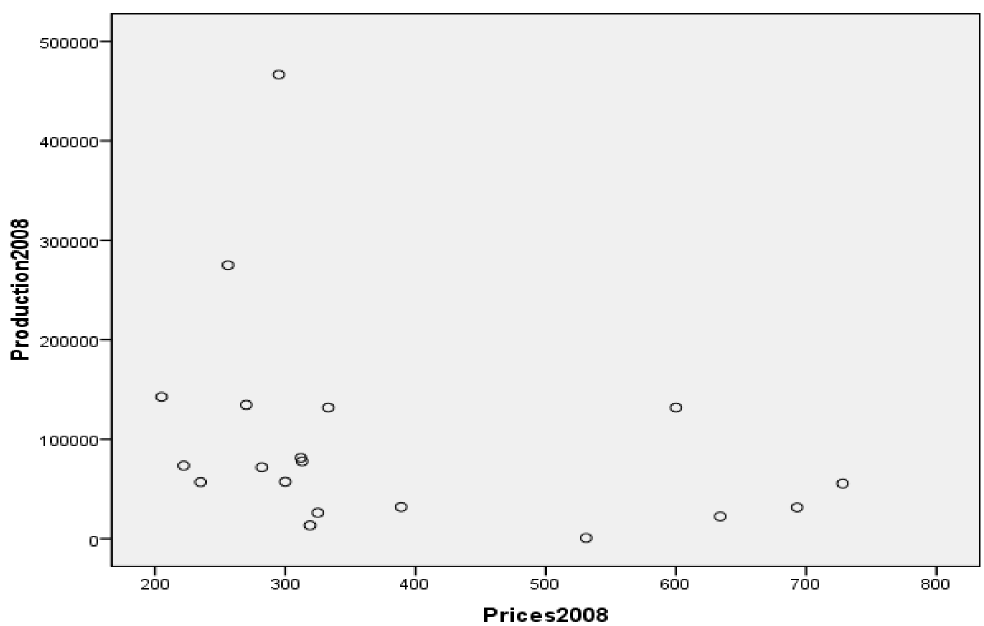


Figure 4-21: Scatter plot for cassava production and prices in 2008

The scatter plot indicates some linear relationship and further statistical analysis indicated weaker negative correlation between cassava production and cassava prices with $r = -0.397$ for 2007 season and $r = -0.310$ for 2008 season (appendix 6 and 7). This is against critical values of -0.444 and 0.444 for $n=20$ and $df=18$.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 Discussion

5.1.1 Distribution of cassava production in Tanzania

Cassava distribution in Tanzania has been analysed and the results indicated that there are variations from one region to another. The proportions of farmers growing cassava, area grown to cassava, cassava yield trends and cassava production figures varied across the country. The observed trend is generally showing a spatially varying pattern of cassava growing zones. With reference to figures 4-1, 4-2, 4-3, 4-4, 4-5 and 4-6 in the results section, it has been observed that the Lake Victoria zone (Kagera, Mwanza and Mara), southern zone (Mtwara Ruvuma and Lindi) and Tanga had the majority (ranging from 7% to 15 % for each of these regions) of the cassava farmers in the country; furthermore, the results also indicate that these very regions except Tanga are amongst the regions that have a bigger proportion of land reserved for cassava production with Mtwara alone registering over 400,000 hectares annually; and finally the same regions have higher cassava production figures than the rest of the regions. These observations are generally consistent with what Mkamilo and Jeremiah 2005 reported. They indicated that the Indian coastal strip (this includes Mtwara, Lindi, Pwani and Tanga) accounts for 48.8%, the Lake zone accounts for 23.7% and the areas around Lake Nyasa (Ruvuma) accounts for 7.9% of total cassava produced in Tanzania. However, some studies reported that the southern zone accounts for 32% of total cassava production in Tanzania, the eastern coast zone accounts for 18%, the Lake Victoria zone accounts for 13% and the southern highlands accounts for

9% with the central and western zone accounting for the rest (Mtunda, 2009). Food security and income generation are the main reasons that make most farmers in these areas to opt for cassava. Mtunda *et al.*, (2002), cited by Mkamilo and Jeremiah 2005, reported that the reason a larger proportion of farmers grow cassava in these regions is because cassava is a major food crop such that it is regarded as either first or second staple food crop.

