AGRICULTURE ALONG THE URBAN-RURAL CONTINUUM

A GIS-based analysis of spatio-temporal dynamics in two medium-sized African cities

Thesis submitted in partial fulfilment of the requirements of

the degree Doctor rer. nat. of the

Faculty of Environment and Natural Resources,

Albert-Ludwigs-Universität

Freiburg im Breisgau, Germany

by

Johannes Schlesinger

Freiburg im Breisgau, Germany

2013

Dean:	Prof. Dr. Barbara Koch
1st Supervisor:	Prof. Dr. Axel Drescher
2nd Supervisor:	Prof. Dr. Rüdiger Glaser
2nd Reviewer:	Prof. Dr. Tim Freytag

Date of thesis' defence: 12 June 2013

Acknowledgements

This study was developed as part of the research project *Livelihoods, urbanisation and natural resources in Africa (LUNA)* funded by the VW Foundation. The dissertation project was financially supported by the Landesgraduiertenförderung Baden-Württemberg, the Council for Tropical and Subtropical Agricultural Research (ATSAF), and the International Graduate Academy (IGA) at the University of Freiburg.

I would like to thank my supervisors Prof. Dr. Axel Drescher, Prof. Dr. Rüdiger Glaser, and Prof. Dr. Tim Freytag for the scientific and organisational support. Furthermore, I would like to thank the other staff at the Physical Geography of the University of Freiburg for fruitful discussions and valuable suggestions. My particular thanks go to my colleagues Hanna Karg, Emmanuel Munishi, and Fabian Sennekamp, with whom I spent a great time inside and outside the office.

This study would not have been possible without the German, Cameroonian and Tanzanian students who supported me during the extensive field work phases. Thanks to all of you! I would also like to thank Takemore Chagomoka and Dr. Wakuru Magigi for their organisational support during my stays in Cameroon and Tanzania and all the other members of the LUNA team for their assistance and mutual scientific as well as social exchange. Thank you to all people I got the chance of working with in local, regional, and national administrative bodies, research institutions, and other organisations in Cameroon and Tanzania. However, the biggest thanks go to the hundreds of interviewees in Moshi and Bamenda for their great hospitality, patience, and willingness to participate in this study.

I am very grateful to my family who always supported me and granted me the freedom to follow my personal interests. I also want to thank my friends, especially Hannah Mangold, for their moral and scientific support throughout my studies. Without them, the last few years would have been much harder.

Most importantly, I thank my great wife Michi, who always believed in me and supported me in every possible way. By sharing the joys and sorrows of the last years, she has contributed so much to eventually finalising this project. Thank you so much!

Abstract

In the time of rapid urban transformation, urban and periurban agriculture has evolved as an important livelihood strategy for millions of urban dwellers in sub-Saharan Africa. Especially in small and medium-sized cities, cultivated areas can be seen as an integral part of the urban patchwork. Yet, little is known about the spatial extent of agricultural production in and around these cities and how the spatial parameters of this complex patchwork change along the urban-rural continuum. The purpose of this study therefore was to enhance the understanding of spatio-temporal dynamics of urban and periurban agriculture along the urban-rural continuum with a special focus on small and medium-sized cities in Africa.

Two cities were selected for this study: 1) Moshi, located at the southern foothills of Mt. Kilimanjaro in northern Tanzania; and 2) Bamenda, the capital and largest city of the Northwest Region of Cameroon. In both cities, four transect polygons – 100 metres wide and up to 15 kilometres long – were laid out radially from the city centre, building the spatial framework for the data collection and analysis process. Within these transects, all agricultural land use was mapped and a representative number of households was interviewed (404 in Moshi and 480 in Bamenda). All data was digitised and geocoded, allowing for the spatial analysis of the two datasets. For data analysis, an inductive approach was chosen, meaning that all spatial classifications were derived from the raw data. An Urban-Rural Index (URI) was calculated based on building density and travel isochrones as the foundation of spatial analysis, ensuring that the process was not biased by the selection of conventional categories, such as *urban*, *periurban* or *rural*.

The results of this study revealed that almost all agricultural parameters showed significant correlations with the respective URI score. Even though correlations in land use data were usually larger than in household data, four characteristic patterns of spatial changes along the continuum could be identified. While building density, the availability of infrastructure, such as electricity and water, or formal flat/house ownership steadily decreased with decreasing URI values (Type A), the proportion of area under cultivation, mean patch sizes and the share of agriculturally active households increased (Type B). Even though these changes have hardly been quantified in previous studies, these patterns were expected, as most of these parameters are more or less evident parts of the definition of *urban*. However, it was found that spatial changes in other parameters were less predictable. While construction activity, crop diversity, and patch size variation were highest in periurban areas (Type C), the numbers on the duration of residence or land ownership were lowest in these areas of transition between the urban core and the rural hinterland (Type D).

The principal conclusion of this thesis was that agricultural parameters usually rather change gradually – forming an urban-rural continuum – than reflecting the artificial administrative boundaries that dichotomously differentiate between urban and rural areas. It could be shown that the periurban areas in between these extremes have distinct characteristics. Consequently, they need to be recognised as distinct parts of the urban-

rural continuum, keeping in mind that these areas are likely to bear a significant potential for conflicts, but also great opportunities for sustainable urban development in the future.

Zusammenfassung

Im Zeitalter schnellen Städtewachstums gewinnt urbane und periurbane Landwirtschaft als Überlebenssicherungsstrategie für Millionen von Stadtbewohnern im subsaharischen Afrika zunehmend an Bedeutung. Insbesondere in kleinen und mittelgroßen Städten stellen landwirtschaftlich genutzte Flächen einen integralen Bestandteil des städtischen Raumes dar. Allerdings ist bisher wenig über das tatsächliche räumliche Ausmaß landwirtschaftlicher Produktion in Städten und deren Randgebieten bekannt. Zudem ist weitgehend unklar, wie sich räumliche Parameter dieses komplexen Landnutzungsmusters entlang des Stadt-Land-Kontinuums verändern. Ziel dieser Arbeit war daher, zu einem besseren Verständnis raumzeitlicher Dynamiken urbaner und periurbaner Landwirtschaft entlang des Stadt-Land-Kontinuums – mit besonderem Fokus auf kleinen und mittelgroßen Städten in Afrika – beizutragen.

Im Rahmen dieser Studie wurden zwei Städte als Fallstudien ausgewählt: 1) Moshi, eine Stadt am südlichen Fuße des Kilimandscharo im Norden Tansanias; und 2) Bamenda, die Hauptstadt und größte Siedlung der Nordwest-Region Kameruns. In beiden Städten wurden jeweils vier Transektpolygone – 100 Meter breit und bis zu 15 Kilometer lang – ausgelegt, deren Ursprung im Stadtzentrum lag und die sich bis in das städtische Hinterland erstreckten. Sie bildeten die Grundlage für die Datenerhebung und –analyse. Innerhalb dieser Transekte wurden alle landwirtschaftlich genutzten Flächen kartiert und ein repräsentativer Teil der Haushalte befragt (404 in Moshi und 480 in Bamenda). Zur Vorbereitung der räumlichen Analyse wurden beide Datensätze digitalisiert und georeferenziert. Zur Datenanalyse wurde ein induktiver Ansatz gewählt, somit beruhte die Entwicklung räumlicher Klassifikationen auf den Rohdaten. Basierend auf Gebäudedichte und Reisezeit zum Stadtzentrum wurde ein Urban-Rural Index (URI) errechnet, der als Grundlage für alle räumlichen Analysen diente. Dadurch wurde sichergestellt, dass der Analyseprozess nicht durch die Auswahl konventioneller Kategorien wie ‚urban', ‚periurban' oder ‚ländlich' beeinflusst wurde.

Die Ergebnisse dieser Studie zeigen, dass fast alle landwirtschaftlichen Parameter signifikante Zusammenhänge mit den jeweiligen URI-Werten aufwiesen. Auch wenn die Korrelationen bei den Landnutzungsdaten durchschnittlich stärker waren als bei den Haushaltsdaten, so konnten doch vier charakteristische Muster räumlicher Veränderungen entlang des Kontinuums identifiziert werden. Während Gebäudedichte, der Zugang zu Infrastruktur, wie Strom und Wasser, oder der formelle Besitz von Häusern und Wohnungen mit sinkenden URI-Werten stetig abnahm (Typ A), nahm der Anteil landwirtschaftlich genutzter Fläche, die durchschnittliche Feldgröße und der Anteil landwirtschaftlich tätiger Haushalte zu (Typ B). Auch wenn diese Veränderungen in bisherigen Untersuchungen kaum quantifiziert wurden, so waren die Ergebnisse doch erwartet worden, da die meisten dieser Parameter mehr oder weniger offensichtliche

Bestandteile der Definition des Begriffes ‚urban‘ sind. Bei der Betrachtung weiterer Parameter zeigten sich jedoch überraschendere Resultate. Während die Bauaktivität, die Anbaudiversität und die Variabilität der Feldgrößen in den periurbanen Räumen am höchsten waren (Typ C), waren die Werte der Wohndauer und des Landbesitzes in den Übergangsräumen zwischen Stadtzentrum und ländlichem Raum am kleinsten (Typ D).

Die wichtigste Erkenntnis, die aus dieser Arbeit abgeleitet werden kann, ist, dass landwirtschaftliche Parameter eher einen graduellen Verlauf aufweisen – und damit ein Stadt-Land-Kontinuum formen –, als künstliche administrative Grenzen widerzugeben, die dichotomisch zwischen städtischen und ländlichen Bereichen unterscheiden. Es konnte gezeigt werden, dass der periurbane Raum zwischen diesen Extremen durch ganz eigene Charakteristika geprägt ist. Folglich muss der periurbane Raum zukünftig als spezieller Teil des Stadt-Land-Kontinuums betrachtet werden. Dies gilt insbesondere, da diese Bereiche ein großes Konfliktpotential in sich tragen, darüber hinaus jedoch auch nicht zu unterschätzende Möglichkeiten im Hinblick auf eine nachhaltige städtische Entwicklung in der Zukunft bieten.

Table of contents

List of figures

List of tables

List of boxes

List of abbreviations

ACF	Action Contre la Faim
BRICS	Brazil, Russia, India, China, South Africa
CBD	Central business district
CIA	Central Intelligence Agency
CRI	Crop Richness Indicator
DEM	Digital elevation model
DFID	Department for International Development
ET	Eastern transect
FAO	Food and Agriculture Organization of the United Nations
GCP	Ground control point
GDP	Gross domestic product
GIS	Geographic Information System
GPS	Global Positioning System
HDI	Human Development Index
ID	Identifier
IFPRI	International Food Policy Research Institute
MPS	Mean Patch Size
NDVI	Normalized Difference Vegetation Index
NPK	Nitrogen, Phosphorus and Potassium
NT	Northern transect
OSM	OpenStreetMap
PD	Patch Density
PRD	Patch Richness Density
PSCV	Patch Size Coefficient of Variation
RPR	Relative Patch Richness
RS	Remote sensing
RUAF	Resource Centres on Urban Agriculture and Food security
SHDI	Shannon’s Diversity Index
SMCs	Small and medium-sized cities
SSA	Sub-Saharan Africa
ST	Southern transect
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFPA	United Nations Population Fund
UPA	Urban and periurban agriculture
URI	Urban-Rural Index
VHR	Very high resolution
WT	Western transect

1. Introduction

1.1 'Growing cities, growing food'[1] – the general context of this study

According to the UN (2012), a turning point in global population distribution was reached recently. For the first time in world history, globally more people live in urban areas than in rural environments. Even though the rural population is still dominating in the African context, the continent's settlement patterns are changing rapidly. The region is already home to as many urban dwellers as North America (Satterthwaite 2007) and urban growth is likely to continue for the next decades (UN 2012; White et al. 2008).

Ensuring the food supply for the growing urban population is increasingly becoming a challenge (FAO 2002), especially in the course of rising food prices. Furthermore, food prices are becoming increasingly volatile and hardly predictable (FAO 2012b), due to, inter alia, changes in global weather patterns and speculation (World Bank 2008).

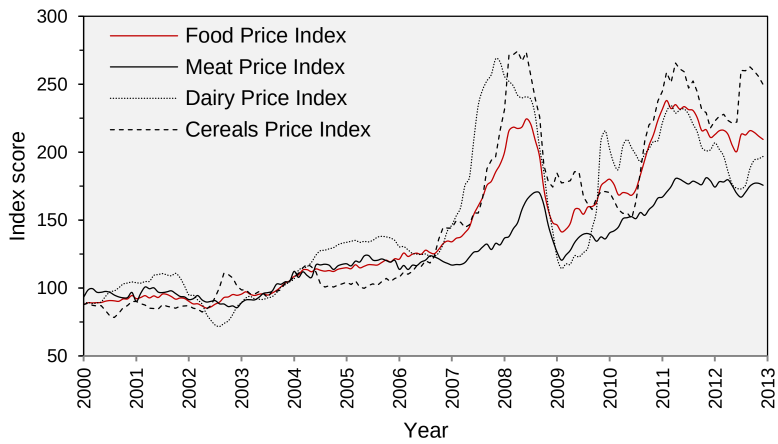


Fig. 1.1: Development of the Food Price Index between 2000 and 2012 (2002-2004=100). Data source: FAO (2013)

One of the groups most vulnerable to these developments is the poor urban population that tends to spend higher shares of their income on food than their rural counterparts (Maxwell et al. 2000; Maxwell 1999). As a consequence, food-energy deficiency incidences are more frequent in urban than in rural areas (IFPRI 2007). However, manifold adaptation and mitigation strategies have evolved, one being the development of alternative forms and locations of food production. Even though urban and periurban[2] agriculture (UPA) is not a new phenomenon, it is becoming more significant, not only for urban and periurban dwellers, but also for the scientific community, policy makers, and

[1] 'Growing cities, growing food' is the title of a widely recognised book that was developed in the course of the upcoming scientific debate on agricultural production in and around cities (Bakker et al. 2000).

[2] Both *periurban* and *peri-urban* can be found in the comprehensive body of literature on the topic. In the interest of simplification, the former is applied in this study.

the general public. While UPA in the context of industrialised countries in many cases is a trend associated with keywords, such as *local agenda 21*, *sustainability*, or *localised/alternative food production*, it needs to be understood as an important livelihood strategy in the development context.

Accordingly, a large body of literature on UPA exists. A wide range of conceptual and empirical studies have investigated the different aspects of UPA, ranging from its importance for household incomes to dominant farming systems. Farmers have been categorised based on their motivation (e.g. Nugent 2000a), farm size (e.g. Dubbeling 2004), or the commodities they produce (e.g. van Veenhuizen and Danso 2007). This knowledge, in turn, helps policy makers to formulate appropriate land use policies or urban development plans, and development agencies to design suitable intervention strategies.

1.2 Research gaps and problem statement

Even though UPA has been characterised as an important aspect of urban food security and income generation and "a permanent part of the urban system" (van Veenhuizen and Danso 2007: 6), there is only a basic understanding of the importance of the locality of farmers and farms within the urban patchwork. Urban areas are highly dynamic and so are urban farming systems. There are complex reciprocal effects between them resulting in heterogeneous land use patterns.

Categorisations were developed, dividing urban agglomerations into the densely-populated urban core and the periurban – the area of transition between the core and the surrounding rural hinterland. However, these categorisations are vague and highly context-specific. Even though they have been commonly applied in UPA research, most authors are reluctant to actually define these categories, making reproduction of and comparisons among individual studies difficult. As a consequence, little is known about the actual changes in agricultural production and its role for the farming households along the urban-rural continuum[3]. In fact, these continuous changes have never been quantified, mainly due to the lack of an appropriate methodology.

The wide majority of research on UPA so far concentrated on the bigger cities, such as Dar es Salaam (e.g. Drechsel and Dongus 2010), Yaoundé (e.g. Gockowski et al. 2003), Accra (e.g. Maxwell et al. 2000) or Kampala (e.g. David et al. 2010). This bias is understandable, as these cities are vivid examples of the immense changes related to the urbanisation process. However, recent data on the distribution of the urban population in sub-Saharan Africa (SSA) suggests that most of the urban dwellers on the continent live in urban areas with less than 500,000 inhabitants (UN 2012). Absolute numbers regarding population increase or transformation of land from cultivated into built-up areas in these – often rapidly growing – small and medium-sized cities (SMCs) might be smaller than in

[3] As the focus of this study is on urban agglomerations and their surroundings, the term *urban-rural continuum* is used, even though the expression *rural-urban continuum* is more common in the relevant literature.

their bigger counterparts. Yet, these changes tend to have a bigger relative impact on the morphology of these smaller urban agglomerations. Due to their smaller size, SMCs should be considered as possible drivers of their future development, while bigger cities are often driven by the development. Understanding the characteristics of UPA and its role within their urban fabric is important for their development in the future.

In the context of this study, the diverse forms of UPA are understood as being a result of complex processes associated with the urbanisation process (see Fig. 1.2). The urbanisation process itself is thereby only the effect of a wide range of driving factors and framework conditions and has several dimensions. Spatial growth of urban areas is the most apparent manifestation, resulting in often massive and rapid land use changes in and – more importantly – around cities. The resulting land use patterns can be heterogeneous and complex. At the same time does the urbanisation process have a severe impact on the social fabric in and around these urban agglomerations.

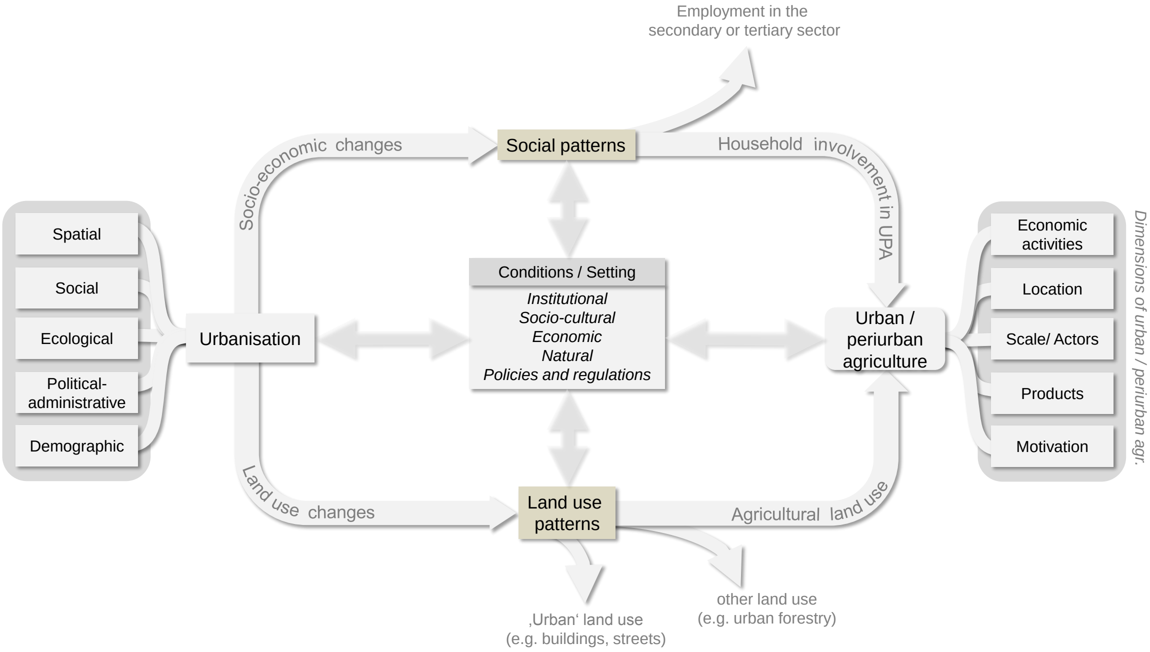


Fig. 1.2: Conceptual framework – Urbanisation and its relation to urban and periurban agriculture[4]

All of these interactions eventually have an impact on the forms and the spatial characteristics of UPA. Bringing together the urbanisation process and the spatial and social characteristics of UPA is a difficult task that has been hardly approached in the past. As previously mentioned, it is especially the understanding of the spatial implications of this process on agricultural activities along the urban-rural continuum that is still lacking.

[4] Unless otherwise noted, all figures were developed and drafted by the author.

1.3 Objective and research questions

Based on the abovementioned research gaps and the conceptual framework portrayed above, the objective of this study is to enhance the understanding of spatio-temporal dynamics of urban and periurban agriculture along the urban-rural continuum with a special focus on small and medium-sized cities in Africa.

The following research questions were formulated in order to contribute to achieving this objective:

1. *Which methodology is suitable to efficiently collect, process, and analyse data on agricultural land use and its role for farming households along the urban-rural continuum?*

To what extent can remote sensing-based approaches be applied to analyse agricultural land use in urban and periurban environments? Under which circumstances do these approaches have to be replaced by in situ methods to capture the complexity of urban and periurban production systems? How can land use as well as household data be collected, processed, and stored in a standardised form allowing for the reproduction of the research in other spatial contexts? How can these data be analysed so that the spatial complexity of urban agglomerations is appropriately reflected?

2. *How does agricultural land use of urban and periurban areas change along the urban-rural continuum?*

Where does agricultural production – with a special focus on crop production – take place? How do landscape metrics, such as patch sizes and crop diversity change along the continuum? Are there any spatial patterns in the distribution of cultivated crops?

3. *How do household characteristics – with a special focus on agriculture – change along the urban-rural continuum?*

How do general characteristics, such as infrastructure availability, tenure situation or duration of residence change? Where do the farmers live and what can be stated about their cultivated areas in terms of location, land tenure, and acreages? Which role does UPA play for the food supply and income generation of households along the continuum?

4. *Which conclusions can be drawn from these results regarding the future understanding of the areas of transition between the two extremes 'urban' and 'rural'?*

To what extent do the current definitions and categories *urban*, *periurban*, and *rural* need to be adjusted in order to appropriately reflect the spatial complexity of rapidly growing cities in the development context? What can be stated regarding the future of UPA in general and its integration into the urban fabric?

Two sub-Saharan medium-sized cities were selected for this study: 1) Moshi, located at the southern foothills of Mt. Kilimanjaro in northern Tanzania; 2) Bamenda, the capital and largest city of the Northwest Region of Cameroon. The methodological approach was developed, tested, and applied in Moshi first. In a later stage, it was tested for its replicability and suitability in Bamenda. In both cities, four transect polygons were laid out radially from the city centre, building the spatial framework for the data collection and analysis process. Within these transects, all agricultural land use was mapped and a representative number of households was interviewed. All data was digitised and geocoded, allowing for the spatial analysis of the two datasets. For data analysis, an inductive approach was chosen, meaning that all spatial classifications were derived from the raw data. With this approach it was ensured that the process was not biased by the selection of conventional categories, such as *urban*, *periurban* or *rural*. The identification of these categories was one of the aims of this study rather than the starting point and foundation for sampling and data collection, as it is the case in most studies on UPA.

1.4 Structure of the work

In the following chapter, a review of the relevant literature is given. After an examination of the definitions and dimensions of the urbanisation process, current trends in urbanisation on the global scale and in SSA in particular are discussed. Then, the special role of small and medium-sized cities in this context are assessed and some theoretical considerations on how urban and periurban areas are shaped are presented. The definition of urban and periurban agriculture is the subject of the following section. Eventually, an overview of the complex interactions between urbanisation and UPA is given.

In chapter 3, the cities of Moshi (Tanzania) and Bamenda (Cameroon), which were selected as study sites for this research, are portrayed with a special focus on the extent of the respective urbanisation process, their environmental setting, and the current conditions for agriculture and its role in and around both cities.

The fourth chapter presents the set of methods that was applied in this study. A special emphasis is laid on the development of the Urban-Rural Index (URI) that formed the basis for the spatial analysis of household data as well as land use data.

In chapter 5, the household and land use data is presented and the changes along the urban-rural continua of both study sites are analysed and discussed. First, the analysis of the general urban morphology are presented before having a closer look at the general non-agricultural spatial dynamics along the transects. Afterwards, the results of the land use analysis are discussed before presenting the results of the analysis of the household data. Eventually, the results are summarised and general conclusions for the respective study sites are drawn.

In the final summary of the study, answers to the research questions posed at the beginning are given. Furthermore, a critical evaluation of the applied approach and methods are conducted before concluding with an outlook and suggestions for further research.

2. Literature review and theoretical background

2.1 The world becomes urban

“Our struggle for global sustainability will be won or lost in cities”
(Ki-moon 2012)

“[…] the demographic literature has tended to overstate the role being played by very large cities and has underemphasized the importance of small- and medium sized cities.”
(Montgomery 2008: 761)

2.1.1 The problem of defining ‘urban’

Defining *urban* is complex and challenging as areas regarded as being urban differ widely in their morphology and character on a global scale as well as within countries and regions. Definitions are context-specific and might be based on “administrative, morphological or functional” (Byfuglien 1995: 83) indicators, depending on the perspective of the respective author or institution (Lerner and Eakin 2011; Montgomery 2008). Furthermore, they are “closely bound to historical, political, cultural, and administrative considerations” (UN 2008a: 104). Therefore, a global and universal definition could not be educed:

> "The distinction between the urban and the rural population is not yet amenable to a single definition that would be applicable to all countries or, for the most part, even to the countries within a region. Where there are no regional recommendations on the matter, countries must establish their own definitions in accordance with their own needs." (UN 2008b: 124)

Most countries worldwide base their definition on population size, applying certain population thresholds to distinguish *urban* from *rural* areas. These demographic thresholds, however, are artificial, vary drastically and therefore make international comparisons difficult. While in Ethiopia agglomerations with a population of more than 2,000 are categorised as urban (IFPRI and EDRI 2009), Ghana applies a threshold of 5,000 people (Tettey 2005), and in Senegal there must be at least 10,000 people living in an agglomeration in order to be categorised as urban (UN 2008a).

About one quarter of the countries in the world also consider population density (Panel on Urban Population Dynamics et al. 2003), which makes these definitions “policy neutral” (UN et al. 2007: 47) as they no longer depend on artificial administrative denominations, such as “‘urban centres’, ‘major cities’, ‘administrative centres’ or ‘municipalities’” (FAO 2005: 3). In some cases, distances between built-up areas and the number of dwellings are an additional factor (e.g. Equatorial Guinea) for the identification of urban areas. More elaborated definitions exist that make categorisation more appropriate, yet more complex.

Functional definitions take into account certain characteristics of urban areas, such as the dominance of the secondary and tertiary sectors, the provision of “specific services and facilities” (UN 2008a: 104). Botswana, for example, incorporates the sectoral distribution of economic activities within a certain spatial unit and thereby emphasises the seemingly inherent differences between urban and rural areas: “Agglomeration of 5,000 or more inhabitants where 75 per cent of the economic activity is non-agricultural” (UN 2008a: 105).

In some cases, definitions differ not only between countries but also within countries. In Tanzania, for example, the Prime Minister’s Office, several ministries and the National Bureau for Statistics have unequal working definitions of the term *urban*, depending on their respective interests (Muzzini and Lindeboom 2008). This hampers the interpretation of relevant statistics, inter-institutional collaboration, and the formulation of appropriate and coherent policies.

As outlined above, comparing data on urbanisation between different spatial units is error-prone and might lead to false conclusions. However, the author is also aware of the impracticality of a universal definition, caused by the differences in historical development, administrative conditions and respective foci. It must be emphasised that all definitions are of limited use when it comes to the micro level. This especially applies to the fuzzy distinction between *urban* and *periurban* areas. This complex issue is addressed extensively in chapter 2.1.7.

2.1.2 Urbanisation as a multi-dimensional process

While defining *urban* already is a complex task, characterising *urbanisation* is even more difficult. Most authors have in common the emphasis of the procedural character of urbanisation. Urbanisation thereby is not just a description of the current situation, it rather has to be understood as “a collective term for a set of changes which generally occur within the appearance and expansion of large-scale coordinated activities in a society” (Tilly 1964: 16). Several interdependent dimensions of these changes were identified (see Fig. 2.1).

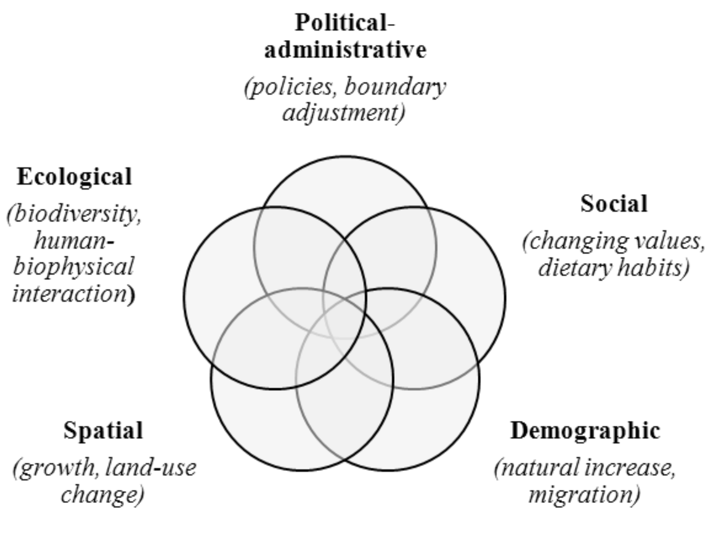


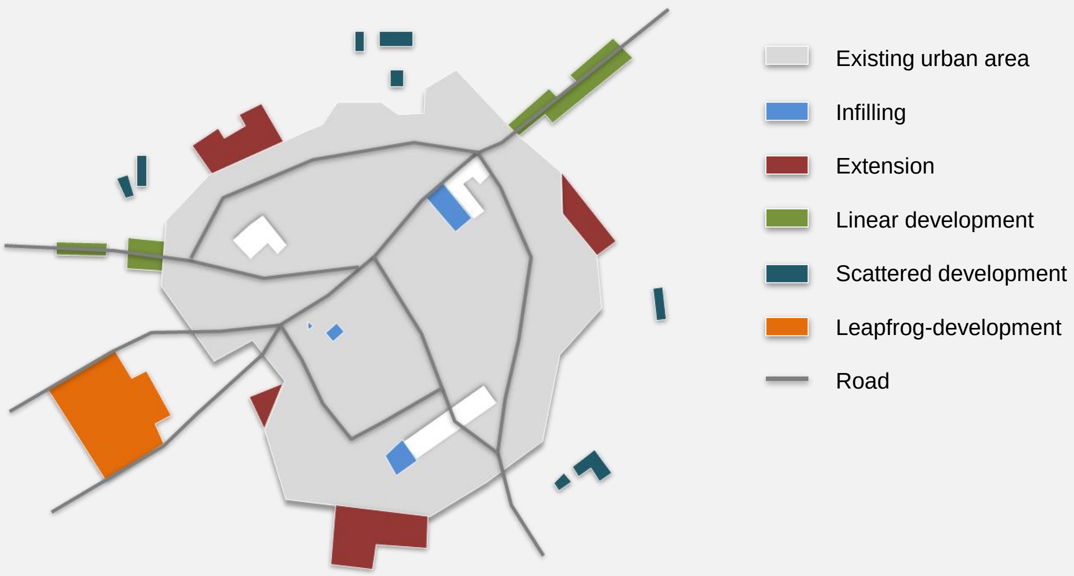
Fig. 2.1: Dimensions of the urbanisation process

Urbanisation as a spatial process

The spatial expansion of urban areas is probably the most obvious manifestation of the urbanisation process. Population growth changes the appearance of cities worldwide. In cities of the developing world these changes can be rapid due to the enormous growth rates some of these cities are facing. As a consequence, urban agglomerations can increase their area significantly within a short time. Studies have shown that some of them have even quadrupled in size within just two decades (e.g. Dar es Salaam) (UN-HABITAT 2010; UN 2012).

An increasing urban population intensifies the demand for urban housing, economic and infrastructure development. While more and more people decide to live in cities, their needs cannot be satisfied within the initial urban area. The pressure on housing markets and the growing demand from private investors and the public sector leads to the spatial growth of urban areas (Satterthwaite et al. 2010). Subsequently, land traditionally used for non-urban purposes, such as agriculture and forestry, is transformed into built-up land. Many factors influence the way how urban areas are growing: the socio-political context with its traditions and policies, economic conditions, and the topography as a potentially limiting factor (Camagni et al. 2002). Depending on these factors, spatial expansion can occur in different forms, ranging from infillings to leapfrog-development (see Box 2.1).

Box 2.1: Forms of urban expansion



Infilling: Redensification of urban areas through - usually informal - building activities on open spaces that still exist within the urban area. These are often zones unfavourable for construction, such as flood-prone river beds, road and railway reserves, steep hills, or potentially contaminated areas.

Extension: Non-infilling urban growth adjacent to built-up areas. In most cases, this form of urban expansion is based on formal urban development plans and housing schemes. As infrastructure provision (water, electricity, and transportation) is generally good and land prices are usually relatively high, middle- and high-class residential areas dominate in this case.

Linear development: Development along important axes of urban transport infrastructure, such as roads and railways. Fuelled by the increasing motorisation of transport of goods and people, areas along transport infrastructure become more attractive for economic development as well as individual housing.

Scattered development: Non-contiguous, low-density development in an area adjacent to the built-up urban area. This form of development is a result of increasing real estate activities and monetisation of land, the conflict between “traditional” and “modern” land tenure systems, a lack of appropriate land use policies and administration, and infrastructure as well as general economic development.

Leapfrog-development: Planned development of large tracts of land that are separated from the main urban area by a fringe of land that has not yet been developed. Often referred to as *greenfield development* and in many cases favoured by politicians as prominent symbols of urban development.

Based on Camagni et al. (2002); World Bank (2005); Ewing (2008)

While most definitions of urbanisation imply a “shift in settlement patterns from dispersed to more dense settlement […], much of the expansion of urban land use is the result of a shift from dense to more dispersed settlement” (Satterthwaite et al. 2010: 2810). With increasing economic development and as many cities have reached their limits in terms of population density, many urban dwellers decide to move to the less densely populated periurban areas. As a consequence, the spatial growth of these cities is further accelerated.

This leads to manifold conflicts, especially in the periurban areas, where most of the urban growth takes place. The increasing consumption of natural resources, such as land, forests, and water caused by the “large-scale conversion of open space and environmentally sensitive lands to urban uses” (Arku 2009: 255) creates new conflicts between those depending on these resources and urban stakeholders (see chapter 2.3.1).

The spatial growth of cities is usually understood as a threat to agriculture in general and particularly to those farmers whose livelihoods depend on it. Many cities have been founded in areas favourable for agricultural production. Thus, agricultural land is especially affected by the spatial growth of cities. In many cases farmers’ land rights are inherited and therefore no official title deeds exist, which makes them vulnerable to expropriation measures supported or even implemented by municipal administrations (Mubvami and Mushamba 2006). The loss of agricultural land often means a loss of income and in many cases the loss of an important source of nutrition. However, the increasing demand for land might also create opportunities for the concerned farmers. Some of them decide to sell their land and shift to other activities sustaining their livelihoods (van Veenhuizen 2006). The financial benefits of selling parts of or the entire agricultural land can be immense.

Urbanisation as a demographic process

Much of the world's population growth takes place in SSA, where fertility rates remain high and mortality rates are slowly decreasing. The region's population is expected to increase by more than 300 million people until 2025, representing about one third of the global increase (UN 2011). Much of this growth will take place in urban Africa. There are basically two demographic factors leading to an increase of the urbanisation level. It is the differences in urban and rural fertility and mortality rates as well as migration to cities that contribute to these changes.

In many cities within SSA there is a natural increase of the urban population. Urban fertility rates tend to be high, as a large share of the urban population is within the reproductive age group (Hope 1998). Urban mortality rates are usually lower than within the respective rural context, due to the health infrastructure, the level of education, and the sanitation and nutrition situation. Wherever the natural increase in the rural areas is lower than within the cities, the urbanisation level increases accordingly.

Migration also plays an important role in the urbanisation process. In this context, migration is discussed with a demographic perspective, even though it has many social, political, and spatial implications. In many countries in the region, rural poverty has to be regarded as the main driver of migration. Mostly young people are "'pushed' out [of the rural areas] by factors such as poverty, environmental degradation, religious strife, political persecution, food insecurity and lack of basic infrastructure and services" (Nsiah-Gyaabah 2004: 1). Many of these push-factors are related to agriculture. As rural populations grow, arable land becomes scarce and access to such land more difficult (Tannerfeldt and Ljung 2006). The cultivation of ecologically sensitive land is a critical issue, as this is a non-sustainable alternative. Unfavourable market conditions and a lack of appropriate transport infrastructure lead to rural-urban migration, "even when land is available in sufficient quantity and quality" (Kasarda and Crenshaw 1991: 475). There is also a long list of factors *pulling* people into the urban areas, such as better education, electricity, water, and health infrastructure. Especially for young people who prefer the conveniences of the modern urban lifestyle, migration to urban areas is an attractive alternative to rural life (Bakewell and Jónsson 2011).

There is a controversy regarding which of the two factors (natural increase and migration) contributes more to the ongoing increase of urban populations all over SSA. The UN (1999) estimate that about half to two thirds of the urban growth in Africa is caused by natural increase. Other authors support these estimates by stating that "sixty per cent of urban population growth in developing countries is natural growth" (Tannerfeldt and Ljung 2006: 27). Gugler (1996: 4) accepts that "natural population growth is a major element in urban growth", but points out that "rural-urban migration makes an even larger contribution in many less developed countries". Hope (1998: 351) emphasises that "in sub-Saharan Africa, where most of the cities are relatively small but growing rapidly, migration from rural areas is a major influence on urban growth" being responsible for as much as 85 percent of urban growth in some countries. Accordingly, Drescher and Iaquinta (2002) stress the importance of migration for the development of urban and periurban areas.

As it is extremely difficult to get reliable data on these shares in a developing context, Kasarda and Crenshaw (1991: 474) propose understanding the contributions of these factors to urbanisation as dynamic over time: "At low levels of urbanisation[5], migration is the prime engine driving city growth, as is now the case in much of Africa. As the urban base grows, however, more and more migrants are required to match urban natural increase, and the pattern reverses itself". Van Veenhuizen and Danso (2007: 9) support Kasarda and Crenshaw's hypothesis by stating that natural increase "is gradually becoming the dominant [factor] in most cities".

The demography of urbanisation is highly context-specific and different types of urban transformation exist. Fig. 2.2 shows typical forms[6] of the urbanisation process in SSA, based on the examples of Botswana, Cameroon, and Tanzania.

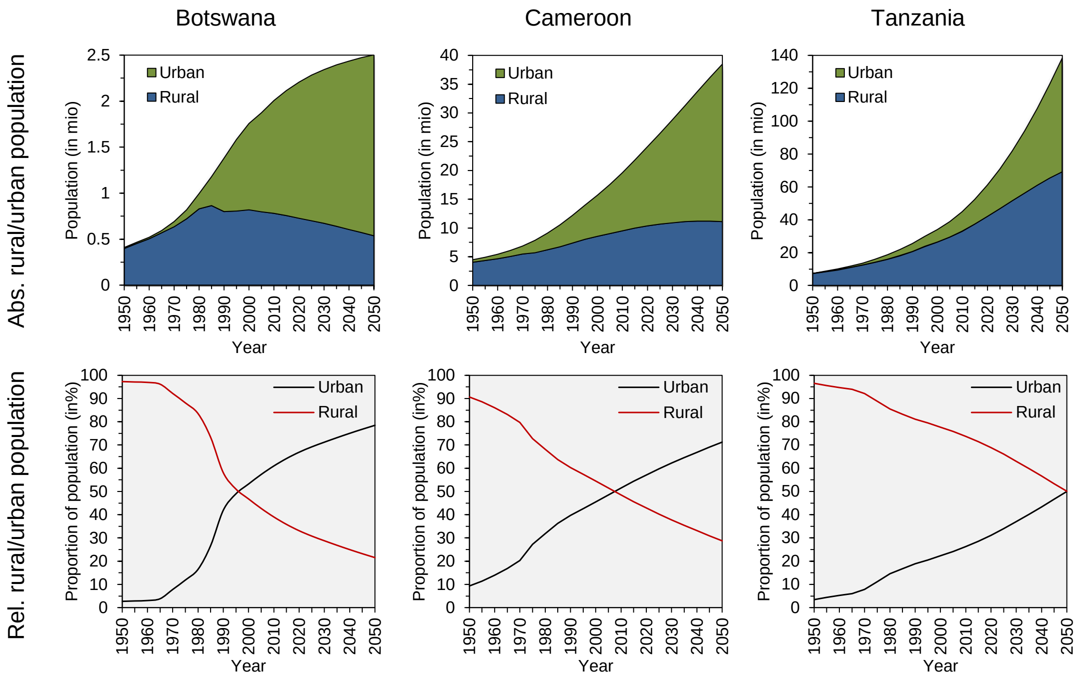


Fig. 2.2: Absolute and relative changes in rural and urban population in selected countries. Data source: UN (2012)

Type 1 (examples: Botswana, Angola, Gabun): This type is characterised by a rapid transformation from a mostly rural to an urban society. In many African countries, the independence marked the starting point of an unprecedented growth of the urban population. As this growth was to a large extent fuelled by uncontrolled rural-urban migration, urbanisation levels rose quickly. Fast modernisation and the growth of the gross domestic product (GDP), based on an export-oriented, natural resource-based economy, led to the formation of primate cities, absorbing most of the increase in urban population (e.g. Gaborone, Luanda, Libreville) as pointed out by Gwebu (2012) and others.

[5] In the interest of readability, citations in American English were converted to British English.

[6] The typology was developed by the author based on the relevant population data (UN 2012).

Type 2 (examples: Cameroon, Nigeria, Ghana): The transformation from rural to urban societies in most of the countries along the Gulf of Guinea followed a similar scheme. The initially dominant rural population is still growing, yet at relatively low rates. Simultaneously, the urban population is growing exponentially. This leads to the inversion of the ratio of urban and rural populations. The majority of these countries have either recently reached this turning point or are expected to reach it within the near future.

Type 3 (examples: Tanzania, Niger, Ethiopia): This type can be found in most of the Sahel countries from Ethiopia to Niger and Senegal as well as in most of the countries along the coast of the Indian Ocean. These countries are characterised by rural, traditional and often pastoralist societies (Thébaud and Batterbury 2001; Fratkin 2001). Urbanisation levels remain low as there is hardly any urban tradition. Settlements are dispersed and usually small. As urbanisation rates remain low and as the rural population is still growing, these countries continue to have a rural character for the decades to come. However, several dynamic growth poles tend to develop that absorb most of the urban growth (Todaro and Smith 2011; Potts 2012).

From an agricultural perspective, the abovementioned demographic processes can have negative as well as positive implications. The migration-related loss of labour force in the agricultural sector might lead to a loss of productivity. As some of the migrants come from other cities and their surroundings, it is not only the rural areas that are affected by these trends. However, the increasing non-agricultural urban population, be it through migration or natural increase, also offers new opportunities for farmers. Urban consumers bear a great potential for urban, periurban as well as rural farmers to sell their products and generate additional income (Mougeot 2005).

Urbanisation as a political-administrative process

In many African cities, urbanisation is unregulated and hardly steered by political and administrative institutions. Nevertheless, urbanisation needs to be understood as a highly political process requiring manifold administrative decisions.

Urbanisation might be catalysed by policies at the national, regional and local level. In some countries, urbanisation is perceived as a goal worth striving for in the long term and policies are set up as a stimulus for urban growth. The modern, western-style urbanism and the transformation from a traditional rural to a modern urban society is often aimed at. “The political significance of physical control over symbolic urban space” (Gugler 1996: 9) might be another motivation.

As cities grow, the demand for adjusting their boundaries is also growing. In its recent State of African Cities Report, UN-HABITAT (2010: 20) emphasises that “expanding the urban administrative territory is an option that should be considered by African governments and city managers, particularly in rapidly growing intermediate-size cities”.

Statistics on urbanisation in most cases depend on the classification of areas as either urban or rural, based on administrative principles or political interests. Changes of these artificial administrative boundaries always have an impact on the respective statistics on urbanisation. As administrative boundaries are adjusted from time to time, formerly rural areas suddenly become urban (Ellis and Sumberg 1998). All people within these newly classified areas become urban residents and urban regulations become effective. It is estimated that 10 to 20 percent of urban growth in developing countries can be explained by changes in urban boundaries (Tannerfeldt and Ljung 2006; Kasarda and Crenshaw 1991).

There are manifold examples of repeated adjustments of municipal boundaries over time. They are not necessarily the result of the evaluation of objective criteria. In many cases, the expansion of administrative areas rather follows the interests of urban politicians and administrations than reflecting the actual realities on the ground (Tinker 1994).

The consequences for urban and periurban farmers, however, can be dramatic. As boundary changes are usually conducted following a top-down approach without consulting the affected farming communities, they can appear arbitrary to the farmers. Especially periurban farmers are confronted with a lack of predictability of future developments (Mougeot 2006). Without even knowing about these changes, farming activities might suddenly become illegal as the newly urban territories fall under municipal jurisdiction (van Veenhuizen and Danso 2007). As municipal bylaws tend to prohibit agricultural activities within areas classified as urban, farmers might be forced to either stop their activities or shift to other areas. Regardless of its importance for many urban dwellers, agriculture is often looked at as a traditional, old-fashioned form of securing livelihoods, which should be kept out of the – administratively defined – cities (Smit et al. 2001).

Urbanisation as a social process

Every day, urbanisation is changing the way of life of urban residents as well as the lives of a large number of migrants with a rural background in Africa. Urbanisation therefore is accompanied by a social transformation that can ideally be summarised as the change from a traditional rural to a modern urban society (Petković 2007). Thereby, cities themselves become social constructions illustrated by the manifold metaphors that exist for urban areas: from *body*, *jungle*, and *maze* to *mosaic* and *organism* (Knox and Pinch 2007).

The impact of the urbanisation process on social structures, traditions and habits is difficult to quantify and varies from one country or region to the other. However, it is widely recognised that cities can act as a hotspot of modernisation. Cities are usually the centres of economic activity and the hubs for different forms of exchange, ranging from information to goods and services (Kessides 2005). Depending on the size, history and location of the city, this exchange can be predominantly international, regional or limited to its respective hinterland. Despite the often negative connotations of city life, such as poor housing, unsecure jobs, and a lack of community, a large proportion of the rural youth aspires to temporarily or permanently migrate to the urban areas. As mentioned before, this is mainly caused by the positive image of cities regarding job opportunities and different forms of freedom (Bakewell and Jónsson 2011).

However, as “the great majority of residents have been born and raised in rural areas” (Gugler 1996: 7), these migrants often bring with them their rural sets of values, traditions and knowledge. In many cases, this also applies to rural diets that migrants tend to preserve, even though dietary habits in general are rapidly changing (Kearney 2010). Mazengo et al. (1997: 314) exemplarily show for the Tanzanian case, that “a more Westernized life-style has been introduced” mainly in the cities, where the “availability of Western foods has improved”. Satterthwaite et al. (2010: 2815) point out that “there will be rising demands for meat, dairy products, vegetable oils and ‘luxury’ foods”. Catalysed by the urbanisation process, the per capita food consumption in SSA is expected to rise from 2,194 kcal per person per day in 2001 to 2,830 kcal in 2050 (Kearney 2010: 2794). Urbanisation and the related changes in people’s lifestyles, such as long office working hours and general individualisation, “is also associated with dietary shifts towards more processed and pre-prepared foods” (Satterthwaite et al. 2010: 2815).

The abovementioned social changes eventually have an impact on agriculture, be it rural or urban. Many urban dwellers perceive agriculture as being backward and old-fashioned which might lead to a renunciation from agricultural activities. The changes in dietary habits are another challenge that farmers have to deal with in order to be able to maintain the marketing of their products (Mougeot 2000; Satterthwaite et al. 2010). However, the changes induced by the urbanisation process also open a window of opportunity for many rural, but especially urban and periurban farmers (Armar-Klemesu and Maxwell 2000). Within an urban context, there are manifold chances for direct marketing which might lead to an increased income, as traders are kept out of the value chain. The increasing awareness of issues of sustainability, of the advantages of short distances *from farm to fork*, and the increasing demand for high-quality and nutritious food that can be observed not only in developed countries but also in many parts of the developing world, offer new options for farmers (Allen et al. 2002).

Urbanisation as an ecological process

As the urbanisation process is characterised by a land cover change from non-urban (e.g. forest, agricultural land, barren land, wetlands) to urban (e.g. buildings, streets, parks), it always has an immanent ecological dimension. The alteration of ecological systems through urbanisation creates distinct new patterns. Alberti (2008) points out that:

> “Cities are complex ecological systems dominated by humans. The human elements make them different from natural ecosystems in many ways. From an ecological perspective, urban ecosystems differ from natural ones in several respects: in their climate, soil, hydrology, species composition, population dynamics, and flows of energy and matter […]. Humans create distinctive ecological patterns, processes, disturbances, and subtle effects […].” (Alberti 2008: 1)

The complex interactions between human activity and the ecosystem as a whole are illustrated in Fig. 2.3. There are a number of driving factors, such as population growth and the expansion of urban areas, that lead to specific urban and periurban landscape patterns. These patterns are "hybrid phenomena emerging from the interplay of human and ecological processes acting on multiple temporal and spatial scales" (Alberti 2008: 13). Existing landscape patterns determine several processes, that themselves can have an impact on the patterns. Increasing soil sealing and land consumption, for example, can cause an increase in surface runoff and erosion, which in turn might influence land use patterns.

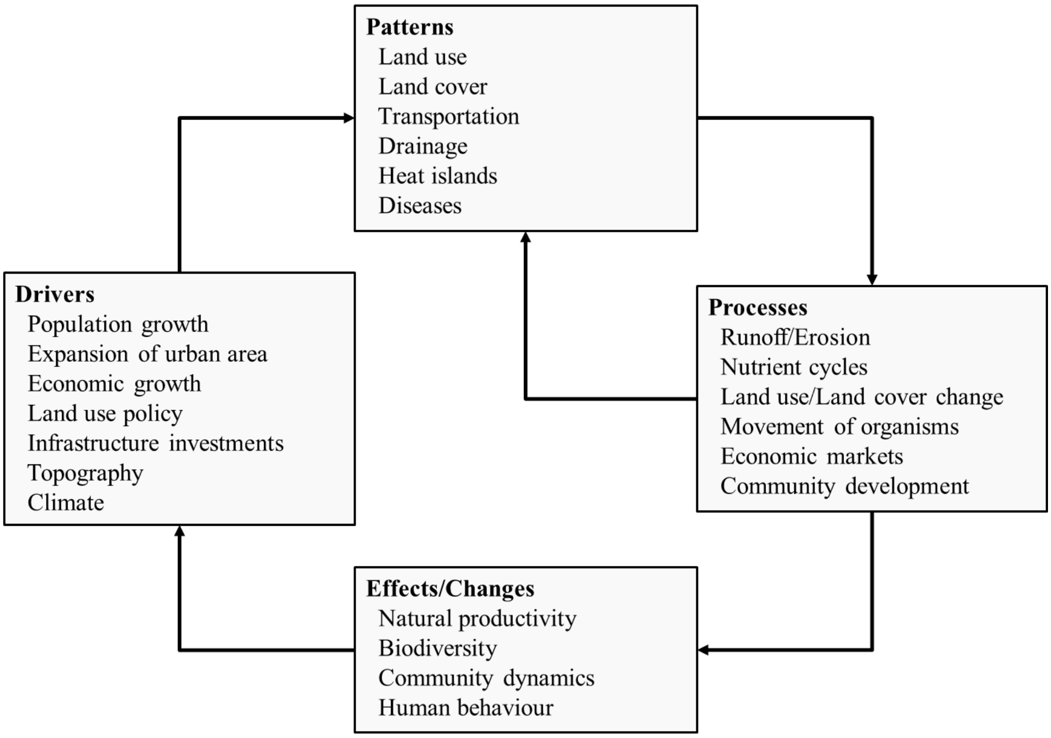


Fig. 2.3: Interactions and feedbacks of coupled human-biophysical systems in urban ecosystems (Alberti 2008: 14, modified)

These processes can have effects on the natural productivity or biodiversity which will eventually influence the abovementioned drivers of urbanisation (Whitford et al. 2001). This means that:

> "humans produce ecosystem dynamics that feed back to influence resource availability and human well-being. […] Thus, there are complex interactions and feedbacks between the direct manifestations of human activity and their diverse ecological consequences, across a range of interacting spatial and temporal scales." (Grimm et al. 2008: 264–265)

In contrast to the general perception, urbanisation does not only have destructive effects on ecosystems. By changing existing landscape patterns, urbanisation always creates distinct new urban ecosystems and increases "landscape heterogeneity" (Alberti 2008: 1). After reviewing 105 studies on the effects of urbanisation on animal and plant biodiversity, McKinney (2008: 161) points out that „species richness tends to be reduced in areas with extreme urbanisation (i.e. central urban core areas)". On the other hand, there are a significant number of studies indicating an increasing biodiversity in areas of moderate urbanisation, such as the periurban areas (McKinney 2008). Luck and Smallbone (2010: 95) support McKinney's findings and emphasise that "patterns for plants often differ from those of faunal species" and that "species richness is positively correlated with city size". Even though these findings might not apply to all cities worldwide, they are valid for urbanisation processes that are accompanied by the conversion of large-scale land use to more heterogeneous small-scale land use patterns.