5.1.2 Clusters of cassava growers

Spatial autocorrelation analysis indicated presence of autocorrelation at global level as shown in Table 4-1. Clustering at local level (Local Indicators of Spatial Autocorrelation) was conducted and indicated only two significant clusters. The significance map clearly indicated presence of two clusters that are significant at 95% confidence level and these are (1) Lindi and Mtwara (2) Singida and Dodoma. The cluster map indicates that the first cluster (Lindi and Mtwara) is a cluster of high-high and the second cluster (Singida and Dodoma) is a cluster of low-low. This implies that in the other regions existence of high or low proportions of farmers could only be because of random chance. Occurrence of a cluster of cassava famers in the southern zone of the country (regions of Mtwara, Lindi and surrounding regions) showed importance of this crop in this zone.

5.1.3 Population by region

Examining spatial distribution of the population across the country was important to compare the trend with cassava distribution in the country as it is already argued that cassava is a food security crop and therefore with growing population there could be a need for more food supply. Map output indicated that some regions with high presence of cassava has high population densities. Examples are Mtwara, Kagera and Mara with a population densities ranging from 59-66 people per square kilometre. With exceptions of Dar es Salaam and Mwanza which are big cities, the three regions above have coincidentally recorded higher population densities as compared to the central non-cassava regions which have low population densities. However, this observation may require further research to ascertain correlation between growing population and increasing cassava production.

5.1.4 Spatial pattern of cassava yield

Analysing the distribution of cassava farmers is important in that it helped to locate the regions where the actual cassava production is taking place. Within these identified regions cassava production potential could not be uniform. This then lead to another level of analysis to identify actual positions with more production potential also called hot spots. A total of 12 significant hot spots with Z-scores of above 1.96 were identified in Lindi (Fig. 4-11), Mtwara (Fig. 4-12), Mara (Fig. 4-13), Mwanza (Fig. 4-14), and Pwani (Fig. 4-15). Mtwara produced the highest number of hot spots (4) followed by Mwanza (3). The analysis also identified a cold spot in Mtwara and Mwanza regions (Figures 4-12 and 4-14) and neither a hot spot nor a cold spot was identified in the regions of Tanga and Kagera (Figures 4-16 and 4-17). In this study the hot spots implied areas with more concentration of high cassava yields.

The observed high yields in hot spots could be attributed to many factors including farmers' efforts on the crop since it is said to be culturally a staple crop in area. However this study did not establish the actual reasons to explain the occurrence of hot or cold spots in the marked areas.

5.1.5 Spatial relationships in cassava market prices and implications

Availability and accessibility of a commodity on the market is a key determinant for both food security and business development. Therefore understanding behaviour of a commodity price on the market i.e. whether they are stable or fluctuates regularly helps to give an insight into food security situation in an area (Shin, 2010) as well as business prospects. Naturally commodity prices in nearby markets do influence each other with commodities moving from where there is surplus supply to where there are deficits thereby reflecting high prices where there is commodity deficit and subsequently balancing commodity availability. Shin (2010), pointed out that the commodity movement situation as described above is a theoretical situation and therefore stressed that considerations should be to check whether autocorrelation of market is constant, or consistent across the region. In this study, autocorrelation of market prices has been tested for two years and in each year autocorrelation has been significant. The significance in the results implies stability of market prices within neighbouring markets and could therefore mean consistent supply of the commodity.

Correlation analysis to examine if there is linear relationship between cassava prices and cassava production showed that there is an insignificant negative relationship. The negative correlation means that with increasing cassava production, the cassava prices decreases. This follows the law of demand and supply. Increasing production could mean increasing supply of cassava on the market and prices could go down as most farmers are desperate to sell their produce since fresh cassava is a short life crop. The insignificance in the correlation implies that apart from cassava prices, there are also other factors that influence cassava production in these regions. Further studies could be instituted to establish them.