Urban and periurban agriculture can be drivers of sustaining and increasing biodiversity by transforming barren land into green areas and by keeping open spaces from being transformed into impervious surface (Mougeot 2000; van Veenhuizen and Danso 2007). As these agricultural activities tend to be driven by the diverse urban demands, the diversity of agricultural production within or close to the cities is often higher than in areas shaped by export-oriented, monocultural production which in turn has an influence on periurban species richness (Deelstra and Girardet 2000).

2.1.3 Global trends in urbanisation

In 2007, the UNFPA State of the World Population stated that a milestone in world history would be reached: in 2008, for the first time half of the world population would live in urban areas (UNFPA 2007).[7] In fact, this marks a turning point in global settlement patterns (see Fig. 2.4). The number of people living in urban areas is expected to grow further, while the rural population is decreasing in relative as well as absolute terms. This leads some authors to the conclusion that an "urban century lies ahead" (Montgomery 2007: 13).

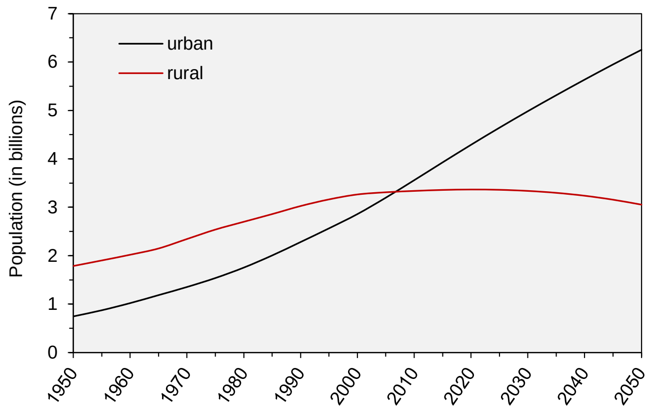


Fig. 2.4: Development of the global urban and rural population between 1950 and 2050. Data source: UN (2012)

Urbanisation in its current form has to be understood as a relatively new development. At the beginning of the 20th century just about five percent of the world's population lived in urban settlements (Njoh 2003). Statistics show that while the world population was about

[7] The press coverage of the mentioned report falsely interpreted the results in a way that from then on, half of the world population would live in cities. However, in this context the distinction between "city" and "urban area" is important. While a considerable proportion of the world's urban population lives in agglomerations classified as cities, a significant part of it lives in urban areas which are still too small to be categorised as towns or cities. In consequence, the number of people living in cities is significantly lower than the number of people living in urban areas (Satterthwaite 2007).

2.5 billion in 1950, it grew by more than 170 percent to 6.9 billion in 2010. The increase in the urban population was even more dramatic. In 1950, just about 750 million people lived in urban areas. By 2010, this number had reached more than 3.5 billion[8]. This is an increase of more than 375 percent (UN 2012). According to all relevant institutions, this trend is not expected to change for the next decades. While the world population is expected to increase by 2.3 billion until the year 2050, the number of people living in urban areas might rise by 2.6 billion. These numbers show that urban areas will be the hotspots of population growth, be it through natural increase or migration from rural areas.

Box 2.2: Terms related to urbanisation

Urbanisation: In the strictest sense of the word, urbanisation basically just means an "increase in the proportion of the population residing in towns, brought about by migration of rural populations into towns and cities, and/or the higher urban levels of natural increase resulting from the greater proportion of people of childbearing age in cities" (Mayhew 2004). However, the term has manifold important connotations that go far beyond this basic definition, such as the increasing importance of urban lifestyles, shifts in employment opportunities and infrastructure development.

Urbanisation level: The proportion of the population living in urban areas usually expressed in percentages (Satterthwaite 2007).

Rate of urbanisation: This term describes the "projected average rate of change of the size of the urban population over the given period of time" (CIA 2011). In general, countries with a low urbanisation level tend to have higher rates of urbanisation than countries where the population is already highly urbanised.

The UN population statistics clearly show that there are significant regional differences in population growth in general and rural-urban population ratios in particular. The more developed regions[9], especially Europe and Japan, have a long tradition of urban forms of life. In most regions of the less developed world, however, urbanisation in its current form is a relatively new phenomenon that has emerged after the independence of most countries in the 1960s. Therefore, these regions are often referred to as being "under-urbanised" (Satterthwaite 2007: 43). Traditionally lower levels of urbanisation, relatively high fertility levels and a very mobile population lead to a much faster increase in urbanisation levels which is also fuelled by industrialisation and other aspects of globalisation (White et al. 2008). These regions are catching up fast with the more developed regions where 78 percent of the population already live in urban areas. In the less developed regions, current average urbanisation levels are at around 46 percent, with

[8] As outlined in chapter 2.1.1, a global comparison of urbanisation levels is difficult due to the different definitions applied on the national level. However, the statistics discussed in this chapter give a rough idea of how the global rural and urban populations are distributed.

[9] The author is aware of the ongoing controversies related to the term *development*. However, according to the UN terminology, the designations *developed* and *developing* are used for statistical categorisation.

Latin America being the most urbanised at 78 percent, followed by Asia (44 percent) and Africa (39 percent) (UN 2012).

The UN expects that by 2050 around 67 percent of the global population will live in urban areas. The vast majority of the growth will be contributed by the less developed regions where the urbanisation level is projected to increase to 64 percent. Supported by these numbers, some authors identified the urban centres of the less developed countries as the "new global frontier" (Martine, ed. 2008: 1), where most of the future economic growth will be generated. Some cities located in the BRICS[10] countries, such as Bangalore in India, Cape Town in South Africa or Guangzhou in China have already proven their economic growth associated with a massive increase in their population. Other examples can be found all over the world and also in SSA, where urbanisation processes increasingly shape countries' economies and the peoples' livelihoods. However, by concentrating on these prominent examples one should not overlook the role small and medium-sized cities play in global urbanisation (see 2.1.5).

2.1.4 Sub-Saharan Africa – a rapidly changing region

SSA is still the least urbanised region in the world. Excluding the northern African countries with their different history of urbanisation, the continent currently has an urbanisation level of just 36 percent (UN 2012). SSA's urban development also fundamentally differs from other regions in the world. White et al. (2008: 309) suggest that, unlike most parts of Asia and Latin America, SSA has "a lack of tradition of town and city settlement, and the historical predominance of agro-pastoral economies". Large parts of the continent are still dominated by rural settlement patterns and lifestyles. Yet, these patterns are currently undergoing massive changes. Partly due to widespread undifferentiated images of Africa, it is often overlooked that the region is already home to as many urban dwellers as North America (Satterthwaite 2007).

According to the UNFPA (2011: 5), SSA is "the one remaining region of the world where the population is set to double or treble in the next 40 years". Much of this population growth is expected to be absorbed by urbanisation which makes the region the fastest-urbanising in the world. Between 2010 and 2015, the urban population in the region is estimated to grow at 3.6 percent per annum compared to 2.0 percent on a global scale. This growth is likely to continue for the next decades (UN 2012; White et al. 2008). Given the abovementioned growth rates, the urban population of the region will grow by more than 770 million people until the year 2050. However, there are significant intra-African differences.

[10] BRICS is the abbreviation for a group of emerging economies, namely Brazil, Russia, India, China and South Africa.

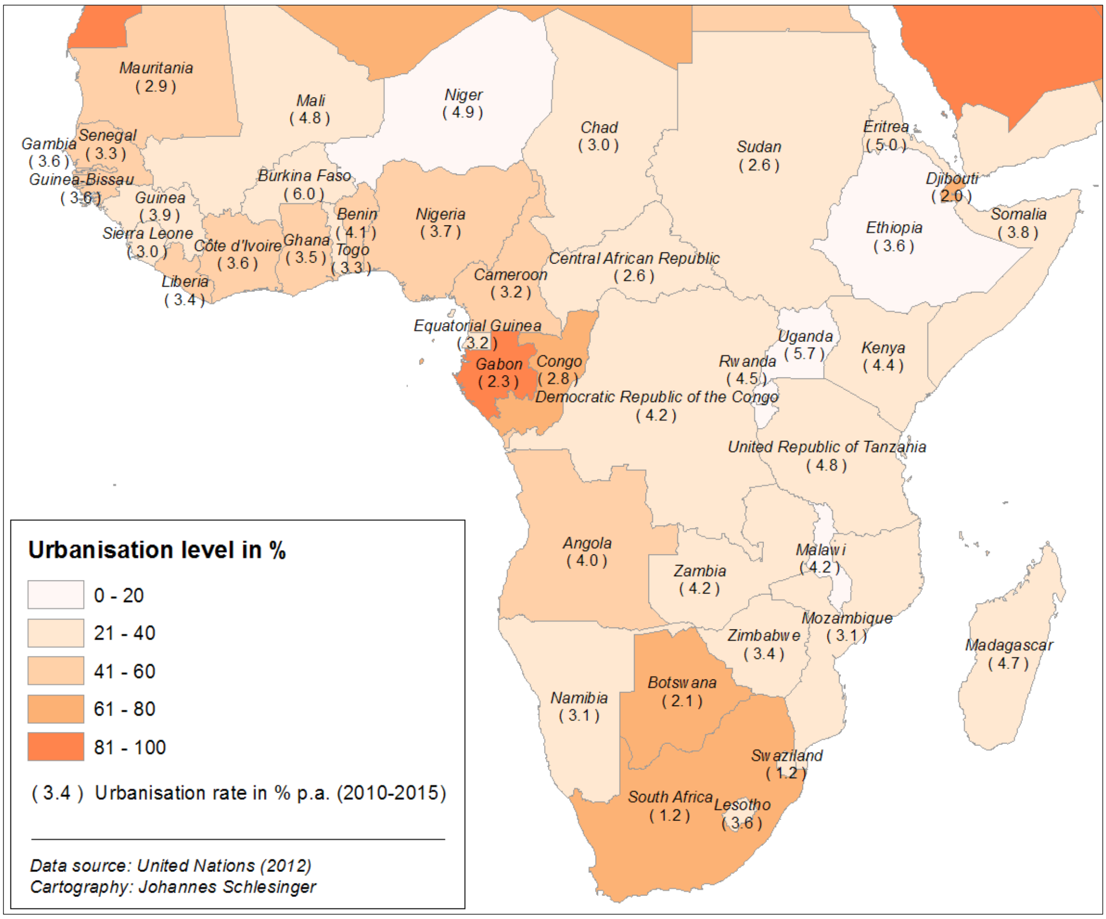


Fig. 2.5: Urbanisation levels and rates of urbanisation in sub-Saharan Africa. Data source: UN (2012)

Southern African countries such as Botswana and South Africa and the countries along the Gulf of Guinea tend to be more urbanised due to the early concentration of large parts of their population in urban areas (see Fig. 2.6). Their urbanisation levels are as high as 40 to 60 percent which is comparable to most countries in northern Africa, Asia and Latin America. Being relatively urbanised already, their rates of urbanisation typically range from two to three percent per annum (see Fig. 2.6). On the other end of the spectrum are countries such as Ethiopia, Niger and Uganda with urbanisation levels of less than 20 percent and rates of urbanisation of up to six percent (UN 2012). They experience what some authors have named “rapid urbanisation”, partly caused by armed conflicts, globalisation and accompanying (inter-)national development policies such as the Structural Adjustment Programmes introduced by the World Bank and the International Monetary Fund in the 1980s and 1990s (Potts 2012; Njoh 2003; Hope 1998; UN-HABITAT 2010).

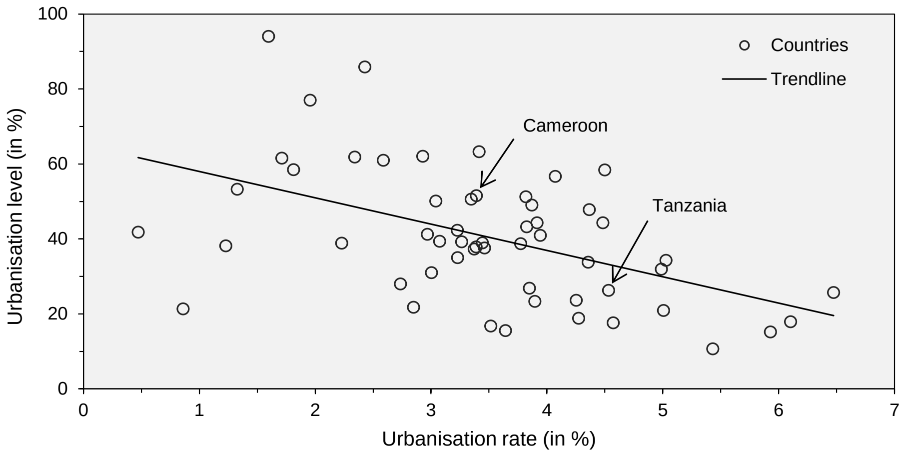


Fig. 2.6: Correlation between urbanisation levels and rates of urbanisation in sub-Saharan Africa in 2011. Data source: UN (2012)

2.1.5 Small and medium-sized cities as drivers of urbanisation

Large cities such as Nairobi, Lagos or Johannesburg are vivid examples of the immense extent of changes related to the urbanisation process (Cohen 2006). These cities shape the images of urbanisation that is associated with the rapid growth of slums, traffic congestions and an increasing gap between rich and poor. Media coverage, research efforts and reports published by the leading international institutions often concentrate on the continent's biggest cities and their role in the urbanisation process (Bell and Jayne 2009)[11]. Large cities are in fact responsible for a large part of urban growth. For the next decades, however, the majority of the urban population is expected to live in urban areas of less than 500,000 inhabitants (Cohen 2006; Matuschke 2009). Small and medium-sized cities (SMCs) play an important role in past, current and future urbanisation worldwide and in SSA in particular. In 2010, more than 150 million Africans lived in SMCs while around 120 million lived in urban agglomerations with a population of more than half a million (see Fig. 2.7). As patterns of urban growth change and SMCs undergo a fast transformation process, they will become more important in future population developments.

[11] UN-HABITAT's State of African Cities Report published in 2010 basically only covers the development of the continent's capitals. However, the role of small and medium-sized cities is hardly mentioned.

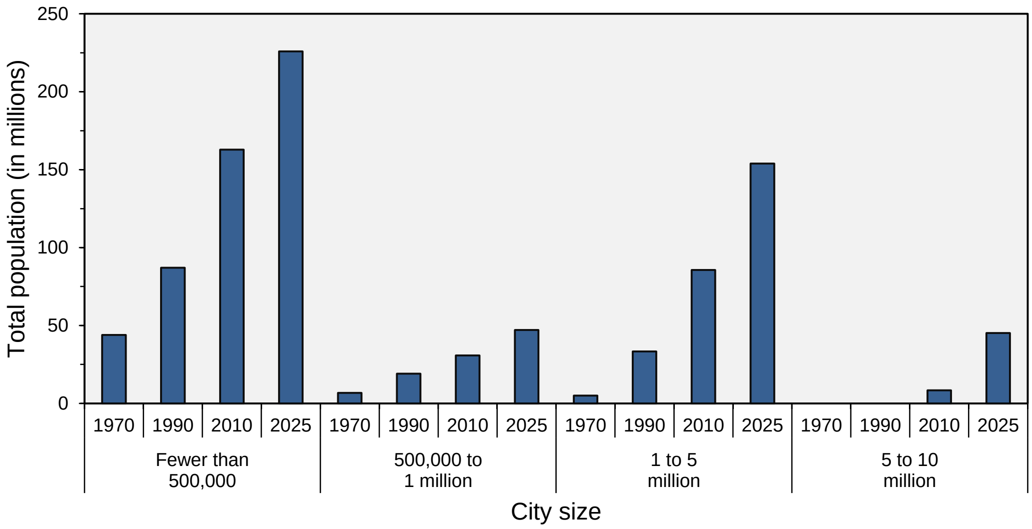


Fig. 2.7: Development of the urban population in sub-Saharan Africa by city size class. Data source: UN (2012)

It must be emphasised that knowledge about urban transformation and the associated problems and opportunities in large cities do not necessarily correspond to the situation of smaller cities. As Martine (ed. 2008) shows, known issues, such as land tenure conflicts and food access, need to be addressed differently and new issues might arise within this context.

Small and undermanaged – challenges for SMCs

As many authors have pointed out, some SMCs tend to have more unaddressed problems than their bigger counterparts, particularly regarding all aspects of infrastructure provision, such as housing for a fast growing population, piped drinking water and sanitation as well as wastewater and solid waste management systems (Martine, ed. 2008; UN-HABITAT 2006). As a result, poverty rates are generally higher in smaller cities which in turn leads to higher levels of infant and child mortality. In some countries statistics even show a negative correlation of poverty indicators to the city size (Cohen 2006).

The inadequate provision of basic services is one of the negative side effects of the ongoing decentralisation process in many countries in SSA (UN-HABITAT 2006; Panel on Urban Population Dynamics et al. 2003). While a lot of responsibilities are relocated to regional and municipal authorities, their human, financial and technical capacities are not developed to an appropriate extent (Montgomery 2008). As a consequence, local administrations cannot meet the expectations regarding service provision associated with the process of decentralisation. This does not just apply to the abovementioned basic services but also to indirect services such as land use zonation, transport system development and the provision of access to food.

The rapid urban transformation process in SMCs comes along with an increased demand for flexible and efficient urban management and governance systems, as these cities have to adjust to new developments quickly. However, many administrations in these cities have not yet adjusted to these new demands and therefore face serious problems in appropriately addressing them (Drescher and Iaquinta 2002; Cohen 2006). The results are unsuitable policies and development strategies which lead to a loss of steering capacity and hence unplanned, unfavourable urban development.

Small is beautiful – why SMCs are better than their reputation

SMCs might face significant problems in terms of the provision of basic services for their citizens. However, the situation in many of those cities is much better than their reputation. In many cases, they are highly flexible. Compared to bigger cities, they can easily adjust to the rapid changes related to the urbanisation process, such as increased demand for housing, accelerating environmental degradation, and the territorial expansion of urban areas (Martine, ed. 2008).

This flexibility is favoured by greater autonomy and independence from the central government. That brings these cities into a position, where they can find locally adjusted solutions rather than following the often biased national policies that are developed in the countries' capitals (Tacoli and Satterthwaite 2003). Informal and personalised contacts between decision makers and those who are affected can increase the accountability of municipal administrations. As a result, the relationship between citizens and their urban governments tend to be „less conflictive than in larger cities" (UN-HABITAT 2006: 1).

Smaller cities bear the potential of bypassing inappropriate technologies and development paths that have been implemented in their larger counterparts in the past (Cohen 2006). Many bigger cities are still suffering from well-meant *development measures* that ended up having unintended and often negative effects. In many cases, these effects have been manifested and still hinder sustainable urban development initiatives.[12] SMCs can learn from these mistakes and incorporate "efficient, ecologically-sound practices" (Cohen 2006: 74) in future city expansion, land use zonation and policy formulation.

[12] For example, current urban development in Dar es Salaam (Tanzania) is still affected by the liberalisation of public transportation services in the 1980s. While the intention was a more efficient and customer-oriented transportation system, the uncoordinated mushrooming of private sector companies lead to a breakdown of inner-city traffic that is expected to remain one of the major obstacles for the city's development in the years to come (Ngowi 2005).

Table 2.1: Generalised comparison of selected indicators of small and medium-sized cities and larger cities in sub-Saharan Africa

Indicator	City category	
	SMCs	Larger cities
Flexibility	High due to small administration	Limited due to large city governments
Relationship citizen - government	Administration easily and informally accessible	Formalised and impersonal relationship
	High degree of accountability of decision makers due to personal relationships	Lack of exchange between stakeholders and therefore unadjusted policies and development measures
Human resources	Lack of human resource capacities to appropriately address responsibilities (partly as a consequence of decentralisation)	Big administrative bodies with high staff numbers ⇨ Possible lack of coordination between big administrative bodies
Opportunities for future development	Framework for future development still to be determined	Future development to a large extent determined by status quo

Based on UN-HABITAT (2006); Cohen (2006); Tacoli and Satterthwaite (2003); Martine (ed. 2008); Drescher and Iaquinta (2002).

It can be summarised that SMCs are usually highly dynamic and flexible urban agglomerations that have been widely neglected in the past and present discourse on urbanisation worldwide and in SSA in particular. In contrast to many larger cities whose structures have been widely laid out in the past and manifested for the decades to come, SMCs still have many options regarding a citizen-oriented, efficient and sustainable future development. This particularly applies to the steering of the spatial expansion of the urban areas and the flexible adjustment of land use zonation. The incorporation of agriculture in urban and periurban land use strategies is often easier in SMCs than it is in big cities. This is an important aspect as many of these cities will experience further growth and eventually host large urban populations that will have to be fed. Fortunately, most of these cities are still in a position to actively shape their future development by recognising the role of agriculture within the urbanisation context.

2.1.6 How urban areas are shaped – some theoretical considerations

In order to understand how future development will change the cities in SSA, one has to know how urban areas are shaped. As urbanisation is a manmade process, the "spatial pattern of land use reflects underlying human processes and influences" (Luck and Wu 2002: 328). This particularly applies to fast growing urban areas in developing countries as the hotspots of human activity:

> "Urban spaces are created by people, and they draw their character from the people that inhabit them. As people live and work in urban spaces, they gradually impose themselves on their environment, modifying and adjusting it, as best they can, to suit their needs and express their values." (Knox and Pinch 2007: 6)

Accordingly, the spatial shape of urban areas is conditioned by human behaviour, be it based on long-term planning mechanisms of administrative bodies or spontaneous decisions of individuals. The resulting patchwork of urban land use and corresponding socio-spatial arrangements are often complex and difficult to capture.

Models of urban morphology

A wide range of sociologists, economists and – most importantly – geographers have developed a large number of models that help generalise the complex morphology of urban areas (Luck and Wu 2002). These models go beyond a simple description of urban structures trying to provide explanations for the abovementioned arrangements in urban contexts. The classical models of urban morphology (see Fig. 2.8) were developed in the first part of the 20th century, yet they still provide a valid entry point for studies on current urbanisation.

The models of urban morphology introduced below have in common the understanding of urban areas as providing the framework for residential, office, manufacturing and infrastructure purposes. The existence of agricultural land use within the city or in periurban areas, however, is not recognised in any of the existing models. Yet, these models help understand the drivers of urban development which eventually lead to current urban morphology. In order to evaluate the current and possible future role of UPA in rapidly growing cities in SSA, one has to consider why African cities are shaped the way they are.

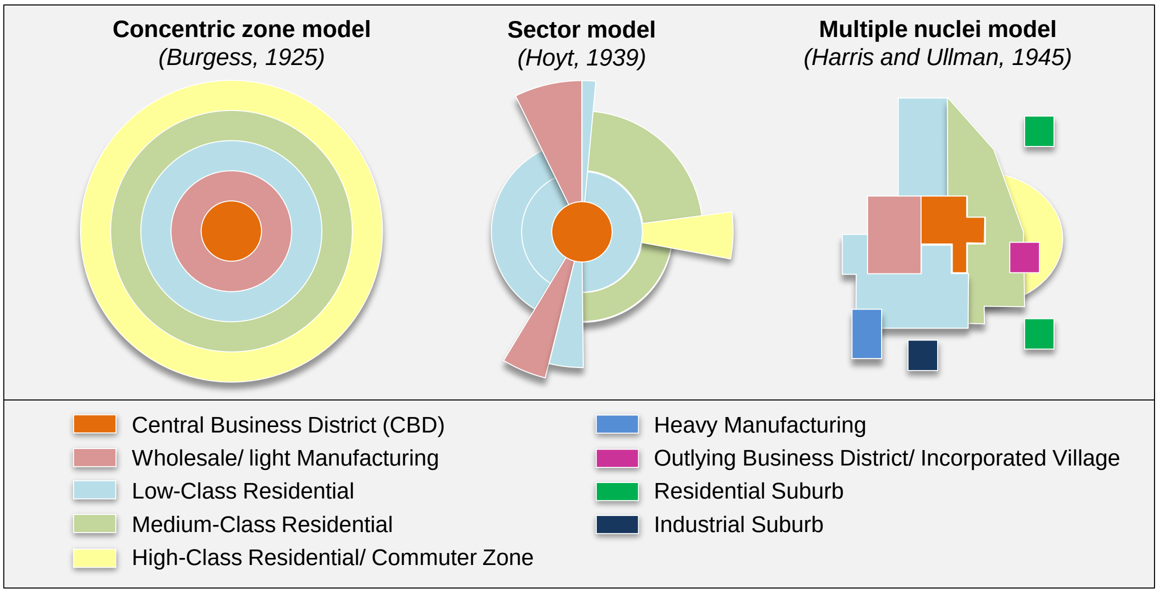


Fig. 2.8: Classical models of urban morphology (based on Park et al. 1925; Hoyt 1939; Harris and Ullman 1945)

The "Concentric zone model" (Park et al. 1925), also known as the Burgess' model, is one of the earliest theoretical approaches to explaining the specifications of urban land use. The model basically transfers considerations by von Thünen (1910) on regional land use to an urban context. The basic assumption of the concentric zone model is the relationship between the socio-economic status of the population and the distance from the city centre, namely the Central Business District (CBD).

Hoyt's (1939) "Sector model" supplemented Burgess' model with sectors that are oriented along important transportation arteries, such as railways and highways. His basic assumption was that these transport lines would become increasingly attractive for the establishment of a manufacturing sector. On the other hand, only socio-economically disadvantaged groups would settle along these lines, as land prices are relatively low because of noise and other forms of pollution. This would in turn lead to a specific form of spatial segregation.

In 1945, the geographers Harris and Ullman (1945) developed the less generalising "Multiple nuclei model". Their model reflected the incorporation of former satellite villages. According to the "multiple nuclei model", these structurally persistent villages become additional nuclei within the growing city. The result is a more diversified and more complex urban landscape.

While the abovementioned models are of limited validity due to the oversimplification of the complexity of urban environments, they are still helpful in understanding urban structures. These models were elaborated based on a western perspective and the experience of an urbanisation process that was shaped by a long-standing tradition of industrialisation. Transferring these models to the African setting with its highly variable spatial structures is difficult (Lowder 1986), even though "urban form tends to converge with North American and European patterns as industrialization accelerates" (Kasarda and Crenshaw 1991: 481). However, there is still a lack of conceptual studies specifically focussing on African urbanisation and the specifications of the local socio-historical context (Potter and Lloyd-Evans 1998; Simon 1989).

Based on the western models of urban morphology, Fouberg et al. (1977) came up with their model of a sub-Saharan city (also known as de Blij's model), acknowledging the diversity of the continent's cities.[13] Their model can be applied specifically to those cities that have been transformed to a large extent during the respective colonial rule. The city centre consists of three distinct sectors; the CBD as a remnant of colonial urbanisation, a traditional CBD that was usually founded before European powers started steering urban planning, and an informal and typically periodic and open-air market zone (see Fig. 2.9).

[13] In the same year, Manshard (1977) published his „basic pattern of urban development in Tropical Africa" (Manshard 1977). Even though his model is more detailed, it largely corresponds to de Blij's model and is therefore not discussed in detail.

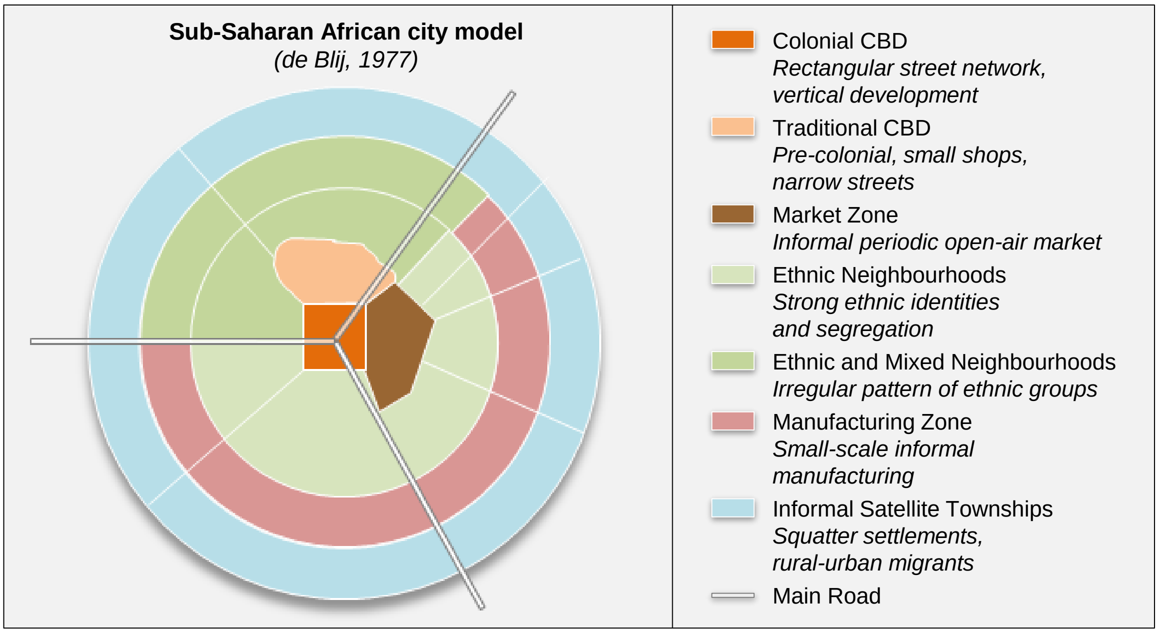


Fig. 2.9: de Blij's model of a typical sub-Saharan African city (based on Fouberg et al. 1977)

Located in close proximity to the city centre are several medium-class neighbourhoods. According to de Blij's model, ethnicity is a key factor for the spatial organisation of the population of African cities. Most of the residential areas are characterised by strong ethnic identities and segregation. Just a small part of the cities is made up of rather mixed neighbourhoods (Fouberg et al. 1977). The manufacturing zone is located at the edge of the inner city, close to the quarters where the workers live. Informal squatter settlements surround the city and provide housing for the poor and migrants from the rural areas.

Even though the abovementioned models of urban morphology provide an entry point for urbanisation research, they cannot sufficiently capture the complex situation in and around rapidly growing cities in SSA. The population growth in these cities usually comes along with an increase in their spatial extent. This, in turn, leads to significant transformations of land use and social settings in – and more importantly – around urban agglomerations. The following chapter therefore discusses the state of research regarding these areas under transformation.

2.1.7 Urban-to-rural gradients and the special role of the periurban

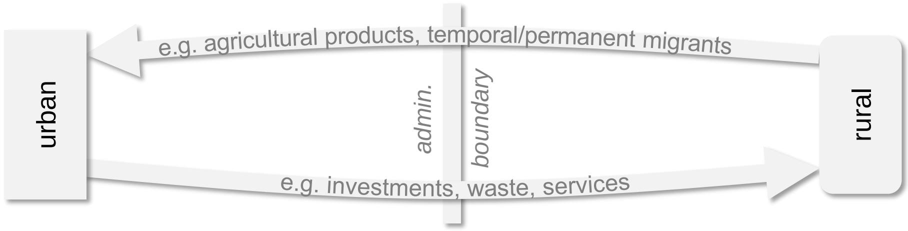
According to Lerner and Eakin (2011: 2), rural and urban spaces have "traditionally been conceptualised in dichotomous terms on the basis of an assumed clear distinction between 'rural' and 'urban' land uses and livelihoods." Both terms have thereby been understood as describing two inherently different and usually opposing extremes. Depending on the respective academic background, urban areas have been described as *modern*, *densely populated*, or *economic hotspots* while rural areas have been defined using their respective antagonisms. However, this dichotomous understanding of urban and rural areas raised the question of the nature of the border between these two extremes. Determining the boundary has been stressed as an important task especially in the course of planning processes and the – often complex – question of land tenure. However, Sadiki and Ramutsindela (2002: 75) describe "locating the rural-urban boundary" as a "practical challenge", especially in SSA where "rural-urban lines are arguably more blurred […] than elsewhere" (White et al. 2008: 310). Simon et al. (2006: 4) summarise that "nowhere is there a neat dividing line where the city meets the savannah, bushveld, forest or desert".

Even though the dichotomous differentiation between urban on the one side and rural on the other has advantages and is sometimes indispensable, such an approach has its insufficiencies and is therefore increasingly rejected not only by the scientific community but also by the planners themselves (Simon et al. 2006; Sadiki and Ramutsindela 2002). According to Allen (2004: 13), "the urban-rural dichotomy [is] […] a reflection of the arbitrary definitions applied by professionals and institutions" that is of limited use for the analysis of changing patterns in human settlements (White et al. 2008). With regard to the African context, White et al. (2008: 311) emphasise that the "dynamic links between rural and urban areas […] are lost in the dichotomous data and projections of rural and urban populations" and Tacoli (1998: 3) stresses that "these distinctions are over-simplified descriptions of both rural and urban livelihoods". According to a statement in a recent publication by the FAO (2012a: 16), this divide is "artificial and counter-productive". Therefore the UN (2008b) summarise:

> "Hence, although the traditional urban-rural dichotomy is still needed, classification by size of locality can usefully supplement the dichotomy or even replace it where the major concern is with characteristics related only to density along the continuum from the most sparsely settled areas to the most densely built-up localities." (UN 2008b: 124)

The understanding of the complex relationship between urban and rural areas that goes beyond a dichotomous thinking has been increasingly established in academia (see Fig. 2.10). Allen (2004: 13) has observes "an increasing recognition of the fact that rural and urban features tend to coexist more and more within cities and beyond their limits". The existence of "land use and demographic gradations around urban centres" (Lerner and Eakin 2011: 2) are increasingly accepted.

a) The urban-rural dichotomy



b) The urban-rural continuum

Fig. 2.10: Urban-rural dichotomy versus urban-rural continuum

This acceptance brings the areas of transition between the two poles – urban and rural – into focus of scientific interest. In the relevant literature, a wide variety of designations for these areas can be found, ranging from *periurban interface* (e.g. McGregor et al., eds. 2006; Rakodi 1999), *urban-rural interface* (e.g. Simon 2004; Browder 2002), *urban fringe* (e.g. Trefon 2009) to *rurban* (e.g. Okafor 1986). Even though the respective authors might have differing research foci and terminologies, they all have in common the recognition of an area of distinct characteristics that needs to be particularly addressed.

Today, the most commonly found term for this particular area of transition is *periurban*. Even though this label is well established and widely used in urbanisation research, these studies still lack a common definition. Several attempts have been conducted to narrow down the essential characteristics of the periurban. The most obvious way of defining it is to take a location-based approach. According to this approach, distance to the city centre and the adjacent built-up area is seen as the most important variable for its definition. Some authors suggest certain distance thresholds for the determination of periurban areas (e.g. Webster and Muller 2004; Adam 2001; Gregory 2005).

However, this simplified approach has been criticised, as it does not appreciate the full complexity of the urban morphology. Simon et al. (2006: 5) stress that “there are different types of transition zones between city and countryside […]. Some may resemble relatively uniform sprawl, others honeycomb structures or spines of growth along specific corridors”. These structures are understood as the manifestation of a wide range of underlying processes (Binns and Lynch 1998). Therefore, several authors propose a rather process-based approach to understand the periurban without neglecting the role of its location. According to Drescher and Iaquinta (2002: 26) “understanding the nature and operation of the [urban, periurban, rural] system requires a focus on the underlying dynamic processes and flows rather than the ‘fixed states’”. The processes are manifold including land use changes, changes in the social structure of its residents, and changes in the legal/administrative frameworks. These processes are strongly interlinked with the respective flows of people (migration), goods (trade), and money (investments).

Defining the periurban as the term for the resulting land use and social patterns is difficult. Yet, a wide range of descriptions of the peculiarities of this area exist. Rakodi (1999) describes it as:

> "a dynamic zone both spatially and structurally. Spatially it is the transition zone between fully urbanised land in cities and areas in predominantly agricultural use. It is characterised by mixed land uses and indeterminate inner and outer boundaries, and typically is split between a number of administrative areas." (Rakodi 1999: 2)

According to Drescher and Iaquinta (2002), there are three major perspectives on this issue:

> "[1] From an ecological perspective, periurban areas can be characterised as an interface or heterogeneous mosaic of 'natural', 'productive' or 'agro-ecosystems' and 'urban' ecosystems, affected by material and energy flows demanded by urban and rural systems. […]
>
> [2] In socio-economic terms, the composition of periurban systems is highly heterogeneous and subject to rapid changes over time. Small farmers, informal settlers, industrial entrepreneurs and urban middle class commuters may all coexist in the same territory but with different and often competing interests, practices and perceptions.
>
> [3] In institutional terms, the periurban interface is characterised by a general lack of institutions capable of addressing the links between urban and rural activities. This is reinforced by the convergence of sectoral and overlapping institutions with different remits." (Drescher and Iaquinta 2002: 25)

As the underlying processes lead to a constant change in the periurban areas, several authors emphasise its dynamics. Rakodi (1999: 2) argues that it "shifts over time as cities expand" and Simon et al. (2006: 10) add that "a periurban[14] zone may change in width and the steepness of what we might call its rural-urban gradient over quite short periods of time, depending on the nature of pressures within the growing metropolis and of migration towards it".

Today, the periurban is widely recognised as an area of distinct processes, structures, and spatial patterns. It is thereby seen as an integral – yet difficult to capture – part of the urban-rural continuum. The recognition of its importance for understanding urbanisation processes has significantly increased in the past. However, definitions are often vague or even contradicting due to the complexity of the area.

Nevertheless, there is an increased understanding of the periurban, with the growing body of research on urban and periurban agriculture playing an important role in this process.

[14] In the interest of readability, *peri-urban* was transformed into *periurban* in all citations.

2.2 Urban and periurban agriculture as part of the urban system

"In an urbanizing world running short of natural resources, the possibility that cities can depend upon the ingenuity of their residents to generate food security for themselves is significant."
(Smit et al. 2001: 1)

Urban and Periurban Agriculture (UPA), also called urban and periurban farming or metropolitan agriculture, is a significant economic activity for a large share of the urban population worldwide. Despite the common perception as being "archaic, temporary, and inappropriate" (Smit et al. 2001: 1), UPA is a common practice in many cities all over the world. As Table 2.2 shows, there were around 800 million urban farmers in 1993, around one fourth of them producing for marketing purposes. Up to date there has been no other global survey on how many people are involved in UPA. However, as the urban population has increased by around 60 percent in the meantime (UN 2012), these numbers are likely to be outdated. The number of farmers involved in UPA might therefore be close to 1.3 billion today. Adding all the other jobs in production and processing, one can state that about 1.5 billion people's livelihoods depend on this activity. This means that one fifth of the global population directly benefits from UPA.

Table 2.2: Global estimates of the level of urban agricultural activity

	Global estimate	
	1993[15]	2012[16]
Urban farmers	800,000,000	1,300,000,000
Market-oriented farmers	200,000,000	300,000,000
Jobs in production and processing	150,000,000	250,000,000
	Range of data	Global significance
Share of urban families involved in UPA	15 – 70 %	ca. 30 %
Proportion of consumption produced in urban areas (vegetables, eggs, meat, fish)	10 – 90 %	ca. 30 %
Urban land used for agriculture	20 – 60 %	more than 30 %

Based on Smit et al. (2001); UN (2012).

About one third of urban families worldwide are estimated to be involved in this activity, cultivating more than one third of the urban space and meeting about one third of the urban demand with their production (see Table 2.2).

[15] The data published by Smit et al. (2001) were based on extrapolations from statistics, census data and other sources. They can therefore only provide a rough estimation of the actual numbers.

[16] For the current estimate, the data was extrapolated based on the respective statistics on the increase of the global urban population (UN 2012). As the urbanisation process is complex and can have different manifestations, a simple data extrapolation might not accurately reflect the actual developments. However, it shows the general significance of urban and periurban agriculture.

As official statistics are often fragmentary and regional studies on the topic are sparse, estimating respective numbers for SSA is difficult. Armar-Klemesu and Maxwell (2000: 103) state that "in 1993, between 15 and 20 percent [17]of the world's food was produced in urban areas" and Mougeot (1994b) estimates that around 40 percent of the urban population in Africa is involved in UPA. Other authors even estimate that 70 percent of urban residents in Africa were engaged in this sector in the 1990s (Bryld 2003). Several case studies have shown its significance all over the continent. According to Moustier (1999) all leafy vegetables in Bangui in the Central African Republic are produced within the city, 80 percent in Brazzaville (Congo) and 90 percent in Bissau (Guinea Bissau). Smit et al. (2001) estimate that the quantity of horticultural production in Mali's capital Bamako is sufficient to meet the demands of the urban market, and that in Kampala (Uganda) about 70 percent of poultry is produced within the urban area. Numerous other studies have support these findings regarding the significance of UPA for the food supply of urban agglomerations in Africa. As urbanisation has transformed livelihoods in and around African cities in the past decades, UPA has become increasingly important and the importance of UPA is likely to grow in the future (Foeken 2005; Lerner and Eakin 2011).

2.2.1 Defining urban and periurban agriculture

The importance of UPA for food security and income generation is widely recognised within the scientific community. However, with growing research interest in the topic, many different definitions have been developed and applied within the numerous case studies. All definitions have in common the implicit or explicit inclusion of "growing of food for human and animal consumption" (Hovorka 1998: 59). Others also include the collection of wild fruits and vegetables, fishing or even the production of non-food products such as fuel and timber (Hovorka 1998).

A very basic definition is proposed by Maxwell and Armar-Klemesu (1998):

> "Urban agriculture refers to farming or livestock keeping within the municipal boundaries" (Maxwell and Armar-Klemesu 1998: 7)

However, as described in chapter 2.1.2, land use including urban and periurban agriculture does not follow artificial municipal boundaries. There is a need for a more elaborated definition that comprehensively captures the different dimensions of UPA. Mougeot (1994b) extends his definition in order to cover the spatial complexity of the urban environment:

> "Urban agriculture […] can be defined as the growing of food and nonfood plant and tree crops and the raising of livestock (cattle, fowl, fish, and so forth), both within (intra-) and on the fringe of (peri-) urban areas." (Mougeot 1994b: 1)

Chapter 2.1.7 shows that defining borders between urban, periurban and rural is difficult. Therefore, definitions of UPA are often vague when it comes to the spatial dimension. Numerous authors define UPA as an activity that takes place "in and around cities"

[17] In the interest of readability, *%* was transformed into *percent* in all citations.

(Graefe et al. 2008; de Zeeuw 2010; Lerner and Eakin 2011). However, certain thresholds to distinguish between urban and periurban are usually not provided. Therefore, periurban space is often defined indirectly by defining periurban agriculture. Maxwell and Armar-Klemesu (1998) specifically define periurban agriculture as follows:

> "the same [agricultural] activities in the area immediately surrounding the city in areas where the presence of the city has an impact on land values, land use, property rights, and where proximity to the urban market and urban demand drive changes in agricultural production." (Maxwell and Armar-Klemesu 1998: 7)

The distinction between urban and periurban agriculture addressed by Maxwell and Armar-Klemesu (1998) is important as there are significant differences between the two. Even though the transition from urban to periurban is fuzzy, some ideal characteristics of agriculture within the respective areas can be distinguished (see Table 2.3).

Table 2.3: Comparison of ideal characteristics of urban and periurban agriculture

Urban agriculture	Periurban agriculture
Small-scale	Medium- to large-scale
Mainly human labour, hardly mechanised	Partly mechanised
Practised by poor urban dwellers	Practised by groups and individuals with ready access to capital markets
Mainly for subsistence	Primarily market-oriented production
Urban agriculture as a part time job	Periurban agriculture as a full time job
Low-value crops	High-value crops

Based on Drescher (2001); de Zeeuw et al. (2000)

The lack of land suitable and accessible for agriculture within the city is the main reason for the small-scale character of urban agriculture in contrast to periurban areas, where larger plots are still available for cultivation. This in turn has implications for the mechanisation and market-orientation of the production. The abovementioned definition of periurban agriculture introduced by Maxwell and Armar-Klemesu (1998) has shown that the proximity to the urban markets combined with the availability of land makes periurban agriculture ideally more market-oriented than its (intra-)urban counterpart. According to previous studies (e.g. Drescher 2001) the agricultural activity tends to be a full-time job for periurban farmers, as their livelihoods often depend on it. On the other hand, as urban farmers cultivate on a limited area, agricultural production is usually not enough for marketing and therefore just supplements their nutrition and/or income.

Characterising all the different forms of UPA based on just one single definition is difficult. However, Smit et al. (2001) propose a definition that attempts to incorporate these different forms. Their much cited definition, originally formulated in 1996 and extended in 2001, can be regarded as the most comprehensive approach to define UPA:

> "Urban agriculture can be defined as […] an industry that produces, processes, and markets food, fuel, and other outputs, largely in response to the daily demand of consumers within a town, city, or metropolis, on many types of privately and publicly held land and water bodies found throughout intra-urban and periurban areas. Typically urban agriculture applies intensive production methods, frequently using and reusing natural resources and urban wastes, to yield a diverse array of land-, water-, and air-based fauna and flora, contributing to the food security, health, livelihood, and environment of the individual, household, and community." (Smit et al. 2001: 1)

In the present study, the abovementioned definition is applied as a working definition.

2.2.2 Deconstructing Smit's definition of urban and periurban agriculture

Based on the abovementioned definition by Smit et al. (2001), several dimensions influencing UPA activities can be identified.

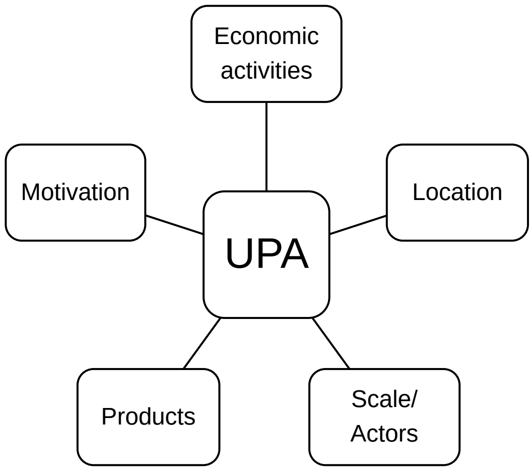


Fig. 2.11: Dimensions of urban and periurban agriculture (based on Mougeot 2000; Smit et al. 2001)

Location

By definition, the location of the agricultural activity is the fundamental criterion to distinguish urban from periurban and rural agriculture. Location is so important because "this points to specific constraints and opportunities such as degree of land access, the land tenure situation, costs and time related to travelling to and from the production site, closeness to markets and risks" (van Veenhuizen and Danso 2007: 15). The literature on UPA offers manifold criteria for the categorisation of UPA based on its location. Mougeot (2000) compiles some of the most commonly used categories:

> "location respective to residence (on-plot or off-plot), development status of site (built-up vs open-space), modality of tenure/usufruct of site (cession, lease, sharing, authorised or unauthorised – through personal agreement, customary law or commercial transaction); the official land-use category of the sector where [urban agriculture] is practised (residential, industrial, institutional, etc.)." (Mougeot 2000: 7–8)

These categories emphasise the wide variety of locations possibly used for agricultural production in urban and periurban areas. UPA can take place in a broad range of settings, often transforming vacant or under-utilised land into productive areas (de Zeeuw et al. 2000). The economic use of this land can be increased, "since income is generated from temporarily available land and lands not suitable for building" (Bryld 2003: 81). This can include the cultivation on private land, such as backyards and around houses, on community and other public lands, such as parks, along roads, railways, power lines and streams or in areas that are too steep for construction (Drescher and Gerold 2010; de Zeeuw et al. 2011; Bryld 2003). Table 2.4 provides an overview of a useful classification of UPA based on its location and legal status:

Table 2.4: Classification of urban and periurban agriculture based on its location and legal status

Category	Legal status	Examples
Private spaces	private	In backyards, gardens and on other private plots suitable for cultivation
Institutional spaces	semi-public	Around hospitals, schools, prisons, and other public buildings
Areas not suitable for construction	semi-public and public	Along roads, railway tracks, power lines and streams; in flood-prone areas and areas too steep for construction
Ecological reserves/protected areas	semi-public and public	In ecological reserves, parks and protected forests
Treatment areas	semi-public and public	Landfills
Green areas	public	In recreational parks and on squares
Public spaces	public	Other municipal public land

Based on Dubbeling (2004)

This table shows that UPA can be an alternative or, in the best case, a supplementation to other urban land uses due to its flexibility in terms of locality.

Scale/Actors

The question of who the urban and periurban farmers are is difficult to answer, as there is not one single type of farmer. Corresponding to the manifold locations where UPA is practiced, there are manifold sorts of those who practice it. Mougeot (2000) points out that farms are generally run by individuals or families and some small and medium enterprises as opposed to larger companies operating on the national or even international level. Moustier and Danso (2006) propose a simple classification of UPA types based on locality and actors involved. Based on earlier attempts to classify the actors, they came up with the differentiation of four types of actors involved in UPA as presented in Table 2.5.

Table 2.5: Types of actors involved in urban and periurban agriculture

Type	Location	Gender
Homes subsistence farmers	urban (periurban)	mainly female
Family-type commercial farmer	urban and periurban	male and female
Entrepreneurs	periurban	mainly male
Multicropping periurban farmers	periurban	male and female

Based on Moustier and Danso (2006)

This basic classification can be applied to most urban and periurban farmers worldwide and in SSA in particular. However, a more elaborate classification might be needed in order to appropriately capture the diversity of UPA actors and their respective farming systems. On a more nuanced level, several different actors on different scales can be identified. Based on the actors involved, RUAF Foundation (2008) and Dubbeling (2004) identify the following production systems that are commonly found in UPA:

Table 2.6: Production systems commonly found in urban and periurban agriculture

System	Actors	Scale	Locations
Micro-farming in and around the house/homestead	both urban poor families, female headed households, as well as medium/high income class families	micro-scale (up to 200 m² but often smaller)	in/on and around the house, especially in marginal urban settlements, urban centres and urban suburbs
Community gardening	urban poor families mainly, female headed households, elderly people, recent migrants	small-scale (500 m² to some ha)	within walking distance of the homes, especially in vacant open areas in or adjacent to popular neighbourhoods
Institutional Urban agriculture	pupils of primary and secondary schools, clients of hospitals, prisons, factories	small-scale (500 m² to some ha)	within the compounds of these institutions; in the built up city or periphery
Small-scale (semi-) commercial horticulture	a. traditional small scale periurban farmers; b. urban poor households that gained some land	small-scale (500 m² to some ha)	mainly in the periurban areas as well as vacant open spaces within the city
Small-scale (semi-) commercial livestock and aquatic farming	a. traditional small scale urban and periurban farmers; b. urban middle class with larger house (as a secondary source of income); c. urban poor households on vacant open land or in lakes or rivers	small-scale (e.g. 1-4 dairy cows, 5-10 pigs or goats)	in older parts of city with larger house plots, vacant open spaces within the city, lakes or rivers, suburbs, periurban
Specialised urban agriculture and forestry production	in general persons/households that have a bit more resources than the poorest families or are supported through specific projects	small-scale to larger scale	various locations
Large-scale agro-enterprises	often urban investors; traditional farmers that sold most of their land for construction to invested in an intensive form of agriculture	large-scale	mainly periurban
Multifunctional farms	farmers with more resources but not highly specialised or with advanced technologies. Sometimes also urban investors	from small scale (family based) to large to very large enterprises (e.g. agro-tourism)	mainly periurban; some intra urban (e.g. “children’s” or “educational” farms)

Based on Dubbeling (2004); RUAF Foundation (2008)

As UPA systems are diverse, they all have certain distinct characteristics, face context-specific problems and offer different opportunities to the farmers. Therefore, the abovementioned classification is helpful for the adequate analysis of actual UPA systems existing all over the world.

Economic activities

As highlighted in the definition created by Smit et al. (2001), UPA is more than just the production of agricultural goods. It also embraces the processing and marketing stages of these goods, which makes it an integral part of the urban food system (Armar-Klemesu 2000). Due to the greater geographic proximity and quicker resource flow, the interactions between the different stages of the value chain tend to be "more interrelated in time and space" (Mougeot 2000: 5) than it is the case in rural agriculture. These close relations are achieved by the small size and dispersion of the production, processing and marketing units, supplemented by an "extensive and decentralised supply system within immediate reach of a massive consumption market" (Mougeot 2000: 5).

As options for the expansion of farms and processing as well as marketing facilities are usually limited, UPA and its associated sectors benefit from economies of agglomeration rather than from economies of scale (Mougeot 1996, 2000). Hence, the level of organisation tends to be high in UPA. The division of labour between the various actors, often between members from the same family, is common (Nugent 2000a). While women and children tend to be responsible for the field work, men are more engaged in processing and marketing of the produce, which in turn has a significant impact on decision making on the household level (Hovorka 1998; Hovorka et al., eds. 2009; Gerstl 2001).