5.2 Conclusion and recommendations

The analysis of cassava distribution in Tanzania has shown that the crop is significantly concentrated in specific zones of the country. These zones are the southern zone, the Lake Victoria zone, and the Indian Ocean coast. The distribution was measured by analysing four factors and these are: proportion of cassava farmers per region; area grown to cassava in each region; cassava yield in each region and total cassava production in each region.

Based on the results of autocorrelation analysis on clustering of cassava farmers, except for the southern zone and the central regions of the country, cassava farmers are randomly distributed across the country. Mtwara, Lindi and surrounding areas were the ones where cassava production was so significant with each one accounting for about 15% of total cassava farmers in the country. Among other factors, traditional of the people in these areas (culture) could be attributed to intensified cassava production in these zones.

Hot spot analysis conducted to locate specific areas as areas of marked difference succeeded in identifying 12 hot spots in 5 regions out of the 7 regions that were found to have more cassava production potential. Mtwara accounts for about 33% and Mwanza 25% of the hot spots identified. The randomness in the other two regions (Kagera and Tanga) could mean that within the region cassava yields are almost the same in all locations implying even distribution. The high yields observed in the identified hot spots could be attributed to effort that farmers put on cassava production as it is an important food crop and therefore these are areas that should be given attention in as far as cassava commercialisation is concerned.

For business sake, stability of cassava prices was analysed through spatial autocorrelation. This analysis was conducted in view of the importance of price as a major influencing factor in supply of a commodity on the market. The results indicated existence of significant autocorrelation of cassava prices across the country. This according to Shin (2010) is a positive phenomenon in business terms as it ensures consistent supply of the commodity on the market. Cassava business ventures established in these areas will be able to access the commodity and sustain. However consistent supply of the commodity may not mean adequate supply. Also amount supplied may vary from region to region depending on many other factors such as: total production in the region and food security situation.

Having established these interesting trends in cassava production and pricing in this study, promoting cassava production and processing makes sense especially in the regions where it has been seen to cluster spatially. The evidence is significant enough to justify establishment of business in these areas. Researchers need to conduct further spatial analysis that would include bio-phyisical and climatic data to explore more trends in cassava production. Also further studies need to be conducted to establish if other business factors are there in the cassava regions for investors to be encouraged to establish their businesses.

REFERENCES

Anselin, L. (1995). Local Indicators of Spatial Association-LISA. In: Geography Analysis vol. 27, No. 2. (April 1995). Ohio state university press.

Anselin, L. (1992). Spatial Data Analysis with GIS: An Introduction to Application in the Social Science. National centre for Geographic information and Analysis. University of California, Santa Barbara, CA 933106. Technical report 92-10

Anselin, L., Syabri., I., & Kho., Y. (2005). GeoDa: An introduction to spatial analysis. Spatial Analysis Laboratory. University of Illinois, Urbana-Champaign Urbana, IL 61810 USA.

Alves, A. A. C. (2002). Cassava Botany and Physiology. In: R. J. Hillocks, J.M. Thresh and A.C. Bellotti, (eds, 2002). CAB International 2002. Cassava: Biology, Production and Utilization (pp 67-89).

Balmann, A., Buchenrieder, G., and Glauben, T. (Eds). (2007). Spatial development of Hungary agriculture in the transition: The case of crop production. Discussion paper No.107. Hungary Acadamy of Sciences, Budapest, Hungary.