Marketing channels include trading at the farm gate, within the neighbourhood, in corner shops, local as well as other markets (van Veenhuizen and Danso 2007). The value chains of UPA products are usually shorter than in rural agriculture as usually fewer middlemen between the producers and consumers are involved (Smit et al. 2001). According to Mougeot (2000), fewer levels of trade and the higher number of producers who are involved in the marketing make it dispersed and often just small quantities are traded. Mostly, it is fresh produce that is being traded. However, selling of cooked meals on the streets or other forms of marketing of processed and packaged UPA products are also common (van Veenhuizen and Danso 2007).

Products

The variety of products of UPA is as wide as the variety of involved actors and locations. In general, it can be distinguished between food and non-food products. The food production can range from different types of crops, such as grains, root crops, vegetables, mushrooms or fruits, to a wide spectrum of animals, such as poultry, rabbits, goats, sheep, cattle, pigs, guinea pigs, and fish. The cultivation or gathering of non-food products, such as herbs for aromatic and medicinal use, ornamental plants and tree products, such as wood for construction or as fuel, is also common (van Veenhuizen and Danso 2007).

Many urban and periurban farmers combine different production systems in order to benefit from positive spill-over effects of mixed production. In this way UPA also has the potential of contributing to sustainable waste management solutions. The relation between UPA and waste management is most obvious where crop production is enhanced by using by-products (e.g. cow dung) of livestock keeping. Accordingly, by-products of crop production can improve livestock production (e.g. left-overs and fodder grass) (Deelstra and Girardet 2000).

According to van Veenhuizen and Danso (2007), a variety of social, economic and physical factors influence the individual decision on what and how things are produced. In many cases this decision is the result of “specific urban and periurban diets and food consumption patterns, which are influenced by culture, climate, soil conditions, socio-economic circumstances, proportion of expatriate market and political economy” (van Veenhuizen and Danso 2007: 16).

Motivation

Based on a review of seventeen city case studies on UPA, Nugent (2000a) identify several different possible motivations for engaging in UPA (ranked in order of importance): production for home consumption, income enhancement, economic crisis, high prices of market food, income or asset diversification, supplementary employment, conflict, poor weather (Nugent 2000a). Two distinctive categories can be identified based on the abovementioned motivations:

> “UPA consists of two disparate and possibly segregated sub-sectors: the commercial horticultural and livestock industries largely located in periurban areas, and the subsistence production of poor households scattered through the urban and periurban zone, wherever land and poverty create the opportunity and need.” (Nugent 2000b)

Other authors emphasise the possibility and importance of mixed types that can be mainly found on the household level and that this is the most commonly found type in many cities (van Veenhuizen and Danso 2007). However, the abovementioned categorical distinction helps understand the fundamentally different motivations of households and enterprises involved in UPA.

Expenditures on food can make up 60 to 80 percent of the income of many poor families (Armar-Klemesu and Maxwell 2000). By engaging in food production and thereby reducing the expenses on purchased food, urban and periurban farmers can save considerable amounts of money. The annual savings may be as much as several months of the respective minimal wage (Mougeot 2005). On the one hand, these savings can be invested to improve other livelihood aspects, on the other hand UPA can directly enhance the food security of the farmers (de Zeeuw et al. 2000). Many households engage in UPA in “response to economic [or political] difficulties, and the need to maintain household subsistence requirements in the face of market prices which are outstripping incomes” (Binns and Lynch 1998: 780). This engagement can be a temporary “crisis induced strategy” (Drescher et al. 2000: 9) and might be discontinued once the situation has improved. On a larger scale, UPA can also permanently flatten seasonality effects (e.g. rising prices, lack of availability) "by lessening dependence on off-season imports, or making up for reduced supplies from rural agriculture during the dry season" (Mougeot 2000: 12).

Apart from being a coping strategy in terms of food security in times of crisis, UPA can also be a strategy to diversify household income sources and generate employment opportunities. Being located close to the urban consumers, UPA has a comparative advantage over other forms of agricultural production, making it an important part of the urban food economy (FAO 2008).

2.3 Urbanisation and its impacts on urban and periurban agriculture

"Ecologically sustainable urbanisation is [...] inconceivable without urban and periurban agriculture"
(Smit and Nasr 1992: 141)

"For both urban and periurban agriculture, there is a need to monitor and assess the increasing competition between agricultural and non-agricultural uses of land, water and other resources, and how such competition and associated changes [...] are affecting [...] food supply, as well as social stability."
(UN 2000)

Urbanisation brings with it manifold changes along the urban-rural continuum. Some of them can have severe impacts on agricultural production in urban and periurban areas, by fuelling existing or creating new conflicts over resources. These changes do not always need to have negative implications, they can also create new opportunities for urban and periurban farmers as well as for sustainable urban development in general.

2.3.1 New conflicts – struggling for resources

Within the urbanisation context, land can be considered as the most contested resource. Its (non-)availability challenges the viability of agricultural activities, "particularly in cities where the built-up area is densely settled, rapid peripheral expansion is occurring and competition for land is great" (Rakodi et al. 2002: 12). In urban and periurban settings, the interests of several stakeholders interested in obtaining power over land resources collide. The bottleneck thereby is not only the availability of land but also the appropriate access to land (Mougeot 2006). Due to the collision of rural and urban land tenure arrangements and the lack of reliable and moderating institutions, conflicts between housing, economic, and agricultural interests arise. Simon (2008: 177) states that the way how these land issues are handled "reflects local institutional structures, land tenure systems, and the relative power of key stakeholders". In many cases, farmers are the weakest players in the system which makes them the group most vulnerable to displacement. Depending on the local institutional arrangements and the availability of land, these farmers may be assigned alternative farmland. However, compensation is often inadequate, and farmers might lose the foundation of their livelihoods (Simon 2008).

Decreasing availability of and access to land as well as its increasing subdivision makes cultivation more difficult as the influence of urbanisation intensifies (van Veenhuizen and Danso 2007). The loss of land suitable for agricultural purposes eventually “reduces local food self-reliance and the ability to sell any surpluses to urban dwellers” (Simon 2008: 177). According to Rakodi et al. (2002) is unplanned urbanisation therefore not only a problem in terms of infrastructure development but more importantly a threat to the viability of UPA and many households depending on it in the developing world.

Predictability of land tenure is important, yet it is not given in most cases especially in the periurban areas. Furthermore, the abovementioned spatial expansion of the urban administrative areas often leads to the enforcement of municipal bylaws prohibiting agricultural activities. As Mougeot (2006: 53) points out, “people are unlikely to invest time and scarce resources into [UPA] if they are afraid that they will be evicted from the land before their crop is ready for harvest or that the crop will be destroyed by over-zealous officials”.

The availability of and access to water is another important source of conflicts fuelled by urbanisation. Growing urban populations increase the water demand for domestic as well as commercial purposes. Even though urbanisation might have positive effects on gross water availability due to the reduced evapotranspiration and increased runoff, these effects are relativised by a lack of water harvesting mechanisms and the pollution of urban runoff (FAO 2003). That means that water availability for agricultural purposes is likely to decline with increasing urbanisation. This trend is accelerated by the growing number of boreholes around the cities that supply the growing number of urban residents who are often using water intensive applications such as flush toilets (Shah et al. 2007).

At the same time, the growing urban population and its growing demand for food comes along with an increasing demand for water in agriculture (FAO 2012a). These increases in water demand lead to a competition for water and rising water prices not only for farmers, but also for non-farming urban households and commercial enterprises. As with the struggle for land, farmers tend to be the weakest competitors in the conflict over water often forcing them to shift to other income earning activities (van Veenhuizen 2006).

Urbanisation is not only responsible for an increased extraction of resources but also for the increasing contamination of resources indispensable for UPA. Soil, surface and groundwater pollution is common and may have a severe impact on farmers and their production (FAO 2003). Agricultural production downstream of urban agglomerations might face problems with highly polluted water bodies, “ranging from raw sewage to household refuse and a cocktail of industrial and chemical effluent, much of it hazardous to health” (Simon 2008: 179). In some cases, irrigating agricultural land with that kind of water might be a threat to the producers and consumers of the respective products (Rakodi et al. 2002). Cultivation on soils contaminated by industrial effluents or on toxic deposits might also pose a risk to their health.

The abovementioned remarks show that urbanisation brings with it several aspects potentially threatening agricultural activities in urban and periurban areas. Farmers as one of the most vulnerable groups therefore particularly face challenges posed by the urbanisation process.

2.3.2 New opportunities – sustainable urban spaces

Even though urbanisation is commonly looked at as a threat, it also entails manifold new opportunities for urban and periurban farmers as well as the respective cities. UPA is highly flexible and therefore able to adapt quickly to rapidly changing conditions. While food supply and the generation of income remain important, UPA also plays a vital role in “environmental management, landscape and biodiversity management, and [the] provision of recreational services” (van Veenhuizen and Danso 2007: 15).

New opportunities for farmers

The continuous spatial changes of urban areas can pose threats to agriculture. However, this changing character can also generate new locations for agricultural production. The demolition of residential, office or industrial areas that are no longer in use might create “new open spaces that may stay vacant for a long time until given a new use and the required investments become available” (van Veenhuizen and Danso 2007: 13–14). There is a potential for UPA along newly built roads and under power lines. These new open spaces created as a side effect of the urbanisation process are usually cultivated on an informal basis (Drescher and Gerold 2010). Mougeot (2006: 50) points out that in most African cities, “there is far more land available than is generally recognized by city managers and elected officials”. In addition to the abovementioned open spaces, this can include vacant lots, underutilised sites and (semi-) public land around schools and hospitals; a fact that is often overlooked by city planners.

As mentioned before, farmers can benefit not only from newly created underutilised land, but also from the increasing commoditisation of land and the accompanying rise in land prices. As farmers often hold large areas of land in urban and periurban areas that are increasingly attractive for all sorts of investors, some of them can benefit from the catalysing effect of urbanisation. Selling or renting out land can be a rewarding alternative to agricultural production (van Veenhuizen 2006).

The growing urban non-farming population creates new economic incentives for urban and periurban farmers. Some farmers adapt to the new situation by intensifying their agricultural production. The specialisation in higher-value horticultural crops may result in higher income, even though it also requires higher investments and risks (Simon 2008). The relative proximity to and better accessibility of the growing urban market has a number of relative advantages for urban and periurban producers: “direct access to urban consumers and markets, availability of cheap inputs such as urban organic wastes and wastewater, closeness to institutions that provide market information, credit and technical advice” (van Veenhuizen and Danso 2007: 14).

Becoming more market-oriented through direct marketing and processing of agricultural products, and implementing new farming systems and technologies, may increase living standards of those farmers willing to take the risk (van Veenhuizen and Danso 2007).

New opportunities for cities

Urbanisation does create new opportunities not only for farmers; UPA in turn creates pathways for the sustainable development of urban areas. UPA is an intensive form of agriculture and therefore production is generally more space efficient than its rural counterpart. According to Smit et al. (2001: 35) the small farms located in urban and periurban areas produce “several times more output per unit of space”. Apart from being an important livelihood strategy and contributing to the sustainability of cities by providing locally produced food, there are various environmental benefits of UPA, ranging from enriching biodiversity to improving the microclimate (see Table 2.7).

Table 2.7: Environmental benefits of urban and periurban agriculture

Type	Example
Landscape enhancement	Enriching biodiversity, creating habitat for wildlife, indirectly protecting forests and other sensitive land from being transformed into farmland
Hydrological management	Absorbing rainwater runoff and flood water, recharging aquifers, disaster risk reduction
Mitigating climatic effects of urbanisation	Reducing heat island effect created by impervious surface, increasing humidity and reducing pollutant load

Based on Rakodi et al. (2002); Smit et al. (2001); RUAF Foundation (2008)

UPA can contribute to sustainable development by closing the nutrient cycle in urban areas. Cities are net consumers of goods while being net producers of organic and inorganic waste. Agriculture can contribute to “cycling and closing of loops in the flows of energy and nutrients across the rural urban continuum” (FAO 2012a: 24). Several studies have shown its potential to reduce urban waste disposal needs by recycling organic solid waste as well as wastewater (Weckenbrock 2010; Drechsel and Kunze 2001; Drescher 1998). It thereby also reduces the financial and environmental costs of commercially traded chemical fertiliser and improves the management of the key elements Nitrogen, Phosphorus and Potassium (NPK) (Simon 2008; RUAF Foundation 2008). The FAO (2012a) illustratively summarises that UPA “can be a digester of […] waste” through the reintegration “of biomass in the form of organic waste into the nutrient cycle” (FAO 2012a: 23).

Several authors underline the potential agriculture has for achieving the goals of the Agenda 21[18], by strengthening local production, reducing imports, and facilitating the establishment of community-based institutions (Deelstra and Girardet 2000; de Zeeuw et al. 2000; Drescher 2003). Once UPA's contribution to local food supply, urban food security, and poverty alleviation is recognised by local institutions, it can become an integral part of creating environmentally and socially sustainable urban areas (Rakodi et al. 2002; de Zeeuw et al. 2011). In addition to the abovementioned environmental benefits of agricultural activities, UPA has several benefits for sustainable community development and social well-being (Smit et al. 2001). Through its community-based institutions, it can support local authorities in upgrading underutilised areas, which eventually benefits the city as a whole (RUAF Foundation 2008). As these institutions often provide well established formal and informal regulatory frameworks, UPA might indirectly serve as a "communitywide crisis management tool" (Eberhart 2012: 10).

To sum up, the urbanisation process can have severe impacts on agricultural production and farming households in urban and periurban areas by causing conflicts over resources, such as land and water. However, increasing urbanisation also comes with manifold new opportunities for UPA. Agricultural activities have the ability to play a crucial role in transforming urban spaces into sustainable cities, closing the nutrient cycle and thereby contributing to the aims of the Agenda 21 at all stages of the urban-rural continuum.

[18] The Agenda 21 is a global environmental and development-oriented plan of action, agreed upon during the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. Its aims are, inter alia: improving human settlement management, promoting the integrated provision of environmental infrastructure, and developing sustainable patterns of production and consumption (UN 1992). In the meantime, municipalities worldwide have adopted their respective Local Agenda 21 that serves as a framework for sustainable urban development.

3. Geographical context of the case studies

Two cities were selected as case studies for this research: Moshi, located at the foothills of Mt. Kilimanjaro in northern Tanzania, and Bamenda, the capital of the Northwest Region of Cameroon. They were selected based on several criteria. These criteria included high population growth rates and therefore a certain spatial dynamic in and around the city, a population of 100,000–500,000 and the presence of urban and periurban agriculture. Furthermore, it was intended to build on previously established relations with local academic institutions and administrative bodies. This was given as both cities were included in the research project *Livelihoods, urbanisation and natural resources in Africa (LUNA)* funded by the *VW Foundation*. While the methodology was elaborated in and for the Moshi case study, Bamenda was selected as the site for testing the replicability of the methodology.

3.1 Tanzania, the Kilimanjaro Region, and Moshi

Tanzania

With an estimated population of about 43 million inhabitants in 2010, and an area of around 885,000 km² – two and a half times the size of Germany – Tanzania[19] is one of the biggest countries in the east African region (National Bureau of Statistics 2011). With 49 inhabitants per square kilometre, Tanzania's population density is relatively low (Germany: 229 inhabitants per square kilometre) and the population is unevenly distributed (National Bureau of Statistics 2011). The majority of the population is concentrated in an area spanning from Mt. Kilimanjaro in the north along the Eastern Arc Mountains to the coastal plains, in the Southern Highlands, and around Lake Victoria (see Fig. 3.1). The plateau in the country's centre is hardly populated due to its harsh environment.

[19] In the interest of simplicity the "United Republic of Tanzania" is referred to as "Tanzania".

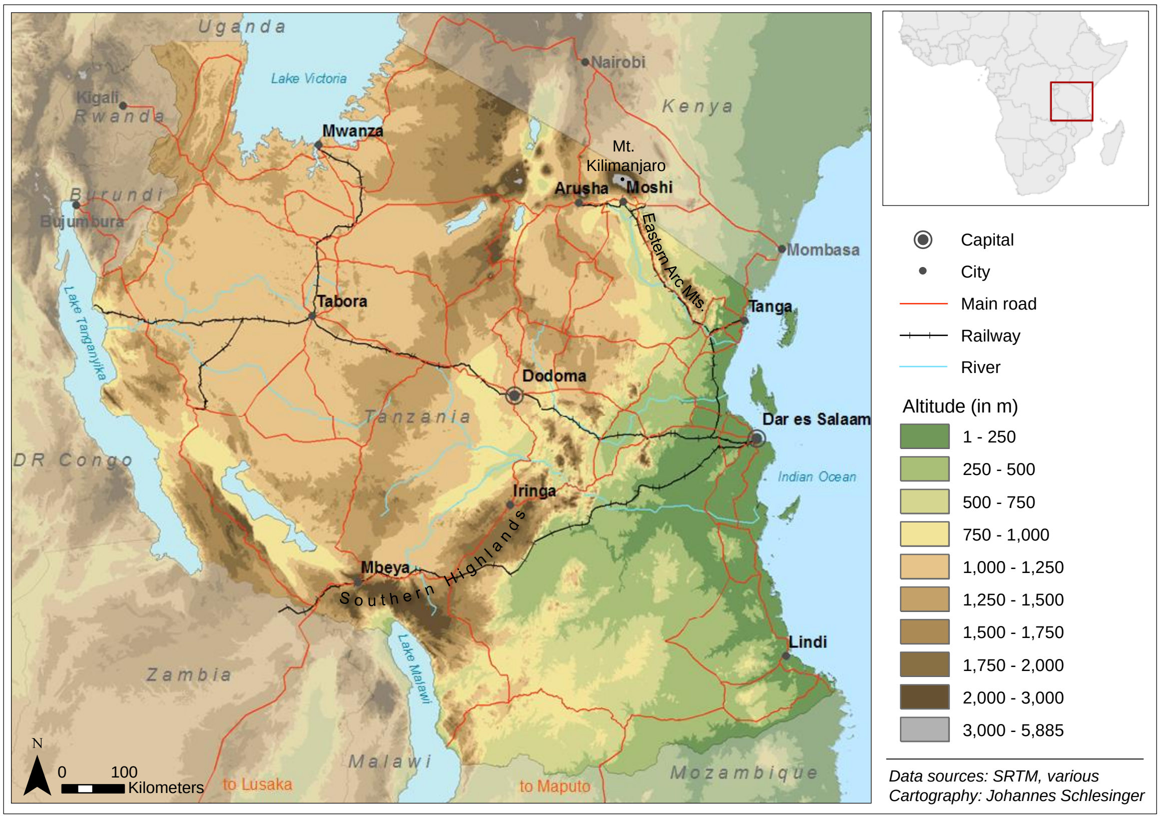


Fig. 3.1: Map of Tanzania

As in most other African countries, the majority of Tanzania's population lives in dispersed rural settlements, just around one fourth of its population lives in urban areas (National Bureau of Statistics 2011). Even though urban agglomerations are growing rapidly, this ratio is changing slowly partly due to high fertility rates in the rural areas (UN 2012). The overall population is currently growing at an estimated rate of 2.9 percent, making Tanzania a country with one of the fastest growing populations in the world (World Bank 2011). The UN (2012) expect the population to more than triple over the next 35 years, while in the same period, the urban population is even expected to quintuple.

In terms of human development, Tanzania outperforms most of its neighbours in the region. However, it is still categorised as a country of *low human development*, ranking 152th out of 187 countries in UNDP's most recent Human Development Index (HDI) (UNDP 2011).

Tanzania is characterised by a tropical climate with two major rainfall regions: the rainfall in the northern parts and along the northern part of the Indian Ocean coastline follow a bimodal pattern with short rains from October to December and long rains from March to May; in the rest of the country there is only one rainy period from December to April (Rowhani et al. 2011). However, rainfall patterns become increasingly variable in terms of period, length and intensity of rains (UNEP 2006; UNDP 2012).

Kilimanjaro Region

The Kilimanjaro Region is located in northern Tanzania, adjacent to the Kenyan border. With a population of 1.6 million and an area of about 13,000 km² (126 inhabitants per square kilometre), it is the 3rd most densely populated mainland region of Tanzania after Dar es Salaam and Mwanza (National Bureau of Statistics 2011). On the slopes of Mt. Kilimanjaro population densities can be as high as 500 to 1,000 inhabitants per square kilometre (Hemp and Hemp 2008).

The Kilimanjaro Region is in many aspects one of the most privileged regions in the country. The climate is heavily influenced by the existence of Mt. Kilimanjaro, the highest mountain in Africa (5,895 m.s.l.). Relatively mild temperatures and orographic rainfall makes the area preferable for intensive agricultural production. The soils of volcanic origin are fertile and constitute an additional advantage for agricultural activities in the area. These conditions lead to the cultivation of about 50 percent of the overall area during the long rainy season, a percentage that is reached by hardly any of the other regions in Tanzania (National Bureau of Statistics 2011).

The Kilimanjaro area is dominated by the Chagga people, widely known for their unique cultivation technique, the so called chagga gardens. This agroforestry system is characterised by several vegetation layers, maximising the use of limited land (Hemp and Hemp 2008). This highly adjusted and sustainable cultivation system was the foundation for the Chagga’s economic success.

Today, they are seen by other Tanzanians as “a relatively wealthy group because of their natural resource endowment and entrepreneurial activities” (O’Brien et al. 2008: 197). Strong ties with the economic centres of the country and the rich endowment with natural resources hence make the Kilimanjaro Region one of the wealthier regions in Tanzania (National Bureau of Statistics and Kilimanjaro Regional Commissioner's Office 1998). In addition to agricultural and other economic activities, many families on the slopes of Mt. Kilimanjaro are supported by financial remittances from family members who temporarily or permanently moved to the bigger cities.

Moshi

Moshi is located at the southern foothills of Mt. Kilimanjaro (see Annexe 6, Photos 1-8) at an altitude of around 850 m.s.l (city centre). While the northern outskirts of the city are located on the gently rising slopes of the mountain (up to an altitude of approximately 1,500 m.s.l.), most of urban and periurban Moshi is located on altitudes ranging from 700 to 900 m.s.l (see Fig. 3.2). Moshi’s upper parts are dominated by anthropogenically transformed montane rainforest, the lower parts are characterised by less dense vegetation. While agricultural activities in the former are concentrated on agroforestry systems, the latter, “where rainfall is less, […] maize and beans or, in very dry places, finger millet and cowpeas” (O’Brien et al. 2008: 197) is planted by the Chagga living around the mountain.

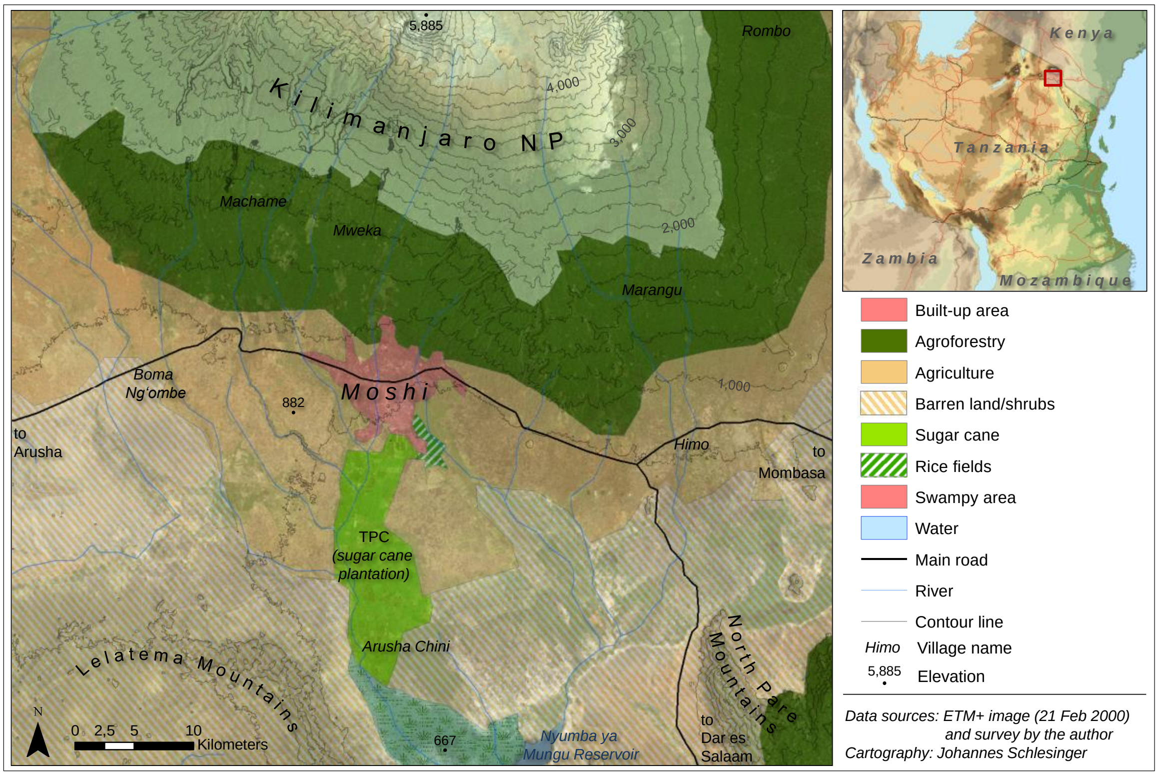


Fig. 3.2: Map of the greater Moshi area

With an estimated population of about 183,000 in 2009 (Moshi Municipal Council 2010), Moshi is the biggest city in the Kilimanjaro region. While the population grew at around seven percent annually in the 1960s and 70s, the growth rate for the last decade was an estimated 2.8 percent annually (Donge et al. 2008).

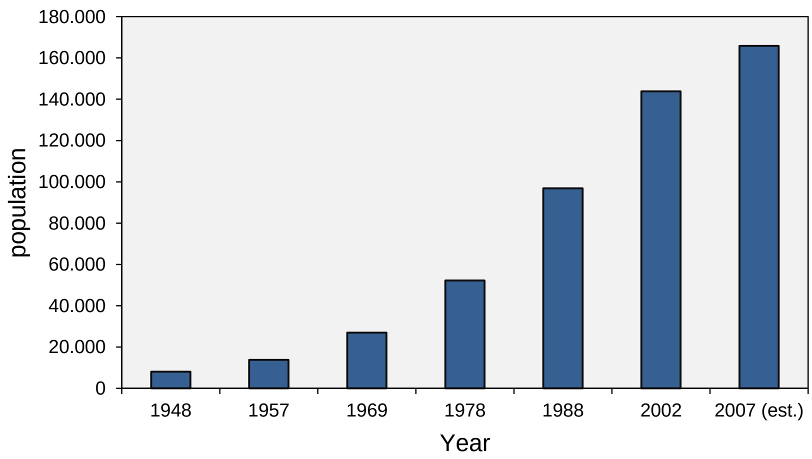


Fig. 3.3: Population growth of Moshi between 1948 and 2009 (based on Moshi Municipal Council 2010; Donge 2006; National Bureau of Statistics and Ministry of Finance and Economic Affairs 2010)

The town was originally established as a military camp in 1892 and was further developed under German colonial rule in the course of the extension of the railway line from Tanga, a harbour located on the Indian Ocean (Ministry of Lands and Human Settlements Development 1998). German and British colonial rule exploited the region's natural resources and transformed much of Mt. Kilimanjaro's southern slopes into export-oriented coffee plantations (Soini 2002a). While Moshi became one of the most important cities for East African coffee trade after the country's independence in 1961, the importance of its production was reduced significantly due to the decreasing prices on the world market and liberalisation measures in the late 1980s and early 1990s (Baffes 2003). However, Moshi developed into one of the most important economic hubs in northern Tanzania. The transport infrastructure is relatively well developed, making Arusha and Dar es Salaam as well as the Kenyan capital Nairobi easily accessible by public and private transport (Donge et al. 2008).

Even though the secondary and tertiary sector become increasingly important as the city grows, the primary sector is still a main foundation for the livelihoods of Moshi's inhabitants. According to Donge et al. (2008) 16 percent of the urban population were involved in agriculture in 2002 (Donge et al. 2008). With the lush montane forests in close vicinity and much of the urban areas being dominated by irrigated avenues and farms, Moshi is often referred to as the "green city" forming a contrast to the dry plains south of Mt. Kilimanjaro.

3.2 Cameroon, its Northwest Region, and Bamenda

Cameroon

Cameroon had a total population of around 19.4 million in 2010 (République du Cameroun 2010). With an area of approximately 475,000 km², it is about half the size of Tanzania. About 20 percent of the country's population is concentrated in the two biggest cities: Douala and Yaoundé (Bureau Central des Recensements et des Etudes de Population 2010). The rest of the population is concentrated in the mountainous western regions and the savannah regions close to the Chadian border. Having recently reached the threshold of 50 percent of its population living in urban areas, Cameroon is one of the most urbanised countries in Africa (UN 2012). The UN (2012) expect the urban population to double by the year 2040.

Similar to Tanzania, Cameroon is a country of *low human development*, being ranked higher than its neighbouring countries (150th out of 187) (UNDP 2011).

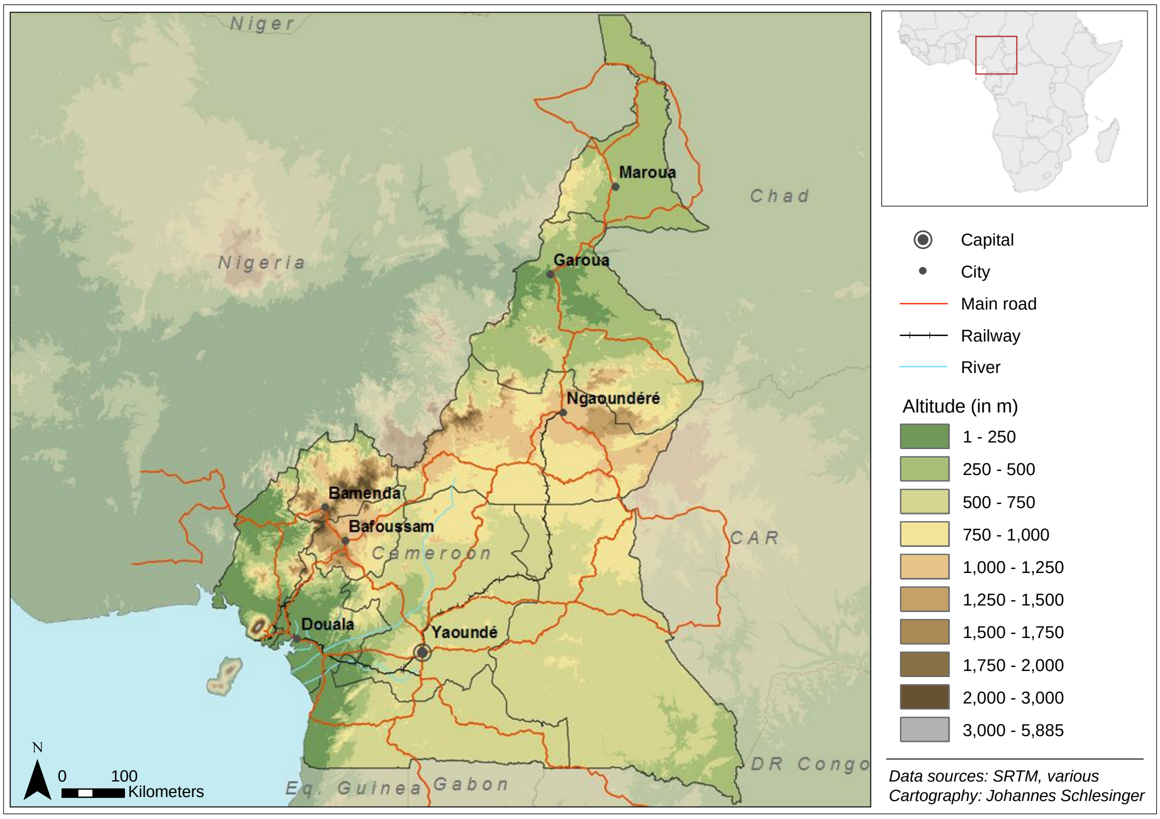


Fig. 3.4: Map of Cameroon

Cameroon's climate is characterised by longitudinal changes from tropical humid along the coast and in the south to semiarid in the northern parts of the country. While rainfalls in the southern parts follow a bimodal pattern with rains from March to June and September to November, there is just one rainy season from June to September in the northern parts of the country (Molua 2006). As in the case of Tanzania, rainfall patterns are expected to change in the course of global warming, posing a threat to the country's important agricultural sector (Laux et al. 2010).

Northwest Region

The Northwest Region is located in the English-speaking part of Cameroon, sharing its northern border with Nigeria. With a population of 1.8 million and an area of 17,000 km² (104 inhabitants per square kilometre), it is the 3rd most densely populated region in the country (République du Cameroun 2010). About 55 percent of the region's population is urban with two fifths of that population being concentrated in the regional capital Bamenda (République du Cameroun 2010).

The region's topography is characterised by a mix of mountain ranges with an elevation of up to 3,000 m.s.l., intermontane basins and plateaus, escarpments and deep valleys (van Ranst et al. 1996). The tropical montane climate shows a significant spatial variability of rainfalls and temperatures on the micro-level due to the orographic diversity. The main rainy season in the region usually lasts from mid-March to mid-November, while there is only little precipitation during the rest of the year (Bayemi et al. 2009). While the mountain ranges are covered by humic ferrallitic soils on basalts, the ferrallitic soils of the lower areas developed on granite (van Ranst et al. 1996). The landscape is heavily anthropogenically influenced, resulting in a “mosaic of cultivated fields, fallows, woodlots, compound farms, natural pastures in wooded savannas, gallery forests and raphia palm groves in valleys” (Ndenecho and Akum 2009: 58).

The diverse landscape patterns go along with a patchwork of ethnic groups, many of them having their origin in Nigeria or the other neighbouring countries (Nkwi 2011). The area is well-connected by transport infrastructure with the rest of the country and neighbouring Nigeria. Established transportation networks catalyse marketing of agricultural production, which is an important economic sector in the region (Kamga Fogue 2011).

Bamenda

Bamenda, the capital and largest city of the Northwest Region, is located at the foot of the Bamenda Plateau at an altitude of about 1,250 m.s.l. (see Annexe 7, Photos 1-8 and Fig. 3.5). With an estimated population[20] of about 380,000, Bamenda is one of the biggest and fastest-growing cities in Cameroon (Bureau Central des Recensements et des Etudes de Population 2010). Its population has increased by a factor of eight within the last 35 years, experiencing higher growth rates than Douala and Yaoundé (Bureau Central des Recensements et des Etudes de Population 2010). With its extensive range of administrative, educational, and market facilities as well as job opportunities in the formal and informal economy, the city attracts an increasing number of temporary and permanent migrants from the surrounding rural areas (Fongjong 2008; Nyambod 2010a).

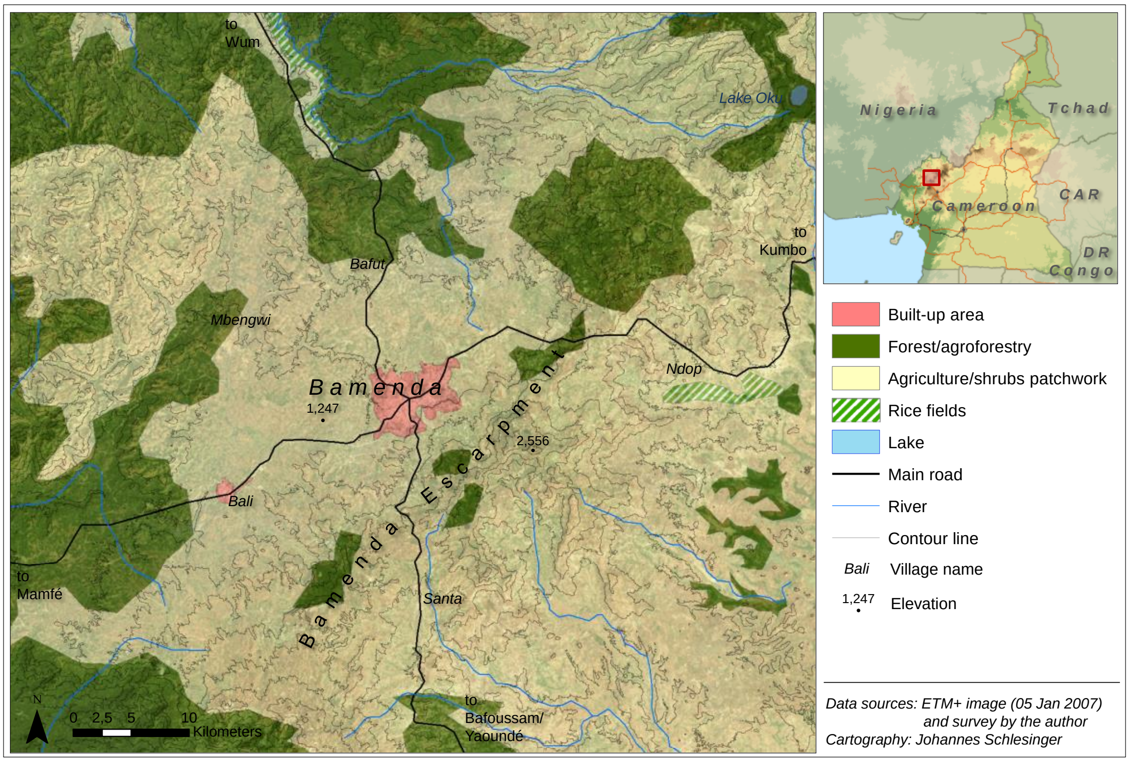


Fig. 3.5: Map of greater Bamenda area

[20] Due to outdated census data, reliable numbers are currently not available. The mentioned number is an estimate calculated based on 2005 census data and an assumed annual growth of five percent.

Bamenda is situated in an area of high variability in terms of altitudes, micro-climates, and soil conditions (van Ranst et al. 1996). It is therefore well suited for a wide variety of agricultural production systems, ranging from large-scale market-oriented maize production to locally adjusted extensive multi-cropping systems (Olayiwola et al. 2011). However, agricultural productivity is hampered by the topography, which makes mechanisation difficult and soil erosion a common problem (Fongjong 2008; Kometa and Akoh 2012).

4. Methodology

“[...] a proper understanding of any city requires a cross-disciplinary approach, whatever the ultimate focus of attention.”
(Knox and Pinch 2007: 1)

Cities are complex systems shaped by manifold ecological, political and societal processes. Constant changes in building densities, economic conditions, legal and administrative frameworks have manifold impacts on urban and periurban land use as well as socio-cultural conditions on city and household level. As pointed out by several authors (e.g. McIntyre et al. 2008; Knox and Pinch 2007), integrated interdisciplinary methodological approaches are needed to fully understand the complexity of the urban system. Urbanisation thereby needs to be understood as the result of an interplay of „spatial, social, and temporal phenomena and thus almost by definition requires an interdisciplinary approach" (Coquery-Vidrovitch 1991: 1).

Geography as a scientific discipline located at the intersection of the *ecosphere* and the *anthroposphere* (Schellnhuber 1998), has been characterised as being “inherently interdisciplinary” (Baerwald 2010: 493). It provides a wide range of methods suitable to unravel the urban fabric and its fuzzy spatial and socio-economic patterns. The methodology developed for this study therefore integrates several complementary approaches ranging from remote sensing (RS) and field mapping to quantitative household surveys and qualitative interviews.

After a comprehensive review of the relevant literature, a transect approach was chosen for data acquisition in order to capture the changes along the urban-rural continuum (see Fig. 4.1). Within the transects, all agricultural land use was mapped, and a representative number of households was randomly selected and interviewed based on a standardised questionnaire. Both datasets were digitised and integrated into a geodatabase. This database was supplemented with secondary information extracted from official as well as academic sources. The data stored in the geodatabase was then analysed with the purpose of identifying patterns regarding the spatial distribution of agricultural production and its importance for the interviewed households along the transect. An Urban-Rural Index (URI) was developed as the foundation for all spatial analyses.

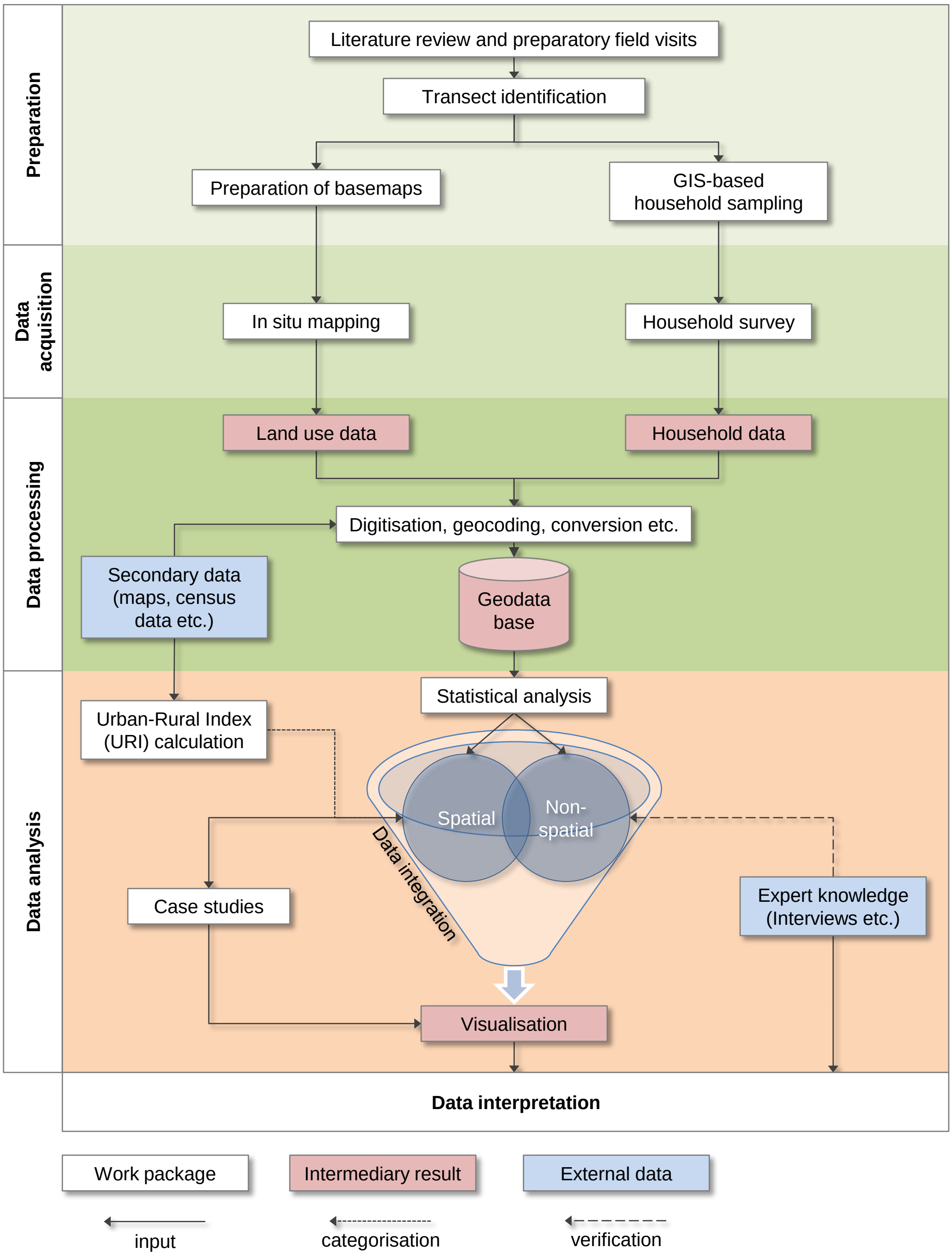


Fig. 4.1: Simplified illustration of the methodology applied in the study

The geocoded household information was integrated with other spatial datasets to eventually visualise spatial changes along the rural urban continuum. The visual representation of the data helped to easily capture the gradual character of the changes along the continuum and to identify spatial patterns that might have been overlooked otherwise. In addition to the visualisation, several representative case studies were selected to illustrate the role of UPA and the urbanisation induced changes affecting agricultural production and marketing at different sections of the transect. Data analysis and interpretation was supplemented by a semi-automated analysis of multi-temporal RS data, interpretation of official statistics and qualitative interviews with relevant experts.

The applied methods are discussed in detail in the following chapters. The chapters thereby follow the structure of the workflow presented in Fig. 4.1.

4.1 Preparation

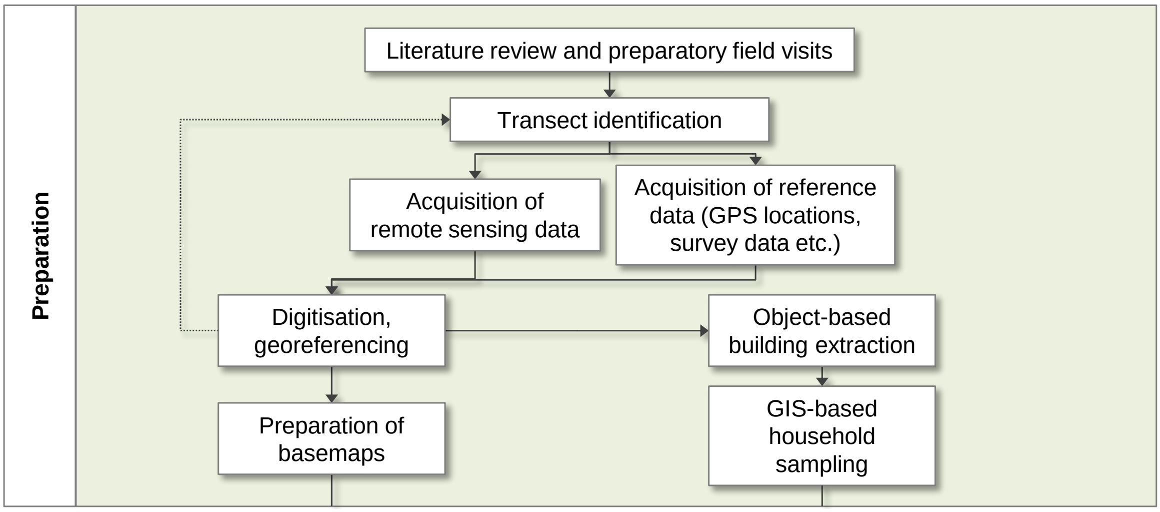


Fig. 4.2: The preparation stage

4.1.1 Literature review and preparatory field visits

According to Hart (1998), the aim of a literature review should always be to uncover what is already known in the scientific community in order to identify possible inconsistencies in the respective body of knowledge. A proper assessment of the state of research is necessary to be able to contribute to theoretical and conceptual progress and to "enhance the scientific community's current understanding of a phenomenon" (Levy and Ellis 2006: 172).

The foundation of the methodology applied in this study was therefore a comprehensive review of the relevant thematic literature on aspects of urban development and UPA with a regional emphasis on the African continent. Furthermore, literature on methods suitable for the analysis of the abovementioned issues was reviewed. The important literature was selected based on its comprehensiveness and relevance. Primary and secondary sources were critically assessed, analysed and synthesised with the aim of identifying knowledge gaps. These sources included research papers, such as conceptual, methodological and theoretical papers, thematic and regional case studies, as well as non-research literature, such as policy papers, legislative documents, and official statistical documents.

Preparatory field visits were conducted in both case study areas facilitating the familiarisation with the local context. Furthermore, local experts were contacted for the identification of knowledge gaps and research needs in order to further adjust the focus of the research.

Based on the literature review and the preparatory field visits, the conceptual and theoretical framework as well as the research methodology was developed.

4.1.2 Transect identification

Transect approaches commonly aim at “quantifying changes in the structure and function of a range of land-use types” (McDonnell et al. 1997: 22). These approaches thereby base on a *gradient paradigm*, defined by McDonnell and Pickett (1990) as

> “the view that environmental variation is ordered in space, and that spatial environmental patterns govern the corresponding structure and function of ecological systems, be they populations, communities, or ecosystems”. (McDonnell and Pickett 1990: 1232)

Thus, the quantification of these changes along urban-rural gradients – based on a transect approach – can contribute to the understanding of the impacts of urban processes on ecosystem functions and services (McDonnell et al. 1997).

Transect approaches have been developed as a tool for vegetation analysis and have been widely applied in the past in the analysis of ecosystems (Luck and Wu 2002). An increasing number of publications investigated the impacts of anthropogenic actions on ecosystems along urban-rural gradients. In his comprehensive meta-analysis of transect-based gradient studies, McKinney (2008) shows the wide variety of research foci, ranging from vegetation diversity in small towns to avian species richness in megacities (e.g. Alberti et al. 2001; Porter et al. 2001; Loewenstein and Loewenstein 2005)[21].

In this study, the transect approach was applied as the guiding principle for data acquisition, visualisation and interpretation. As a first step, four transects were identified in each of the two case study sites. The preliminary identification was based on the visual interpretation of multi-temporal RS data. For this first step of the identification process, a set of Landsat images covering the respective study areas was used. Landsat data was considered appropriate due to following reasons: 1) multi-temporal imagery for the study areas with acquisition dates ranging from 1976 to 2006 was available; 2) data was easily accessible and available free of charge; 3) semi-automated processing techniques, such as the natural colour transformation, were well-established and easily applicable. Even though spatial resolution of Landsat data was coarse, it was still suitable for the identification of urban areas and agricultural land use. Furthermore, topographic maps and other spatial information, such as digital data from OpenStreetMap (OSM)[22], were taken into consideration for the transect identification.

During a first field visit to the study areas, the preliminary layout of the transects was checked for possible difficulties during the data collection. Accessibility of the study areas was tested and first contacts with local stakeholders were established. Furthermore, the central market as the location of the transect origin was validated.

---

[21] A more theoretical discussion of the effects of the urbanisation process on ecological systems can be found in the works of Duany (2002), Brower (2002) and others originating from the *New Urbanism* debate.

[22] OSM is a collaborative non-profit project aiming at creating a comprehensive editable map of the world. The data can be downloaded from an online platform (www.openstreetmap.org) in common GIS formats and can be used under the Open Database License.

After the first field phase, multi-temporal Very High Resolution (VHR) satellite imagery covering all transects was acquired (see Table 4.1).

Table 4.1: Comparison of GeoEye-1 and Ikonos-2 sensor characteristics

Sensor		GeoEye-1	Ikonos-2
Spatial resolution[23]	Multispectral:	2.0 m	4.0 m
	Panchromatic:	.5 m	1.0 m
Spectral bandwidth	Blue:	450 - 510 nm	445 - 516 nm
	Green:	510 - 580 nm	506 - 595 nm
	Red:	655 - 690 nm	632 - 698 nm
	Near Infrared:	780 - 920 nm	757 - 853 nm
Image availability for study areas (years)		2010 - 2012	2001 - 2011

Based on ERDAS (2010); Dial et al. (2003)

Delivery of the satellite images was in standard geometrically corrected form without any further processing. In order to make use of the advantages of VHR data, the images were processed using the *ERDAS IMAGINE 2011* software package.

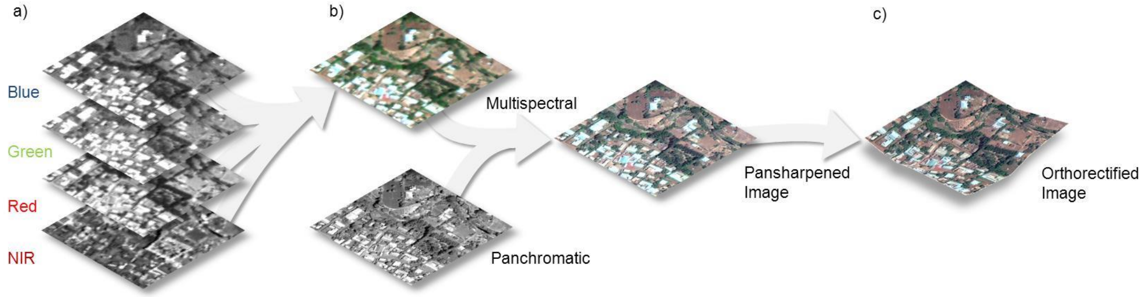


Fig. 4.3: Schematic representation of the very high resolution image processing
a) Layer stack; b) Pansharpen; c) Orthorectification

As a first step, the single images representing the different spectral bands were stacked for easier handling and processing of the data. The resulting multispectral layer stack had the same spatial resolution as the original bands. Therefore, a spectral image sharpening was performed in order to enhance the sharpness of the multispectral data by merging it with the respective high resolution panchromatic image. After visual assessment of the results produced using different pansharpening algorithms, the *High Pass Filter Resolution Merge* was chosen for further processing (ERDAS 2010). The resulting pansharpened image had the colour information of the multispectral bands and the spatial resolution of the panchromatic band.

As the original dataset had only been processed in terms of standard geometrical correction, further orthorectification was necessary in order to obtain correctly referenced images. Spatial accuracy was important for the interoperability of the satellite data with other spatially referenced datasets. Since no high resolution Digital Elevation Model

[23] The spatial resolution mentioned is that of the product delivered by the data distributor. Theoretically, the sensors are able to produce images with slightly higher spatial resolutions.

(DEM) was available for the automatic orthorectification, a manual rectification using several hundred Ground Control Points (GCP) was applied. The GCPs were extracted from official survey maps as well as from spatial information exported from OSM. Furthermore, GCPs had been collected during the first field phase using the Global Positioning System (GPS). A *3rd Order Polynomial Transformation* was performed, resulting in the final orthorectified images (ERDAS 2010).

The last step was the layout of the final transects by defining their exact boundaries. All transects originated in the city centre, in both case studies represented by the central market. Four transects were laid out radially, heading towards North, East, South, and West, respectively. The author is aware of the influence study area specific characteristics, such as topography or urban development policies, may have on the data obtained using this method. However, a sufficient degree of representativeness of the results is guaranteed by the way the direction of the transects was defined. By choosing the four directions of the compass, a quasi-random sample was selected. In contrast, laying out transects along major infrastructure features, such as roads or railway lines, would have had an unwanted influence on the data.[24]

The identified polygonal transects were 100 metres wide, ensuring that a representative number of households were located within the respective polygon. Based on this approach, an amount of land use data could be collected that was sufficient for the landscape metrics-based spatial analysis. The transects were up to 15 kilometres long, depending on the respective availability of VHR satellite imagery.

4.1.3 Preparation of the land use mapping

After the initial literature review, the application of (semi-)automatic classification of RS data for the spatial analysis of UPA in the research areas was rejected. These techniques bring with them several limitations to the data analysis. Even though optical RS data has proven successful for the classification of larger patches of UPA in the past (Kemeling et al. 2002; Forkuor and Cofie 2011; Ifatimehin and Musa 2008; Forster 2009), the spatial resolution of commercially available RS data is not high enough for the reliable detection of small-scale UPA in backyards or on road reserves. Furthermore, in tropical areas UPA is commonly practiced as part of complex agricultural systems, such as agroforestry (Carsan et al. 2010). The widely practiced intercropping makes the classification of spatial entities – be it a pixel or an object – hardly feasible. Another limitation to the interpretation of images from space-borne optical sensors is the availability of cloud-free data (ERDAS 2010; Lamb et al. 2011). As especially periurban agriculture is often rainfed (Drechsel and Dongus 2010; Mougeot 2000), it is only practiced during the rainy season, when clouds interfere with data acquisition. This reduces the availability of satellite images suitable for (semi-)automatic classification significantly.

[24] Building densities tend to be higher along paved roads, as their development facilitates commuting. The increased building density, in turn, has an influence on e.g. the availability of land for agricultural production.

Therefore, in this study the application of an *in situ* mapping approach was preferred over strictly RS based approaches. Even though field mapping is resource intensive, this method was chosen as higher accuracies could be reached. Several authors have already shown the feasibility and accuracy of *in situ* mapping approaches (e.g. Dongus 2009; Addo 2010).

In preparation of the field mapping, a series of basemaps with a scale of 1:550 was prepared, incorporating satellite imagery and – as far as available – official survey data. For basemap creation, the transect polygons were divided into equally sized sections, covering 100 x 155 metres each. *ArcGIS's Data Driven Pages* tool was applied in order to attain a series of up to 85 basemaps per transect, depending on the transects' length. The contrast of the satellite images was enhanced and additional information was added for easier map readability and orientation in the field (see Fig. 4.4).

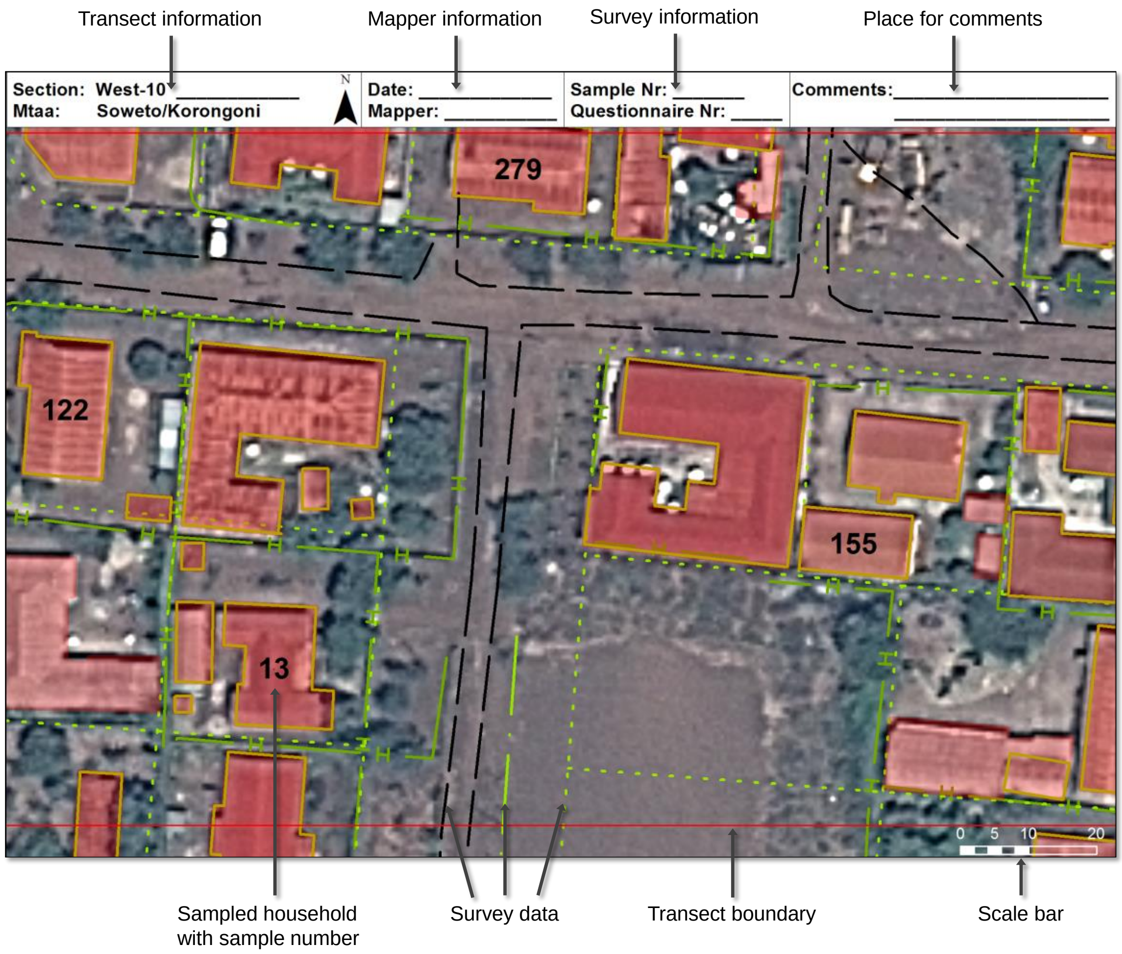


Fig. 4.4: Example of a basemap prepared based on satellite imagery and official survey data

4.1.4 Preparation of the household survey

Household sampling

A geographic information system (GIS)-based random sampling of households was performed in the preparation stage of the standardised household survey. It was preferred over other sampling methods due to its advantages in relation to the transect approach.

While other methods, such as snowball sampling (Given 2008), do not necessarily take into account the household's location, in this study it was of particular importance that all sampled households were located within the transect polygons. However, for a GIS-based random sampling, a complete inventory of all buildings within the transects was necessary. As no comprehensive digital dataset on the location of households for the sampling existed and as a manual digitisation would have been time-intensive, a semi-automatic extraction of buildings from VHR satellite images was applied.

An object-based extraction method was preferred over pixel-based image classification techniques. The ability of object-based approaches in the interpretation of VHR satellite images and their advantages over pixel-based approaches have been widely discussed (e.g. Blaschke 2010; Maeyer et al. 2010; Qian et al. 2007). While the latter analyses the spectral characteristics of single pixels, object-based approaches look at pixel regions as objects or features, evaluating pixels within their context. Therefore other characteristics, such as shape and texture, play a more important role than just the spectral reflectance. Object-based classification methods have been widely applied recently (Mathieu et al. 2007). It could be shown that these methods can produce much higher accuracies than pixel-based methods, especially in terms of automatic building extraction (Maeyer et al. 2010; Freire et al. 2010; Myint et al. 2011).

Definiens eCognition Developer 8.0 software was used for the building extraction process (Definiens 2010) (see Fig. 4.5). As a first step, a *Multiresolution Segmentation* of the original RS data was executed. This segmentation is recommended as it is especially suitable for "extracting features that are characterised not purely by color but also by shape homogeneity" (Definiens 2010: 18), which is the case with most man-made features, and buildings in particular. Segmentations using several different parameter combinations were performed. After visual assessment of the different segmentation results, the parameters resulting in the most accurate segmentation were identified. In a second step, several segments were manually classified as training areas. These training areas were used for a *Nearest Neighbour Classification*, resulting in a classified satellite image. The segments classified as buildings were then exported as an ArcGIS Polygon Shapefile.

The Polygons were then converted into Point Shapefiles using ArcGIS, as they were less data intensive and easier to handle in the GPS devices during the field phase. A final visual check of the accuracy of the extraction was performed in order to identify and correct false classifications.

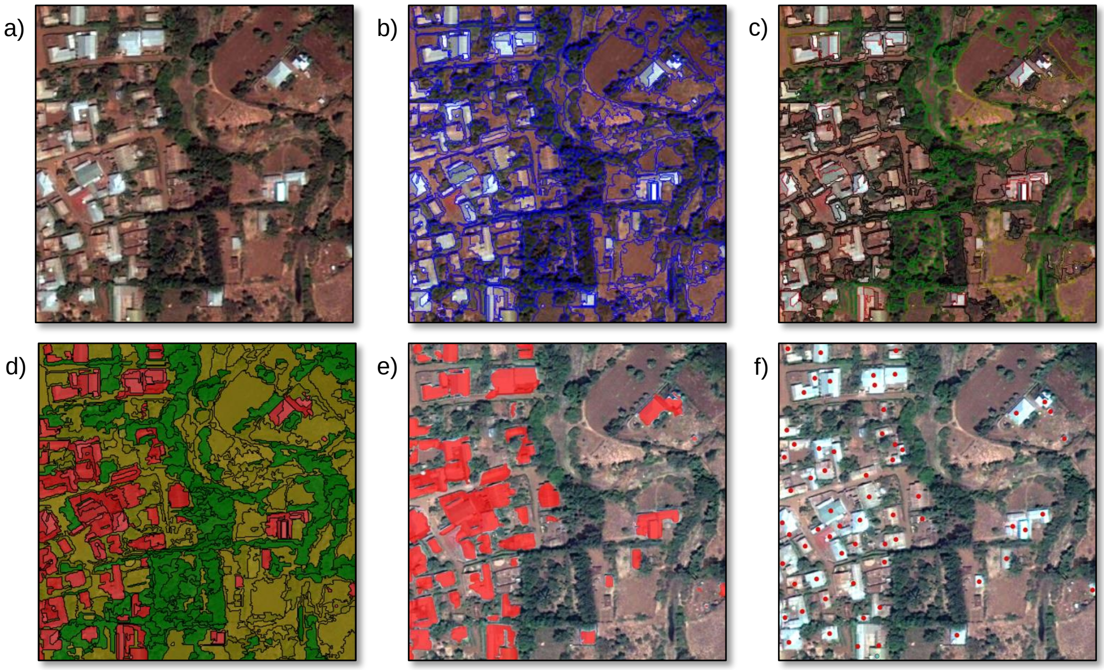


Fig. 4.5: Schematic representation of the workflow of the semi-automatic building extraction from very high resolution satellite data: a) satellite image; b) image segments; c) training areas; d) classification result; e) building polygons; f) buildings as points containing spatial information

Finally, random numbers were allocated to the extracted buildings, so that a random sampling could be performed. The following formula was applied for the calculation of the sample size n (ACF International 2010; Israel 1992):

$$n = \left(\frac{N}{1 + N * e^2}\right) * 1.1$$

where N is the population size – in this case the number of buildings identified within the transects –, and e is the level of precision[25]. A buffer of ten percent was added to make sure representativeness was still given after the removal of incomplete questionnaires.

According to the abovementioned formula, 440 households were sampled for the Moshi case study and 520 for the Bamenda case study respectively. Once the sample size for each of the study areas was calculated, the n buildings with the smallest random numbers were selected for the survey (see Fig. 4.6). As no data on the number of households per building existed, it was assumed that every building was inhabited by one household. Even though this was not always the case, the effects on the data collection process could be neglected.

[25] The level of precision e is defined as „the range in which the true value of the population is estimated to be" (Israel 1992), usually expressed in percentage points. In this study, a level of precision of ±5 percent was aimed at.

Fig. 4.6: Part of a transect with sampled households (green) and non-sampled households (red)

After completing the household sampling, all sampled buildings were marked with their respective sample numbers in the basemaps. Furthermore, the locations of identified households were exported to a GPS for easier navigation during the survey.

Questionnaire development

In order to obtain information on UPA related activities and other household characteristics within the study areas, a standardised household questionnaire was developed (see 0). As with all household surveys, a suitable balance had to be found between interview length and interview detail. Therefore, literature on questionnaire design was reviewed (Oppenheim 1992; Siniscalco and Auriat 2005) and several household questionnaires used in other studies were evaluated (e.g. ACF International 2010; Dinar et al. 2008; IFPRI and ILCA 1989). Eventually, a draft questionnaire containing the following sections was prepared:

A and B) Interview metadata, such as sample number, GPS coordinates of the household, and date of the interview

C and D) General information on the interviewee and the overall living situation

E) Information on other household members, such as age, educational level, and occupation

F) Agricultural production data, such as cultivated crops, area under cultivation, and inputs applied

G) Marketing of agricultural production

H and I) Changes in agricultural production, such as cultivation of different plants, increasing water scarcity, and land sales

J) Livestock production

K) Nutritional status of the household

L and M) Household's income and expenditures

The questionnaire mainly consisted of closed questions with a number of possible answers provided. These answers were identified based on local expertise on the respective topic. In some parts the questionnaire was supplemented by open questions.

As the elaboration of the questionnaire was seen as an iterative process, several pretests were conducted. The first draft of the questionnaire was extensively pretested with local research assistants, so that a possible lack of clarity, duplications, and other contradictions could be identified. A second draft was pretested with randomly selected households located outside the transects. After further adjustment, the questionnaire was translated into the respective local language by the research assistants. Afterwards this questionnaire was translated back into English by someone else with the purpose of identifying possible translation errors. Eventually, the final version was printed for the household survey.

4.2 Data acquisition

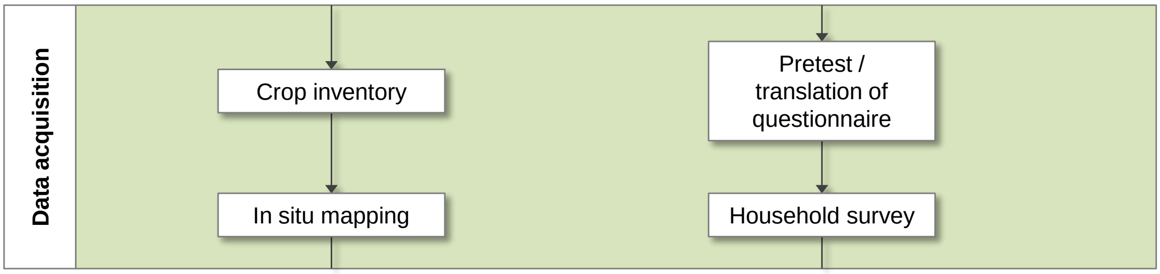


Fig. 4.7: The data acquisition stage

As mentioned above, the data acquisition consisted of two major parts: an in situ mapping of agricultural production and a representative household survey, based on a standardised questionnaire.

4.2.1 Land use mapping

As the land use mapping was based on the identification of local agricultural production, an inventory of locally produced crops – together with local experts – was conducted at an early stage. Furthermore, extensive pretests were carried out for the elaboration of the mapping technique. Special emphasis was thereby laid on the degree of generalisation of the areas under cultivation.

During the data collection process, a local research assistant was present at all times in order to assist in the identification of local crops and to act as a contact person for the local population. The data collection consisted of the visual assessment of crop production within the transect and the analogue recording of areas under cultivation. Therefore, every piece of land where crops were cultivated was identified and marked on the basemaps. Depending on which crops were cultivated, the respective crop codes were added on the basemap.

Initially, it was intended to collect further metadata for the areas under cultivation, such as information on the plot owner, status of irrigation, and inputs applied. However, this was not feasible due to the circumstance that – especially in the periurban areas – most plot owners lived relatively far away from their plots. Therefore the respective owners could not always be identified.

As the transects were laid out with no regard to infrastructure and natural features, such as rivers and escarpments, the general accessibility of the areas to be mapped was sometimes limited. Furthermore, some plots were protected by fences or walls making direct observation difficult. Wherever possible, plot owners were asked for permission to enter their property.

The small window of opportunity for field mapping was another challenge encountered during the data collection process. Due to the complex growth periods of the different plants, the mapping had to be started a few weeks after the beginning of the rainy season. However, high-growing plants, such as maize, still needed to be small enough to be able to identify possible intercropping. Mapping had to be conducted as fast as possible, so that the influence of season induced changes in vegetation patterns could be minimised. Field mapping in the Moshi case study took place in March and April 2011, in Bamenda mapping was carried out in April and May 2012.

4.2.2 Household survey

The household surveys were conducted from April to May 2011 in Moshi and from April to May 2012 in Bamenda. Due to the language barrier, a local research assistant was present during all interviews in order to communicate with the interviewees in their local language. These languages included Swahili and Chagga in Tanzania as well as Pidgin English in Cameroon.

The GPS as well as the basemaps were used to identify the buildings which had been sampled for the survey. Several cases occurred, where no one could be interviewed in the sampled building, due to the following reasons: 1) the sampled building was not used for residential purposes; 2) no possible interviewee could be found; 3) no one living in the building was willing to participate. In these cases, the closest house located within the transect was selected. In those cases where the building consisted of multiple flats, it was always the left most flat that was selected for the interview.

The survey was executed in accordance with common research ethics. The assistant provided some information about the research project, made clear that all data was collected anonymously, and answered questions asked by the interviewee before every interview. The interview itself was usually conducted in the local language, minimising the risk of respondents misunderstanding the questions. As the passive language skills of the author were sufficient for basic understanding, the answers to closed questions were usually filled in the questionnaire by the author without further translation. The answers to open questions, however, were translated into English by the research assistant.

The author is aware of the limitations inherent to any household interview. There are manifold possible sources of errors in every interview situation that need to be considered before, during, and after the household data collection process. Particular attention was given to the accuracy of translations in order to minimise any skewing of data. Furthermore, all assistants were asked not to push the interviewees, not to ask suggestively, and not to influence the respondents in any other way. Nevertheless, answers might have been influenced by the assistants or even the sheer presence of a foreign researcher. It is therefore necessary to reflect on the special role a (foreign) researcher inevitably has in this context (Mizock et al. 2011). It has been widely discussed whether answers might be somehow "determined by the [assumed] imbalance of social and political power" (Rhodes 1994: 550) between interviewer and interviewee. Interviewees might portray themselves as poor and needy as they might expect some sort of support. On the other hand, respondents might present themselves as wealthy and successful and therefore as an attractive partner for collaboration in any way. The possibility of inadequate answers therefore particularly applies to the issues of monetary income and expenditures. The answers to questions on quantities, such as amounts produced, area under cultivation, and volumes marketed also needed to be reflected critically.

4.3 Data processing

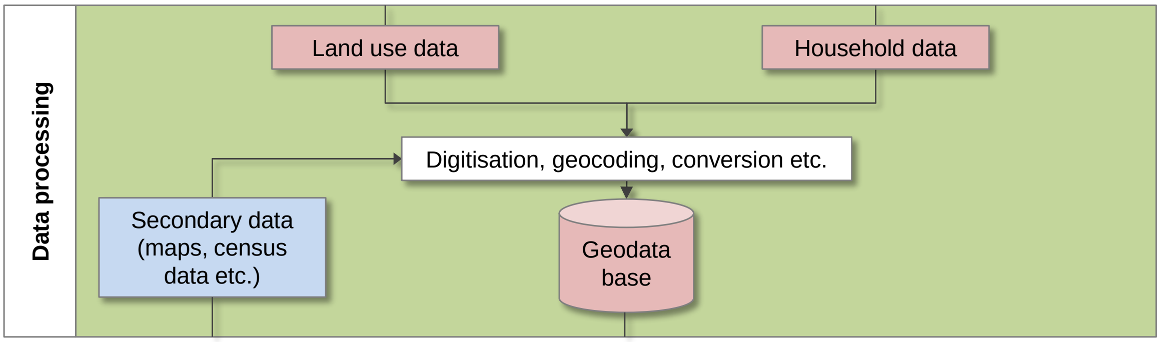


Fig. 4.8: The data processing stage

4.3.1 Land use data

The collected land use data underwent several processing steps. The basemaps used during the field mapping were scanned, imported into the GIS, and georeferenced based on VHR satellite images and survey data. The shape of the polygons marking the spatial extent of areas under cultivation was then digitised in ArcGIS. Once a polygon was digitised, several attributes were added. These attributes included, inter alia, type of crops grown, information on the location, and area in m² (see Fig. 4.9).

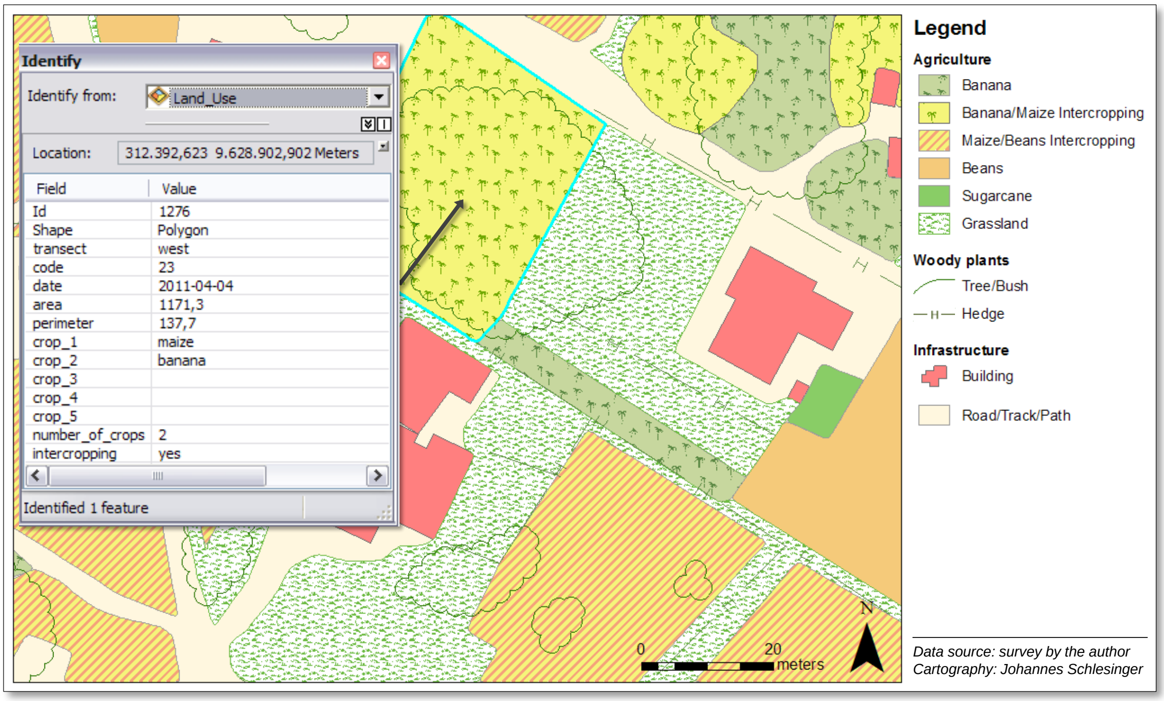


Fig. 4.9: Digitised land use data including respective attributes

The digital land use dataset contained data on all areas under cultivation within the transects of the study areas.

4.3.2 Household data

As with the land use data, several processing steps were necessary for the collected household data before the data could be smoothly integrated into the geodatabase. Firstly, all questionnaires were digitised: For all closed questions, a simple coding system was applied. In the case of open questions, the answers were categorised for easier analysis. Secondly, data cleaning was performed in order to ensure data accuracy and consistency. Obviously false data was corrected or deleted entirely from the spreadsheet to prevent unwanted effects at the analysis stage. Thirdly, the household information was geocoded based on the sample numbers. Therefore, the data spreadsheet was joined in ArcGIS with the existing building inventory derived from the object-based extraction process described in chapter 4.1.4. As a result, all household data could be linked to an exact location within the transect. This was an indispensable precondition for the spatial analysis of the survey data.

4.3.3 Geodatabase

A geodatabase was set up with the aim of creating a central repository for the storage and management of all spatial information collected in the course of the research (ESRI 2012b). Different datasets, including the land use and household survey data, were integrated based on location. Furthermore, all other spatial information, such as topographic maps, census data and other spatial statistics, was digitised, geocoded, and added to the geodatabase.

The resulting geodatabase was a comprehensive set of spatial data on the study areas and their surroundings with a special emphasis on the surveyed transects. This geodatabase served as the foundation for all spatial analyses performed. Its ability to easily store, combine, integrate, and export spatial data made it a convenient tool for the investigation of UPA in this context.

4.4 Data analysis

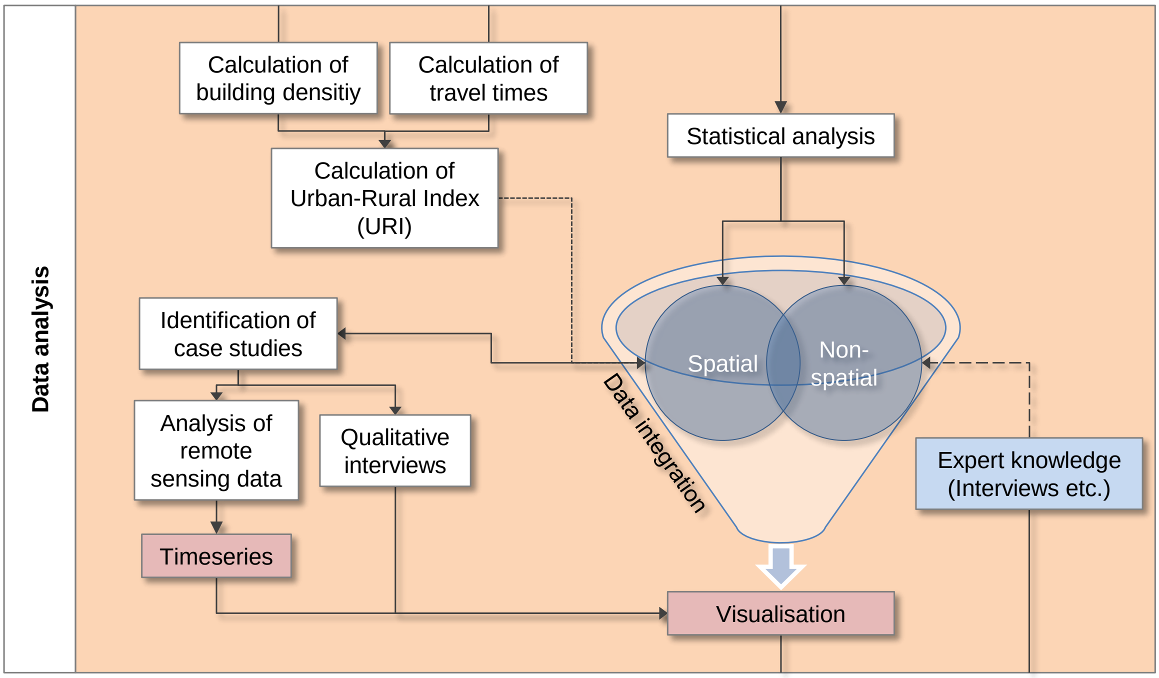


Fig. 4.10: The data analysis stage

4.4.1 A generalising view – the Urban-Rural Index

As discussed in chapter 2.1.7, hardly any classification of the urban-rural continuum exists that is based on objective criteria. Therefore, one aim of this research was to develop a basis for the analysis of spatial data that is founded on objectively measured criteria that makes a reproduction in other spatial contexts possible.

In this study, an Urban-Rural Index (URI) was developed and calculated for the two research areas (see Annexe 2 for the respective ArcGIS model). The URI was calculated based on two subindexes representing: 1) the kernel density of existing buildings and 2) the travel times from the city centre. The advantage of this index over common categorisations of urban, periurban, and rural areas lies in its ability to quantify the spatial implications of urban morphology.

Weighted Kernel Density of buildings

A high population density is an integral part of most definitions of what urban is. Unfortunately, spatial and temporal resolutions of census data providing population density information are insufficient for the level of precision that was aspired in this research. Information on built-up area, however, can be easily extracted from medium to high-resolution RS data. Therefore, the building density was chosen as an indirect indicator for population density. Even though exceptions might exist, these two parameters are usually highly correlated. As population densities decrease with increasing distance from the city centre, so do building densities in most cases.

To calculate a standardised raster-based index value for each point of interest within the research area, several (semi-)automatic extraction and conversion steps had to be conducted. As described in chapter 4.1.4, all buildings were extracted from a recent satellite image. The resulting polygons were converted into points, each containing the information on the area of the respective original polygon.

A Kernel Density analysis was chosen for the analysis of spatial patterns in the point data representing the buildings. It offers considerable advantages over other techniques of point density analysis, such as “simple mapping of point patterns or ‘quadrant count’ analysis” (Kloog et al. 2009: 56). This method is commonly used in statistics “to obtain smooth estimates of […] probability densities from an observed sample of observations” (Gatrell et al. 1996: 259). It is a data smoothing technique, transforming geographically referenced point data into a continuous and smoothly curved surface “indicating the intensity of individual observations over space” (Kloog et al. 2009: 56). The values of the surface raster resulting from a Kernel Density analysis are highest at the geographical location of the respective point and decrease with increasing distance from it (ESRI 2012a).

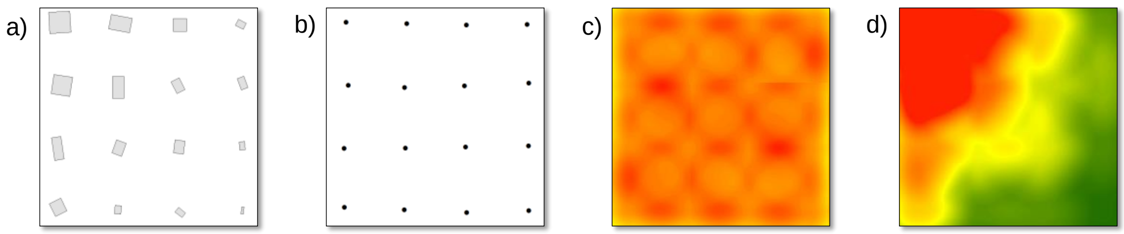


Fig. 4.11: Kernel Density calculation: a) Polygons; b) Points containing spatial information; c) Simple Kernel Density; d) Weighted Kernel Density

In this study, a Weighted Kernel Density was calculated, using the area of the buildings as the weight (see Fig. 4.11). As a result, not only the density of buildings, but also their surface area was included in the calculation process, resulting in higher values for larger buildings (e.g. multi-storey town houses, roofed markets) and lower values for smaller buildings (e.g. single-storey private houses, huts, sheds). The raster calculated through this process had a spatial resolution of ten metres. The highest values were reached in the densely built-up areas in the city centre and in some sub centres located outside the actual centre. Areas without any buildings, such as dense forests or large agricultural areas outside the city, were represented by low values.

All density values were then normalised on a scale of 0 (lowest density) to 1 (highest density) for further calculation.

Travel times from the city centre

The abovementioned Weighted Kernel Density was suitable as a measure of the building density as one indicator of the urban-rural gradient. However, it had its weaknesses in differentiating urban from periurban agglomerations as it did not consider the spatial relations between them. Therefore, building density had to be supplemented by another measure in order to appropriately capture the spatial complexity of the urban morphology. One approach to solving this problem would have been the calculation of the Euclidean distance between the density raster cells and the city centre. However, this way of measuring the spatial relation between any given point and the centre is not sufficient, as discussed in chapter 2.1.7. As a consequence, the travel time from the city centre was chosen as a relative measure as it more adequately reflects the spatial complexities of the urban-rural continuum.

A comprehensive road network dataset was necessary for the calculation of travel times from any given location. The online map service OSM already provides spatial information on the main road infrastructure in most cities worldwide. The georeferenced datasets for the respective areas of interest were downloaded and assessed in terms of spatial accuracy and coverage. As coverage still is rather low in African cities, missing transport infrastructure was digitised based on recent satellite imagery. Subsequently, all roads were categorised according to their order.

Based on the extended OSM dataset, a street network was created using the ArcGIS Network Analyst. Travel times for all road segments (sections between two junctions) were calculated based on their length and their respective categories with the following formula:

$$t_x = \frac{d_x}{v_x}$$

where t_x *time needed to pass road segment x in minutes*
d_X *length of the road segment x*
v_X *average velocity on the road segment x*

The calculation was based on the following hypothetical average velocities:

Table 4.2: Average velocities in relation to road category

Road category	Average velocity	
	km/h	m/min
Main roads (paved)	60	1,000
Other paved roads	40	667
Unpaved roads	10	167

As the next step, the travel polygons[26] were calculated and converted into isolines. Based on these isolines, travel times were interpolated for the whole research area. The resulting raster had the same spatial resolution (10 metres) as the Kernel Density raster described above. Eventually, the raster representing the travel times from the city centre to any given location in minutes was normalised on a scale of 0 (shortest travel time) to 1 (longest travel time).

Combination of the subindexes

After both subindexes had been calculated, the normalised raster datasets were incorporated[27] into the Urban-Rural Index (URI). The resulting raster with a spatial resolution of ten metres contained an individual value between 0 (least urban) and 1 (most urban) for every location within the area of interest (see Fig. 4.12).

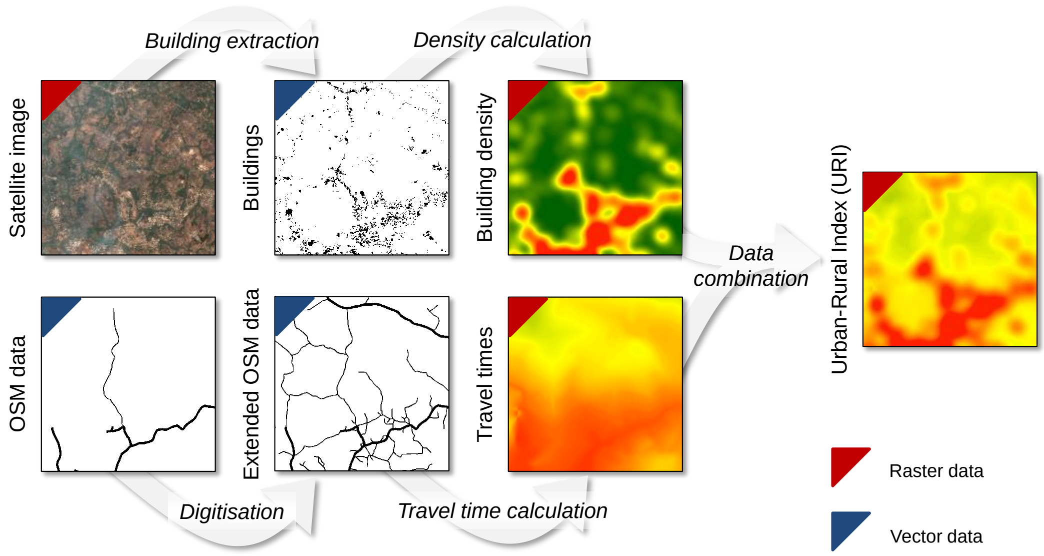


Fig. 4.12: Calculation of the Urban-Rural Index based on building density and travel times

The URI was developed as it had significant advantages over common, more vague classifications of urban, periurban, and rural. In contrast to other forms of measurements, such as the Euclidean distance from the city centre or administrative boundaries, the URI is a reproducible representation of the spatial complexity of the urban landscape and its surrounding areas along the urban-rural continuum. It was therefore used as the foundation for all spatial analyses within this research.

4.4.2 Having a closer look – quantifying the urban fabric with landscape metrics

Quantifying the urban fabric is as complex as urban areas and their surroundings are with their manifold social interactions and the resulting heterogeneous land use patterns. The urbanisation process leads to distinct arrangements that can be observed at the landscape-level. As Turner (1990: 21) points out, these “phenomena [are] […] receiving increasing

---

[26] Travel polygons define the area that can be reached within a given time.

[27] See Annexe 2 for a detailed model of the URI calculation.

attention as questions of global change become more prominent". The spatial changes associated with the urbanisation process are obvious manifestations of global change. The mosaic of landscape elements formed by that process is in turn responsible "to a great extent [for] the physiognomy, the visual appearance and the human perception of a landscape" (Eiden et al. 2000: 7). To understand these landscapes, an objective quantification, analysis, and interpretation of this mosaic is needed. Landscape metrics have proven to be a suitable tool in landscape analysis, even though there are limitations when it comes to up- and downscaling of the generated results (Uuemaa et al. 2009; Uuemaa et al. 2005; Mander et al. 2005).

Landscapes are composed of patches that can be of natural origin or altered by human activity. These patches can thereby "vary in size, shape, and arrangement" (Turner 1990: 22). With landscape metrics the spatial heterogeneity of landscapes can be measured by taking into consideration the landscape composition and configuration (Uuemaa et al. 2009) (see Fig. 4.13). While the former "refers to features associated with the presence and amount of each patch type within the landscape but without being spatially explicit" (McGarigal and Marks 1995: 9), the latter describes the spatial arrangement of landscape patches (Uuemaa et al. 2009; McGarigal and Marks 1995). Landscape metrics can be calculated with categorical data, which makes the availability of classes an essential precondition for the calculation process. In the case of agricultural research, classes would most commonly include the crop type of a patch.

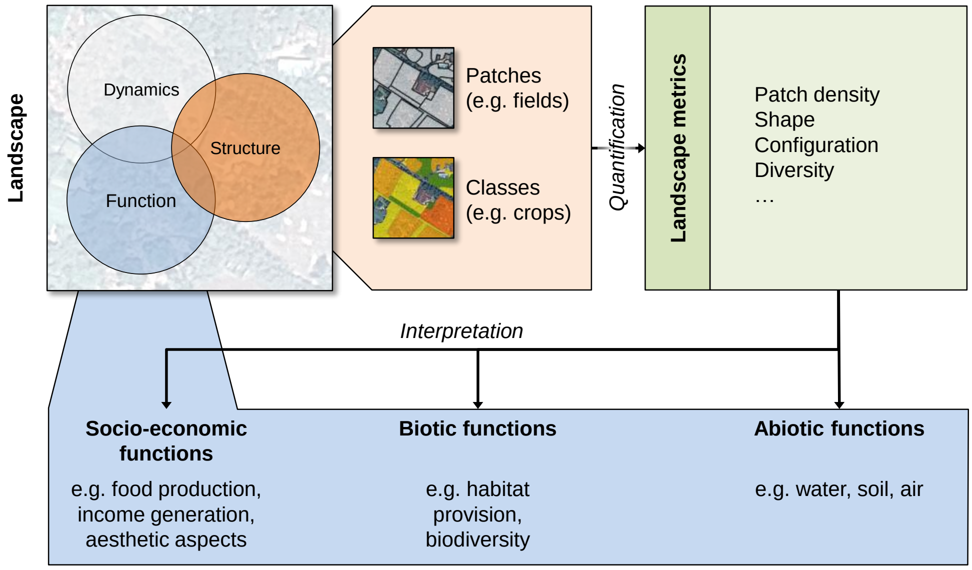


Fig. 4.13: The application of landscape metrics (based on Lausch 2002)

As Luck and Wu (2002) show in their gradient analysis of the urban landscape pattern in Phoenix (USA), landscape metrics can be successfully applied to identify changes in land use from urban to rural environments. In this research, several metrics were calculated based on the land use data generated through in situ mapping as well as based on official survey data. For the analysis of changes in the metrics along the urban-rural continuum, several metrics were calculated for each transect. Therefore, the transects were split into square sectors with an edge length of 100 metres. Accordingly, the resulting landscape quadrants had an area of one ha each (see Fig. 4.14). For every quadrant, different kinds of metrics were calculated. They were then used for the interpretation of land use changes along the continuum. While some of the metrics described below were used for the assessment of agricultural diversity, others were used as indicators for agricultural land use intensity. The calculation of all landscape metrics was performed using the vector-based *vLATE Extension for ArcGIS*.

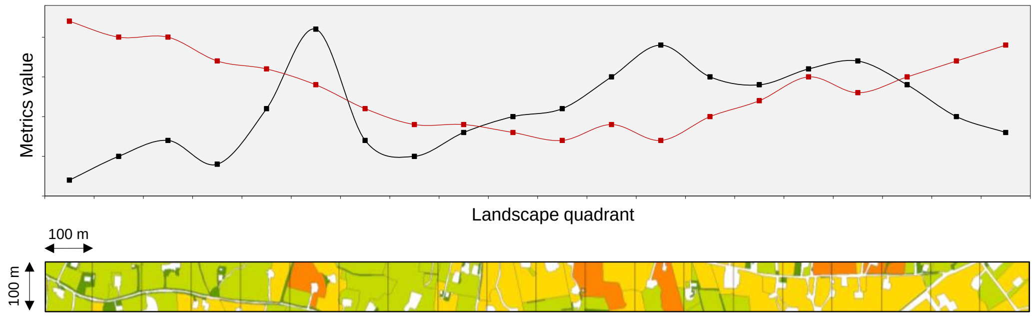


Fig. 4.14: Transect divided into sectors and exemplary visualisation of change in respective landscape metrics

Patch Density (PD)

As mentioned before, landscapes are a composite of patches, each representing an area that is covered by a single land cover class. The Patch Density (PD) can be used as an expression of the absolute number of patches within a certain reference unit (McGarigal and Marks 1995). The PD is given by the equation

$$PD = \frac{n}{A}(10{,}000)$$

where *n* is the total number of patches and *A* is the total landscape area. It is multiplied by 10,000 to convert from m² to ha.

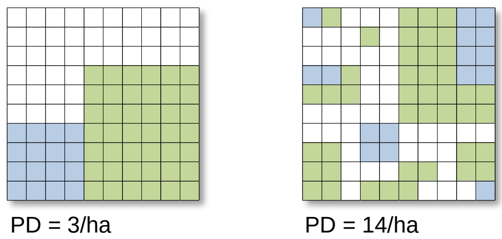


Fig. 4.15: Illustration of different patch densities (based on Eiden et al. 2000)

Fig. 4.15 above shows two different examples of landscape patterns. While both landscapes consist of the same number of land cover classes covering the same area, the resulting patch densities are different. The landscape with the higher PD (right) is more fragmented than the rather homogeneous landscape on the left. PD serves as a good measurement for spatial heterogeneity, as shown in the example above.

Mean Patch Size (MPS)

The Mean Patch Size (MPS) is an indicator for landscape fragmentation. According to McGarigal and Marks (1995: 26), the MPS as a measure of the average area of the patches within a landscape "is perhaps the single most important and useful piece of information contained in a landscape". Mathematically, the MPS is given by

$$MPS = \frac{\sum a}{n}\left(\frac{1}{10{,}000}\right)$$

where $\sum a$ is the total area occupied by patches and n is the total number of patches within a landscape. The MPS is usually expressed in ha. The smaller the MPS, the more fragmented a landscape is. In the case of agricultural production, MPS might be used as an indirect indicator for social framework conditions, such as land tenure arrangements. In areas where land division among heirs is a common practice, MPS might be smaller than in areas where land descends to the eldest son.

Patch Richness Density (PRD) and Relative Patch Richness (RPR)

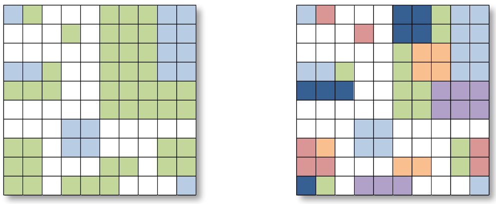
While the abovementioned metrics only provide information about the area occupied by and the shape of patches within a certain landscape, Patch Richness Density (PRD) and Relative Patch Richness (RPR) are basic measures of the diversity of classes (e.g. crops) within a landscape. The former is given by the equation

$$PRD = \frac{m}{A}(10{,}000)$$

where m is the number of classes present in the landscape and A is the total area of the landscape. It is multiplied by 10,000 to convert from m² to ha. The RPR as a relative measure is expressed as

$$RPR = \frac{m}{m_{max}}(100)$$

where m_{max} is the total number of classes observed in all landscapes studied. As mentioned above, PRD and RPR are usually applied to obtain information on class diversity. Two landscapes may be similar in terms of shape and structure, and nevertheless have very different levels of diversity (see Fig. 4.16).



PRD = 3/ha
RPR = 43 %

PRD = 7/ha
RPR = 100 %

Fig. 4.16: Different Patch Richness Density and Relative Patch Richness (based on Eiden et al. 2000)

PRD thereby standardises class richness to a per area basis, facilitating the comparison between landscape quadrants. The RPR is an expression for the proportion of the maximum potential richness of a landscape (McGarigal 2008). In this study, this maximum is defined by the total number of classes observed within the whole research area.

Percentage of landscape (%LAND)

As one of the foci of this study was the identification of spatial patterns in the distribution of cultivated crops, the Percentage of Landscape (%LAND) was calculated for every landscape quadrant. Its mathematical expression is

$$\%LAND = P_i = \frac{\sum_{j=1}^{n} a_{ij}}{A}(100)$$

where $\sum_{j=1}^{n} a_{ij}$ is the sum of the areas of all patches of the respective patch type and A is the total landscape area. Hence, the %LAND is an expression for the proportion of the total landscape that is comprised of the respective patch type (McGarigal and Marks 1995), e.g. one particular crop.

Patch Size Coefficient of Variation (PSCV)

In landscape metrics, variation of patches in a landscape is often given as the Patch Size Standard Deviation (PSSD) as a measure of absolute variation (McGarigal and Marks 1995). However, in this study, the Patch Size Coefficient of Variation (PSCV) as a standardised relative measure of variation was preferred. The PSCV measures the relative variability of the mean and is expressed as

$$PSCV = \frac{PSSD}{MPS}(100)$$

where *PSSD* is the standard deviation in patch size (see Annexe 3 for the respective formula) and *MPS* is the Mean Patch Size. The PSCV is usually given as a percentage and therefore allows for a simple comparison of different landscapes of varying size.

Shannon's Diversity Index (SHDI)

It is challenging to express the diversity of a landscape in a simple and easily understandable index value that takes into account the complexity of the issue. However, the Shannon's Diversity Index (SHDI) that was developed by Shannon and Weaver (1949) is a convenient measure of diversity as it translates this complexity into a single index value.[28] Its mathematical expression is

$$SHDI = -\sum_{i=1}^{m}(P_i \circ lnP_i)$$

where m is the number of patch types within the landscape and P_i is the proportion of area that is covered by patch type i. The SHDI is based not only on the number of different patches but also on their distribution (Eiden et al. 2000).

[28] The Shannon's Diversity Index is based on information theory. Also known as the Shannon entropy, it was originally developed as a quantification of the information content in strings of text (McGarigal and Marks 1995). However, it has been increasingly applied in ecological studies as a measure for biodiversity (e.g. Lin et al. (2011) as an example of its application in an urban context).

While the absolute value is not meaningful, the SHDI can be "used as a relative index for comparing [diversity within] different landscapes or the same landscape at different times" (McGarigal and Marks 1995: 49).

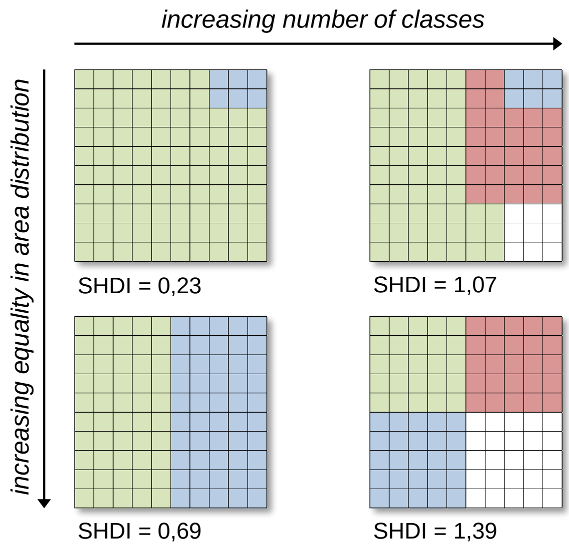


Fig. 4.17: Influence of number of classes and area distribution on Shannon's Diversity Index (based on Eiden et al. 2000)

As shown above, SHDI values "increase as the number of different patch types (=classes) [e.g. crop types] increases and/or the proportional distribution of the area among patch types becomes more equitable" (Eiden et al. 2000: 9). The maximum SHDI values are reached when all patch types of a landscape have the same area.

In addition to the abovementioned landscape metrics, several others were calculated[29] to facilitate better understanding of differences in landscape configuration, such as patterns in built-up area and different land use systems.

4.4.3 Statistical analysis and visualisation

The aforementioned landscape metrics were applied to analyse the spatial characteristics of agricultural land use along the urban-rural continuum. However, these analyses were not sufficient to fully understand the changes along the gradient. Therefore, the spatial analysis of land use data was supplemented by statistical analyses of non-spatial relationships as well as a comprehensive investigation of the household data collected along the transects (see Fig. 4.18).

[29] See Annexe 3 for an overview of all landscape metrics that were applied.

		Dataset	
		Land use	Household survey
Analysis	Spatial	Changes in crop diversity along the continuum	Land tenure situation of farmers along the continuum
	Non-spatial	Mean patch sizes of different crops, analysis of dominant intercropping systems	Relationship between duration of residence and land tenure situation

Fig. 4.18: Datasets, analytical approaches, and examples of analyses

One of the main objectives of this study was to analyse the spatial changes in land use data along the urban-rural continuum of the two case study sites. As previously mentioned, the transect polygons were therefore divided into quadrants, each having an edge length of 100 metres covering an area of one hectare. For each of these quadrants the respective landscape metrics were calculated based on the land use dataset derived from the in situ mapping. Furthermore, every quadrant was assigned the respective mean URI value as well as metadata, such as the ward name and a sequential identifier (ID).

Id	Shape *	transect	section	city	ward	URI	PD	PRD	CRI	MPS	SHDI	BDens_1992	BDens_2003	BDens_2010	LAND_agric
17	Polygon	west	17	MOS	Karang	0,6788	9	3	3	218,3327	0,370	16	30	30	18
18	Polygon	west	18	MOS	Karang	0,7939	11	1	1	99,2908	0,000	12	26	29	9
19	Polygon	west	19	MOS	Karang	0,8285	12	3	3	66,3677	0,339	17	27	27	7
20	Polygon	west	20	MOS	Karang	0,8249	18	2	2	65,0750	0,110	23	25	27	7
21	Polygon	west	21	MOS	Karang	0,7939	15	4	4	333,4523	0,938	8	13	15	29
22	Polygon	west	22	MOS	Karang	0,7339	17	6	5	224,4735	1,209	8	16	23	27
23	Polygon	west	23	MOS	Karang	0,6986	10	5	4	654,1940	0,623	5	15	17	29
24	Polygon	west	24	MOS	Karang	0,6746	9	2	2	765,5632	0,405	0	0	1	44
25	Polygon	west	25	MOS	Karang	0,6499	20	4	4	275,7324	1,093	2	8	8	43
26	Polygon	west	26	MOS	Karang	0,5899	23	5	5	179,0605	0,458	0	10	13	31

Fig. 4.19: Selected attributes of landscape quadrants shapefile

The data was then imported to *SPSS Statistics 20* for further analysis. Before the variables were analysed with respect to correlations, outliers were identified and excluded from the analysis. The individual variables were then plotted separately against the URI in order to identify the nature of possible relationships. In the case of linear relationships, a bivariate correlation analysis was performed. Whenever logarithmic relationships were identified based on the plotted data, a logarithmic transformation was carried out before executing the correlation analysis.

A slightly different approach had to be applied for the analysis of the household survey dataset, taking into account the different nature of the data. While the land use data was stored as a shapefile that could be accessed and analysed using ArcGIS, household data was originally stored in tabular form. It was geocoded based on the respective ID of the building dataset derived from the semi-automatic building extraction (as described in chapter 4.1.4). However, in contrast to the land use data, the survey data was characterised by a high spatial variability. Furthermore did the transect quadrants not contain equal numbers of households, which could have possibly led to the over- or underrepresentation of some households by simply considering average values.