Cassava for food and energy security. (2008). Food and Agriculture Organization of the United Nations. Retrieved February 2, 2012, from http://www.fao.org/newsroom/en/news/2008/1000899/index.html

Dauda, T.O., Asiribo, O.E., Ojo, L.O., Adekeye, K.S. & Agbaje, G.A. (2010). Evaluation of Global and Local indicators of spatial autocorrelations in Kenaf in experimental plots in South western Nigeria. Journal of Agricultural Research 2010, 48(2), pp 239-252

Food and Agriculture Organization of the United Nations. (2008). FAOSTAT Cassava data. Retrieved February 1, 2012, from http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

Hintze, P. & Lakes, T. (2009). Geographically Refernced Data for social science. German Council of Social and Economic Data (RatSWD) working paper No. 125. International Institute of Tropical Agriculture. “Integrated Cassava Project”. Retrieved February 1, 2012, from http://www.cassavabiz.org/

Kothari, C.R. (Ed). (2004). Research Methodology: *Methods and Techniques*. 3rd ed Delhi: New Age International.

Lentz, J. (2009). Global and Local Statistics references.

Match maker Associates. (2012). Scoping study on value chain initiatives in Tanzania for Irish aid and DANIDA (April 2012 final report).

Match maker associates. (2007). Cassava value chain analysis. Studycommissioned by KILIMO Trust.

Mkamilo G. S., and Jeremiah S. C., 2005. Current status of cassava improvement programme inTanzania. In: African Crop Science Conference Proceedings Vol.7. pp 1311-1314. African Crop Science Society.

Minot, N. (2010). Staple Food Prices in Tanzania. Report prepared for COMESA policy seminar on “Variation in staple food prices: causes, consequences and policy options”. Maputo, Mozambique 25-26 June 2010 under the African Agriculture Marketing project (AAMP).

Mpagilile, J.J., Ishengoma R. & Gillah P. (2008). Agribusiness Innovation in six African Countries: The Tanzanian experience. Report prepared for the World Bank Institute.

Mtunda, K.J. (2009). Breeding, evaluation and selection of cassava high starch content and yield in Tanzania. Unpublished doctoral thesis submitted to University of KwaZulu-Natal, RSA.

Mueller-Warrant, G. W., Whittaker, G.W. & Young, W.C. (2008). GIS Analysis of spatial clustering and temporal change of grass seed crops. Journal of *Weed Science* 2008 56:647-669

Living Standards Measurements Study-Integrated Surveys on Agriculture. (2009). National Bureau of Statistics. Retrieved February 2012, from http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:22757455~menuPK:6415356~pagePK:64168445~piPK:64168309~theSitePK:3358997~isCURL:Y~isCURL:Y,00.html

Tanzania Agriculture-sample survey. (2002-2003) National Bureau of statistics Retrieved February 6, 2012 from http://www.nbs.go.tz/tnada/index.php/ddibrowser/11

Results of the 2002-03 National Agricultural Sample Census. (2007). National Bureau of Statistics . Volume II. National Bureau of Statistics, Ministry of Agriculture and Food Security, Ministry of Cooperatives and Marketing, and Ministry of Livestock. Dar es Salaam.

Nkuba, M.J., Mushoba, C., & Mirandu, E. (2007). Unpublished report on Cassava on-farm voucher evaluation in Kagera region, Tanzania.

Nweke, F. (2004). Mechanisation of cassava commercialization as a livestock feed and industrial raw material in Africa. A paper presented at NEPAD/IGAD conference in Nairobi. November 22-25 2004 “Agricultural successes in the Greater Horn of Africa”

Oloveau, S., & Guilmoto, C.Z. (2004). Spatial Correlation and Demography. Exploring India’s demographic pattern.

Pica-Ciamarra, U., Baker, D., Chassama, J., Fadiga, M., & Nsiima, L. (2011). Linking smallholders to livestock markets: Combining market and Household survey data in Tanzania. Presented during 4th meeting on statistics of Rural Development and Agriculture Income. Rio de janeiro, Brazil, 9-11November 2011.

Rowhani, P., Lobell, D. B., Linderman, M. & Ramankutty, N. (2011). Climate variability and Crop Production in Tanzania. Agricultural and Forest Meteorology (2011) 449-460.

Sewendo, P.T., Mdoe, N.Y.S. & Mutabazi, K.D.S. (2011). Farmer’s preferential choice decisions to alternative cassava value chain strands in Morogoro rural district, Tanzania. Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture, Morogoro, Tanzania.