Therefore, the household data was not analysed based on the transect quadrants, but based on classes derived from the URI values. An equal interval classification was performed whereby particular attention was given to an appropriate balance between the number of cases per class and the number of classes. On the one hand, classes had to contain enough cases to ensure representativeness; on the other hand, the number of classes had to be large enough so that no information about the spatial changes along the continuum was lost.

As with the spatial relationships, all non-spatial relationships were identified, analysed, and visualised using the *SPSS Statistics 20* software package.

5. Results and discussion

This chapter presents the results from both case studies: Moshi, located at the foothills of Mt. Kilimanjaro in northern Tanzania, and Bamenda, the capital of the Northwest Region of Cameroon. The presentation of the results from both case studies thereby largely follows the same structure. The results of the Urban-Rural Index (URI) calculation are discussed first, before having a closer look at changes of non-agricultural variables along the urban-rural continuum, such as the building density. The following sections then concentrate on the agricultural landscape metrics, such as proportion of area under cultivation and crop diversity. Thereafter, the results from the analysis of the household data are portrayed. At the end of the respective chapter the results from the case studies are summarised.

As one of the aims of this study was to develop and test a methodology for analysing spatial changes along the urban-rural continuum rather than comparing two case studies, the results from Moshi and Bamenda are not compared in detail. However, general conclusions from both case studies are drawn and summarised in chapter 0.

5.1 Moshi

5.1.1 Moshi's urban morphology

The analysis of the URI raster dataset - complemented by the visual analysis of VHR satellite images - revealed Moshi's specific urban morphology. Several spatial patterns could be identified that together form the complex and often interdependent pieces of the urban fabric of the city and its surroundings.

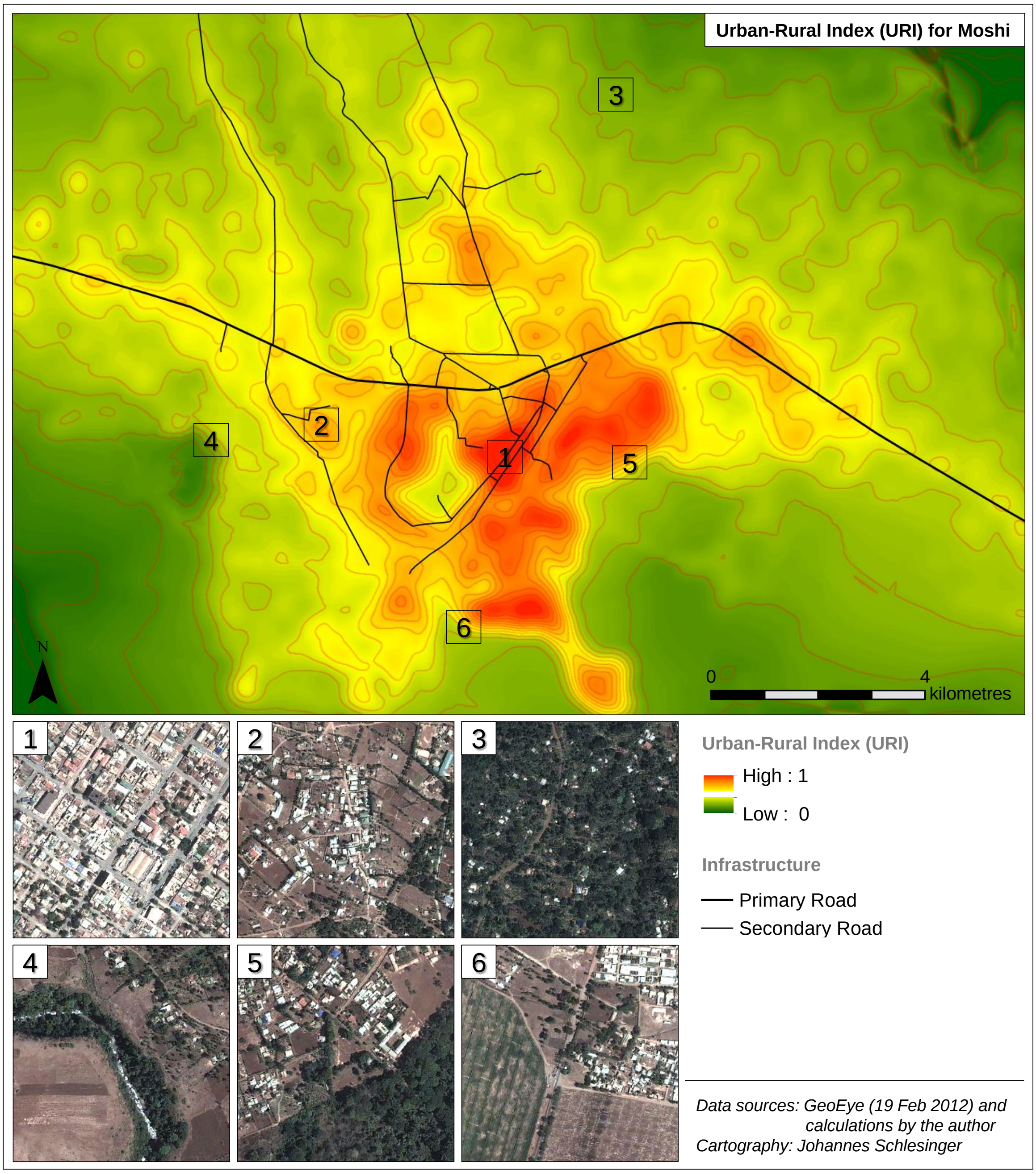


Fig. 5.1: The Urban-Rural Index for Moshi showing highest values (most urban) in red and lowest values (least urban) in green

Fig. 5.1 shows that maximum URI values were reached in the area of the city centre (see Fig. 5.1, 1). This area is characterised by a very high building density and well developed road network. It can be seen as the economic and administrative heart of the city where a large number of shops and other companies as well as administrative bodies are located. These include institutions at the municipal, district, and regional level. The area that is called *Bondeni* today (Swahili for *in the valley*) was developed in the late 19th century under colonial rule as a military and economic hub in the region (Ministry of Lands and Human Settlements Development 1998). The layout and structure of Moshi's city centre is dominated by its rectangular road network and the dominance of two- and three-storey buildings. They still reflect the systematic town planning during the colonial period. As this historic centre has been surveyed, planned and built up over a century ago, the general potential for urban development is rather low. Hardly any open spaces are left in the city centre, making further redensification almost impossible. Fig. 5.2 shows the limited changes in the built-up area within the last 20 years.

Fig. 5.2: Spatial development of Moshi's city centre between 1992 and 2012.
Image sources: Aerial photographs, 8 August 1992 (Surveys and Mapping Division, Tanzania); Satellite image, 10 March 2003 (GeoEye); Satellite image, 19 February 2012 (GeoEye)

Agricultural production can hardly be found within this area due to the limited availability of open spaces suitable for agricultural purposes. However, some production can be found along the currently unused railway lines just southeast of the city centre. Further areas of agricultural production in the central area of Moshi include an unused part of the Moshi Airfield located around one kilometre southwest of Bondeni[30].

Vast areas of medium URI values were generally located adjacent to the urban centre and predominantly along the major roads reflecting the linear development along these axes. This applied in particular to the main road linking Moshi with Arusha and Dar es Salaam. Areas along some other paved roads leading towards the villages located on the slopes of Mt. Kilimanjaro north of Moshi also showed medium URI values.

These areas are particularly interesting to urban developers, as land prices tend to be lower than within the city centre. Furthermore, these areas are well linked to the city centre and other parts of the inner city by a well-developed road network. These circumstances make them especially attractive for commuters who take advantage of both the easy accessibility and the low land prices.

The further analysis of the URI revealed another spatial pattern that could be commonly found throughout the research area. Several sub centres could be identified that showed lower URI levels than the Bondeni area, but showed significantly higher levels than their surrounding areas. Most of these areas are former villages that are slowly incorporated into the urban fabric. One example for that kind of urban development is located in the Karanga area around 3.5 kilometres west of the city centre (see Fig. 5.1, 2).

[30] The airfield can be easily identified in Fig. 5.1 as a yellow area located west of the city centre being surrounded by more urban areas (red areas).

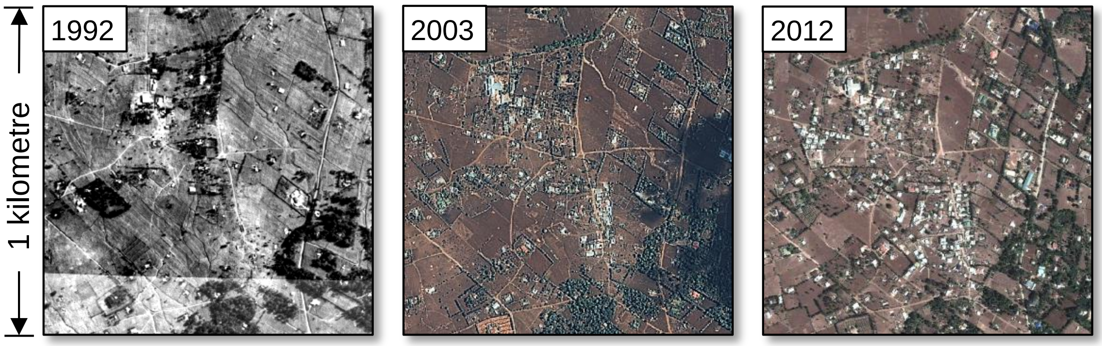


Fig. 5.3: Spatial development of Karanga sub centre between 1992 and 2012.
Image sources: Aerial photographs, 8 August 1992 (Surveys and Mapping Division, Tanzania); Satellite image, 10 March 2003 (GeoEye); Satellite image, 19 February 2012 (GeoEye)

In 1992, several houses already existed in the area. Even though most of them were scattered, some of them were concentrated in the middle of the scene by that time. Due to its location close to the Moshi-Arusha road, low land prices, and an increasing demand for housing, the area has developed into a sub centre within the last 20 years. The heterogeneous land use structure is an indicator for the informality of the ongoing development. The ongoing conflict between formalised and traditional land tenure arrangements also contributes to this development pattern. As road, water, and telecommunication infrastructure is currently developed, a further increase in population numbers and built-up area can be expected for the future.

Areas of similar URI values could be identified in the northern parts of Moshi (see Fig. 5.1, 3). This part of Moshi is not as easily accessible as the areas of linear development along the main roads. However, URI values are still relatively high due to the high population and hence high building density. The forest zone along the slopes of Mt. Kilimanjaro is traditionally dominated by the Chagga people and their well-established agroforestry system, also known as the Chagga gardens (Hemp and Hemp 2008; Fernandes et al. 1984). Intensive multi-storey intercropping on relatively fertile soils as well as an increasing division of land leads to increasing population densities.

Areas of low URI values are usually separated from the other parts of the city by either natural or manmade structures that form a barrier to urban development. The Machame Kusini area, for example, is cut off from the rest of the city by a deeply incised river valley, making it unattractive for urban development (see Fig. 5.1, 4). This area is therefore primarily used for relatively large-scale production of maize and beans. The Kimochi area, located southeast of the city centre, faces a similar situation. In this case the protected Rau Forest forms a natural barrier to further development (see Fig. 5.1, 5). Kimochi is characterised by rice production as well as the cultivation of maize and beans. An example for a manmade impediment of urban growth could be found in the southern part of the research area (see Fig. 5.1, 6). The Tanzania Planting Company (TPC) cultivates sugar cane for industrial processing on large pieces of land. The transformation of this privately held land into building land is not expected.

However, it is not only the abovementioned barriers leading to generally lower URI values in the southern part of the research area. The agricultural system practiced traditionally in the region also contributes to this development pattern. The agroforestry system of the Chagga is traditionally supplemented by the large-scale production of starchy crops - such as maize and beans - in the lowlands. As the majority of this land is still owned and cultivated by the Chagga, the options for converting it into urban land are limited under current conditions. However, giving up the agricultural production on this land becomes increasingly attractive as land prices start rising in the course of increasing urbanisation.

5.1.2 The transect analysis – spatial changes along Moshi's urban-rural continuum

The previous chapter discusses the general morphology of the research area. Building on these results, this chapter presents the results of the transect analysis. In the Moshi case study, four transects were identified in order to obtain a wide range of data that facilitates quantifying changes along the urban-rural continuum (see Fig. 5.4).

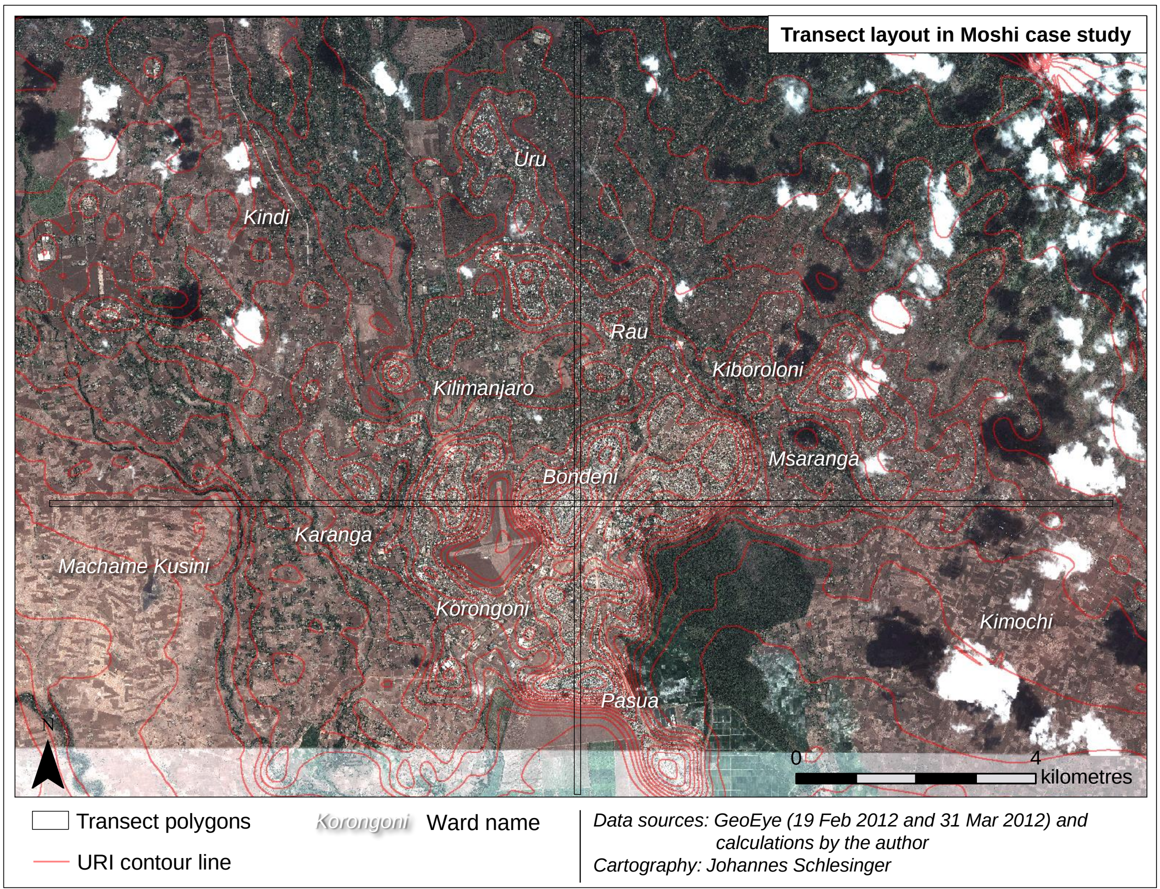


Fig. 5.4: Layout of transects in the Moshi area

The transects were laid out radially, originating at *Soko la kati* (Swahili for *central market*), and heading towards North, East, South, and West having a length of 8, 9, 5, and 9 kilometres, respectively. The length of the transects was limited by the availability of VHR satellite imagery, as previously discussed. Even though not all aspects of the urban-rural continuum could be covered, the four transects provided a good foundation for an increased understanding of the spatio-temporal dynamics in and around Moshi.

The following sections reflect on the importance of space for land use as well as for socio-economic household-based parameters. First of all, spatial changes of several indicators for urbanisation are presented and discussed. Secondly, the analysis of land use data collected within the transect polygons is introduced. Eventually, the spatial analysis of the household data is presented. The chapter then concludes with an analysis of the interrelations between the abovementioned parameters.

Distance and other indicators of urban-to-rural changes

Administrative boundaries or linear distance from the city centre are commonly used for the categorisation of *urban*, as discussed in chapter 2.1.1. However, the analysis of URI values of the Moshi study area showed that the actual situation was much more complex. The assumption, that the urban-rural continuum could be sufficiently analysed and understood based on the abovementioned categorisations, would lead to an oversimplification of the spatial complexity and heterogeneity of cities and their surroundings. Fig. 5.5 shows that distance from the city centre and changes of the degree of *urbanity*, as measured by the URI, are indeed correlated. It could be therefore basically summarised that the larger the distance from the city centre, the less urban the area was. As the travel time as an indirect indicator of distance from the city centre is one variable of the URI, this is – at least to a certain extent – self-evident. Nevertheless, a closer look at the relation between distance and URI unveils the complexity of the urban morphology.

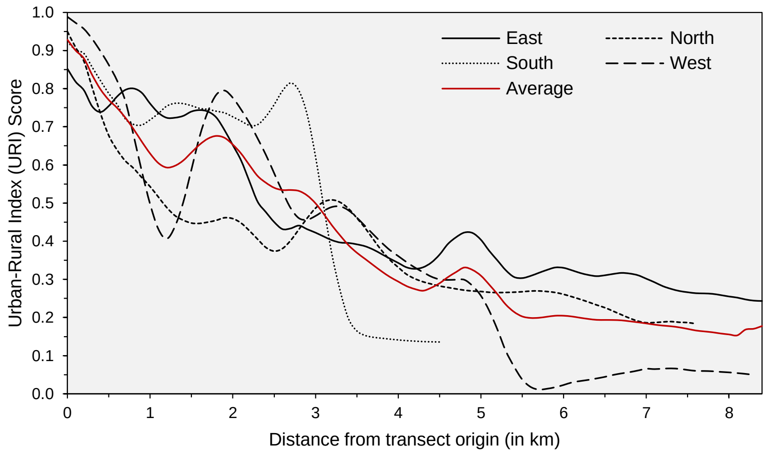


Fig. 5.5: Changes in Urban-Rural Index values with increasing distance from the city centre (n = 292)

Even though the abovementioned simplified assumption generally applied to the average URI value calculated from the four transects, the changes along the individual transects were more complex. URI values in the southern transect (ST) decreased at relatively low rates within the first three kilometres from the transect origin before rapidly declining to levels below .2. In contrast, URI values within the northern transect (NT) declined to levels around .4 just outside the city centre before further decreasing to .2 at the end of the transect.

The abovementioned differences illustrate to what extent historical, social, political, and topographical circumstances influence the spatial development of urban areas (Camagni et al. 2002). The rapid changes in URI values in the ST can be explained by the current property situation. As previously mentioned, large areas south of Moshi are owned and cultivated by a private company, making urban expansion impossible. The decline in the NT is a consequence of the historical development of the city. During colonial times, the residences of European officers and administrative staff were built in the area just north of the city centre. As the area was never redensified, it is still characterised by large plots, low building densities, and a generally low proportion of impervious surface.

The previous elaborations show that using simple categorisations based on distance for the analysis of changes along the urban-rural continuum would lead to distortions in the data. Therefore, the URI was used in this study as a measure for the degree of urbanisation.

Building density and construction activity

Understanding and visualising spatial as well as temporal changes in building density within the transects is important, as it is usually negatively correlated to the availability of agricultural land. Changing building densities are caused by construction activity that can contribute to the redensification of already built-up areas or to an increasing building density at the fringes of the city, be it in form of linear, leapfrog or scattered development. An increase in building density leads to a decrease in land available for other forms of land use, such as the cultivation of crops (see Annexe 6, Photo 5). In many cases, increasing construction activities and the resulting loss of agricultural land lead to conflicts over land. As previously discussed (see chapter 2.3.1), periurban areas tend to be hotspots of these conflicting interests. Fig. 5.6 shows the changes in building densities along the western transect (WT) of the Moshi case study, calculated on the basis of multi-temporal RS data.

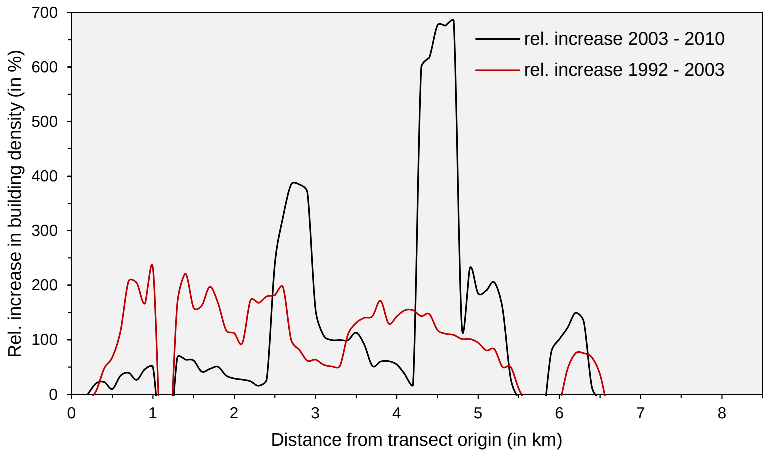


Fig. 5.6: Changes in building densities along the western transect (n = 84)

Construction activity was relatively low in the immediate city centre before reaching a first maximum in the area east of the airport (large open space in a north-south direction, about 1.2 kilometres from the transect origin). While no construction activities could be identified on the former airfield due to building restrictions, built-up area has significantly increased over the past 20 years in the *Soweto* area, located west of the airport. This area has been identified by municipal administration for formal urban development. Plots have been selected during a systematic survey of the area and road infrastructure has been developed, leading to a rapid development of the area. The development of the *Karanga* area (about 4 to 6 kilometres from the city centre), located on the western side of the deeply incised *Karanga River*, still remains limited, yet has an increasing momentum. It can be divided in two phases: while the increase in built-up area was rather limited between 1992 and 2003, construction activity has led to a considerable increase in buildings between 2003 and 2010. As previously mentioned, this ongoing development was facilitated by the recent improvement of the road infrastructure in the area. The areas located west of *Karanga* (more than 6 kilometres from the transect origin) have seen little changes in building density within the observation period, mainly due to their secluded location (see Fig. 5.6). As transportation infrastructure is still lacking, it has not yet become interesting for urban developers.

The observations in the WT show how construction activities and building densities change along the urban-rural continuum. These changes are to a large extent influenced by topography, town building restrictions, and infrastructure developments. Taking into account the data from the other transects, more general observations could be made. Fig. 5.7 shows the relative increase in built-up area between 1992 and 2010 within the transect quadrants plotted against their respective URI values.

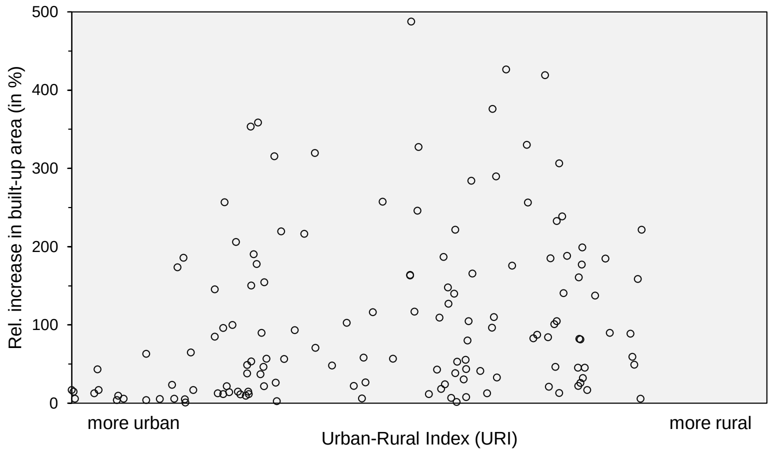


Fig. 5.7: Changes in built-up area between 1992 and 2010 (all transects) plotted against URI values (n = 162)

Little changes could be observed in the city centre with its high URI values, due to the limited availability of construction sites. Areas of low URI values (more rural) also showed little changes in the built-up area between 1992 and 2010. In these cases, it rather is their location than the availability of land that hampers urban development. The most dynamic growth was observed in the area of medium URI levels, the transition zones between urban and rural areas.

5.1.3 Land use data analysis – diverse areas of transition

Spatial and temporal changes of building densities and other aspects of urban development come along with respective changes in agricultural production patterns. The more land is occupied by typically urban land uses, such as housing and transportation infrastructure, the less land is available for agriculture. In the Moshi case study, a total area of 301 ha was mapped of which 193 ha – including grassland – were under cultivation (see Annexe 5 for an illustration of the actual changes of agricultural land use along all surveyed transects). This area was composed of 2,315 patches.

Based on the land use data collected during the field phases, several landscape metrics with a special emphasis on agricultural land use were calculated. The following sections discuss how specifications of agricultural land use, such as area under cultivation, patch sizes, and the diversity of cultivated crops changed along the urban-rural continuum.

Cultivated area and patch sizes

As previously discussed, the proportion of the area under cultivation is often – albeit indirectly – used as a foundation for the differentiation between *urban* and *rural*. Official statistics, such as the *Tanzanian National Sample Census of Agriculture* (United Republic of Tanzania 2007), commonly provide data on the area under cultivation on a regional or district level. However, the GIS-based analysis of land use data collected in this study provide a much more detailed picture of the actual situation along the urban-rural continuum.

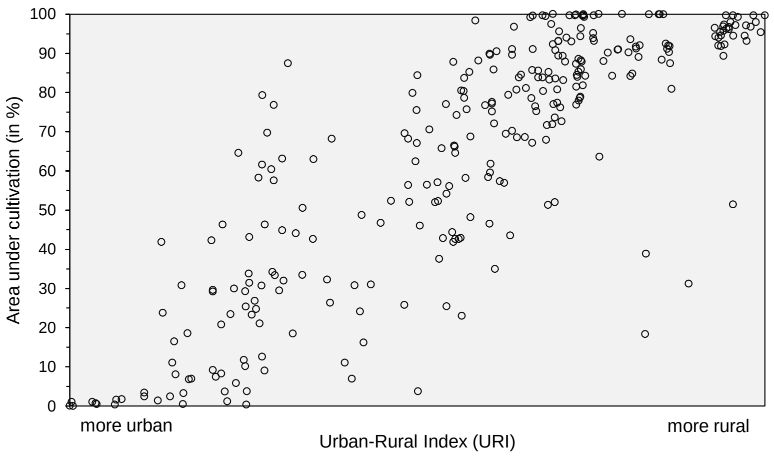


Fig. 5.8: Increasing area under cultivation with decreasing Urban-Rural Index scores (n = 292)

Fig. 5.8 illustrates the gradual transformation from the hardly cultivated city centre to areas that were almost entirely used for agricultural production ($r = -.840$, $p < .01$)[31]. The area in between can be interpreted as an area of transformation where agricultural land use is important yet not necessarily the dominating land use. In contrast to the general trend, a few quadrants showed low URI values and small shares of cultivated land. This

[31] For the analysis of linear dependence between several variables and the URI, Pearson's product-moment correlation coefficient (usually expressed as *r*) was calculated. It gives a value between +1 (variables show a perfect positive correlation) and -1 (variables are perfectly negatively correlated) (Cleff 2011). The p-value represents the probability of obtaining by chance a result at least as extreme as the one observed (Cleff 2011). In other words, the p-value is the probability of an observed result arising by chance. Generally spoken, the lower the p-value, the more significant the relationship.

constellation could be observed in areas where slope or soil conditions made cultivation difficult or where periurban settlement clusters lead to a higher degree of built-up land. On the other hand, some quadrants close to the URI maximum showed disproportionally high percentages of area under cultivation. These anomalies are caused by the aforementioned cultivation of open spaces located close to the city centre, such as abandoned railway lines and airfields (see Annexe 6, Photos 2-3).

The calculation of the Mean Patch Size (MPS) showed a logarithmic relationship with the URI ($r = -.804$, $p < .01$) (see Fig. 5.9).

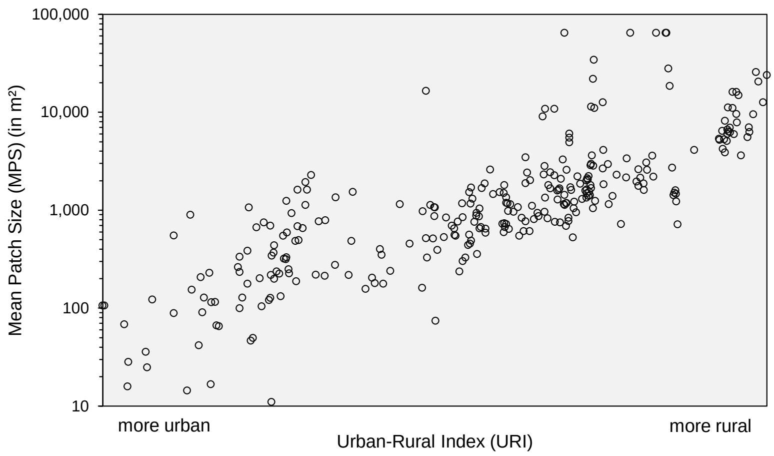


Fig. 5.9: Changes in Mean Patch Size along Moshi's urban-rural continuum (n = 291)

The small MPS in the most urban areas is a consequence of the limited availability of land suitable for agricultural purposes. In these areas, patch sizes hardly exceed 400 to 500 m². This could be interpreted as an indication of the small-scale cultivation in homegardens or on open spaces of limited size, such as road reserves. The areas of medium URI levels are dominated by MPS ranging from about 500 to 2,000 m². Within the least urban areas, where the urban influence is still limited and large pieces of land are available for cultivation, MPS of more than 2,000 m² are common (see Annexe 6, Photos 7-8).

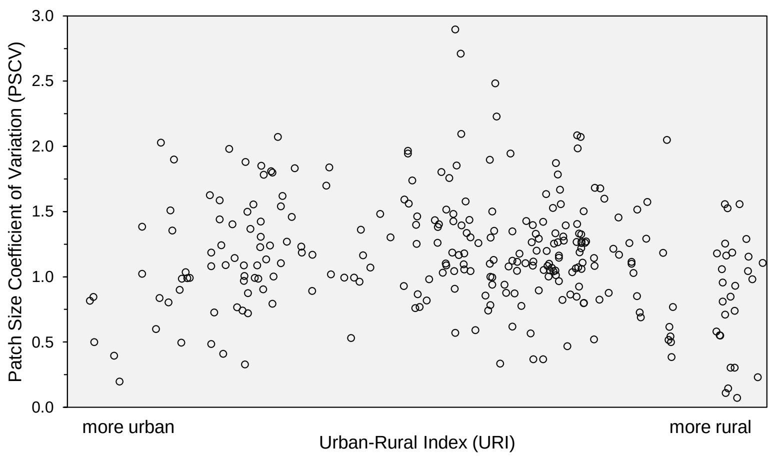


Fig. 5.10: Patch Size Coefficient of Variation as a relative measure of variability (n = 278)

Fig. 5.10 illustrates the changes of the Patch Size Coefficient of Variation (PSCV) along the urban-rural continuum. The PSCV is a measure of the relative variability of patch sizes. Transect sections where low PSCV values could be found were characterised by little variation in patch sizes. This was usually the case in urban areas where only small-scale cultivation in backyards could be found. Low PSCV values were also found in the least urban areas, where only large-scale cultivation of staple foods was existent. In contrast, the highest variability was observed in the areas of medium URI values. A large range of patch sizes could be found here, resulting in a heterogeneous land use pattern. In terms of agricultural land use, large-scale cultivation of staple crops was found next to the micro-scale production of vegetables for home consumption, contributing to high agricultural diversity.

Crop diversity

In the context of global change, the issue of biodiversity is increasingly becoming a focus of interest as it has important implications for global sustainability. As an increasing amount of formerly natural habitats is being converted into agricultural land, agrobiodiversity as a "vital sub-set of biodiversity" (FAO 2004) becomes increasingly important as well. In this study, the focus lies on crop diversity as part of agrobiodiversity[32] (see Fig. 5.11).

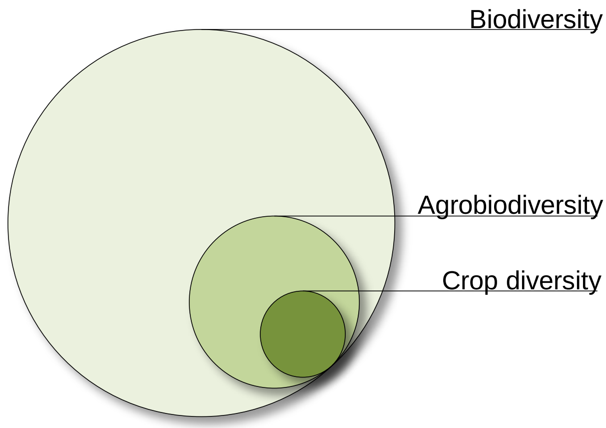


Fig. 5.11: Biodiversity, agrobiodiversity and crop diversity

Crop diversity does not only have important ecological implications, but is also crucial for food security[33].

In this study, three indicators for crop diversity were calculated based on the land use data. The Crop Richness Indicator (CRI) is an expression of the number of different crops that were grown on a respective field. In addition to this patch-level indicator, two other

[32] Agrobiodiversity can be seen as the umbrella term describing all aspects of agricultural diversity, ranging from crops to livestock, soil fauna, and weeds.

[33] The FAO (1996) defines food security as the state „when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". Crop diversity is thereby especially important for the provision of sufficient nutrients and specific dietary needs.

diversity indicators were calculated for the landscape (transect quadrant) level. The Patch Richness Density (PRD) was used as a representation of the number of different (inter-) cropping systems per quadrant.

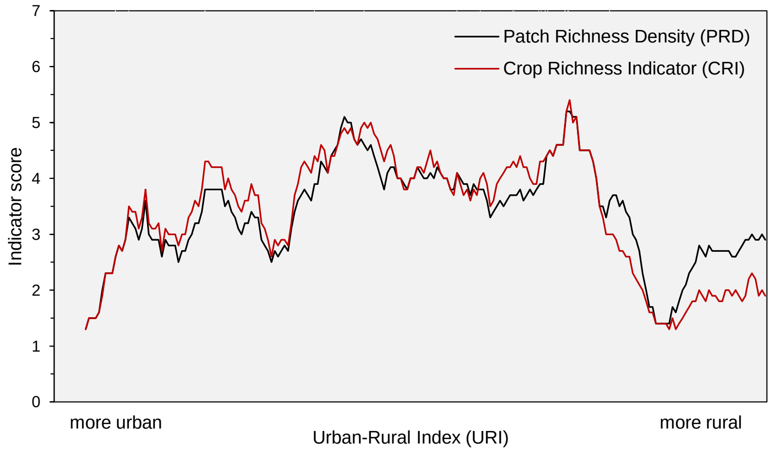


Fig. 5.12: Changes in crop diversity indicators along the continuum (n = 215)

Fig. 5.12 shows that crop diversity as expressed by the CRI and PRD was highest in the areas of medium URI values[34], whereas both indicators showed low values for the most urban as well as for the least urban areas. The low crop diversity in the most urban areas can be interpreted as a consequence of the limited availability of areas suitable for cultivation, as previously shown. However, wherever cultivation in backyards was practiced, there was a tendency towards growing a wide range of crops, such as tomatoes or leafy vegetables for home consumption[35]. Low CRI and PRD values in the least urban areas are a result of the production on larger fields, as illustrated above. The large-scale production of maize and beans was the most common practice in these areas. As hardly any homegardens with their typically more diverse production system could be found, crop diversity was low.

In contrast to the abovementioned indexes for crop diversity, the Shannon's Diversity Index (SHDI) is not only based on the number of different patches or crops cultivated within a transect quadrant, it also takes into account the spatial distribution of patches.

[34] Due to the distinct characteristics of agricultural production on the slopes of Mt. Kilimanjaro, the data from the northern transect was excluded from the calculations. The findings from this transect are discussed in Box 5.1.

[35] See below for a more detailed analysis of crops grown within the research area.

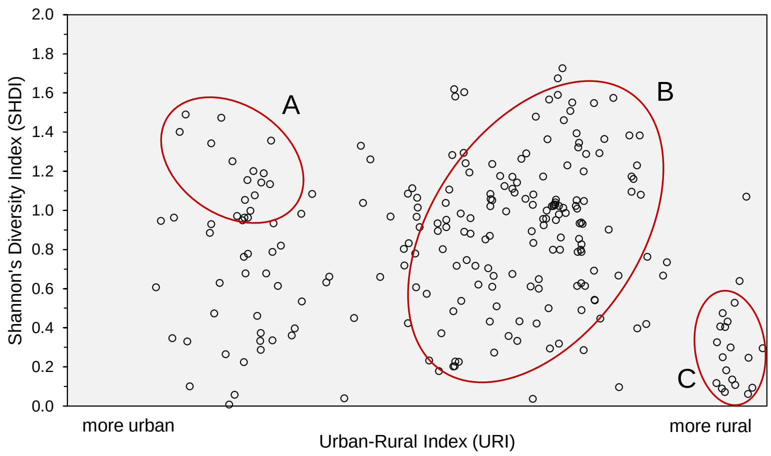


Fig. 5.13: Patterns in Shannon's Diversity Index scores (n = 236)

Even though the overall tendency illustrated by the abovementioned indexes was validated, the SHDI provided a more nuanced picture of the crop diversity along the transects. Three clusters were identified in the crop diversity data:

A) Wherever cultivation on open spaces located close to the city centre, such as the previously mentioned airfield, could be found, the SHDI was high. In particular, the cultivation of maize and beans on open spaces next to a wide variety of vegetables resulted in a high crop diversity.

B) The heterogeneous land use pattern that could be found in areas of medium URI levels was reflected by high SHDI values. Homegardens with small-scale production for home consumption could be found next to fields with market-oriented staple food production, leading to a diverse agricultural landscape.

C) Areas of large-scale cultivation of maize, sometimes intercropped with beans or sunflowers, were characterised by low levels of diversity. The large-scale cultivation of sugar cane south of Moshi is also reflected in this cluster.

Box 5.1: The special case of the northern transect – agriculture on the slopes of Mt. Kilimanjaro

Mt. Kilimanjaro with its distinct topography has a great impact on land use north of Moshi's city centre. Changes along this transect are still influenced by the mountain rather than by urbanisation processes, even though urban growth already has an impact on the people living on the slopes.

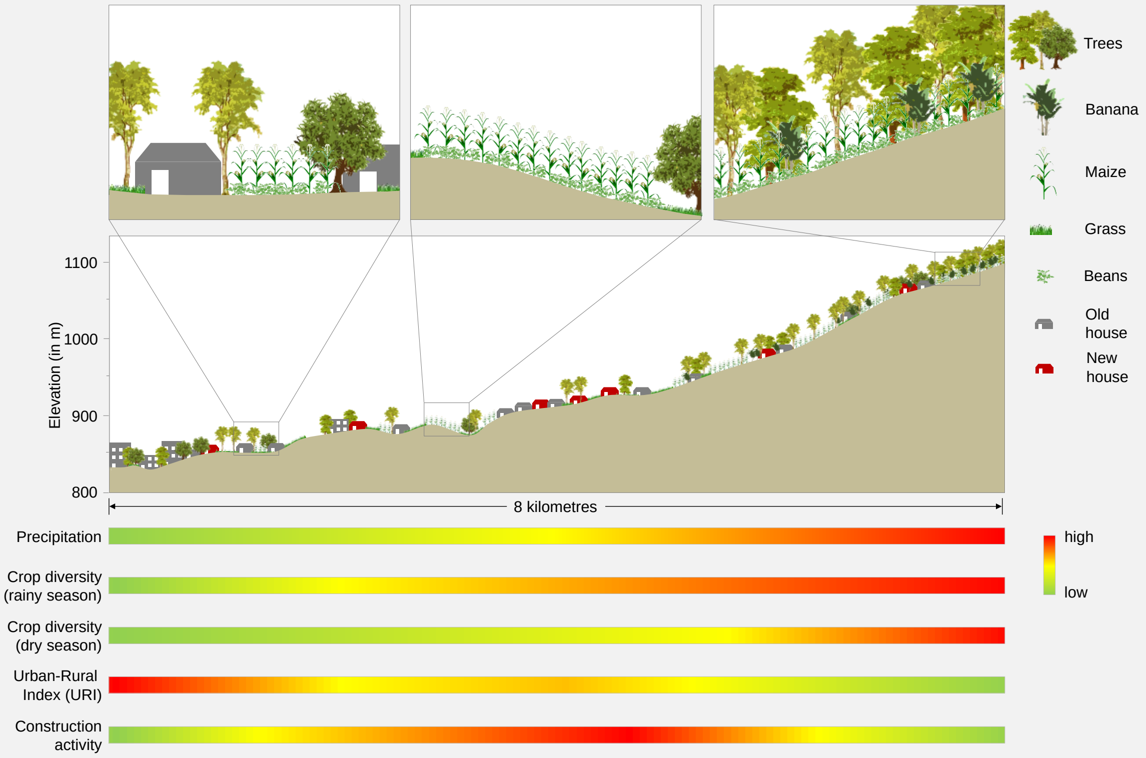


Fig. 5.14: Profile of Moshi's northern transect

As illustrated in Fig. 5.14, altitude and the associated changes in precipitation shape the agricultural land use and vegetation communities along the NT. Agriculture in the region is to a large extent rainfed. Cultivation on the lower slopes of Mt. Kilimanjaro therefore has a strong seasonal characteristic. Most of the fields are under cultivation from March to early October, due to seasonal rains. However, a large proportion of these areas lies fallow during the dry season, partly because of a lack of irrigation systems. In contrast, cultivation in the more elevated areas (above around 900 metres) is less dependent on seasonal rains. Precipitation is more evenly distributed and levels of evapotranspiration are usually lower than in the lowlands due to the more frequent cloud cover. The natural vegetation is therefore a montane rainforest that is traditionally used by the Chagga.

These ecological preconditions are responsible for deviating land use patterns along the NT. While crop diversity along the other transects had its maxima in the areas of medium URI levels, diversity indicators in this transect showed their maximum values in the least urban areas. In these areas land use is dominated by the chagga garden, an agroforestry system that is characterised by several vegetation layers, maximising the use of limited land (see Fig. 5.15 and Annexe 6, Photo 6).

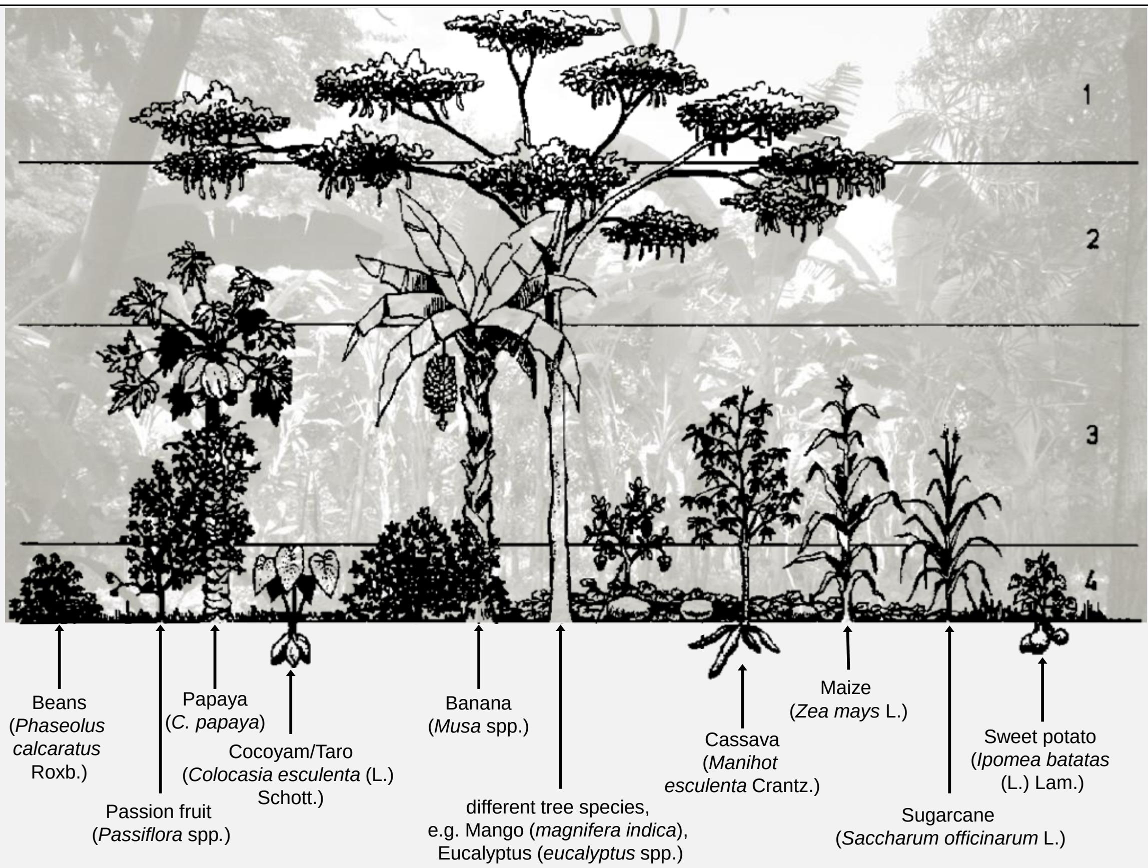


Fig. 5.15: Multi-storey structure of a typical Chagga garden (Niñez 1985: 4, modified)

The top layer is dominated by remnants of the former forest cover and some cultivated fruit trees, such as Avocado and Mango, providing shadow, fodder, and firewood (Hemp and Hemp 2008). Below this layer, usually a banana canopy with some fruit and fodder trees can be found, followed by a layer of young trees and shrubs as well as coffee, medicinal, and food plants. The lowest zone is made up of food crops, such as beans and sweet potatoes, cultivated mainly for self-consumption (Fernandes et al. 1984).

One of the integral parts of this distinct agroforestry system is its complexity and diversity that is clearly reflected in the results of the transect analysis.

The temporal dimension of diversity

Diversity not only has a spatial dimension that is heavily influenced by urban areas. It also has a temporal dimension, as changes in vegetation communities can be altered by the urbanisation process. While it is commonly assumed that the diversity of vegetation would decrease with increasing urban growth (McKinney 2002; Goddard et al. 2010), the analysis of multi-temporal satellite images from Moshi showed that urbanisation can also have a positive impact on quantity and diversity of urban and periurban vegetation.

Fig. 5.16 shows how the vegetation has changed in an area that has experienced a significant increase in building density over the last decade.

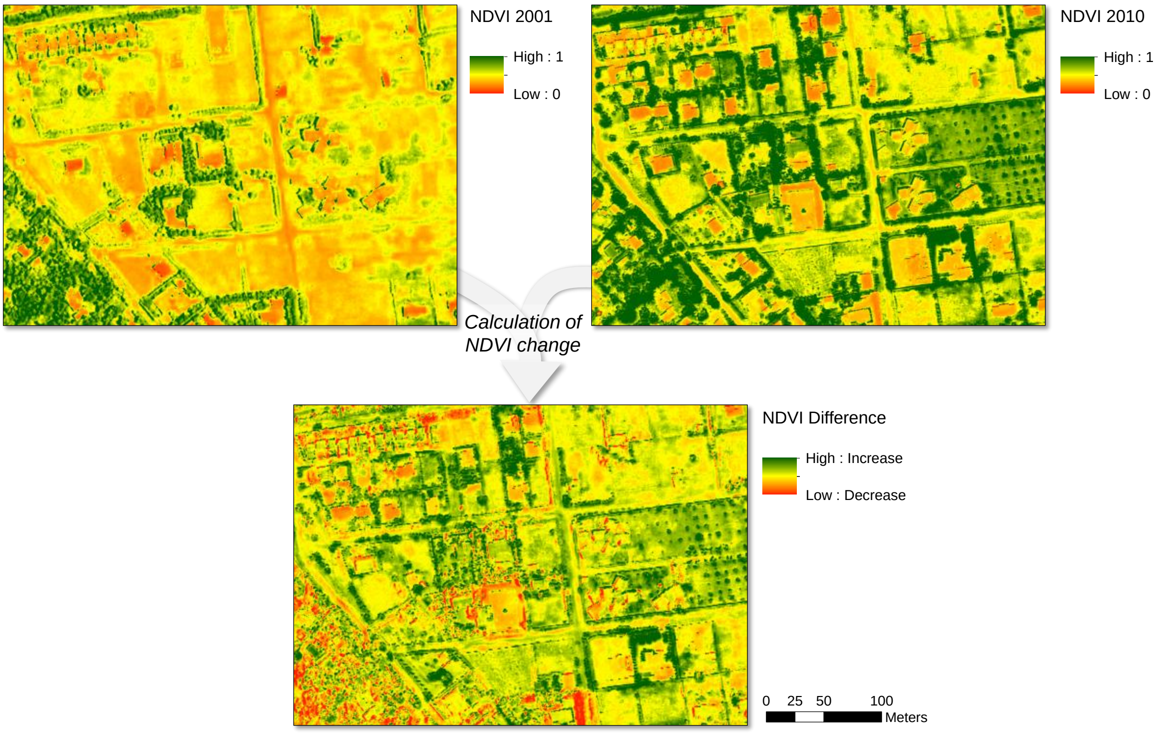


Fig. 5.16: Urban growth and its impacts on vegetation quantity. Example of Moshi showing the NDVI in 2001 (top left) and 2010 (top right) (red = low vegetation intensity, green = high vegetation intensity), and the difference between 2001 and 2010 (bottom)

The left image shows the Normalised Difference Vegetation Index (NDVI)[36] of the area in 2001, just before the planned urban development took place. The area is characterised by relatively large-scale rain-fed cultivation of staple crops interrupted by a few scattered houses. The right image shows the same area in 2010, after the transformation of the area to a surveyed settlement. Hedges and trees have been planted along the plot boundaries; rain-fed cultivation has been converted to an irrigated small-scale cultivation of diverse vegetables and staple crops. That means that urban and periurban areas can still be "supporting a rich diversity of plant species" even though – or because – they are "highly modified landscapes" (Luck and Smallbone 2010: 95).

Cultivated crops

In the Moshi case study, a total of 28 different cultivated crops were identified[37]. Table 5.1 lists those crops and crop combinations that were identified on at least ten patches within the transects[38].

[36] The NDVI is defined as $NDVI = \frac{(a_{\mathrm{nir}} - a_{\mathrm{vis}})}{(a_{\mathrm{nir}} + a_{\mathrm{vis}})}$ where a_{nir} is the surface reflectance in the near infrared spectrum and a_{vis} represents the reflectance in the visible spectrum (Carlson and Ripley 1997). It is commonly used as an indicator for vegetation concentration.

[37] Even though grassland should not be directly addressed as a crop it was included as it is an integral part of the agricultural system, be it as a nitrogen fixing legume or as a fodder plant.

[38] See Annexe 4 for a list of all crops identified in the two case studies.

Table 5.1: Most commonly cultivated crops in Moshi (excluding grassland)

	Nr of patches	Share of patches (in %)
Pure cropping		
Maize	377	18.5
Beans	236	11.6
Sugar cane	123	6.0
Banana	86	4.2
Elephant grass	50	2.5
Sunflower	38	1.9
Amaranthus	36	1.8
Groundnut	17	.8
Sweet potato	15	.7
Pumpkin	15	.7
Other	20	1.0
Subtotal	1,013	49.8
Intercropping		
Maize, beans	749	36.8
Maize, beans, banana	78	3.8
Maize, banana	43	2.1
Banana, grassland	35	1.7
Banana, coffee	28	1.4
Banana, coffee, grassland	26	1.3
Maize, beans, banana, coffee	15	.7
Maize, beans, sunflower	12	.6
Maize, sunflower	12	.6
Other	25	1.2
Subtotal	1,023	50.2
Total	2,036	100.0

In addition to providing information about the cultivated crops, Table 5.1 also reflects the dietary habits of the population of the area. Maize and beans – an integral part of the diet in Moshi – were found on a large number of patches. These two crops combined made up almost two thirds of the patches on which only one crop was cultivated (excluding grassland), illustrating their importance as staple food crops. Even though banana was commonly cultivated in intercropping systems, it was still found on about 8 percent of the patches with pure cropping (and 4.2 percent of the total patches). 17 other crops in this category were identified, amounting to about 15 percent of the patches under pure cropping.

Intercropping is an important concept of urban and periurban agriculture in general (Pasquini et al. 2009; Mougeot 1994a), and on the slopes of Mt. Kilimanjaro in particular (Soini 2002b; Hemp and Hemp 2008). It can be defined as “a multiple cropping system, in which two or more crops species [are] planted simultaneously in a field during a growing season" (Mousavi and Eskandari 2011: 483). Intercropping has several advantages over pure cropping. The most frequently mentioned are: increased production; better use of available resources (e.g. land, labour, water, nutrients); reduction of pests, diseases and weeds; improved soil fertility; and socio-economic and other advantages (e.g. less vulnerability, improved economic situation, more diverse nutrition) (Vandermeer 1989; Mousavi and Eskandari 2011).

In the Moshi case study, a total of 26 different crop combinations were identified. The combination of maize and beans was found on more than three quarters of the patches in which intercropping was practiced, followed by the combination of maize, beans, and banana (about eight percent) and maize and banana (about four percent). Banana based intercropping was most frequently found along the northern transect, where the Chagga gardens play a crucial role. In contrast, maize based mixes were predominantly found in the less urbanised lower areas that are much drier than their more elevated counterparts.

Patch sizes per crop

The ecological preconditions in the Moshi area are favourable for intensive and widespread intercropping. This was clearly reflected in the agricultural production patterns (see Fig. 5.17).

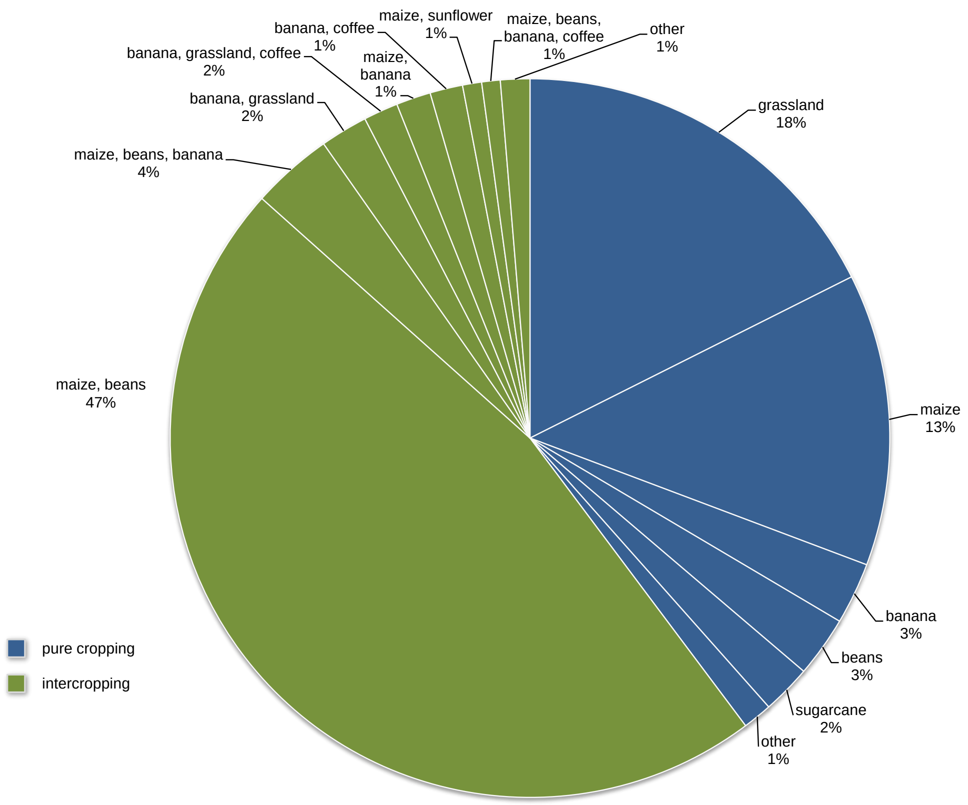


Fig. 5.17: Relative shares of cultivated area by crop/crop community (n = 2,036)

About 60 percent of the area under cultivation is used for intercropping, with the combination of maize and beans being by far the biggest contributor. In the case of pure cropping, grassland and maize had the biggest share in cultivated area, followed by banana and beans.

In order to fully understand the differences between pure cropping and intercropping systems in this context, the analysis of MPS of the different categories provided a more detailed insight into patterns of agricultural production (see Fig. 5.18).

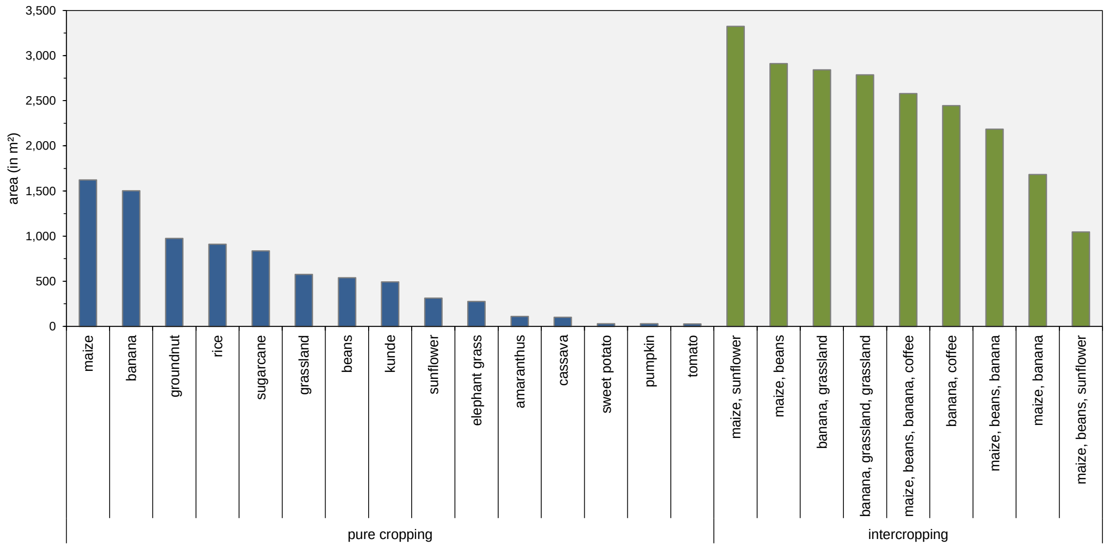


Fig. 5.18: Average field sizes of selected crops/crop communities (n = 1,999)

MPS of pure cultivation patches were generally smaller than patches with intercropping. A number of factors influence this difference in average area under cultivation, making generalisations difficult. These findings were surprising as a number of preceding studies produced contrary results. While pure cultivation is usually associated with large fields and large-scale investments (e.g. Smale et al. 2011; Hallam 2011), intercropping systems are often described as locally adjusted small-scale solutions (e.g. Drescher 1998; Oluoch et al. 2009). The results from this analysis, however, show that intercropping is also commonly practiced on a larger scale.

The location of the fields along the urban-rural continuum was identified as the most important factor for the occurrence and shape of agricultural production as well as for the distribution of specific crops. It is therefore discussed in detail below.

Spatial distribution of crops

The abovementioned analysis of crop diversity already provides a general overview of changes along the urban-rural continuum and general characteristics of crop production. However, a more detailed analysis of crops and crop communities along the transects revealed a more complex pattern in agricultural land use in Moshi.

Fig. 5.19 illustrates the changes in the number of patches and areas covered for eight different forms of agricultural land use along the continuum.

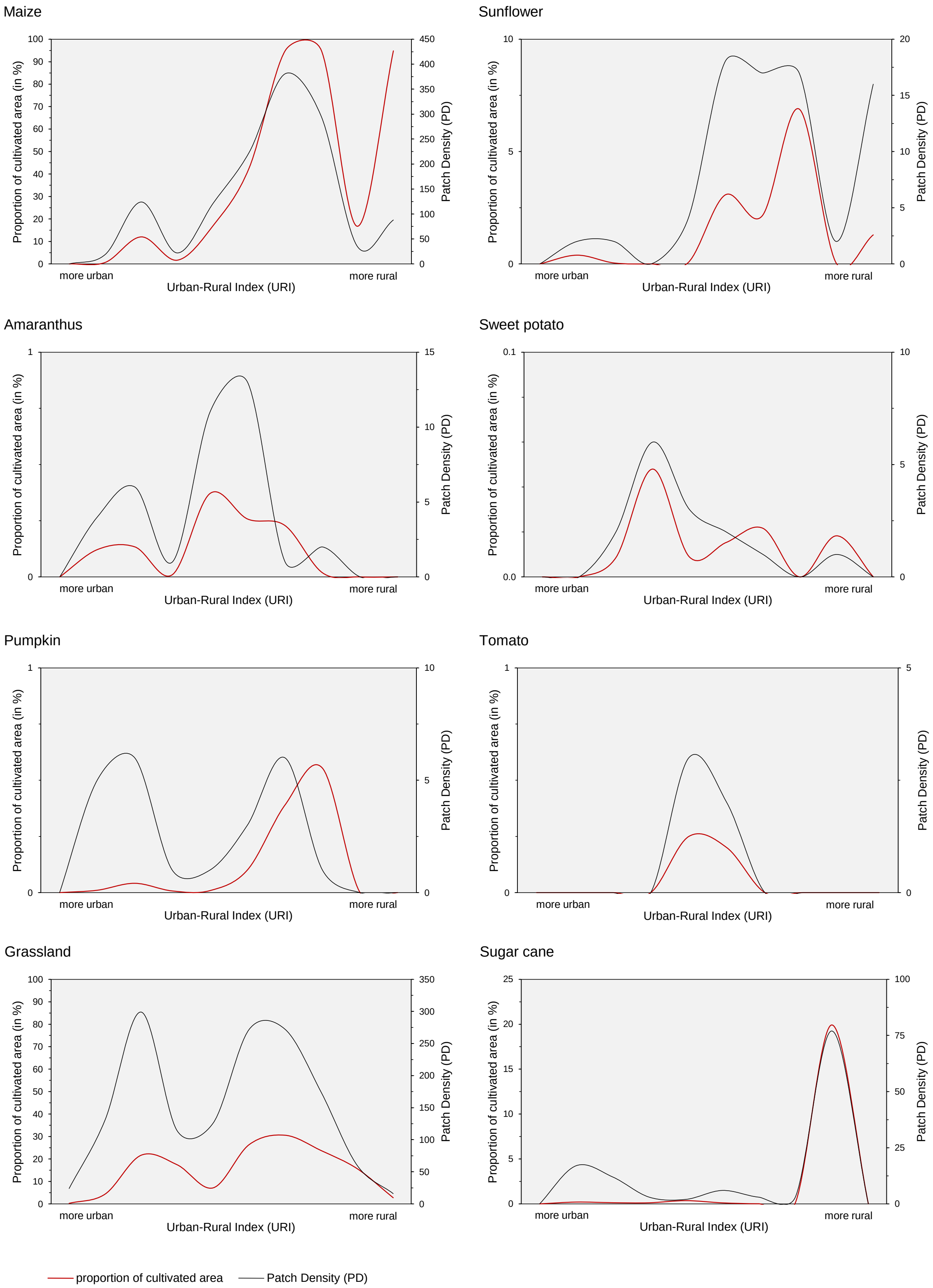


Fig. 5.19: Patch Density and area for selected crops

Three characteristic patterns could be identified:

A) Extensively cultivated crops (e.g. maize, sunflower, beans, banana)
The crops in this category could hardly be found in the most urban areas. In order to harvest amounts that are sufficient for self-consumption or even marketing, these crops usually need to be cultivated on larger patches which are not available in the city centre. However, the data shows that maize and sunflower were cultivated on the previously mentioned open spaces, such as the airfield and the railway area. This cultivation explains the smaller peak in PD and area under cultivation in the more urban areas. There were significant changes in the MPS along the urban-rural continuum. The less urban the area, the larger the patches generally became. The share of market oriented production tended to be higher in the more rural areas, where large-scale crop production is possible.

B) Crops of the homegardens (e.g. amaranthus, sweet potato, pumpkin, tomato)
The distribution patterns of the four crops in this category were distinctively different from those in the first category. Amaranthus, a leafy vegetable that is an important part of the Tanzanian diet, was widely cultivated on small patches in urban and periurban homegardens. It is mainly used for self-consumption. The same applies to sweet potatoes, pumpkins, and tomatoes that were also widely distributed in these gardens, although sweet potatoes and tomatoes were more prevalent in periurban gardens. Even though the overall area covered by these crops was significantly lower than in the case of the abovementioned staple crops, the crops in this category play an important role in the households' nutritional status.

C) Other forms of agricultural land use (e.g. grassland, sugar cane)
Grassland is a commonly found form of land use in and around cities. In the Moshi case study, three different forms of grassland could be identified:

- In the high-income areas located close to the city centre, grassland is a form of beautification. As there is no need for cultivation on the homestead plot due to the households' financial situation, these areas could be transformed into grassland.
- In the heterogeneous periurban areas, grassland is often used on temporarily unused fields as a legume that facilitates nitrogen fixation. Furthermore it provides fodder for livestock that can be commonly found in this area.
- In the least urban areas, grassland could be found in areas that are not suitable for other forms of agricultural land use, such as river beds, steep slopes, and on rocky ground.

The analysis of the spatial distribution of sugar cane revealed two different forms of cultivation. In the more urban areas a relatively large number of patches of sugar cane was found. As these patches were usually small and hardly ever exceeded 5 to 10 m², the overall area covered was limited in these areas. However, the analysis showed that large-scale production of sugar cane could be found in the more rural areas, where land is available and private investors could develop large plantations.

The elaborations above discuss the patterns in the spatial distribution, shape, and other characteristics of agricultural production. The following section summarises the findings regarding agricultural production in the Moshi case study.

Agricultural production along the urban-rural continuum - An interim summary

Based on the analysis of several landscape metrics, five distinct patterns of land use could be identified along the urban-rural continuum. The sequence of these patterns is illustrated in Fig. 5.20 using the WT as an example.

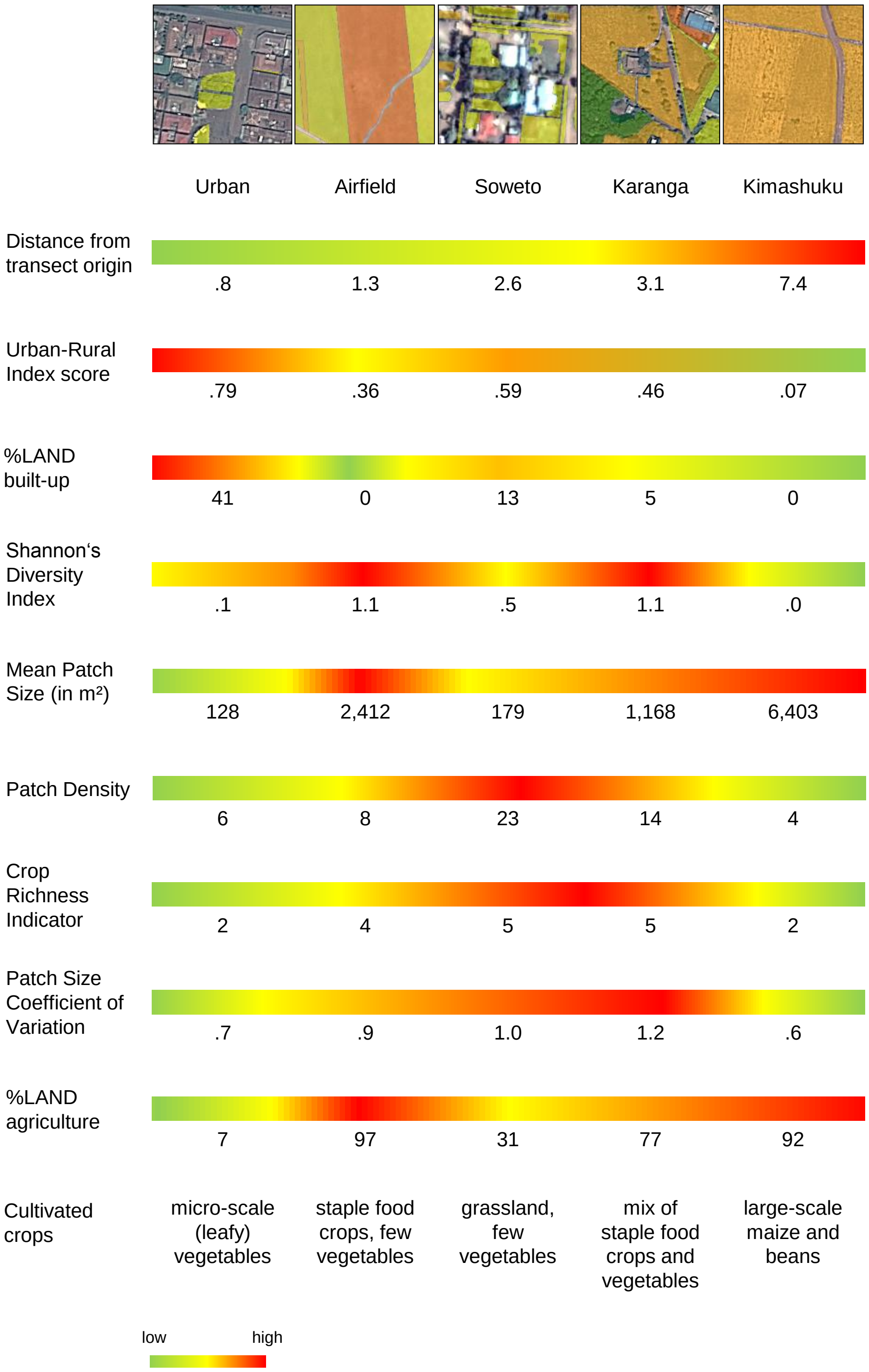


Fig. 5.20: Summary of selected landscape quadrants and respective landscape metrics along the western transect

The abovementioned patterns were identified based on the landscape metrics that were derived from the land use mapping along the transects. The spatial changes of these metrics were generally gradual, as illustrated above. With a built-up area of more than 40 percent – not including other forms of impervious surface – the urban core as the transect origin was per definition characterised by a high building density. In contrast, several agricultural landscape metrics, such as diversity indicators and patch sizes, showed low values.

The second pattern that could be identified in all transects was the cultivation on open spaces located in close vicinity to the city centre. In the WT the airfield was an example of this pattern with a few large patches, a relatively high diversity of cultivated crops and a large proportion of land used for agricultural production.

A third pattern, that was found in three out of the four transects showed a generally more diverse mix of land uses. These usually formal and surveyed residential areas were characterised by relatively large plots. The share of built-up land in these areas therefore hardly exceeded 10 to 15 percent. As grassland was found on most of these plots, the fraction of land potentially used for agricultural purposes was higher than in the urban core. However, if grassland was excluded from the analysis, this share would have fallen below 10 percent. Patches were small and diversity was limited due to the dominance of grassland for beautification purposes.

With further decreasing URI levels, the proportion of built-up area decreased while agricultural land use became more dominant. The heterogeneous pattern in this area of transition from urban to rural was reflected in several landscape metrics. With more than 1,000 m² mean patch sizes were large. The patch size variability reached its maximum in this area where large fields with staple crops could be found next to small patches with a large variety of crops. Correspondingly, the crop diversity indicators also reached their maxima at this part of the continuum.

In contrast, the areas with the lowest URI values were the least diverse along the continuum. The Shannon’s Diversity Index as well as the index for crop richness showed low values. These areas were characterised by very low building densities and the dominance of the cultivation of maize and beans, resulting in a rather homogeneous land use pattern. The share of agriculturally used land tended towards 100 percent and mean patch sizes reached their maxima with relatively little variability.

This summary of the spatial changes in selected landscape metrics makes clear that land use patterns change gradually. Nevertheless, certain characteristic and distinct patterns could be identified along the continuum. Even though these patterns are heavily influenced by topography, political-administrative conditions, and socio-economic processes, more or less congruent patterns could be found in all transects in the Moshi case study. However, to fully understand the manifestation of certain spatial characteristics, it is not sufficient to base the analysis exclusively on information derived from satellite images and in situ mapping. Therefore, the analysis of geocoded household data is discussed in the next chapter.

5.1.4 Household data analysis – gradual changes along the continuum

Measuring spatial changes in household characteristics is difficult, as they are influenced by even more complex factors than the spatial patterns of land use that could be derived from remotely sensed data. In general, household data cannot be interpolated, making large datasets inevitable for the analysis of spatial peculiarities. As previously mentioned, a sample of 404 households was interviewed and analysed according to the procedure discussed in chapter 4.4. In the following, spatial changes in several household characteristics are discussed, starting with changes in general infrastructure-related variables along the continuum before elaborating on more social variables of the households, such as duration of residence and wealth status. Finally, several indicators of the households' agricultural involvement are analysed.

Setting the frame – infrastructure availability and general household characteristics

Three variables were selected as indicators for the infrastructural situation of the interviewed households: access to electricity, piped water on site and the general condition of the buildings.

There is a wide range of conceptual work as well as case studies on the access to electricity and piped water within urban or rural contexts (e.g. Foster and Briceño-Garmendia 2010; Kemausuor et al. 2011; Rygaard et al. 2011). Some of these studies have a comparative view, while hardly any takes into account the actual changes along the urban-rural continuum. A simple analysis of the access to and the availability of these basic infrastructural features in Moshi reveals how it changes while moving out of the city[39].

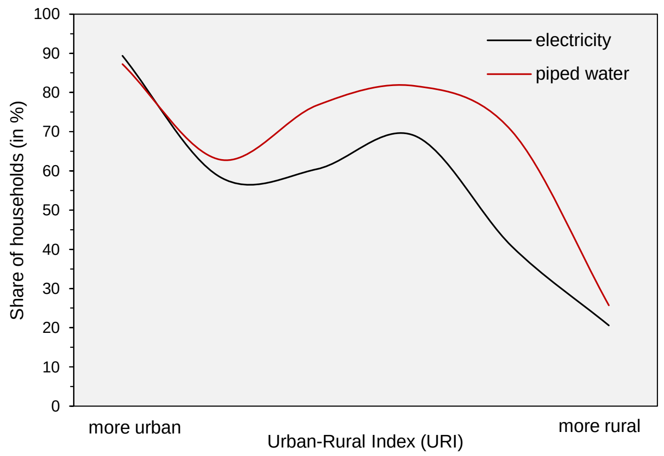


Fig. 5.21: Access to electricity and piped water on site along Moshi's urban-rural continuum (n = 402)

Fig. 5.21 illustrates the continuous changes of the households' infrastructural facilities. In the most urban areas about 90 percent of the households were connected to the electricity grid. Percentages were similar regarding access to the piped water system on the plot.

[39] Line charts were selected for household data visualisation for easier readability, even though data was analysed on the basis of six URI categories.

These surveyed areas were historically connected to the main infrastructure networks, making the city centre the best served part of Moshi until now (Donge et al. 2008).

However, these numbers dropped to about 55 percent in electricity and 65 percent in piped drinking water in an area adjacent to the city centre. This drop can be explained by the generally more informal structure of an area surrounding the city centre. Most of these quarters developed rather informally and unplanned (Ministry of Lands and Human Settlements Development 1998), leading to a lack of electricity and water infrastructure (Donge et al. 2008).

As previously mentioned, surveyed areas could be found further outside Moshi’s centre. This circumstance was reflected as a second peak in Fig. 5.21. These planned areas were well-connected to the grids, even though shares were slightly lower than in the urban core.

With further decreasing URI values, the proportion of households with access to electricity and piped water also decreased. The minima were reached in the least urban areas that were covered by the transects. Here, about one fifth of the households were connected to the electricity grid and about one third had access to piped drinking water on their plot, a trend that has been similarly documented by Allen (2006) and others. Zvoleff et al. (2009) show that this situation could be interpreted as a consequence of the higher costs associated with the provision of infrastructure in less densely populated areas located further away from the city centre.

These gradual changes in access to electricity and water were also reflected in the general condition of the buildings along the continuum.

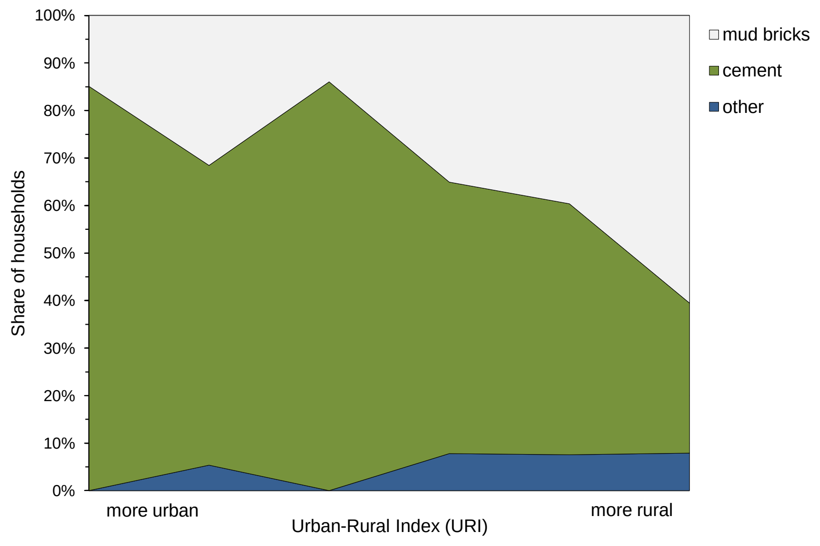


Fig. 5.22: Condition of buildings along the continuum (n = 404)

While the percentage of houses made of cement was highest in the most urban area, it gradually decreased with declining URI levels ($r = .849$, $p < .05$). In contrast, the share of houses which were mainly made of mud or mud bricks generally increased the less urban the area was. Other studies have shown that these findings reflect a general trend in the African context, where the use of natural resources is an integral part of building construction in more rural communities as opposed to their urban counterparts (Drescher and Iaquinta 2002; Shackleton et al. 2002; Pouliot and Treue 2012 (in press)).

Several studies have investigated the ownership or rental status within urban, periurban or rural contexts (e.g. Lynch et al. 2001). Yet, little is known about how land ownership is changing along the urban-rural gradients of African towns and cities. Fig. 5.23 illustrates how the ownership/rental status changed along Moshi's urban-rural continuum.

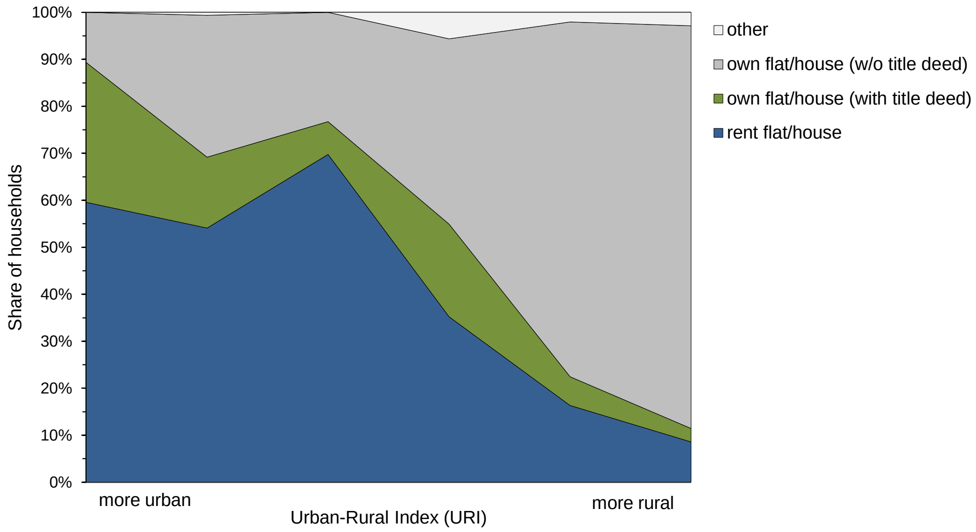


Fig. 5.23: Ownership/rental status of the interviewed households in Moshi (n = 402)

In Moshi's city centre, about 60 percent of the interviewed households rented the flats or houses they lived in ($r = .874$; $p < .05$). Three quarters of the remaining part owned the property and had the respective title deed. The proportion of households owning the property without any formal registration was 11 percent. These figures reflect the general trend in African cities, as described by Watson and McCarthy (1998), Tipple (1994) or Fekade (2000).

In contrast to the city centre, ownership of flats or houses was the most common property arrangement in the least urban areas covered by the transect ($r = -.941$, $p < .01$). The large share of ownership without title deeds could be interpreted as a consequence of the dominance of informal housing markets and traditional tenure arrangements. They are hardly affected by urban administrative bodies, which tend to have an interest in the formalisation of housing arrangements (Bromley 2009; Payne et al. 2008).

Furthermore, Fig. 5.23 illustrates the heterogeneous situation in the transition zone, where informal housing markets exist next to the more formalised system (Drescher and Iaquinta 2002). In this area, huts inhabited by farming families for generations could be found next to newly constructed multi-flat buildings constructed by urban developers and serving the increasing number of students in Moshi.

Duration of residence as an indicator of social dynamics

The duration of residence was used as an indicator for the social dynamic along the continuum. The analysis showed that there was a non-linear correlation between the URI and the time the interviewees had already lived in the area (see Fig. 5.24).

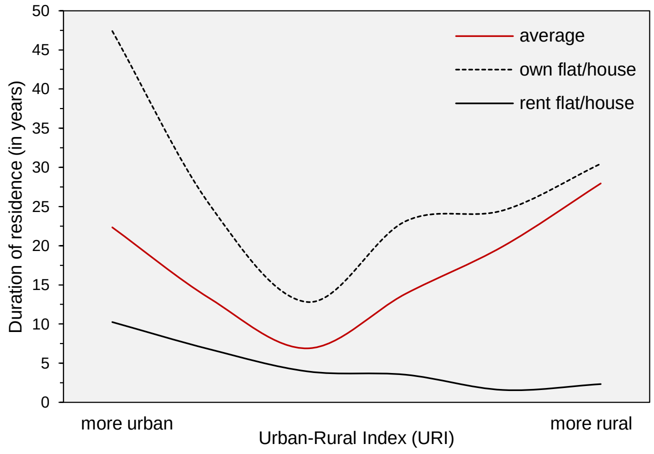


Fig. 5.24: Duration of residence of flat/house owners and renters (n = 399)

The interviewed households in the city centre had an average duration of residence of 20 to 25 years. These high numbers reflect the consolidated housing market in the urban centre where most of the house owners tended to live for their whole life. Even though duration of residence of households that had a rental agreement was generally lower, it still had its maximum in the city centre.

In both cases, duration of residence steeply declined with decreasing URI values. However, while they increased again with further decreasing URI values in the case of ownership, the decrease continued in the case of rented housing units.

The minimum was reached in the area of transition that had already been identified in the aforementioned analyses. With an average of less than seven years, this area could be characterised as highly dynamic with a constantly changing composition of its population. Thus, drawing on previous findings, this area is highly dynamic not only in terms of social mobility but also in terms of changing land use (see chapter 5.1.3). These findings correspond to several other studies investigating periurban dynamics (e.g. Adell 1999; Mandere et al. 2010). Drescher and Iaquinta (2002: 26) summarise that these areas could be addressed as “places of social compression and dynamic social change”.

Involvement in crop and livestock production

The previous analysis of spatial changes of more general household features unveiled distinct spatial patterns along the continuum. The following section discusses similarities and differences in the spatial characteristics of the households’ involvement in agricultural activities.

Even though agricultural activities are generally more visible in rural settings, an increasing body of literature has shown that in many African countries agriculture also plays a crucial role for securing the livelihoods of a large share of the urban and periurban population (e.g. Mougeot 2000; de Zeeuw et al. 2011; Drescher 1998). The analysis of household data from the Moshi case study showed that 61 percent of the interviewed households were involved in crop production. In their comparative study on the importance of urban agriculture in 15 countries - of which four were located in SSA[40] - Zezza and Tasciotti (2010) observe slightly lower percentages regarding the participation in crop cultivation. While it was only about one third of the urban population in Nigeria, almost half the urban population in Malawi was involved in this activity (Zezza and Tasciotti 2010). Dossa et al. (2011) report similar observations from three West African towns, where participation ranges from 30 to 65 percent of the households.[41] The higher values regarding the involvement in UPA in the Moshi case study could be interpreted as a result of the city's ecological preconditions and its size. The area's climatic and soil conditions are favourable for crop cultivation in general and therefore also for UPA. Furthermore, Moshi as a medium-sized city is historically and geographically embedded in the surrounding area. Its population is strongly linked to agricultural activities in and around the urban agglomeration, a circumstance that might be less pronounced in bigger cities.

When it comes to the spatial arrangement of households involved in urban and periurban agriculture an unequal distribution along the urban-rural continuum could be identified in the Moshi case study (see Fig. 5.25).

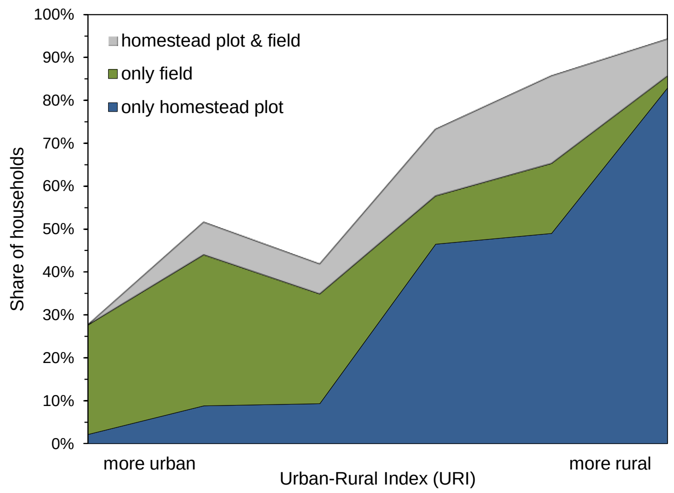


Fig. 5.25: Share of crop producing households by type of area under cultivation (n = 242)

In Moshi's urban centre, about 28 percent of the interviewed households were involved in crop production. Due to the shortage of land within the centre, the large majority of these

[40] The African countries included in this comparative study where Ghana, Madagascar, Malawi, and Nigeria.

[41] As with all cross-country statistics definitions might vary making an actual comparison between different country datasets difficult.

households cultivated fields outside the central area.[42] With decreasing URI values – and correspondingly decreasing building densities – the overall share of households involved in crop production increased ($r = -.950$, $p < .01$). In the least urban areas covered by the transects, involvement in crop production reached its maximum at more than 90 percent of the households. These numbers largely correspond to shares found in rural settings (Zezza and Tasciotti 2010). This increase can to a large extent be explained by the increase of the proportion of households producing on the area around their houses. As more land was available and plot sizes tended to be bigger in the more rural areas, cultivation on the homestead plot became more dominant. In contrast, the percentage of households involved in cultivation of other pieces of land decreased, largely due to a lack of necessity of additional production or the lack of access to available land.

Even though the focus of this study is on crop production, it is important not to overlook livestock production as it was often described as an integral part of UPA. Sumberg (1997) shows that 60 percent of the dairy products consumed in Dar es Salaam are produced in the city's urban and periurban areas and other studies show that livestock and crop production are often interdependent in the intensive and highly adjusted urban and periurban farming systems (Mougeot 2000; Smit et al. 2001).

The proportions of households involved in livestock production roughly corresponded to those of crop cultivation. However, a considerable difference was identified between production of small livestock, such as chicken and ducks, and other livestock, such as goats, sheep, cows and pigs.

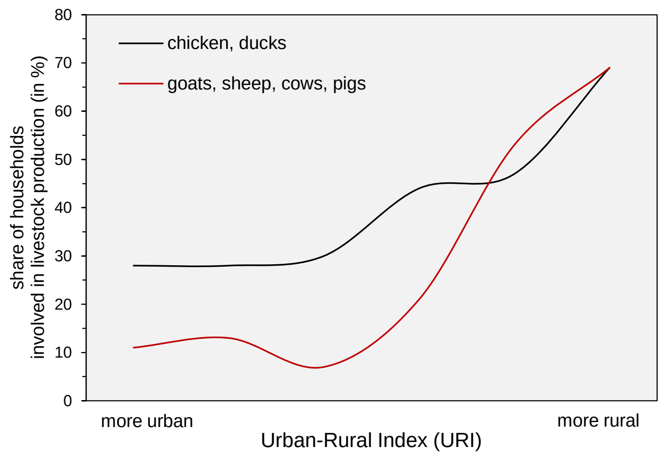


Fig. 5.26: Livestock production by type of livestock (n = 181)

While about one third of the households interviewed in the more urban areas kept chicken or ducks, keeping other livestock was less common. This was mostly caused by the unfavourable conditions, such as limited space and regulations banning those forms of livestock production in the urban area. The less urban the area was, the higher was the

[42] Data on crop production was collected with special consideration given to its location. It was therefore distinguished between production on the plot adjacent to the house and the production on a field located somewhere else, commonly known as *shamba* (Swahili for *field*).

percentage of livestock keeping households (small livestock: $r = .924$, $p < .01$; big livestock: $r = .885$, $p < .05$) and the narrower was the gap between the different forms of livestock production. In the least urban areas more than two thirds of the interviewed households were keeping livestock, many of them in combination with crop production. These mixed farming systems are mutually beneficial: the livestock excrements can be used as manure while side products from the crop production can be used as fodder.

Access to land – an important factor for crop production

The land tenure situation is an issue of particular importance to urban and periurban farmers. Previous studies have shown that it can have an influence on the willingness to improve the land and the choice of crops (Place and Hazell 1993; Breman et al. 2001), on market orientation, household food security and resilience (Maxwell and Wiebe 1999). The analysis of the respective data from the Moshi case study revealed distinct land tenure patterns along the urban-rural continuum (see Fig. 5.27).

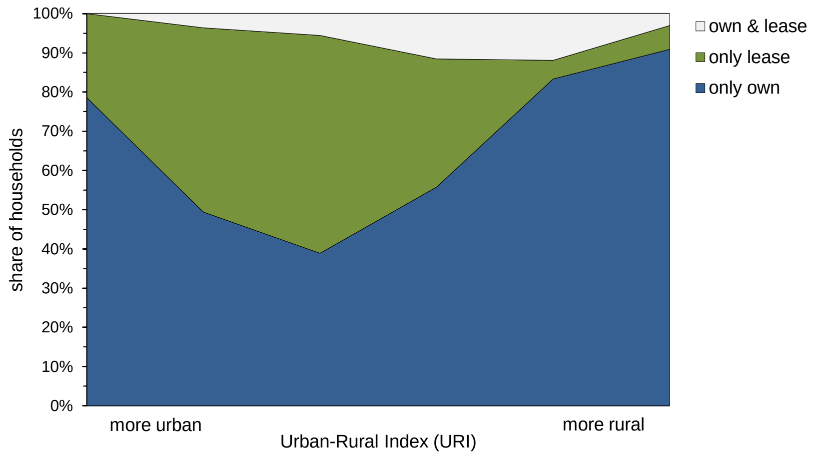


Fig. 5.27: Land tenure situation of interviewed farmers (n = 228)

In the most urban as well as in the least urban areas covered by the transects, land ownership – be it with or without the respective title deed – was the dominant form of land tenure.[43] In the area between these extremes, however, leasing land for agricultural production was much more common.

These findings have to be interpreted in relation to the previously discussed analysis of general household characteristics. It could be shown that there was a strong relation between the duration of residence, the involvement in agricultural production and the land tenure situation of the interviewed households (see Table 5.2).

[43] The land tenure situation of all areas of agricultural production cultivated by the households located within the transects was evaluated, regardless of whether these areas were located within or outside the transects.

Table 5.2: Duration of residence, involvement in agriculture and land tenure situation

Duration of residence (in years)	Share of households involved in farming (in %) (n = 404)	Share of farming households owning the plot (in %) (n = 228)
0 to 10	48	29
11 to 20	68	39
21 to 30	81	41
30 and more	74	58
Total average	61	44

The longer the interviewed households had already lived in the area, the more likely they were to engage in agricultural production. Similar studies show that involvement in UPA is strongly linked to the question of access to land (Bryld 2003; Maxwell 1995). According to Bryld (2003: 83), migrants who recently came to the city tend to have difficulties in leasing or even buying pieces of land as "getting access to land requires social and political information about where land is available, what the ownership is, and what risks there are from cultivating".

Overall, the share of farming households owning the land they cultivate was only 44 percent. Even though these numbers were higher than reported by other studies[44], it still illustrates the often insecure and temporary character of these farming activities. As with general involvement in UPA, a relation between duration of residence and land ownership was identified. The longer the farmers lived in the area, the more likely they were to own the land they cultivate. As land ownership is usually long-term and therefore more reliable than leasing arrangements, it might have a positive impact on the overall livelihood situation of the farming households.

The land tenure situation was an important factor for the overall situation of the households as it not only had a direct impact on the involvement in UPA, but also had an influence on the households' agricultural parameters, such as their acreage. Table 5.3 provides an overview of selected parameters in relation to land tenure arrangements.

Table 5.3: Acreage in relation to land tenure arrangements, averaged

	Acreage (in ha) averaged (n = 226)	
Land tenure	Homestead plot	Field
Own	.25	.85
Lease	.05	.57
Own and lease	.21	.47
Total average	.24	.76

[44] Bryld (2003) reports that only 20 percent of the urban farmers in developing countries own the land they cultivate. Other studies report a share of 19 percent in Kampala (Maxwell 1995), 24 percent in Nairobi (Lado 1990), and 25 to 30 percent in Freetown (Lynch et al. 2012 (in press)).

The table shows that farming households owning the land they cultivate – be it their homestead plot or a field in other parts of the area – had more land at their disposal than those households leasing the land. Two major causes for this situation could be identified:

1) Land ownership in the region is traditionally organised and usually inherited from one generation to the other. Therefore access to land is to a large extent determined by the integration into existing family-based social networks. As land ownership was positively correlated to the duration of residence in the area, those households that had their origins in the region were more likely to own larger pieces of land.
2) A large proportion of the households that recently migrated from other parts of the country came to the Moshi area to improve their overall livelihood situation. As these households tended to have limited financial resources, they usually leased smaller pieces of land.

Box 5.2: Access to land – two farmers, two perspectives

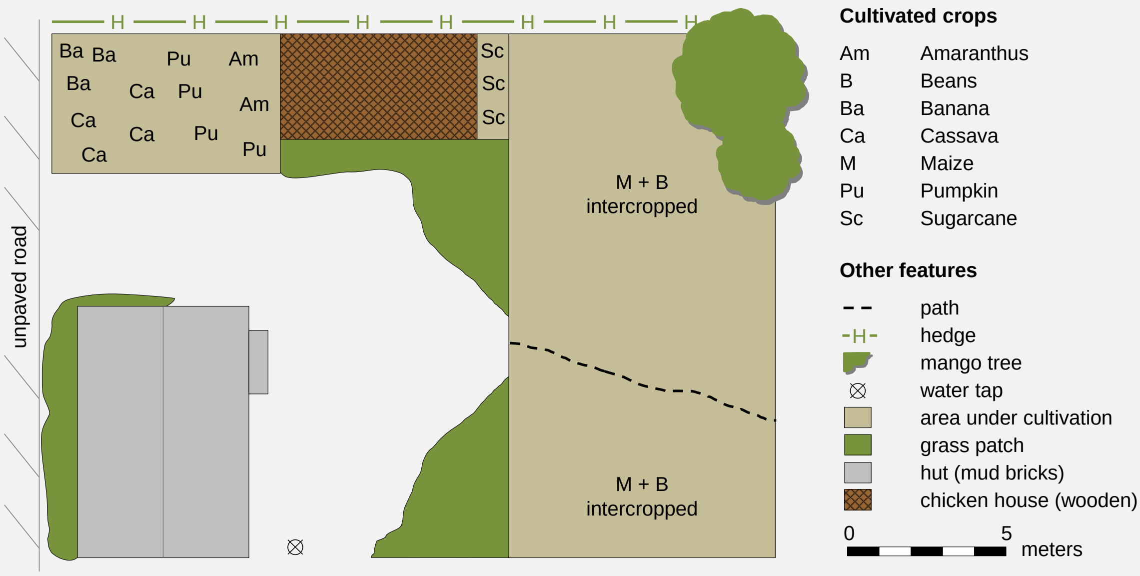
Access to land is an important factor that does not only have an impact on agricultural activities of households but also on their overall livelihood situation. The portraits of two exemplary farming households in Moshi, one being located in the urban centre (farmer 1) and one being located in the periurban area (farmer 2), illustrate the diversity of urban and periurban farming households.

1) Farmer 1 is the descendant of a long-established Chagga family, living on the slopes of Mt. Kilimanjaro for several generations. While his ancestors used to live on the upper slopes of the mountain, he and his family moved to Moshi's city centre once he had finished his tertiary education in Dar es Salaam. However, he maintains strong ties with the rest of the extended family still living about ten kilometres uphill. As he is the oldest son, he inherited about 1.25 ha of arable land located on the lower slopes of the mountain east of Moshi (see picture below). This land was traditionally used for staple food production, supplementing the production in the more elevated chagga homegarden. However, as Farmer 1 has a well-paid formal job in one of the Region's administrative offices, his family's food security no longer depends on agricultural production. As land prices are constantly increasing and traditional obligations regarding land issues are still important, he has not yet sold the land. In the meantime he and his family cultivate the land, selling most of the produce to a related trader.

Farmer 1: Large-scale market-oriented production

Farmer 2: Small-scale production for self-consumption

2) Farmer 2 used to live in the coastal town of Tanga before he and his family moved to the outskirts of Moshi about two years ago, where they live in a rented hut. Even though some of his friends and relatives came to Moshi about a decade ago, it was difficult for him to find work. As a day labourer in the construction business, his income is irregular and not sufficient to cope with the rising food prices. Therefore he decided to lease the small plot around their hut (see picture above) where his wife grows maize, beans, and vegetables to provide at least a basic diet for them and the three children. Recently, they have started raising chicken in a small stable.



Sketchmap of Farmer 2's homegarden

However, the harvest is hardly enough for all of them and they can never be sure for how long they are allowed to cultivate. Some of the neighbouring plots have already been built up and rented out to newly arrived migrants from other regions of the country.

The previous elaborations on access to land and respective acreages showed that there was a relation between land tenure and the households' duration of residence. A detailed investigation of the spatial specifications of acreages revealed distinct changes along the urban-rural continuum.[45]

[45] In order to avoid drawing wrong conclusions, the author wants to again point out that the analysis of household data along the continuum takes into account the location of the households and not the location of the areas of agricultural production.

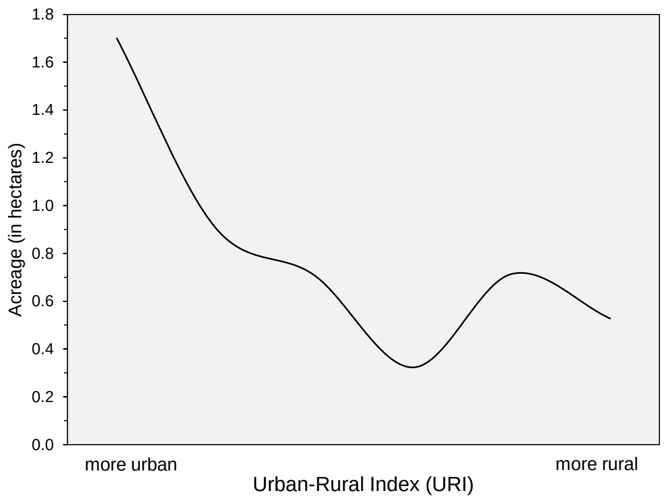


Fig. 5.28: Changes of farming households' average acreage along the urban-rural continuum (n = 226)

Fig. 5.28 shows that households located in Moshi's urban centre cultivated an area of 1.7 ha on average, be it owned or leased while the minimum of only about .3 ha was reached in the area of transition between the more urban and the more rural areas, where many of the recently migrated families were located (see Fig. 5.24). At first glance, these findings might be surprising, as the urban population is generally not addressed as the cultivators of significant pieces of land. Even though the percentage of farmers in the total population was lower in the urban areas, those households who were involved in farming had larger acreages at their disposal than the more rural farming households. As with the legal status of the land, the explanation for this discrepancy lies in the very nature of land distribution in the Moshi area. Most farmers residing in the urban area were descendants of Chagga families traditionally owning land on the slopes of Mt. Kilimanjaro. Other urban farmers belonged to a small minority of financially well-equipped migrant families who had enough financial resources to buy large pieces of land in the area, partly for speculative purposes, a practice that can be widely found in and around rapidly growing African cities (Allen 2010; Toulmin 2009).

Urban and periurban agriculture as a means of food production

As mentioned in the first part of this study, several different types of urban and periurban farmers have been identified, ranging from home subsistence farmers to entrepreneurs producing solely for the purpose of income generation. This corresponds with the findings of other authors (e.g. Moustier and Danso 2006; van Veenhuizen and Danso 2007). In order to identify the spatial distribution of these farmers along the urban-rural continuum, data on the contribution of agricultural production to food consumption as well as data on marketing of their produce was analysed.

Fig. 5.29 shows how the relative share of own agricultural production in the farming households' food consumption changed along the continuum.

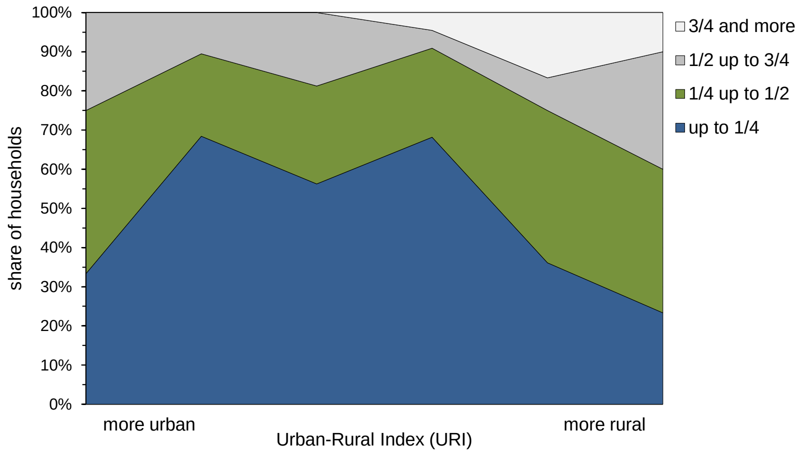


Fig. 5.29: Part of the farming households' food grown by themselves (n = 214)

About 75 percent of farming households located in the most urban areas produced less than half of the food they consumed. With 60 percent producing less than half of their food in the least urban areas covered by the transects the share was only slightly lower than in Moshi's city centre. However, no households in the urban area stated to produce more than three quarters of their food, while about ten percent did at the other end of the continuum. The area in between those extremes was dominated by farming households whose food predominantly came from other sources. These findings supplement previous studies on the contribution of UPA to farming households' food supply (e.g. Maxwell 1995; Crush et al. 2011; Lynch et al. 2012 (in press)) by unveiling the spatial non-linearity of changes in its importance.

For the interpretation of spatial changes along the continuum it is important to take into account the average acreage of farming households (as described in Fig. 5.28). As farmers located in the urban centre tended to cultivate larger pieces of land, they usually had a bigger agricultural production, resulting in a higher significance for the households' food supply. In contrast, farmers located in the more rural areas had a much smaller acreage at their disposal. As a consequence, the agricultural production tended to be insufficient for playing an important role for the households' food consumption.

In addition to these spatial patterns, a correlation between the land tenure situation and the contribution to the households' food consumption could be identified as illustrated in Table 5.4.

Table 5.4: Contribution of agricultural production to households' food situation in relation to land tenure arrangements and acreage (in percent)

	Part of food grown (n = 214)			
	Up to ¼	¼ to ½	½ to ¾	More than ¾
Land tenure				
Own	49	28	16	6
Lease	67	27	5	0
Own and lease	50	36	7	7
Total average	54	28	13	5

The analysis showed that farming households that owned the land they cultivated were more likely to produce a more significant amount of their own food than households relying on leasing agreements. While 22 percent of land owners produced at least half of the food they consumed, this was the case with only five percent of those leasing the land. 67 percent of land leasers stated that only up to one quarter of their food came from their own production.

The following causes were identified based on the household survey data:

1) Farmers leasing land tended to have less arable land at their disposal than land owners (see Table 5.3). As less land was cultivated, harvests were generally lower. As a consequence, agricultural production was not sufficient to significantly contribute to the households' diet.
2) Farmers cultivating leased plots were less willing to invest in the production, a trend that has been observed by several authors in other contexts (e.g. Place and Hazell (1993) for the cases of Rwanda and Ghana). Informal short-term contracts are common, especially in areas affected by various effects of urbanisation induced dynamics. This hampers long-term planning of cultivation cycles and input application, with the consequence of soil exploitation and reduced harvests.

These reasons were confirmed by the analysis of the farming households' area under cultivation and its relative contribution to their food situation as illustrated below.

Table 5.5: Contribution of agricultural production to the households' food situation in relation to area under cultivation (in percent)

	Part of food grown (n = 214)			
	Up to ¼	¼ to ½	½ to ¾	More than ¾
Acreage (in ha)				
Up to .25	73	13	7	7
.26 to .50	42	38	18	2
.51 to .75	19	56	19	6
.76 to 1.00	61	28	6	6
1.01 to 1.25	45	35	10	10
1.26 and more	38	35	27	0

Of those households having up to a quarter of a hectare of arable land at their disposal, the great majority (73 percent) stated that their own production contributed not more than one quarter to their food supply. For only 14 percent of these households the own production contributed more than half of their food. In contrast, 27 percent of the households cultivating more than 1.26 ha indicated that it contributed more than half of their food supply.