Sewando, P.T. (2012). Urban markets- linked cassava value chain in Morogoro Rural district, Tanzania. In: journal of sustainable development in Africa. Vol 14, No. 3, 2012, pp 284-300.

Silayo V.C.K., Balegu W.R., Mpagalile J.J. & Lwasai H.S. (2007). Participatory evaluation and improvement of cassava and sweet potato processing machines for Eastern zone of Tanzania. Proceedings of the 13th ISTRC Symposium, 2007, pp 672-871.

The cassava industry in Mozambique and Tanzania: Production, Processing, Distribution and Consumption of cassava and its related policy challenges. Subsistence Agriculture Study. (2011) Ministry of Agriculture. (A study conducted by PROMAR CONSULTING)

The cassava sub-sector analysis. (2012). Eastern Africa Root Crops Research Network. Retrieved March 6, 2012, from http://asareca.org/earrnet/cassava_sub-sector_analysis.htm.

Westby. A. (2002). Cassava Utilization, Storage and Small-scale Processing. In: R. J. Hillocks, J.M.Thresh and A.C. Bellotti, (Eds). (2002). CAB International 2002. Cassava: Biology, Production and Utilization.

Why cassava. (2010). Food and Agriculture Organization of the United Nations. Retrieved February 2, 2012, from http://www.fao.org/ag/agp/agpc/gcds/

Woodard. S. M. (2010). A spatial analysis of Illinois agriculture cash rents. Unpublished MSc thesis submitted to the University of Illnois at Urbana-Champaign.

APPENDICES

Appendix 1: LSMS-ISA data on cassava production

Region Code	RegName	hhid	plotnum	Crop code	Cropname	Number of plants	Year planted	Crop Harvest
1	Dodoma	01010140020761	M1	21	MIHOGO	300	2007	200
1	Dodoma	01030130040468	M1	21	MIHOGO	50	2007	120
2	Arusha	02020120010059	M1	21	MIHOGO	8	2009	0
2	Arusha	02050020070124	M2	21	MIHOGO	85	2008	300
2	Arusha	02050020070175	M1	21	MIHOGO	10	2009	375
3	Kilimanjaro	03010060030115	M1	21	MIHOGO	10	2008	0
3	Kilimanjaro	03010060030419	M2	21	MIHOGO	15	2009	20
3	Kilimanjaro	03010120020097	M1	21	MIHOGO	20	2007	45
3	Kilimanjaro	03010140020656	M1	21	MIHOGO	30	2008	0
3	Kilimanjaro	03020040030315	M1	21	MIHOGO	3	2008	0
3	Kilimanjaro	03020040030356	M2	21	MIHOGO	1150	2006	480
3	Kilimanjaro	03030233030022	M3	21	MIHOGO	30	1998	1950
3	Kilimanjaro	03050040020175	M3	21	MIHOGO	10	2008	200
3	Kilimanjaro	04010150020006	M1	21	MIHOGO	12	2008	0
4	Tanga	04010150020030	M1	21	MIHOGO	800	2008	420
4	Tanga	04010150020158	M1	21	MIHOGO	300	2008	120
4	Tanga	04010150020412	M1	21	MIHOGO	1200	2008	140
4	Tanga	04010150020440	M1	21	MIHOGO	100	2007	0
4	Tanga	04010150020543	M1	21	MIHOGO	667	2008	0
4	Tanga	04010270040350	M4	21	MUHOGO	332	2007	225
4	Tanga	04020040050193	M1	21	MIHOGO	725	2007	540
4	Tanga	04020040050317	M1	21	MIHOGO	10	2008	40
4	Tanga	04020040050419	M2	21	MUHOGO	20	2008	5
4	Tanga	04020083520002	M2	21	MIHOGO	60	2007	200
4	Tanga	04020083520009	M2	21	MIHOGO	40	2008	0
4	Tanga	04020083520015	M3	21	MIHOGO	120	2007	20
4	Tanga	04020083520023	M1	21	MIHOGO	200	2008	200
4	Tanga	04020083520029	M1	21	MIHOGO	300	2009	0
4	Tanga	04020083520035	M2	21	MIHOGO	120	2008	450
4	Tanga	04020083520050	M1	21	MIHOGO	200	2008	0
4	Tanga	04020120020084	M3	21	MIHOGO	450	2009	800