There is a wide range of studies investigating the relation of the practice of UPA and the nutritional situation of the respective farming households. In accordance with the findings from the Moshi case study, Cofie et al. (2003) show that UPA can significantly contribute to the food supply of urban and periurban areas in general and to that of farming households in particular. While for Nairobi and Lusaka they report that "farming households produce between 20 and 30 percent of their food requirements, in Harare and Kampala, up to 60 percent of food consumed […] was self-produced" (Cofie et al. 2003: 7). Other studies provide similar numbers for other major cities, as reported by Armar-Klemesu (2000: 104–105): "nearly 50 percent of 260 Dar es Salaam residents indicated that urban agriculture provided 20-30 percent or more of their household's food supply. In Kampala, 55 percent of 150 producers obtained 40 percent or more and 32 percent obtained 60 percent or more of their household food needs from their own urban garden […]. In Harare, a disaggregated profile of self-produced food consumption and its variation by income indicated that 60 percent of food consumed […] was self-produced". The findings from Moshi supplement these findings by showing that UPA plays a crucial role for farming households' food supply not only in those big cities but also in medium-sized cities.

Urban and periurban agriculture as a means of income generation

Many urban and periurban households engage in agriculture for the purpose of marketing the produce to the closely located urban consumers (Mougeot 2000; van Veenhuizen 2006). While some of them see the marketing of surpluses as an additional and therefore optional income source, others have specialised in producing solely for the urban markets (de Zeeuw et al. 2011). In the Moshi case study, 40 percent of the farming households were involved in marketing their produce. In correspondence with the findings above, farmers owning their land were more likely to produce for the markets (41 percent) as those leasing their land (34 percent). This was expected as the former usually had more land at their disposal and therefore produced enough to feed themselves leaving enough to sell the surplus on the market.

There is a wide range of literature on the location of market oriented agriculture showing that it is the periurban where a large proportion of arable land is used for the production for urban consumers (e.g. Drescher 2001; de Zeeuw et al. 2000). While urban markets can be easily accessed, there is still enough available land for a profitable market oriented production. However, due to the lack of combination of land use and household data in previous studies, it was often overlooked that farmers producing in the periurban areas might be living in the city and even rural agriculture might be conducted by urban or periurban farmers. Therefore, in this study, data was collected on the location of their farms in addition to the farmers' location. Fig. 5.30 illustrates the proportion of the interviewed farming households involved in marketing based on the location of their residence.

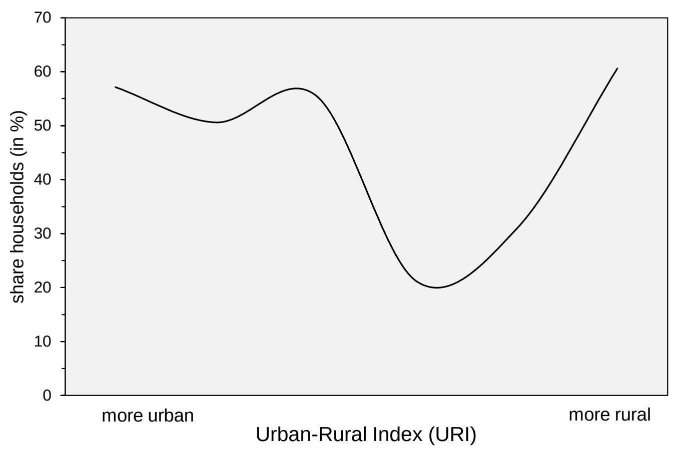


Fig. 5.30: Share of farming households involved in marketing of agricultural products (n = 237)

At around 60 percent the shares of market oriented households were similar in the most and least urban areas covered by the transects. It is shown before that urban farmers tended to have large acreages at their disposal, resulting in harvests that leave enough for own consumption and marketing of the produce. The high proportion of the least urban households could be interpreted as a consequence of the lack of other sources of income. Most of these households had a long tradition in agricultural production, making them highly dependent on the income generated through the marketing of agricultural products. In contrast, only about 20 percent of the farming households located in the areas of medium URI levels were involved in marketing their produce. This area of low levels of market orientation of farming households was on average characterised by a short duration of residence and small acreages, as previously discussed. Many of these farmers where recent migrants with limited access to land and to the complex marketing system that – to a large extent – builds on long-term personal relations (Porter et al. 2007). Taking into account the above elaborations on the land tenure situation and its impacts on productivity, it can be assumed that the surpluses, if at all, produced by these farmers where not sufficient for marketing purposes.

The results of a more detailed investigation of those households involved in marketing their produce showed that for a large proportion of farming households this activity generated only a small part of their overall income.

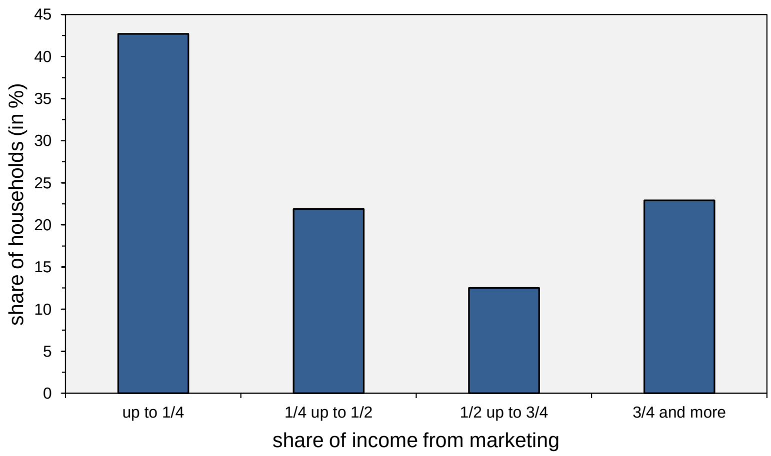


Fig. 5.31: Share of income generated through the marketing of agricultural products (n = 96)

Almost two thirds of these households stated that marketing generates only up to half of their income. These numbers show that it is generally seen as an additional source of income rather than the main economic activity. Only 23 percent of the households stated that they would depend almost entirely on it. Zezza and Tasciotti (2010) come to similar results: They show that the average share of total income from agriculture ranged from 12 percent in Malawi to 27 in Nigeria. However, regarding the households earning more than half of their income from agriculture, the numbers range from 12 percent in Malawi to 23 percent in Nigeria, compared to 36 percent in the Moshi case study. As with the previously discussed aspects of UPA, the comparison of the Moshi data with other cities shows the specifications of UPA in medium-sized cities. The comparably high percentage of households earning a significant part of their income by marketing agricultural produce could be interpreted as a consequence of the traditionally strong links between the population and agricultural activities. Rural-urban linkages are still strong and agricultural production and marketing play an important role in peoples' livelihoods.

The spatial analysis of these numbers largely correspond to previously identified patterns along the urban-rural continuum (see Fig. 5.32).

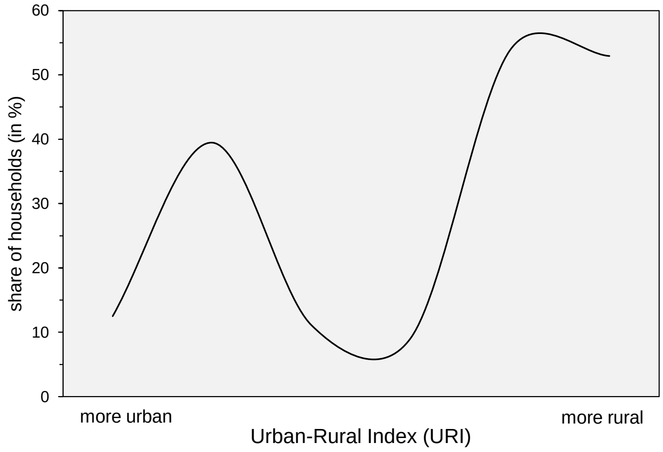


Fig. 5.32: Share of households selling agricultural products that create more than half of their income through marketing (n = 237)

In the urban centre, only about ten percent of the farming households generated more than half of their income from the marketing of agricultural production, even though they had large pieces of land. This was a consequence of the dominance of non-agricultural income sources in the urban context. In many urban households, agriculture was the responsibility of women while men had an often well-paid formal job. In contrast, agriculture tended to be the dominant income source in many less urban households, resulting in more than 50 percent of these households generating more than half of their income from selling agricultural products.

The households located in the area in between these extremes were less dependent on this activity. For less than ten percent of these households, it generated more than half of their income. These numbers contradict the results of previous studies (e.g. Nugent 2000a; de Zeeuw et al. 2000), stating that periurban farmers mainly produce for the sake of marketing. As previously suggested, this discrepancy might be the result of the limited understanding of the spatial relations between farmers and farms. In the case of Moshi, areas of medium URI levels were characterised by the spatial juxtaposition of households cultivating their small homestead plots mainly for self-consumption and large plots cultivated by farmers traditionally owning the land while living somewhere else.

Fig. 5.33: Map showing homegarden for self-consumption next to large-scale market oriented production of maize and beans

Fig. 5.33 illustrates the spatial complexity of an area intensively used for the cultivation of different staple crops and vegetables. While the production on one of the homestead plots was characterised by the small-scale production of a wide variety of crops, the majority of the arable land in this area was dominated by the market-oriented cultivation of maize and beans as staple food crops, showing the discrepancy regarding the location of market oriented producers and the location of areas under production.

The analysis of farmers' involvement in marketing in relation to the acreage they have at their disposal showed that this factor was an important determinant of the households' ability to sell surpluses on the markets. Fig. 5.34 shows how shares of farming households' involvement changed in relation to their acreage.

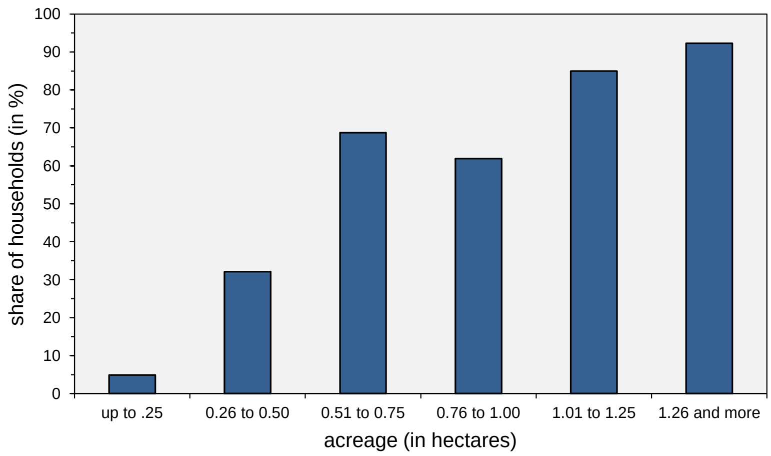


Fig. 5.34: Farmers' involvement in marketing in relation to acreages (n = 96)

As previously mentioned, it was the farmers owning or leasing bigger pieces of land who were in the position to market parts of their produce. 92 percent of the farmers cultivating more than 1.26 ha of land were involved in marketing while this was the case with only five percent of those farmers cultivating up to a quarter of a hectare. While the latter typically cultivated a variety of crops for self-consumption on their homestead plots, the former concentrated on large-scale staple food production to serve the urban demand. As discussed above, it was the areas of medium and low URI values, where this market oriented production was located, a trend that is widely acknowledged in the literature (e.g. Drescher 2001; de Zeeuw et al. 2000).

Households along the urban-rural continuum - An interim summary

The previous discussion of a wide range of household parameters support the findings from the land use analysis by showing that spatial changes show a gradual and continuous form rather than being shaped by abrupt changes and the dichotomy between urban and rural areas. Based on the analysis of household data, six exemplary sections of the urban-rural continuum could be identified for the Moshi case study, each having its own peculiarities. The illustration below provides an overview of selected parameters and their changes along the continuum.

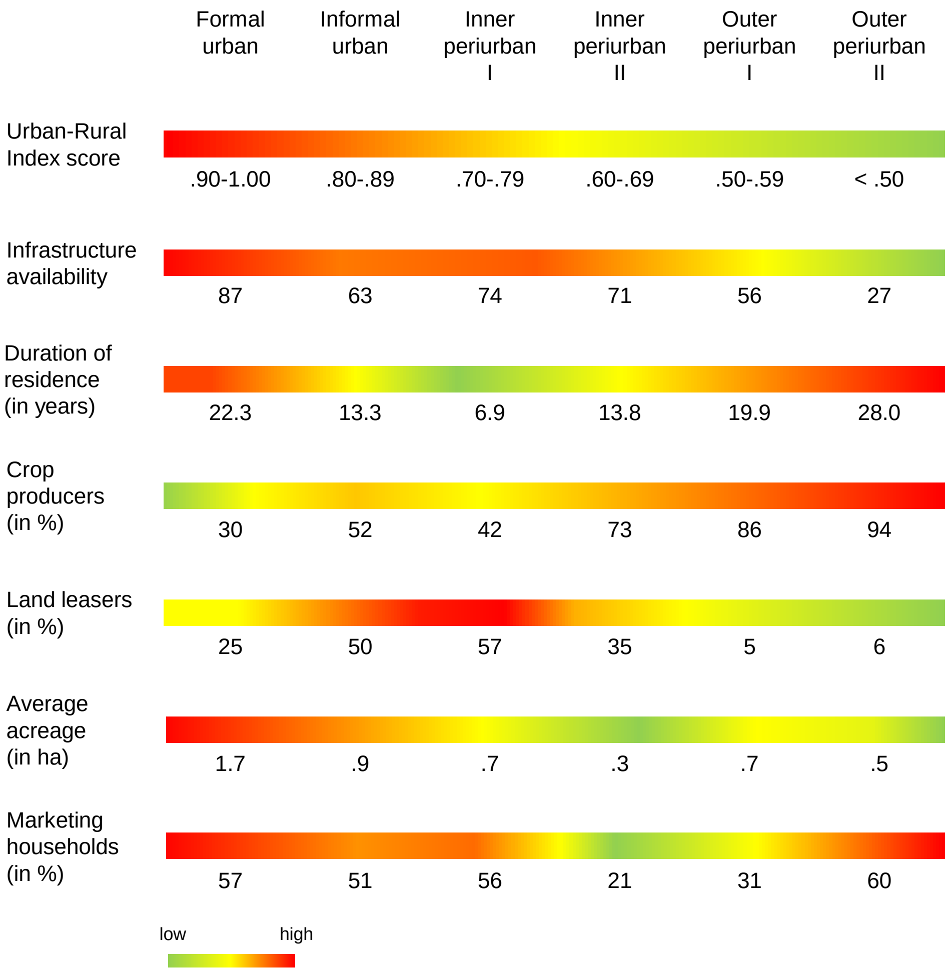


Fig. 5.35: Summary of changes in household characteristics along Moshi's urban-rural continuum

The urban core as the transect origin was characterised by high levels of infrastructure availability and an average duration of residence of more than 20 years, making it an area of relative stability. The percentage of crop producers was the lowest along the continuum. However, those households involved in any form of agriculture usually had large pieces of land at their disposal, a result of their social background and the traditional system of land inheritance in the region. Most of the farmers owned their land that was commonly located in the periurban areas and widely used for market oriented production of staple food crops.

Results from the Moshi case study indicated that the areas of slightly lower URI values than the city centre were commonly dominated by informal settlements. These areas were characterised by a comparably low level of infrastructure availability and a relatively short duration of residence of the dwellers. More than half of the interviewed households were engaged in agriculture. However, half of them did not own the land they cultivated. Having on average around one hectare of land at their disposal, a slight majority of the farmers were involved in marketing of their crops that were usually cultivated on open spaces, such as along the abandoned railway line, or on fields located a few kilometres away from where they lived. As other income sources were scarce, agriculture played an important role in securing their livelihoods.

The adjacent areas were the most dynamic along the continuum. Closely located to the city centre and with good access to the road network as well as to the water and electricity grid, it was an area dominated by newly arrived migrants from other parts of the country as well as wealthier urban dwellers who preferred living at the outskirts of the city. About two fifths of the households were engaged in UPA, most of them on leased plots due to a lack of funds or social networks as discussed above. More than half of the farmers stated that marketing was a part of their income generating activities.

With further decreasing URI values, infrastructure availability started decreasing while the share of households involved in the cultivation of crops increased. The proportion of farmers not owning their land was only around one third. However, the smallest acreages were found in this part of the continuum resulting in the lowest percentage of households marketing their produce.

The fifth section was characterised by decreasing urban influence. Access to the grids was lower than in the more urban areas, while the share of crop producing and marketing households was higher. The lower building densities resulted in higher average acreages of the farmers that mostly owned their land.

The respective trends already identified in the previously discussed section of the continuum were further consolidated in the area of the lowest URI values. Even though these areas were located not more than nine kilometres away from the city centre, the analysis of all relevant household parameters suggested the categorisation as a rural area. With very low infrastructure availability, an average duration of residence of almost 30 years, and with almost all farmers owning their land, these parameters are comparable to rural areas. It is only the high proportion of households marketing their produce that is an indication for the area's closeness to the urban markets.

5.1.5 Summary

With a population of around 200,000 and a growth rate of about three percent (Moshi Municipal Council 2010; Donge et al. 2008), Moshi is a lively and dynamic town that nevertheless maintains strong links with its hinterland. The climatic conditions and soils are favourable for agricultural production, and its population has a traditionally strong agricultural background.

While agricultural land use in the urban centre was limited to a few backyard gardens and open spaces, the share of area under cultivation gradually increased with decreasing URI values. With more than 90 percent of the area under cultivation, maxima were reached in the most rural areas covered by the four transects. However, the analysis of several diversity indicators showed the highest crop diversity in the heterogeneous area of transition between urban and rural. In this area the large-scale production of staple food crops, such as maize and beans could be found next to small homegardens where a wide range of vegetables and staple foods were produced. Intercropping was found on most of the cultivated land with maize and beans being by far the most common combination. Furthermore, it was shown that there were distinct patterns in the distribution of cultivated crops. While some crops, such as sweet potato, tomato, and pumpkins, were commonly found in the more urban areas, the more rural areas were dominated by the large-scale production of staple crops.

The analysis of data derived from 404 standardised household interviews showed distinct spatial patterns in a wide range of household parameters. While infrastructural parameters, such as availability of electricity, water, or cement housing, gradually declined with decreasing URI values, the changes in other parameters were less predictable (e.g. farmers living in the urban area while owning large pieces of land outside the centre). An area of transition could be identified, where the duration of residence, the level of land ownership, and acreages were generally low. As a result, households located in this area were less likely to be involved in crop production or the marketing of their produce.

The analysis of land use data as well as the results of the household survey showed that the differentiation between urban and rural is inappropriate to comprehensively capture the complexity of spatial changes along the urban-rural continuum. Several spatial patterns could be identified using the transect approach that would have remained undiscovered if conventional approaches would have been applied.

5.2 Bamenda

5.2.1 Bamenda's urban morphology

As a first step of spatial analysis in the Bamenda case study area, the URI index was calculated for an area of approximately 565 km². Fig. 5.36 shows the spatial distribution of URI values in Bamenda.

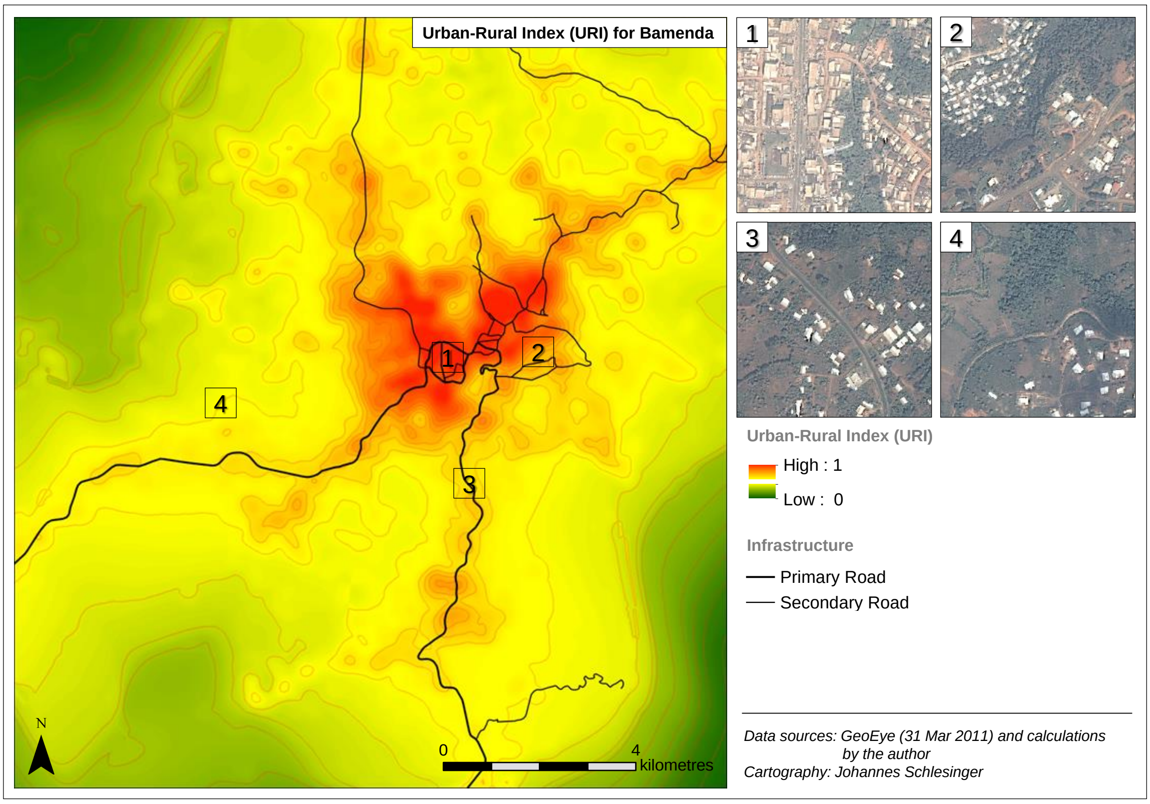


Fig. 5.36: The Urban-Rural Index for Bamenda showing highest values (most urban) in red and lowest values (least urban) in green

As pointed out by other authors before (e.g. Kamga Fogue 2011; Nyambod 2010b), no sharp distinction between urban and rural areas can be identified in Bamenda. Gradual changes in URI values support the idea of an urban-rural gradient rather than a dichotomy between the two extremes *urban* and *rural*. Bamenda's urban core is dominated by two city centres. While the origin of the city is located east of what is the main road today, the *modern* city centre is located west of this road (see Fig. 5.36, 1). Even though both areas have quite different structures in terms of street layout and current use of the buildings, their URI values were quite similar. While the *traditional* centre evolved over time and is primarily used for housing purposes, the *modern* area is characterised by a planned grid road network pattern and multi-storey buildings that are predominantly used for business purposes. Due to the high building densities, agricultural production could hardly be found in this area, except for some banana plantations along the creeks flowing through the centre.

One of the dominant features influencing the spatial development of the city is the Bamenda Escarpment, located southwest of the city centre. It is oriented in a northeastsouthwest direction and can be regarded as a natural barrier for urban expansion (see Fig. 5.36, 2). In the area located at the foot of the escarpment – often informal – redensification is a common phenomenon due to a lack of easily accessible land for expansion (Nyambod 2010a). However, vacant plots are commonly used temporarily for cultivation by the low-income population. Once the plots are developed, the farmers shift to other areas or give up agricultural production completely.

In contrast, the *Hill Station*, as the more elevated area is known, is dominated by a planned low density development. This is where most of the administrative bodies of the Northwest Region are located. Even though the proportion of impervious surface is relatively small, hardly any of this land is used for agricultural purposes due to the functional use of the area for government bodies.

The densely populated areas of Bamenda (red) were surrounded by vast areas with lower population densities (yellow). However, this pattern was occasionally interrupted by areas of higher URI values. This is the result of the common linear development along the usually paved roads leading out of the city (see Fig. 5.36, 3), as already described by Nyambod (2010a). Building densities were relatively high in direct vicinity of the road infrastructure, and were decreasing quickly with increasing distance from these roads.

The abovementioned areas of lower population densities were quite heterogeneous as illustrated by Fig. 5.36, 4. Natural as well as human-induced preconditions lead to distinct patterns, representing the complexity of the periurban. More or less isolated clusters of buildings, be it long-standing villages or areas of recent developments, have an impact on the URI values as well as on the predominant forms of land use.

5.2.2 The transect analysis – spatial changes along Bamenda’s urban-rural continuum

A transect analysis was performed following the same approach as in the Moshi case study. Accordingly, four transects were laid out radially, originating at the city’s central market (see Fig. 5.37). Due to the availability of RS data and due to Bamenda’s population – about twice the population of Moshi – the transects were up to 15 kilometres long, compared to 9 kilometres in the Moshi case study.

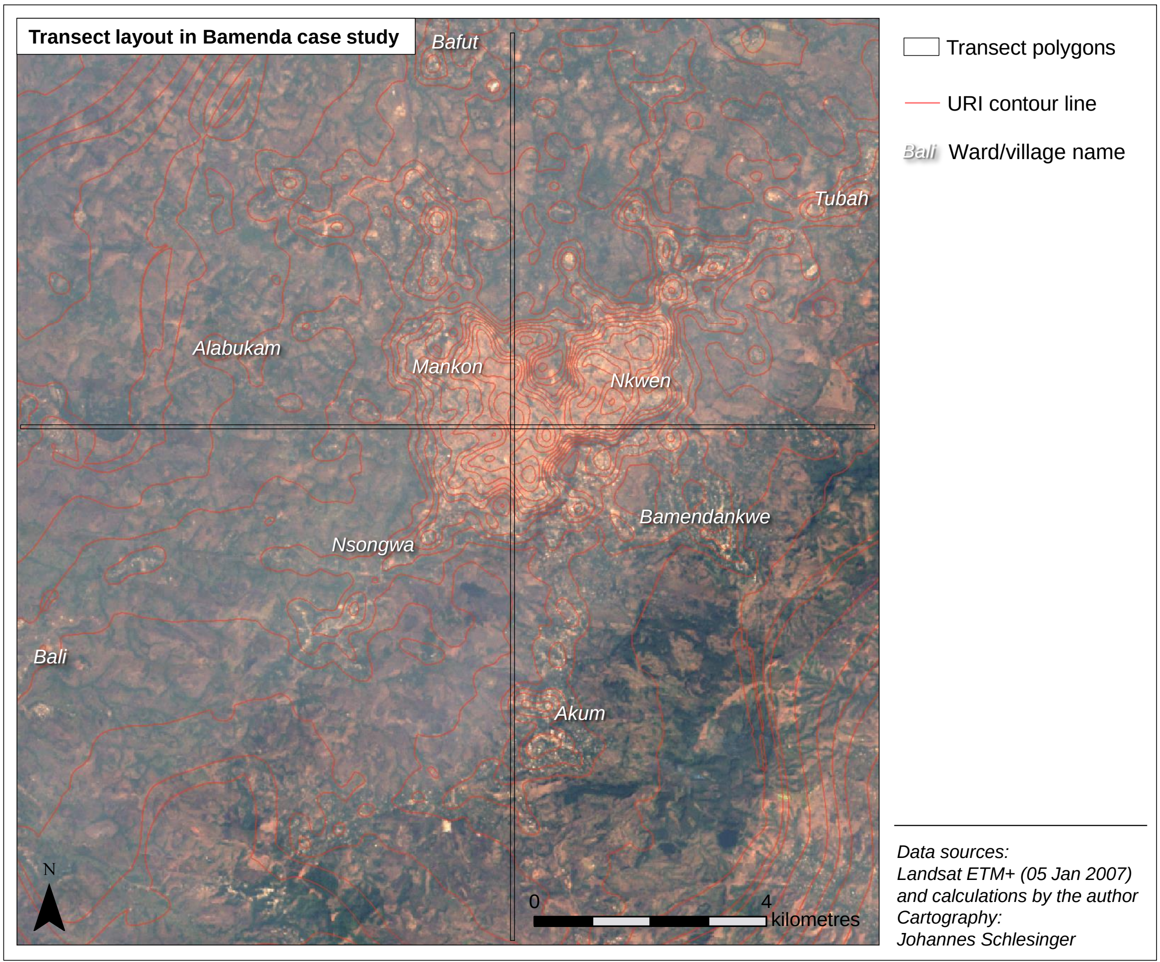


Fig. 5.37: Transects laid out in the Bamenda area

While the northern (NT) and western transects (WT) covered the intensively cultivated undulating landscape at the foot of the Bamenda Escarpment, the southern (ST) and eastern transects (ET) ended on top of the escarpment. Therefore, a wide range of aspects of urban development as well as agricultural activity could be covered by the analysis.

Distance, the Urban-Rural Index and building density

Bamenda has a distinct urban pattern, as shown in the previous chapter. Fig. 5.38 shows the URI values of the transect quadrants plotted against the distance from the transect origin.

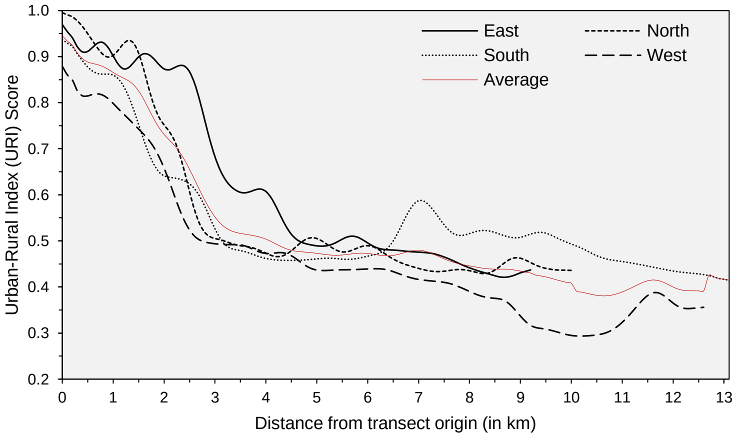


Fig. 5.38: Changes in Urban-Rural Index values with increasing distance from the city centre (n = 585)

The visualisation of changes of the degree of *urbanity* above unveiled significant similarities among the four transects. A sharp decline in URI values was observed in a transition zone located between two and three kilometres from the city centre (see Fig. 5.39 and Annexe 7, Photos 1 and 5). This area was characterised by immense changes in building densities within a short distance, illustrated by the accumulation of isolines.

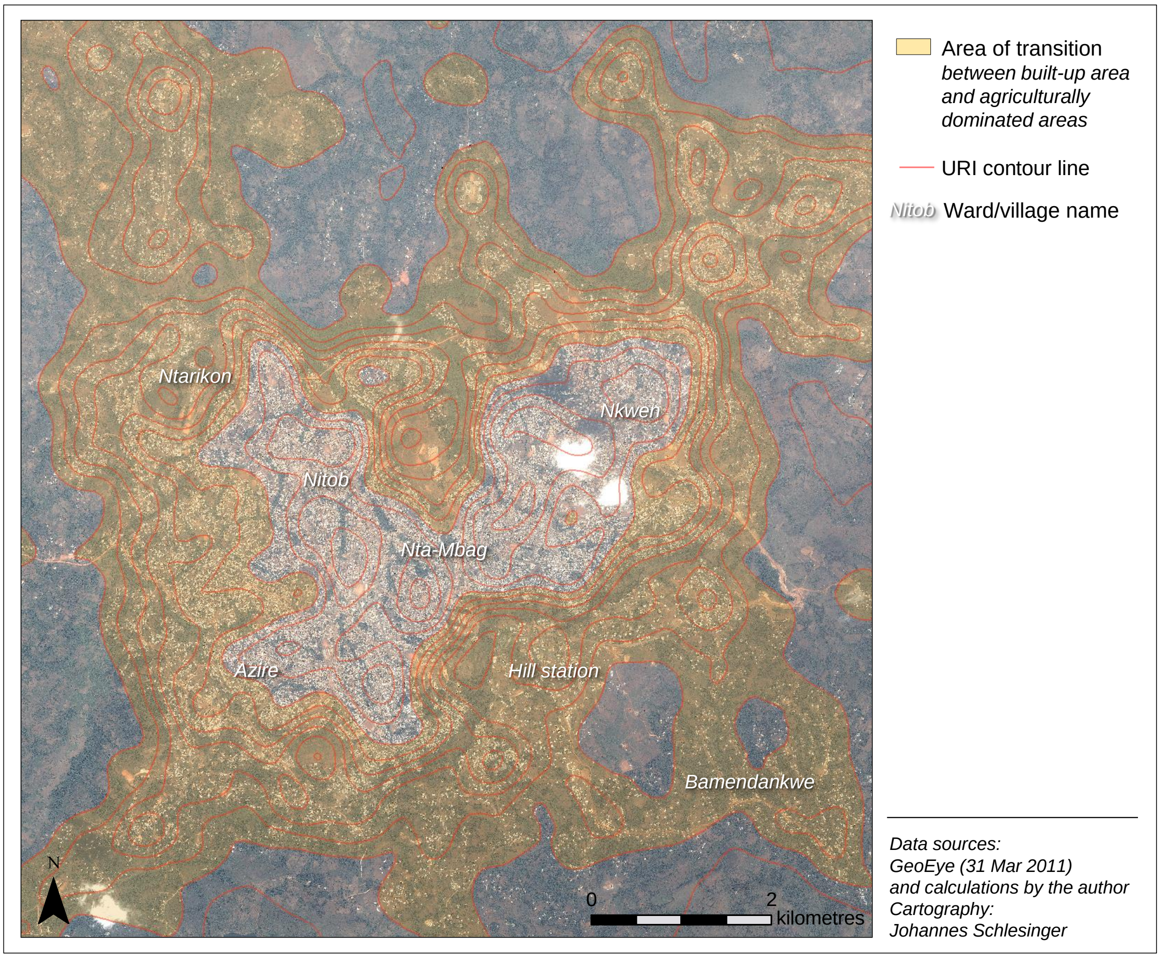


Fig. 5.39: Highly dynamic area of transition between the densely built-up urban core and the surrounding areas of low-density

In Bamenda, main causes for this sharp decline in building densities are natural features that hamper urban expansion. While the expansion to the south and east is slowed down by the steep escarpment, urban development in the north is affected by the wide and seasonally flooded bed of the *Mezam River* (Nyambod 2010a; Kometa and Akoh 2012). It is only to the west that there are no natural features limiting the city's growth, resulting in a lower density of isolines (see Fig. 5.39).

5.2.3 Land use data analysis – less urban, more agriculture

The abovementioned changes in building densities were also reflected in several other landscape metrics that were calculated based on the mapping of agricultural land use along the urban-rural continuum. In the Bamenda case study, a total area of 452 ha was mapped. 250 ha – including grassland – were under cultivation, divided into a total of

2,874 patches (see Annexe 5 for an illustration of the actual changes of agricultural land use along all surveyed transects).

Box 5.3: Bamenda's creeks – a spatial peculiarity affecting the data

The topography of the area located north and west of Bamenda's city centre is characterised by a constant change between gentle hills and narrow valleys. While the crests are – to a large extent – under cultivation, dense natural vegetation with bushes and small trees can be found along the small creeks (see Fig. 5.40).

Fig. 5.40: Profile of creek valley with typical vegetation composition

Even though these valleys play a role in the provision of fire wood, wild fruits, and other natural resources, no actual cultivation takes place within the valleys (see Fig. 5.41). Due to the vertical erosion, which is facilitated by heavy seasonal rains, the slopes of these valleys are usually too steep for agricultural activities.

Fig. 5.41: Dense natural vegetation along creeks north and west of Bamenda and exemplary transect quadrant covering a creek (GeoEye satellite image, 31 January 2010)

This specific topography induced characteristic of the area mainly affected the results regarding the area under cultivation and the Mean Patch Size (MPS).

Cultivated area and patch sizes

As in the Moshi case study, the proportion of the area under cultivation changed along the urban-rural continuum ($r = -.425$, $p < .01$). Fig. 5.42 illustrates these gradual changes from the urban areas, where only a small share is under cultivation, to the more rural areas that are dominated by agricultural land use.

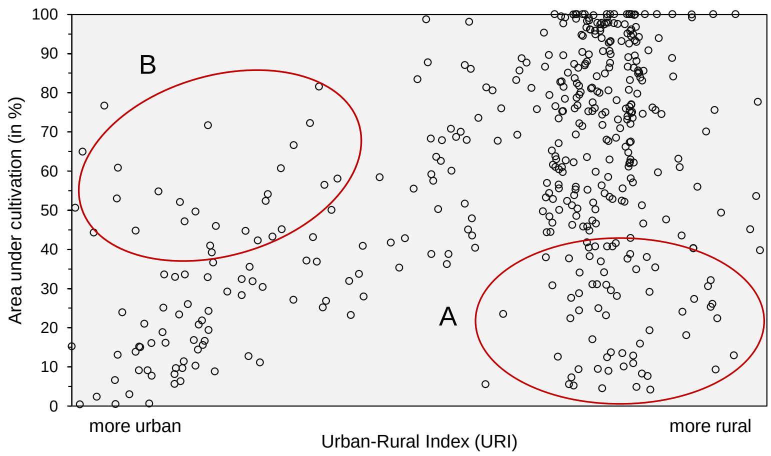


Fig. 5.42: Changes in the area under cultivation along Bamenda's urban-rural continuum (n = 435)

In the area of medium URI values, the percentage of area under cultivation usually ranged between 30 and 70 percent. The bulk of quadrants in the least urban areas showed percentages of 70 percent and more. The still relatively large number of quadrants with less than 40 percent under cultivation (see Fig. 5.42, A) could be explained by the dense natural vegetation in the numerous small valleys, as described above. In the urban regions hardly more than 30 percent of the area was cultivated.

Even though this general trend was expected, it must be emphasised that there was also a significant number of quadrants with high URI values where at least 40 percent of the area was under cultivation (see Fig. 5.42, B). This is an indication for the importance that urban areas have for agricultural production.

The analysis of the Mean Patch Size (MPS) showed a negative logarithmic relationship with the URI value ($r = -.521$, $p < .01$) (see Fig. 5.43).

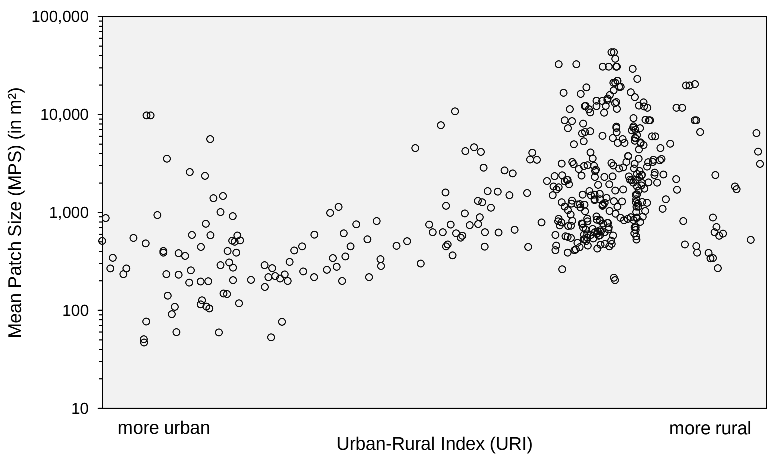


Fig. 5.43: Mean Patch Sizes in Bamenda (n = 435)

Areas with high URI values were generally characterised by MPS of less than 1,000 m², due to the limited availability of land suitable for agriculture. However, a few outliers could be identified in the urban area. These values represent urban agriculture on large plots within the temporarily flooded river bed just north of the city centre (see Annexe 7, Photo 7). MPS values exponentially increase with decreasing URI values and reach their maxima of around 5,000 m² in the more rural areas, where large pieces of land are suitable and available for agriculture.

Crop diversity

As intercropping was a common practice in agricultural production along all transects in the Bamenda case study, the analysis of the respective indicators showed accordingly a heterogeneous situation. Compared to the Moshi case study, the Crop Richness Indicator (CRI) as well as the Patch Richness Density (PRD) showed significantly higher values, due to the higher complexity of intercropping systems in the Cameroonian case study.

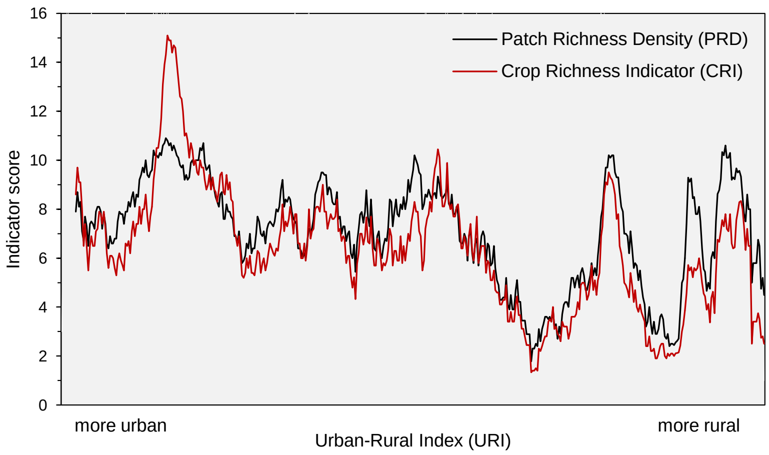


Fig. 5.44: Patch Richness Density and Crop Richness Indicator scores along the continuum (n = 435)

Small – although statistically significant – linear correlations were detected between URI and PRD ($r = .277$, $p < .01$) as well as between URI and CRI ($r = .218$, $p < .01$), indicating that crop diversity was higher the more urban the area was. Three distinct patterns could be identified along the continuum. The urban centre was characterised by relatively high PRD and CRI values (see Annexe 7, Photos 3-4). However, the adjacent area of transition between the densely populated urban areas and the areas of more rural character showed even higher values, a circumstance that is caused by the heterogeneous land use in this area. The more rural the area was, the lower the indicator values became. However, this trend was interrupted by scattered settlements, leading to several peaks in the more rural sections of the transects (see Fig. 5.44).

These trends were further supported by the analysis of the Shannon's Diversity Index (SHDI) that takes into account the variation in patch sizes in addition to the crop diversity. Even though the data showed a similarly heterogeneous pattern (see Fig. 5.45), a small linear correlation could be identified ($r = .378$, $p < .01$).

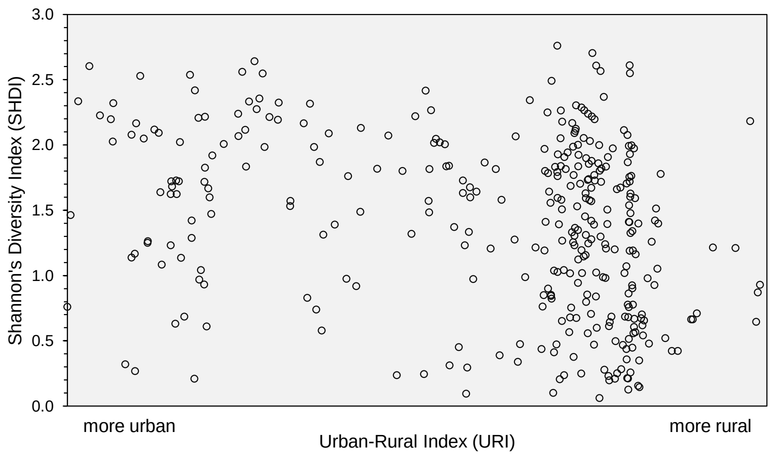


Fig. 5.45: Shannon's Diversity Index as illustration of heterogeneous land use in Bamenda (n = 343)

As with the previously discussed diversity indicators, the variability in SHDI values can be interpreted as a result of the generally high degree of land use heterogeneity in the Bamenda case study. Intercropping of several crops was commonly found, especially in areas that were highly influenced by urban settlements. Therefore the SHDI was generally higher in these areas.

Cultivated crops

In the Bamenda case study, a total of 24 different cultivated crops were identified. Table 5.6 lists the crops and crop combinations that were most commonly identified within the transects and their respective parameters.

Table 5.6: Most common crops and crop combinations found in Bamenda

	Nr of patches	Share of patches (in %)	Area (in m²)	Share of cultivated area (in %)	Average patch size (in m²)
Pure cropping					
Banana	397	13.5	158,336	9.0	399
Cassava	143	4.9	89,619	5.1	627
Herbs	62	2.1	19,837	1.1	320
Maize	40	1.4	16,760	1.0	419
Yam	31	1.1	28,607	1.6	923
Sugar cane	22	.7	7,943	.5	361
Sweet potato	18	.6	7,894	.5	439
Cocoyam	15	.5	3,201	.2	213
Pumpkin	14	.5	4,868	.3	348
Irish potato	12	.4	4,402	.3	367
Other	26	.9	20,640	1.2	573
Subtotal	779	26.5	362,106	20.7	500

	Nr of patches	Share of patches (in %)	Area (in m²)	Share of cultivated area (in %)	Average patch size (in m²)
Intercropping					
Maize, beans	201	6.8	103,718	5.9	516
Maize, beans, cocoyam	91	3.1	38,376	2.2	422
Maize, beans, yam	88	3.0	45,981	2.6	523
Cassava, yam	78	2.6	81,382	4.6	1,043
Maize, beans, yam, cocoyam	66	2.2	29,645	1.7	449
Maize, beans, banana	39	1.3	38,817	2.2	995
Maize, beans, cocoyam, banana	36	1.2	36,951	2.1	1,026
Maize, beans, cassava, yam, cocoyam	32	1.1	26,578	1.5	831
Cassava, grassland	30	1.0	23,479	1.3	783
Other	1,504	51.1	966,095	55.1	642
Subtotal	2,165	73.5	1,391,022	79.3	643
Total	2,944	100.0	1,753,128	100.0	595

Banana and cassava were by far the most commonly found crops in pure cropping systems in terms of number of patches as well as area. While the large share of banana could be explained by its importance as a staple food for self-consumption, the appearance of crops, such as cassava, maize, and yam was due to the market orientation of some farmers located mainly in the more rural areas. This interpretation was supported by the relatively large average areas on which these crops were grown.

With four fifth of the cultivated area used for intercropping, these integrated crop cultivation systems were similarly dominant as it was the case in the Moshi study (see 5.1.3). However, the diversity of intercropping systems was much higher in Bamenda. 459 different crop combinations were observed along the transects. Most of these intercropping systems were based on the cultivation of maize or banana, supplemented by other crops, such as beans, cassava, yam or cocoyam. As previously discussed, these intercropping systems tend to be highly adjusted and sustainable in terms of soil quality, hydrologic balance, and output (Mousavi and Eskandari 2011; DFID 2004; Pasquini et al. 2009; Mougeot 1994a).

Spatial distribution of crops

The previous analysis of the main basic parameters of different crops and crop communities provided some information on the overall character of agricultural land use in the Bamenda area. However, these analyses were supplemented by the spatial analysis of the distribution of specific crops along the urban-rural continuum. The graphs below show the spatial changes in three parameters of selected crops: the proportion of the total area that was covered by the crop, its proportion of the cultivated area, and the mean patch size.

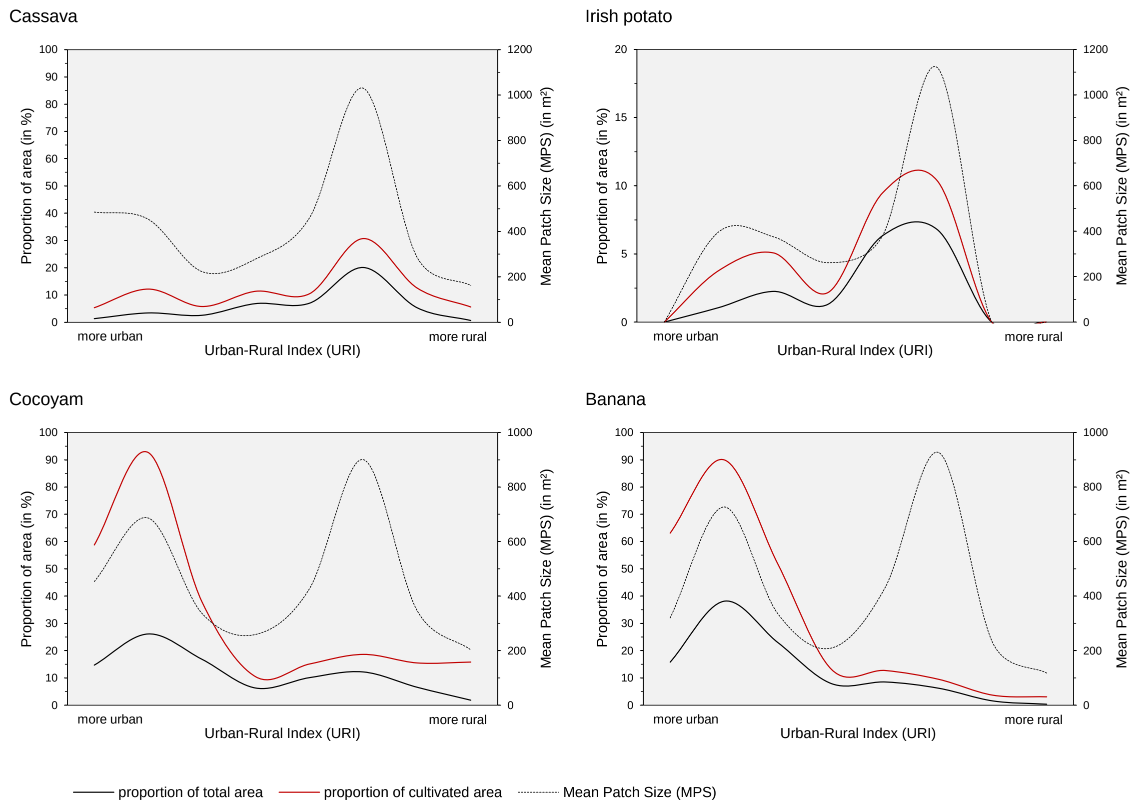


Fig. 5.46: Spatial distribution of selected crops

All of these crops had in common that the mean patch sizes peaked in the more rural areas, where large pieces of arable land were available. However, the proportion of area covered by these crops showed significant differences. Banana and cocoyam were most commonly found as part of intercropping systems in the more urban areas (see Annexe 7, Photo 3), where these crops were cultivated in homegardens or on open spaces, such as the undeveloped areas along the streams. In contrast, cassava and Irish potato were mainly cultivated in more rural areas. Even though intercropping was also common, the number of different crops per area was generally small (see Annexe 7, Photo 6). This cultivation could be categorised as being oriented towards the close urban markets rather than for self-consumption as in the cases of banana and cocoyam. These findings are supported by previously discussed studies focusing on the spatial distribution of market oriented agriculture and production aiming at self-consumption (Drescher 2001; de Zeeuw et al. 2000).

Summary of agricultural land use in Bamenda

The analysis of land use data generally supported the findings from the Moshi case study. Gradual changes in several spatial metrics could be observed, resulting in a characteristic sequence of land use patterns along the continuum. With decreasing building densities, the proportion of agricultural land use as well as the mean patch size increased, while the crop diversity indicators showed a more complex pattern. Intercropping was the dominant form of agricultural land use, with banana, cassava, maize, and yam being the most common crops.

The spatial analysis of the crop distribution unveiled distinct patterns. While, inter alia, banana and cocoyam were dominant in urban homegardens, large-scale production of cassava, Irish potato and other crops for marketing was found in the more rural areas.

5.2.4 Household data analysis – socio-economic changes along the continuum

Similar to the Moshi case study, a household survey (n = 480) was conducted in the transects laid out in Bamenda in order to improve the understanding of socio-economic changes – with an emphasis on agricultural activities – along the urban-rural continuum. In the following the spatial changes of selected household parameters are discussed.

Infrastructure availability, duration of residence and the flat/house ownership status

Access to electricity and piped water as well as the general condition of the buildings was assessed as indicators for the overall infrastructural situation.