Appendix 2: Population data for Tanzania from National Bureau of Statistics

Code	Region	Capital	Area (km^2)	Population 1988	Population 2002	Population 2008 Prj	Population density
1	Dodoma	Dodoma	41,311	1,235,328	1,692,025	2,005,000	49
2	Arusha	Arusha	36,486	744,479	1,288,088	1,570,000	43
3	Kilimanjaro	Moshi	13,309	1,104,673	1,376,702	1,569,000	118
4	Tanga	Tanga	26,808	1,280,212	1,636,280	1,880,000	70
5	Morogoro	Morogoro	70,799	1,220,564	1,753,362	2,022,000	29
6	Pwani	Dar es Salaam	32,407	636,103	885,017	1,015,000	31
7	Dar es Salaam	Dar es Salaam	1,393	1,360,850	2,487,288	2,961,000	2126
8	Lindi	Lindi	66,046	646,494	787,624	887,000	13
9	Mtwara	Mtwara-Mikandani	16,707	889,100	1,124,481	1,272,000	76
10	Ruvuma	Songea	63,498	779,875	1,113,715	1,303,000	21
11	Iringa	Iringa	56,864	1,193,074	1,490,892	1,680,000	30
12	Mbeya	Mbeya	60,350	1,476,278	2,063,328	2,502,000	41
13	Singida	Singida	49,341	792,387	1,086,748	1,295,000	26
14	Tabora	Tabora	76,151	1,036,150	1,710,465	2,171,000	29
15	Rukwa	Sumbawanga	68,635	698,718	1,136,354	1,399,000	20
16	Kigoma	Kigoma-Ujiji	41,311	1,235,328	1,692,025	2,005,000	49

Appendix 3. Market price data from Ministry of Agriculture

ID No.	Market	Region	District	Ycoord	Xcoord	Average07	Average08
1	Bukoba	Kagera	Bukoba Urban	-1.3290	31.8030	444	388
2	Biharamulo	Kagera	Biharamulo	-2.6270	31.3110	200	125
3	Tukuyu	Mbeya	Rungwe	-9.2500	33.6670	291	227
4	Same	Kilimanjaro	Same	-4.0580	37.7490	237	233
5	Geita	Mwanza	Geita	-2.9167	32.2500	223	158
6	Kwimba	Mwanza	Kwimba	-3.0419	33.3177	196	210
7	Musoma Urban	Mara	Musoma Urban	-1.5000	33.8110	224	400
8	Bunda	Mara	Bunda	-2.0000	33.8333	363	315
9	Sengerema	Mwanza	Sengerema	-2.6560	32.6430	368	233
10	Bariadi	Shinyanga	Bariadi	-2.7500	34.5000	170	1063
11	Kahama	Shinyanga	Kahama	-3.8190	32.5990	328	393
12	Kibondo	Kigoma	Kibondo	-3.5780	30.7210	301	292
13	Kasulu	Kigoma	Kasulu	-4.4167	30.3333	279	228
14	Kigoma	Kigoma	Kigoma Urban	-4.8720	29.6250	183	291
15	Tunduru	Ruvuma	Tunduru	-11.0430	37.3290	223	400
16	Serengeti	Mara	Serengeti	-2.0000	34.8330	96	222
17	Singida	Singida	Singida Urban	-5.7120	34.4970	258	294
18	Igunga	Tabora	Igunga	-4.2840	33.8820	150	436
19	Kiomboi	Singida	Iramba	-4.3333	34.5000	225	150
20	Simanjiro	Manyara	Simanjiro	-4.0000	36.5000	894	831
21	Hanang	Manyara	Hanang	-4.5788	35.3177	975	550
22	Mbulu	Manyara	Mbulu	-3.7500	35.3333	150	550
23	Sikonge	Tabora	Sikonge	-5.6180	32.7480	183	200
24	Kiteto	Manyara	Kiteto	-5.4841	36.6861	160	606
25	Arusha	Arusha	Arusha	-3.3700	36.6840	470	742
26	Arumeru	Arusha	Arumeru	-3.1333	36.8667	487	644
27	Hai	Kilimanjaro	Hai	-3.1667	37.1667	466	409
28	Moshi Urban	Kilimanjaro	Moshi Urban	-3.5000	37.5000	525	950
29	Ruangwa	Lindi	Ruangwa	-10.0667	38.9333	178	298
30	Tabora	Tabora	Uyui	-4.9175	32.8333	211	212
31	Korogwe	Tanga	Korogwe	-5.1570	38.4600	250	250
32	Handeni	Tanga	Handeni	-5.4210	38.0210	250	221
33	Namtumbo	Ruvuma	Namtumbo	-10.4833	36.0333	150	200
34	Bagamoyo	Pwani	Bagamoyo	-6.4420	38.8940	744	1188
35	Kibaha	Pwani	Kibaha	-6.7667	38.9167	181	304
36	Kisarawe	Pwani	Kisarawe	-7.3157	38.7282	422	472
37	Mpwapwa	Dodoma	Mpwapwa	-6.6666	36.4167	283	333

38	Dar es Salaam	Dar es Salaam	Kinondoni	-6.7051	39.1704	322	392
39	Ilala	Dar es Salaam	Ilala	-6.8240	39.2490	455	421
40	Mafia	Pwani	Mafia	-7.8500	39.7833	430	438
41	Morogoro	Morogoro	Morogoro	-6.8230	37.6600	373	350
42	Ifakara	Morogoro	Kilombero	-8.2500	36.4167	200	275
43	Chunya	Mbeya	Chunya	-7.7500	33.0000	496	344
44	Mbeya Urban	Mbeya	Mbeya Urban	-8.8833	33.4166	383	350
45	Tanga	Tanga	Tanga	-5.0740	39.1050	164	276
46	Kyela	Mbeya	Kyela	-9.5833	33.9167	218	204
47	Mbalali	Mbeya	Mbarali	-8.5833	38.6667	267	500
48	Liwale	Lindi	Liwale	-9.7950	37.9210	150	67
49	Pangani	Tanga	Pangani	-5.4180	38.9800	50	192
50	Lindi	Lindi	Lindi Urban	-9.9900	39.7190	415	250
51	Mwanza	Mwanza	Ukerewe	-1.8420	32.8966	516	675
52	Mtwara Rural	Mtwara	Mtwara Rural	-10.2860	40.1900	194	200
53	Masasi	Mtwara	Masasi	-10.7310	38.8040	226	389
54	Temeke	Dar es Salaam	Temeke	-6.8690	39.2610	275	354
55	Nachingwea	Lindi	Nachingwea	-10.5000	38.3330	250	390

Appendix 4: Cassava production data from Famine Early Warning Systems Network

REGION	YEAR	AREA (ha)	PRODUCTION (mt)	YIELD (mt/ha)
Arusha	2005/06	18784	31557	1.7
Arusha	2006/07	13227.04886	27776.8026	2.1
Arusha	2007/08	11995	26388	2.2
Arusha	2008/09	17605	31600	1.8
Coast	2005/06	75786	62550	1.8
Coast	2006/07	54097.17333	18250	2.2
Coast	2007/08	53840	24100	2.1
Coast	2008/09	73270	131886	1.8
Dodoma	2005/06	71764	105275	1.5
Dodoma	2006/07	55597.92359	77837.09302	1.4
Dodoma	2007/08	61621	73946	1.2
Dodoma	2008/09	73270	131886	1.8
Dar es salaam	2005/06	16487	41859	2.5
Dar es salaam	2006/07	13351.16644	28037.44953	2.1
Dar es salaam	2007/08	12684	26636	2.1
Dar es salaam	2008/09	16835	31987	1.9
Iringa	2005/06	1285	2756	2.1
Iringa	2006/07	970.2945986	2037.618657	2.1
Iringa	2007/08	922	1936	2.1
Iringa	2008/09	1107	2325	2.1
Kagera	2005/06	97176	2037.618657	1.9
Kagera	2006/07	68317.75445	166900.2741	2.4
Kagera	2007/08	88087	118002.7332	2.6
Kagera	2008/09	130971	275039	2.1
Kigoma	2005/06	40879	110708	2.7
Kigoma	2006/07	42927.30255	118002.7332	2.7
Kigoma	2007/08	48740	112103	2.3
Kigoma	2008/09	56094	134630	2.4
Kilimanjaro	2005/06	4670	10274	2.3
Kilimanjaro	2006/07	3452.70133	7734.05098	2.2
Kilimanjaro	2007/08	3340	7347	2.2
Kilimanjaro	2008/09	4412	824	2.0
Lindi	2005/06	109718	159091	1.5
Lindi	2006/07	65807.53937	135563.5311	2.1

Appendix 5. Great Lakes Cassava Initiative data

Latitude	Longitude	Altitude	Crop	VarietyType	Plot	Size	RootProd	PlotHarvest	PlotYield
-2.63216	31.39404	1434	CASSAVA	Local	1	1.2	1980	1485	1238
-2.64305	31.38597	1437	CASSAVA	Local	1	1.2	230	115	96
-2.64433	31.38731	1439	CASSAVA	Local	1	4	4950	2475	619
-1.86626	31.6008	1214	CASSAVA	Local	1	0.4	900	450	1125
-1.86626	31.6008	1214	CASSAVA	Local	1	0.4	900	450	1125
-3.12073	31.04955	1287	CASSAVA	Local	1	4	7000	3500	875
-2.64453	31.34199	1441	CASSAVA	Local	1	0.4	300	300	750
-1.76521	31.55172	1522	CASSAVA	Local	1	0.2	360	360	1800
-1.8469	31.62892	1204	CASSAVA	Local	1	0.4	180	90	225
-1.27603	31.64556	1208	CASSAVA	Local	1	0.4	240	120	300
-2.67931	31.33879	1408	CASSAVA	Local	1	0.3	3000	1286	4286
-2.67936	33.882	1389	CASSAVA	Improved	1	0.5	5250	1313	2625
-1.76334	31.55018	1531	CASSAVA	Local	2	0.4	4800	427	1067
-2.64109	31.34337	1430	CASSAVA	Local	1	0.4	200	200	500
-2.64109	31.34337	1430	CASSAVA	Local	1	0.4	200	200	500
-2.10367	31.57692	1148	CASSAVA	Local	1	0.5	10	5	10
-2.95356	31.20821	1278	CASSAVA	Local	1	0.2	200	200	1000
-1.27384	31.64435	1121	CASSAVA	Local	1	0.4	400	267	667
-2.63324	31.39211	1410	CASSAVA	Local	1	0.8	120	120	150
-1.84374	31.62754	1213	CASSAVA	Local	1	0.2	150	75	375
-1.867	31.59978	1203	CASSAVA	Local	1	0.6	180	90	150

Appendix 6: Cassava prices and production for 2007 correlation analysis table

		Production2007	Prices2007
Production2007	Pearson Correlation	1	-.397
	Sig. (2-tailed)		.092
	N	19	19
Prices2007	Pearson Correlation	-.397	1
	Sig. (2-tailed)	.092	
	N	19	19

Appendix 7: Cassava prices and production for 2008 correlation analysis table

		Production2008	Prices2008
Production2008	Pearson Correlation	1	-.310
	Sig. (2-tailed)		.196
	N	19	19
Prices2008	Pearson Correlation	-.310	1
	Sig. (2-tailed)	.196	
	N	19	19