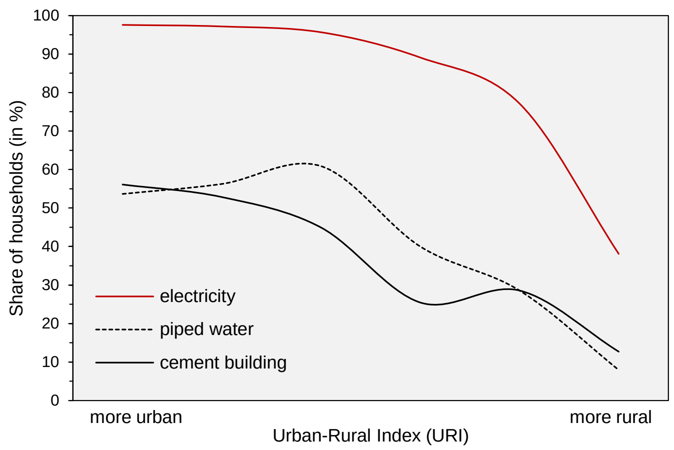


Fig. 5.47: Changes in infrastructural conditions along Bamenda's continuum (n = 480)

Fig. 5.47 shows that there is a positive correlation between URI and the percentage of households having access to electricity ($r = .844$, $p < .05$) and those having access to piped water on the plot ($r = .881$, $p < .05$). While almost all households in the urban area had access to electricity and about half of them access to piped water, in the least urban areas these shares dropped to about 40 percent and less than 10 percent, respectively. As previously discussed, these numbers are a consequence of higher costs for the provision of infrastructure in less densely populated areas (Zvoleff et al. 2009). The numbers regarding the presence of cement buildings as the most sophisticated and costly form of construction changed accordingly ($r = .963$, $p < .01$). With decreasing URI values, cement structures were increasingly substituted by buildings made of natural resources, such as wood and mud bricks.

The analysis of ownership or rental status of the interviewed households showed gradual changes similar to those observed in the overall infrastructural situation (see Fig. 5.48).

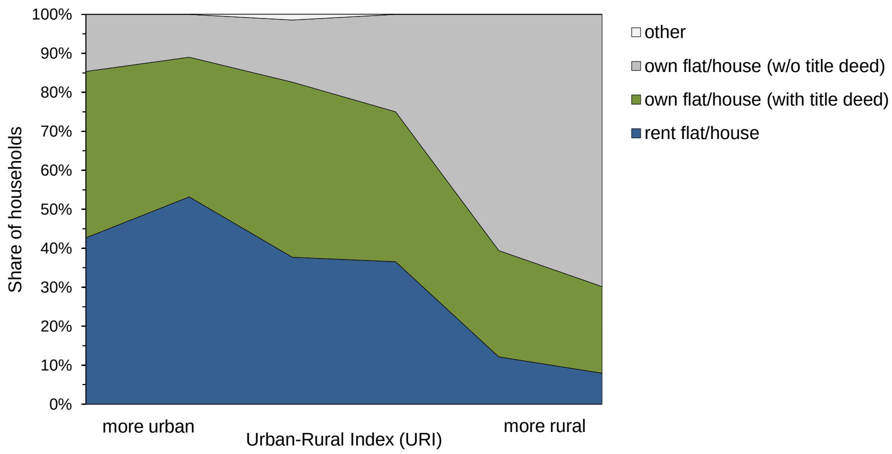


Fig. 5.48: Ownership/rental status of interviewed households (n = 472)

In Bamenda's city centre, more than one third of the interviewed households rented the flats or houses they lived in. About three quarters of the remaining part officially owned the property, while about one quarter owned it without any title deed. The less urban the area was the more important traditional ownership became ($r = -.901$, $p < .05$). Accordingly, percentages of households with title deeds ($r = .825$, $p < .05$) or rental agreements ($r = .906$, $p < .05$) decreased, reaching their minima in the most rural areas with 22 and eight percent, respectively. As in the previously discussed case study, these numbers are a reflection of the higher importance of informal housing markets in the more rural areas. Furthermore, they illustrate the complex situation in the areas of transition between urban and rural (Drescher and Iaquinta 2002) where formal and informal ownership as well as rental arrangements are equally present.

The Moshi case study showed that the duration of residence could be successfully used as one of the indicators for the social dynamics along the continuum. Fig. 5.49 illustrates how this parameter changed in the Bamenda case study.

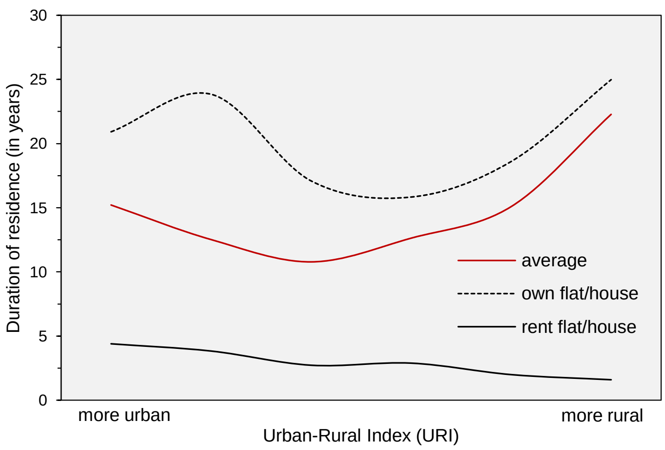


Fig. 5.49: Duration of residence by ownership/rental status (n = 475)

Similar to the findings from Moshi, the analysis showed a non-linear correlation between the URI and the time the interviewees already lived in the area. Urban households had an average duration of residence of 15 years, with significant differences between the subgroups of house/flat owners and house/flat renters. While the numbers for the latter steadily decreased, the overall duration of residence had its minimum in the area of medium URI levels before increasing again. In the most rural areas covered by the transects, the overall duration was more than 22 years. These findings underscore the previously discussed existence of an area of transition with its own characteristics between the urban and the rural (e.g. Adell 1999; Mandere et al. 2010; Drescher and Iaquinta 2002).

In the Moshi case study, the duration of residence was identified as one of the most important factors influencing several other parameters of the households' agricultural activity. The analysis of the respective data from Bamenda revealed similar correlations (see Table 5.7).

Table 5.7: Relation between duration of residence and other household parameters

Duration of residence (in years)	Share of households involved in farming (in %) (n = 480)	Share of farming households owning the plot (in %) (n = 368)	Share of farming households involved in marketing (in %) (n = 371)
0 to 10	66	66	32
11 to 20	86	75	45
21 to 30	97	92	52
30 and more	89	91	57
Total average	77	76	51

The longer the interviewed households lived in the area, the more likely they were to produce crops. The same applied to land ownership and involvement in marketing of their produce. Duration of residence seemed to be an important determinant for the households' agricultural parameters. As previously discussed, it is the group of recently migrated households that tend to have difficulties in getting access to land, as it requires certain social networks that need time to develop (Bryld 2003). Limited access to land in turn has implications on the households' acreage, production, and – eventually – on the ability to market surpluses.

Land tenure and marketing of agricultural products

The analysis of household data from the Bamenda case study showed that 77 percent of the interviewed households were involved in crop production, a number that is extremely high compared to reports from other studies (e.g. Zezza and Tasciotti 2010; Dossa et al. 2011). The high proportion of farming households is the result of the favourable climatic conditions, strong rural-urban linkages despite the fast urban growth, and the availability of arable land in the region.

Even though the spatial changes in the shares of households involved in crop production were less distinctive than in Moshi, a trend could be observed.

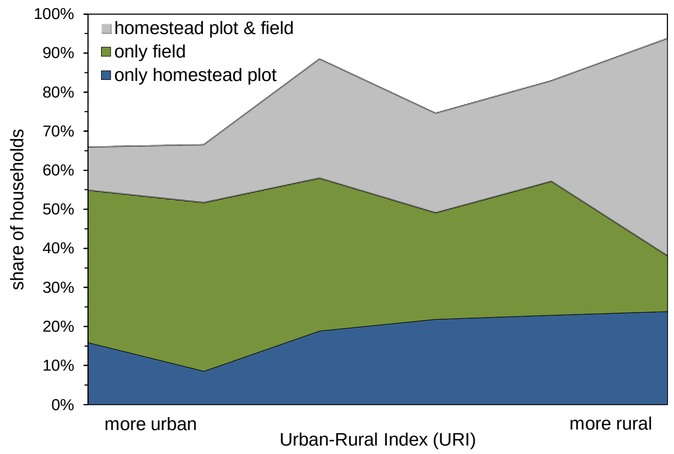


Fig. 5.50: Share of households involved in crop production (n = 480)

In Bamenda's urban centre, 65 percent of the interviewed households were involved in crop production. While less than a third of them cultivated parts of their homestead plot, the vast majority produced on fields outside the built-up urban area. In general, the less urban the area was the more households were involved in crop production ($r = -.853$, $p < .05$). With 95 percent of the interviewed households, shares reached their maximum in the most rural sections covered by the transects. These numbers largely correspond to the findings from the Moshi case study as well as other studies (Zezza and Tasciotti 2010). In these areas, cultivation on the homestead plot was much more common than in the urban areas due to the availability of arable land around the houses. However, most of the households cultivated fields located somewhere else in addition to their homestead plot, which can be interpreted as a spatial diversification strategy.

A common strategy to diversify the household income was to engage in the marketing of agricultural produce. The analysis showed that 51 percent of the farming households marketed parts of the crops they produced. However, shares were unevenly distributed along the continuum, as illustrated in Fig. 5.51.

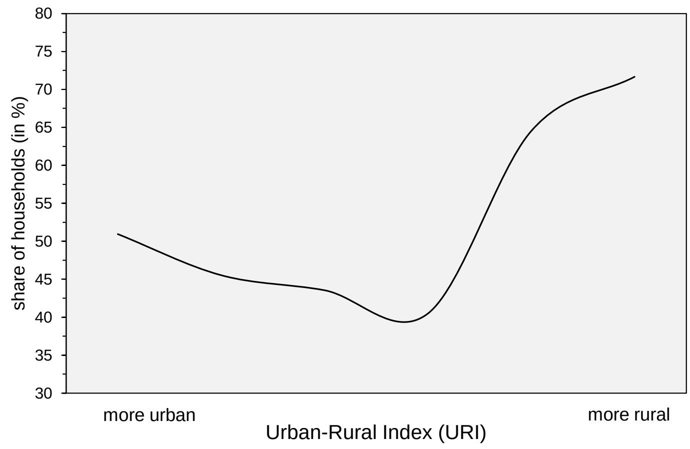


Fig. 5.51: Changing shares of farming households involved in marketing of agricultural products (n = 371)

About half of the farmers located in the urban centre of Bamenda were involved in marketing, while more than 70 percent were involved in the least urban parts of the continuum. It was the area of transition between the most urban and most rural parts, where market orientation was least common, as illustrated above. These findings are surprising taking into account previous studies on the market orientation of urban and periurban farmers (e.g. Nugent 2000a; de Zeeuw et al. 2000). However, they do – to a large extent – correspond to the findings reported from the Moshi case study (see 5.1.4). These changes are a consequence of the duration of residence and the households' acreages, as previously discussed.

While the spatial patterns in the parameters discussed above were largely congruent to those observed in the Moshi case study, the findings regarding the land tenure situation differed considerably. While land leasing dominated in Moshi's areas of medium URI levels, this was not the case in Bamenda (see Fig. 5.52).

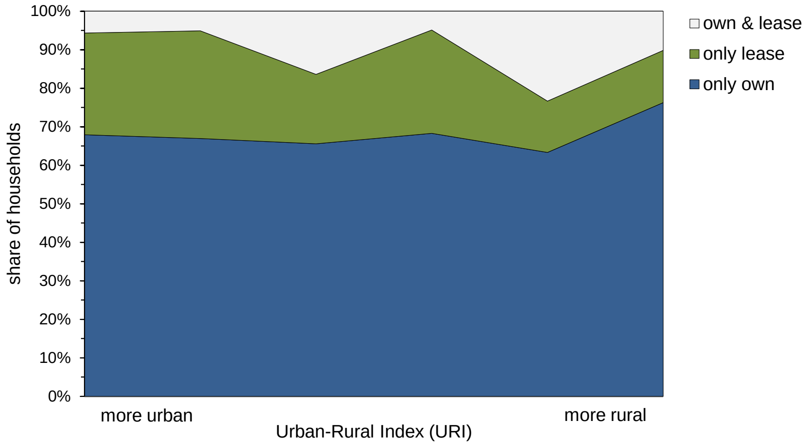


Fig. 5.52: Land tenure situation of farming households along Bamenda's urban-rural continuum (n = 368)

Percentages of households owning the land they cultivated were constantly high with only slight differences between the city centre and the surrounding areas. Accordingly, no particular pattern could be identified in land tenure arrangements along the continuum. As in the case of overall involvement in agriculture, these numbers can be partially explained by the strong rural-urban linkages of the interviewed farming households. The ties with their places of origin located in the rural areas tended to be strong, resulting in a large share of households still cultivating fields traditionally owned by their families. The importance of a land leasing market is therefore rather limited, illustrated by just about one third of farming households leasing land.

5.2.5 Summary

With an estimated population of around 400,000 Bamenda is the capital and economic hub of the Northwest Region of Cameroon (Bureau Central des Recensements et des Etudes de Population 2010). Within the last 35 years, its population has increased eightfold, making it one of the fastest-growing cities in the country (Bureau Central des Recensements et des Etudes de Population 2010). Its diverse ecological settings facilitate crop production in the area, resulting in a high importance for the economy and the households.

In general, the analysis of land use data from the Bamenda case study revealed several similarities with the data from Moshi. The less urban the area was, the more land was used for crop cultivation. Furthermore, patch sizes tended to increase with decreasing URI values. The results regarding crop diversity were less clear, even though a significant positive correlation between all three crop diversity indicators and the URI could be identified, showing that the more urban the area the higher the diversity was. More than 450 different crop combinations were identified, most of them being based on the cultivation of maize or banana, and supplemented by other crops, such as beans, cassava, yam or cocoyam. It could be shown that distinct patterns in the distribution of different crops exist. While the cultivation in the more urban areas was dominated by crops for self-consumption, such as cocoyam and banana, the more rural areas – where larger pieces of arable land were available – were dominated by the large-scale market oriented cultivation of staple food crops, such as cassava or Irish potato.

The analysis of data from 480 households along the urban-rural continuum supported the findings from the Moshi case study. The presence of electricity, water, and cement buildings decreased along the transect. The same trend could be observed regarding official ownership and rental arrangements. However, the analysis of the duration of residence, involvement in marketing, and other parameters indicated that there was an area between the most urban and the most rural areas that had its own distinct characteristics, as previously discussed.

6. Overall summary and conclusions

In this decade when – for the first time in global history – more people live in urban than in rural areas, the question of food supply for the growing number of urban residents becomes increasingly important (FAO 2002). In most African towns and cities, urban and periurban agriculture is one of the most commonly found and most persistent strategies not only for food production, but also for income generation through marketing of the products. A wide range of theoretical and case studies have investigated different aspects of UPA, yet little is known about the complex interactions between urbanisation and agricultural land use. However, an improved understanding of the spatio-temporal dynamics of agricultural activities along the urban-rural continuum is essential for the formulation of appropriate land use policies, urban development plans, and respective intervention strategies.

The objective of this study therefore was to enhance the understanding of spatio-temporal dynamics of urban and periurban agriculture along the urban-rural continuum with a special focus on small and medium-sized cities in Africa. A transect approach was applied in two cities, guiding all steps of data collection and analysis. Remote sensing and in situ mapping approaches were applied for the detailed inventory of land use along the continuum. Furthermore, a household survey was conducted in both study areas to allow for analysing socio-economic household characteristics with a special focus on agriculture and respective spatial changes. A GIS-based approach was employed using the Urban-Rural Index (URI) as the independent variable for all spatial analyses.

6.1 Agriculture and the urban-rural continuum – answering the research questions

This study aimed at answering four research questions. While the first question dealt with an appropriate methodology for data collection and analysis, the following two questions concentrated on the changes of agricultural activities along the urban-rural continuum. The fourth question was related to the general conclusions that can be drawn with regard to the future understanding of the urban-rural continuum.

The most important findings relevant for answering these questions are summarised below.

1. *Which methodology is suitable to efficiently collect, process, and analyse data on agricultural land use and its role for farming households along the urban-rural continuum?*

The heterogeneous spatial manifestations of urbanisation processes can be complex and sometimes difficult to capture. As pointed out in the previous chapters, a methodological approach that is complex, interdisciplinary and yet efficient is necessary (McIntyre et al. 2008; Knox and Pinch 2007). However, most previous studies have – if at all – rather concentrated on selected case study sites along the urban-rural continuum (e.g. Maxwell 1995; David et al. 2010) than actually investigating the gradual changes of different variables, such as area under cultivation or household involvement in UPA. A wide range of methods have been applied in these studies:

- Remote sensing-based approaches (e.g. Forkuor and Cofie 2011) have proven successful in capturing land use on a large scale while lacking the spatial and spectral resolution to allow for a detailed analysis of crop production.
- Just a few studies so far applied in situ mapping techniques. However, they were either covering only a small spatial extent or focussed on cultivation on open spaces (e.g. Dongus 2009) excluding small-scale backyard cultivation from the data collection process.
- A wide range of household surveys with different foci have been conducted (e.g. Maxwell 1995; Dossa et al. 2011; Foeken et al. 2004). Yet, they either concentrated on artificial administrative units or a non-random sampling technique that might have affected the data.

In order to overcome these limitations, a combination of remote sensing, in situ mapping, and interview methods was developed for data collection in this study. The data collection process was thereby guided by a transect approach, ensuring the collection of a continuous set of land use as well as household data.

In terms of data analysis, the aim of this study was to overcome the common categories that are usually based on administrative bodies or the linear distance from the city centre. Therefore, the URI was developed as a simple and yet convenient measure of the complex urban morphology. The incorporation of the Weighted Kernel Density of buildings and the travel times from the city centre allowed for the translation of the complex situation *on the ground* into a reproducible index value.

Developing the methodology in one case study site before transferring and reproducing it in a second site proved successful. It could be shown that this methodology was flexible enough to be applied in different – more or less comparable – spatial settings.

2. *How does agricultural land use of urban and periurban areas change along the urban-rural continuum?*

While this study also looked at the temporal dimension of change along the urban-rural continuum, its focus was on the changes across space. Based on the data collected and analysed on the basis of the abovementioned methodology, the hypothesis of the gradual character of spatial changes along the urban-rural continuum can be supported. These changes can thereby be interpreted as the manifestation of the varying influence of the urban agglomeration.

This varying influence on agricultural land use could be observed in almost all landscape related indicators. Even though both case study sites had different historical developments, social as well as environmental prerequisites, the analysis of landscape metrics showed considerable similarities between both cities. However, marked differences were observed between the landscape metrics measured along the transects in each city. While some of them showed linear correlations with the URI, a few showed logarithmic or non-linear correlations, most of them being statistically significant.

Thereby, the results of the analysis of some landscape metrics were expected and supported previous findings. The increase in the area under cultivation with decreasing URI levels, for example, is one of the most obvious spatial characteristics of the urban-rural continuum that had been discussed before. The same applies to the changes in mean patch size, for instance. Furthermore, the analysis of agricultural land use showed distinct spatial patterns of crop distribution. While amaranthus, cocoyam, and other crops that are mainly cultivated for self-consumption were dominating in the densely populated urban areas, it was the extensive large-scale cultivation of staple food crops, such as maize and Irish potato, that dominated the more rural sections of the transects. These spatial trends had been reported before. Yet, for the first time, they could be actually quantified for vast areas along – quasi-randomly laid out – continuous transects.

Furthermore, some findings contradicted previous reports. All crop diversity indicators reached their maxima in the heterogeneous area of transition between the urban and rural ends of the spectrum. In addition, the analysis of multi-temporal RS data revealed an increase in vegetation quantity in the course of urban transformation in some parts of the continuum. These findings emphasise the complex and yet distinct impacts of urbanisation on agricultural land use along the urban-rural continuum.

3. *How do household characteristics – with a special focus on agriculture – change along the urban-rural continuum?*

The changes in household data were less predictable and more resource intensive to capture and to analyse than changes in agricultural land use. Yet, somewhat similar trends regarding spatial changes along the urban-rural continuum could be identified. As in the case of agricultural land use, clear similarities between the spatial patterns in household variables from both case studies were observed.

For example, the changes in infrastructure – namely electricity, piped water, and cement housing – were almost congruent in both case studies. As expected did the percentage of households with access to these facilities decrease with decreasing URI values. Changes in the proportion of households that were involved in crop or livestock production were also similar in both cities. Negative correlations between household variables and the URI were usually linear and statistically significant at the .01 level. However, considering only these – more obvious – trends would have led to wrong conclusions regarding spatial patterns of household characteristics along the continuum.

A closer look at the interrelations between other variables unveiled a more complex situation. It could be shown that the duration of residence was an important factor for a wide range of agriculture related variables. It had a significant impact on acreages, land ownership, and eventually on the role of UPA for the households' food production and income generation. Hence, the areas adjacent to the densely populated urban cores were heterogeneous not only in terms of land use, but also in terms of socio-economic conditions. The results show that these diverse and highly dynamic areas should not only be understood as the area between *urban* and *rural*. They should be rather seen as areas of distinct social patterns and as an integral part of the urban-rural continuum.

4. *Which conclusions can be drawn from these results regarding the future understanding of the areas of transition between the two extremes 'urban' and 'rural'?*

Based on the literature review, the oversimplification of the complexity of the urban morphology was identified as a constraint to research as well as to policy formulation and implementation efforts. The thinking in *urban* and *rural* as dichotomous categories often hinders these efforts. However, an increasing body of literature investigates the actual character of spatial and temporal changes in between these two poles. The periurban as an area of distinct characteristics is increasingly recognised and researched upon. Yet, changes along the urban-rural continuum have been hardly quantified. The aim of this study was therefore to contribute to the understanding of spatio-temporal dynamics along the urban-rural continuum with a special focus on agricultural activities.

Based on the two case studies, some more general conclusions regarding the spatial characteristics were derived. By incorporating land use data as well as household data in the analysis process, a comprehensive picture of the urban-rural continuum could be drawn. Four ideal types of spatial change in the variables were identified (see Fig. 6.1).

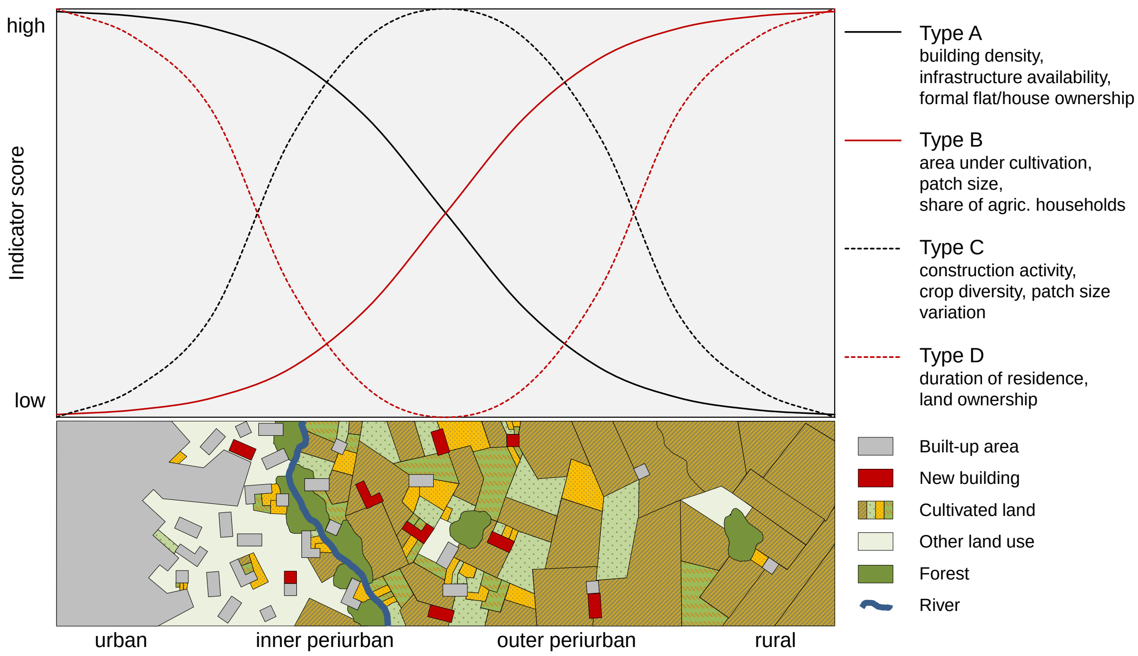


Fig. 6.1: Ideal types of change along the urban-rural contiuum

While some of the variables show the highest values in the urban core before decreasing in the less urban areas (Type A), others reach their maximum in the rural areas (Type B). In addition to that, two other ideal types could be identified: variables that reach their maximum in the periurban areas (Type C) and those showing minimum values in these areas (Type D).

Based on these ideal types of changes along the urban-rural continuum, four more or less homogeneous sections of the continuum can be identified.

Urban area: The urban area is per definition characterised by a high building and population density. Infrastructure availability (e.g. piped water and electricity) is usually high and the degree of formalisation of flat/house ownership as well. As little land is left for the development of housing, the construction activity is generally low. Accordingly, hardly any land in the urban centre is used for agricultural purposes. Only small patches are used for backyard gardening or roadside cultivation. Hence, diversity indicator values and the share of households involved in agriculture are also low.

Inner periurban: Even though building densities, infrastructure availability, and flat/house ownership are not as high as in the urban area, the respective scores are still relatively high. However, they show a decreasing tendency towards the rural areas. Agricultural activities, in turn, are more important than in the urban areas, even though still on a small scale. As these areas are located in close proximity to the city centre, they are hotspots of urban development with a high percentage of recently migrated households. The high construction activity leads to a rapid conversion from arable to built-up land.

Outer periurban: This area is characterised by a mix of large and small pieces of cultivated land and a few scattered buildings. Construction activity and crop diversity indicators are generally high with a decreasing tendency towards the rural areas. Land ownership is usually less formally organised than in the more urban areas. Yet, as the city grows, this area becomes increasingly interesting for urban investors, resulting in conflicts over resources (e.g. land, water).

Rural area: This area can be seen as the counterpart to the urban centre. These areas are usually dominated by agricultural land use with most households being agriculturally active. Land and houses are usually informally owned and most families used to live in the area for generations. Hardly any of the households are connected to the water and/or electricity grid and the lack of road infrastructure makes travelling to the urban centre difficult. The large-scale cultivation of staple crops is therefore the dominant way of securing the livelihood.

The actual shaping of the variables and hence the resulting patterns are highly influenced by a wide range of factors, such as size and growth rate of the city, its environmental setting, and political-administrative frameworks. Furthermore, it needs to be emphasised that these areas are dynamic. Once the city is growing and the urban influence extends its reach, periurban areas might become urban and rural areas the new periurban. The urban-rural continuum is therefore not a static spatially manifested structure. It should be rather understood as a dynamic space that also has a strong temporal dimension.

6.2 Recommendations for future research

This study showed that spatial changes in a wide range of land use variables as well as household variables have a gradual character rather than being dichotomous. Urban planners and policy makers, however, tend to remain thinking in the categories *urban* and *rural* as determined by administrative boundaries. Yet, these boundaries are artificial and to a certain degree static. Administrative divisions are in many cases obsolete, due to the – often rapid – urban and periurban development and a lack of administrative steering capacity. Hence, the dichotomous thinking rather hampers a planned and sustainable development than supporting it. Recognising the gradual character of changes along the urban-rural continuum could be a first step.

Future research should therefore more intensively concentrate on the patterns along the continuum and their role in the urbanisation process. Applying the methodology developed in the course of this study to other towns and cities could provide a more comprehensive dataset on the continuum. Following studies focussing on bigger cities (e.g. Dar es Salaam or Yaoundé), cities located in other climate zones (e.g. arid or semi-arid areas), or cities with other socio-economic or political preconditions (e.g. Bangkok, Jakarta or São Paulo) would be of particular interest.

Furthermore, having a closer look at the temporal dimension of change along the urban-rural continuum could improve its understanding. The transect approach with its set of methods could be applied to the same city at intervals of several years. Such a research could unveil characteristic patterns and dynamics eventually shaping the form of urban agglomerations.

In the past, most studies on urban and periurban agriculture did not clearly differentiate between the location of farmers and the location of their farms. Results from this study, however, showed that there is not necessarily a congruency between the two. Even though hardly any urban land might be under cultivation that might be where the "biggest" farmers live. In turn, periurban households might have hardly any land at their disposal despite being surrounded by arable land. This differentiation is important for the formulation of future land use policies as well as for development interventions.

6.3 Outlook

According to recent UN estimates, the urbanisation process is likely to severely affect the way the global population will live in the decades to come (UN 2012). Even though the relative share of the population living in small and medium-sized cities will decrease globally, the absolute numbers – especially in sub-Saharan Africa – are expected to rise significantly (UN 2012; Cohen 2006; Matuschke 2009). The ongoing rural-urban migration as well as the natural increase of the urban population will lead to a spatial expansion of these towns and cities in the region. As this growth is often fast, informal, spontaneous, and usually hardly steered, it leads to even bigger areas of scattered development and heterogeneous land use.

The tensions between *urban* and *rural* interests are likely to become more important in the future. This especially applies to areas where UPA becomes an essential livelihood strategy in the course of higher and increasingly volatile food prices.

However, in order to exploit the full potential of UPA, an anticipatory planning is necessary. Two basic framework conditions would facilitate this process:

- Seeing UPA as an integral part of the urban (food) system rather than as a problem that needs to be overcome. As a wide range of examples have shown, integrating UPA in urban and periurban spatial planning is feasible and rewarding not only for the farmers, but for the cities as a whole.
- Recognising the distinct spatio-temporal dynamics along the urban-rural continuum. The more detailed the knowledge about the peculiarities of different parts of the continuum is, the more appropriate and adjusted can the respective steering measures be.

While achieving the former goal is mainly a task for politicians and activists, the latter is a task – and a challenge – for the scientific community. It remains to be hoped that scientific findings in general and this study in particular can contribute to a better understanding of the spatio-temporal dynamics of urban and periurban agriculture along the urban-rural continuum.

References

ACF International (2010), *Identification of vulnerable people in urban environments: Assessment of sustainable livelihoods and urban vulnerabilities* (Paris).

Adam, M. (2001), 'Definition and boundaries of the peri-urban interface: patterns in the patchwork', in P. Drechsel and D. Kunze (eds.), *Waste composting for urban and peri-urban agriculture. Closing the rural-urban nutrient cycle in sub-Saharan Africa* (Colombo), 193–208.

Addo, K. A. (2010), 'Urban and Peri-Urban Agriculture in Developing Countries Studied using Remote Sensing and In Situ Methods', *Remote Sensing*, 2010: 497–513.

Adell, G. (1999), *Theories and models of the peri-urban interface: a changing conceptual landscape* (London).

Alberti, M. (2008), *Advances in urban ecology: Integrating humans and ecological processes in urban ecosystems* (New York).

Alberti, M., Botsford, E., and Cohen, A. (2001), 'Quantifying the urban gradient: Linking urban planning and ecology', in J. M. Marzluff, R. Bowman, and R. Donnelly (eds.), *Avian ecology and conservation in an urbanizing world* (Boston), 89–116.

Allen, A. (2004), 'Managing Sustainable Urban Development: A Technical or Political Task?', in K. R. Gupta and P. Maiti (eds.), *Urban development debates in the new millennium. Studies in revisited theories and redefined praxes* (New Delhi), 1–24.

Allen, A. (2006), 'Understanding Environmental Change in the Context of Rural-Urban Interactions', in D. F. M. McGregor, D. Simon, and D. A. Thompson (eds.), *The peri-urban interface. Approaches to sustainable natural and human resource use* (London ; Sterling, VA), 30–43.

Allen, A. (2010), 'Neither Rural nor Urban: Service Delivery Options that Work for the Peri-urban Poor.', in M. Kurian and P. L. McCarney (eds.), *Peri-urban water and sanitation services. Policy, planning and method* (Dordrecht; New York), 27–61.

Allen, A., You, N., Meijer, S., and Atkinson, A. (2002), *Sustainable urbanisation: Bridging the green and brown agendas* (London).

Arku, G. (2009), 'Rapidly Growing African Cities Need to Adopt Smart Growth Policies to Solve Urban Development Concerns', *Urban Forum*, 20/3: 253–270.

Armar-Klemesu, M. (2000), 'Urban Agriculture and Food Security, Nutrition and Health', in N. Bakker, M. Dubbeling, S. Gündel et al. (eds.), *Growing cities, growing food. Urban agriculture on the policy agenda ; a reader on urban agriculture* (Feldafing), 99–117.

Armar-Klemesu, M., and Maxwell, D. (2000), 'Accra: Urban Agriculture as an asset strategy, supplementing income and diets', in N. Bakker, M. Dubbeling, S. Gündel et al. (eds.), *Growing cities, growing food. Urban agriculture on the policy agenda ; a reader on urban agriculture* (Feldafing), 183–208.

Baerwald, T. J. (2010), 'Prospects for Geography as an Interdisciplinary Discipline', *Annals of the Association of American Geographers*, 100/3: 493–501.

Baffes, J. (2003), *Tanzania's Coffee Sector: Constraints and Challenges in a Global Environment*, Africa Region Working Paper Series, No. 56 (Washington, DC).

Bakewell, O., and Jónsson, G. (2011), *Migration, Mobility and the African City*: *Synthesis report on the African Perspectives on Human Mobility research programme* (Oxford).

Bakker, N., Dubbeling, M., Gündel, S., Sabel-Koschella, U., de Zeeuw, H. (2000), *Growing cities, growing food. Urban agriculture on the policy agenda ; a reader on urban agriculture* (Feldafing).

Bayemi, P. H., Webb, E. C., Ndambi, A., Ntam, F., and Chinda, V. (2009), 'Impact of management interventions on smallholder dairy farms of the western highlands of cameroon', *Tropical Animal Health and Production*, 41/6: 907–912.

Bell, D., and Jayne, M. (2009), 'Small Cities? Towards a Research Agenda', *International Journal of Urban and Regional Research*, 33/3: 683–699.

Binns, T., and Lynch, K. (1998), 'Feeding Africa´s growing cities into the 21st century. The potential role of urban agriculture', *Journal of International Development*, 10/6: 777–793.

Blaschke, T. (2010), 'Object based image analysis for remote sensing', *ISPRS Journal of Photogrammetry and Remote Sensing*, 65/1: 2–16.

Breman, H., Groot, J., and van Keulen, H. (2001), 'Resource limitations in Sahelian agriculture', *Global Environmental Change*, 11/1: 59–68.

Bromley, D. W. (2009), 'Formalising property relations in the developing world: The wrong prescription for the wrong malady', *Land Use Policy*, 26/1: 20–27.

Browder, J. O. (2002), 'The urban-rural interface: Urbanization and tropical forest cover change', *Urban Ecosystems*, 6/1/2: 21–41.

Brower, S. (2002), 'The Sectors of the Transect', *Journal of Urban Design*, 7/3: 313–320.

Bryld, E. (2003), 'Potentials, problems, and policy implications for urban agriculture in developing countries', *Agriculture and Human Values*, 20: 79–86.

Bureau Central des Recensements et des Etudes de Population (2010), *Rapport de présentation des résultats définitifs* (Yaoundé).

Byfuglien, J. (1995), 'On the search for an urban definition at the European level', *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography*, 49/1-2: 83–85.

Camagni, R., Gibelli, M. C., and Rigamonti, P. (2002), 'Urban mobility and urban form: the social and environmental costs of different patterns of urban expansion', *Ecological Economics*, 40/2: 199–216.

Carlson, T. N., and Ripley, D. A. (1997), 'On the relation between NDVI, fractional vegetation cover, and leaf area index', *Remote Sensing of Environment*, 62/3: 241–252.

Carsan, S., Osino, D., Opanga, P., and Simons, A. J. (2010), 'Urban Agroforestry Products in Kisumu, Kenya: A Rapid Market Assessment', in G. Prain, D. Lee-Smith, and N. Karanja (eds.), *African Urban Harvest. Agriculture in the Cities of Cameroon, Kenya and Uganda* (New York, NY), 249–63.

CIA (2011), 'The World Factbook'. <www.cia.gov/library/publications/the-world-factbook/>, last access: 5 September 2012.

Cleff, T. (2011), *Deskriptive Statistik und moderne Datenanalyse*: *Eine computergestützte Einführung mit Excel, PASW (SPSS) und STATA* (2nd edn., Wiesbaden).

Cofie, O., van Veenhuizen, R., and Drechsel, P. (2003), *Contribution of urban and peri-urban agriculture to food security in sub-Saharan Africa*: *Paper presented at the Africa session of 3rd WWF, Kyoto, 17th March 2003* (Kyoto).

Cohen, B. (2006), 'Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability', *Technology in Society*, 28/1-2: 63–80.

Coquery-Vidrovitch, C. (1991), 'The Process of Urbanization in Africa. (From the Origins to the Beginning of Independence)', *African Studies Review*, 34/1: 1–98.

Crush, J., Hovorka, A., and Tevera, D. (2011), 'Food security in Southern African cities: The place of urban agriculture', *Progress in Development Studies*, 11/4: 285–305.

David, S., Lee-Smith, D., Kyaligonza, J., Mangeni, W., Kimeze, S., Aliguma, L., Lubowa, A., and Nasinyama, G. W. (2010), 'Changing Trends in Urban Agriculture in Kampala', in G. Prain, D. Lee-Smith, and N. Karanja (eds.), *African Urban Harvest*. *Agriculture in the Cities of Cameroon, Kenya and Uganda* (New York, NY), 97–122.

de Zeeuw, H. (2010), 'Cities farming for the future. Multi-stakeholder policy formulation and action planning on urban agriculture in developing countries', in G. Prosdocimi Gianquinto, A. Chuisoli, and F. Orsini (eds.), *Proceedings of the IInd International Conference on Landscape and Urban Horticulture*. *Bologna, Italy June 9-13, 2009* (Leuven), 97–109.

de Zeeuw, H., Gündel, S., and Waibel, H. (2000), 'The integration of agriculture in urban policies', in N. Bakker, M. Dubbeling, S. Gündel et al. (eds.), *Growing cities, growing food*. *Urban agriculture on the policy agenda ; a reader on urban agriculture* (Feldafing), 161–182.

de Zeeuw, H., van Veenhuizen, R., and Dubbeling, M. (2011), 'The role of urban agriculture in building resilient cities in developing countries', *The Journal of Agricultural Science*, 149/S1: 153–163.

Deelstra, T., and Girardet, H. (2000), 'Urban Agriculture and Sustainable Cities', in N. Bakker, M. Dubbeling, S. Gündel et al. (eds.), *Growing cities, growing food*. *Urban agriculture on the policy agenda ; a reader on urban agriculture* (Feldafing), 43–65.

Definiens (2010), *eCognition Developer 8.0.1 – User Guide* (Munich).

DFID (2004), *Agricultural Sustainability,* Working paper series, No. 12 (London).

Dial, G., Bowen, H., Gerlach, F., Grodecki, J., and Oleszczuk, R. (2003), 'IKONOS satellite, imagery, and products', *Remote Sensing of Environment*, 88/1-2: 23–36.

Dinar, A., Hassan, R., Mendelsohn, R., and Benhin, J. (2008), *Climate change and agriculture in Africa*: *Impact assessment and adaptation strategies* (London; Sterling, VA).

Donge, L. (2006), *Evaluation Report of Sustainable Moshi Programme*: *Prepared for the Sustainable Moshi Programme* (Moshi).

Donge, L., Towo, E., Kimambo, E., and Tiruhungwa, R. (2008), *Environmental Profile of Moshi Municipality* (Moshi).

Dongus, S. (2009), 'Urban agriculture and operational mosquito larvae control. Mitigating malaria risk in Dar es Salaam, Tanzania', Doctoral dissertation (Basel, Universität Basel).

Dossa, L. H., Buerkert, A., and Schlecht, E. (2011), ‘Cross-Location Analysis of the Impact of Household Socioeconomic Status on Participation in Urban and Peri-Urban Agriculture in West Africa’, *Human Ecology*, 39/5: 569–581.

Drechsel, P., and Dongus, S. (2010), ‘Dynamics and sustainability of urban agriculture. Examples from sub-Saharan Africa’, *Sustainability Science,* 5/1: 69–78.

Drechsel, P., and Kunze, D. (2001), *Waste composting for urban and peri-urban agriculture*: *Closing the rural-urban nutrient cycle in sub-Saharan Africa* (Wallingford, Oxon, UK; New York, NY).

Drescher, A. W. (1998), *Hausgärten in afrikanischen Räumen*: *Bewirtschaftung nachhaltiger Produktionssysteme und Strategien der Ernährungssicherung in Zambia und Zimbabwe* (Pfaffenweiler).

Drescher, A. W. (2001), *Urban and peri-urban agriculture*: *A briefing guide for the successful implementation of Urban and Peri-urban Agriculture in Developing Countries and Countries of Transition,* FAO Handbook Series, III (Rome).

Drescher, A. W. (2003), ‘Urban Agriculture and Land Use Planning. The integration of Urban Agriculture into urban planning – An analysis of the current status and constraints’, in ETC Netherlands (ed.), *Annotated Bibliography on Urban and Periurban Agriculture* (Leusden), 555–616.

Drescher, A. W., and Gerold, J. (2010), ‘Urbane Ernährungssicherung. Kreative landwirtschaftliche Nutzung städtischer Räume’, *Geographische Rundschau,* 62/12: 28–33.

Drescher, A. W., and Iaquinta, D. L. (2002), *Urbanization - Linking Development Across the Changing Landscape* (Rome).

Drescher, A. W., Jacobi, P., and Amend, J. (2000), ‘Urban Agriculture, a response to crisis?’, *Urban Agriculture Magazine*, 1/1: 8–10.

Duany, A. (2002), ‘Introduction to the Special Issue: The Transect’, *Journal of Urban Design*, 7/3: 251–260.

Dubbeling, M. (2004), *Optimizing use of vacant space for urban agriculture through participatory planning processes.*: *Paper presented at Workshop on IDRC-Supported Initiatives on Urban Agriculture and Food Security, Ryerson University, Toronto* (Toronto).

Eberhart, A. E. (2012), *The Edible Skyline: Crisis, Social Dislocation, and the Political Invisibility of Urban Agricultural Policy in Africa’s Growing Cities* (Princeton).

Eiden, G., Kayadjanian, M., and Vidal, C. (2000), ‘Capturing landscape structures: tools’, in European Commission (ed.), *From land cover to landscape diversity in the European Union* (Brussels), 7–15.

Ellis, F., and Sumberg, J. (1998), ‘Food Production, Urban Areas and Policy Responses’, *World Development*, 26/2: 213–225.

ERDAS (2010), *ERDAS Field Guide*™ (Norcross).

ESRI (2012a), ‘ArcGIS Desktop Help 10.0’. <help.arcgis.com/en/arcgisdesktop/10.0/help/>, last access: 8 October 2012.

ESRI (2012b), ‘Geodatabase. Overview’. <www.esri.com/software/arcgis/geodatabase>, last access: 19 September 2012.

Ewing, R. H. (2008), 'Characteristics, Causes, and Effects of Sprawl. A Literature Review', in J. M. Marzluff, E. Shulenberger, W. Endlicher et al. (eds.), *Urban ecology. An International Perspective on the Interaction Between Humans and Nature* (New York), 519–65.

FAO (1996), *Rome Declaration on World Food Security and the World Food Summit Plan of Action* (Rome).

FAO (2002), *Urban food security*: *World Food Summit - five years later* (Rome).

FAO (2003), *Groundwater Management*: *The search for practical approaches,* FAO Water Reports, No. 25 (Rome).

FAO (2004), *Building on gender, agrobiodiversity and local knowledge*: *A training manual* (Rome).

FAO (2005), *Mapping global urban and rural population distributions,* Environment and Natural Resources Working Paper, No. 24 (Rome).

FAO (2008), *Urban Agriculture For Sustainable Poverty Alleviation and Food Security* (Rome).

FAO (2012a), *Food, Agriculture and Cities*: *Challenges of food and nutrition security, agriculture and ecosystem management in an urbanizing world* (Rome).

FAO (2012b), *High and volatile food prices*: *FAO support to country level contingency planning* (Rome).

FAO (2013), *FAO Food Price Index* (Rome). <www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/>, last access: 12 January 2013.

Fekade, W. (2000), 'Deficits of formal urban land management and informal responses under rapid urban growth, an international perspective', *Habitat International*, 24/2: 127–150.

Fernandes, E., Oktingati, A., and Maghembe, J. (1984), 'The Chagga homegardens: a multistoried agroforestry cropping system on Mt. Kilimanjaro (Northern Tanzania)', *Agroforestry Systems*, 2/2: 73–86.

Foeken, D. (2005), *Urban agriculture in East Africa as a tool for poverty reduction*: *A legal and policy dilemma?,* ASC Working Paper, No. 65 (Leiden).

Foeken, D., Sofer, M., and Mlozi, M. (2004), *Urban agriculture in Tanzania*: *Issues of sustainability* (Research Report, Leiden).

Fongjong, L. N. (2008), 'Issues of Rural Development in North-western Cameroon', in A. V. Burlingham and W. N. Townsand (eds.), *Rural Development Issues* (New York), 193–214.

Forkuor, G., and Cofie, O. (2011), 'Dynamics of land-use and land-cover change in Freetown, Sierra Leone and its effects on urban and peri-urban agriculture – a remote sensing approach', *International Journal of Remote Sensing*, 32/4: 1017–1037.

Forster, D. (2009), 'Agricultural land use and associated nutrient flows in peri-urban production systems', Doctoral dissertation (Rostock, Universität Rostock).

Foster, V., and Briceño-Garmendia, C. (2010), *Africa's infrastructure*: *A time for transformation* (Washington, DC).

Fouberg, E. H., Murphy, A. B., and Blij, H. J. de (1977), *Human geography*: *People, place, and culture* (1st edn., Hoboken, N.J).

Fratkin, E. (2001), ‘East African Pastoralism in Transition: Maasai, Boran, and Rendille Cases’, *African Studies Review*, 44/3: 1–25.

Freire, S., Santos, T., Navarro, A., Soares, F., Dinis, J., Afonso, N., Fonseca, A., and Tenedório, J. (2010), ‘Extraction of buildings from Quickbird imagery for municipal planning purposes. Qualitiy assessment considering existing mapping standards’, in International Society for Photogrammetry and Remote Sensing (ISPRS) (ed.), *GEOBIA 2010-Geographic Object-Based Image Analysis. Ghent University, Ghent, Belgium, 29 June – 2 July* (Ghent).

Gatrell, A. C., Bailey, T. C., Diggle, P. J., and Rowlingson, B. S. (1996), ‘Spatial point pattern analysis and its implication in geographical epidemiology’, *Transactions of the Institute of British Geographers*, 21/1: 256–274.

Gerstl, S. (2001), ‘The Economic Costs and Impact of Home Gardening in Ouagadougou, Burkina Faso’, Doctoral dissertation (Basel, Universität Basel).

Given, L. M. (2008), *The Sage encyclopedia of qualitative research methods* (Los Angeles, CA).

Gockowski, J., Mbazo’o, J., Mbah, G., and Fouda Moulende, T. (2003), ‘African traditional leafy vegetables and the urban and peri-urban poor’, *Food Policy*, 28/3: 221–235.

Goddard, M. A., Dougill, A. J., and Benton, T. G. (2010), ‘Scaling up from gardens: biodiversity conservation in urban environments’, *Trends in Ecology & Evolution*, 25/2: 90–98.

Graefe, S., Schlecht, E., and Buerkert, A. (2008), ‘Opportunities and challenges of urban and peri-urban agriculture in Niamey, Niger’, *Outlook on Agriculture*, 37/1: 47–56.

Gregory, P. (2005), *A Symthesis of peri-urban research of Kumasi, Hubli-Dharwad and Kolkata peri-urban interfaces*: *Final Report of NRSP Project R8491* (Tregaron).

Grimm, N. B., Foster, D., Groffman, P., Grove, J. M., Hopkinson, C. S., Nadelhoffer, K. J., Pataki, D. E., and Peters, D. P. C. (2008), ‘The changing landscape: ecosystem responses to urbanization and pollution across climatic and societal gradients’, *Frontiers in Ecology and the Environment*, 6/5: 264–272.

Gugler, J. (1996), ‘Regional Trajectories in the Urban Transformation: Convergences and Divergences’, in J. Gugler (ed.), *The Urban transformation of the developing world* (New York), 1–17.

Gwebu, T. D. (2012), ‘Botswana's mining path to urbanisation and poverty alleviation’, *Journal of Contemporary African Studies*, 30/4: 611–630.

Hallam, D. (2011), ‘International investment in developing country agriculture—issues and challenges’, *Food Security*, 3/S1: 91–98.

Harris, C. D., and Ullman, E. L. (1945), ‘The Nature of Cities’, *Annals of the American Academy of Political and Social Science*, 242/Nov.: 7–17.

Hart, C. (1998), *Doing a literature review*: *Releasing the social science research imagination* (London).

Hemp, C., and Hemp, A. (2008), ‘The Chagga Homegardens on Kilimanjaro’, *IHDP Update*, 2008: 12–17.

Hope, K. R. (1998), ‘Urbanization and Urban Growth in Africa’, *Journal of Asian and African Studies*, 33/4: 345–358.

Hovorka, A. (1998), *Gender Resources for Urban Agriculture Research: Methodology, Directory & Annotated Bibliography*, Cities Feeding People Series, Report 26 (Ottawa).

Hovorka, A., de Zeeuw, H., and Njenga, M. (2009) (eds.), *Women feeding cities*: *Mainstreaming gender in urban agriculture and food security* (Bourton).

Howard, N. K. (2005), *Multiscale analysis of landscape data sets from northern Ghana*: *Wavelets and pattern metrics* (1st edn., Göttingen).

Hoyt, H. (1939), *The structure and growth of residential neighborhoods in American cities* (Washington, DC).

Ifatimehin, O. O., and Musa, S. D. (2008), *Application of geoinformatic technology in evaluating urban agriculture and urban poverty in Lokoja* (Anyigba).

IFPRI (2007), *The world's most deprived*: *Characteristics and causes of extreme poverty and hunger*, A. U. Ahmed, R. Vargas Hill, L. C. Smith et al. (Washington, DC).

IFPRI, and EDRI (2009), *Urbanization and Spatial Connectivity in Ethiopia*, Summary of ESSP-II Discussion Paper No. 3: "Urbanization and Spatial Connectivity in Ethiopia: Urban Growth Analysis using GIS" (December, 2009), Ethiopia Strategy Support Program II (ESSP - II) Research Notes, No. 5 (Washington, DC).

IFPRI, and ILCA (1989), *1989 IFPRI Survey Data Documentation. Household Questionnaire*: *IFPRI/ILCA Survey on Drought and Food Shortages in Ethiopia* (unknown).

Israel, G. D. (1992), *Determining Sample Size* (Gainesville).

Kamga Fogue, A. (2011), *Impact de l'urbanisation sur le livelihood*: *Impact de l'urbanisation sur les systèmes de production des cultures maraichères le long du continuum rural-urbain de Bamenda, nord-ouest Cameroun* (Saarbrücken).

Kasarda, J. D., and Crenshaw, E. M. (1991), 'Third World Urbanization. Dimensions, Theories, and Determinants', *Annual Review of Sociology*, 17: 467–501.

Kearney, J. (2010), 'Food consumption trends and drivers', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365/1554: 2793–2807.

Kemausuor, F., Obeng, G. Y., Brew-Hammond, A., and Duker, A. (2011), 'A review of trends, policies and plans for increasing energy access in Ghana', *Renewable and Sustainable Energy Reviews*, 15/9: 5143–5154.

Kemeling, I., de Jong, S. M., van Teeffelen, P. B. M., van den Berg, L. M., and Roerink, G. J. (2002), 'Remote sensing and GIS for good governance. Analysis of high spatial resolution IKONOS imagery for surveying agricultural activities in the city of Ouagadougou, Burkina Faso', in ICT/University of Wageningen (ed.), *Proceedings of the 6th Seminar on GIS for Developing Countries, Enschede, 15-18 May 2002*, 18.1-18.8.

Kessides, C. (2005), *The Urban Transition in Sub-Saharan Africa: Implications for Economic Growth and Poverty Reduction*, Africa Region Working Paper Series, No. 97 (Washington, DC).

Ki-moon, B. (2012), 'Our struggle for global sustainability will be won or lost in cities. Speech to the High-level Delegation of Mayors and Regional Authorities meeting in New York, US, on 23 April 2012'.

Kloog, I., Haim, A., and Portnov, B. A. (2009), 'Using kernel density function as an urban analysis tool: Investigating the association between nightlight exposure and the incidence of breast cancer in Haifa, Israel', *Computers, Environment and Urban Systems*, 33/1: 55–63.

Knox, P. L., and Pinch, S. (2007), *Urban social geography*: *An introduction* (5. ed., Harlow).

Kometa, S. S., and Akoh, N. R. (2012), 'The Hydro-geomorphological Implications of Urbanisation in Bamenda, Cameroon', *Journal of Sustainable Development*, 5/6: 64–73.

Lado, C. (1990), 'Informal urban agriculture in Nairobi, Kenya', *Land Use Policy*, 7/3: 257–266.

Lamb, D., Schneider, D., Trotter, M., Schaefer, M., and Yule, I. (2011), 'Extended-altitude, aerial mapping of crop NDVI using an active optical sensor: A case study using a Raptor™ sensor over wheat', *Computers and Electronics in Agriculture*, 77/1: 69–73.

Lausch, A. (2002), 'Applicability of landscape metrics for the monitoring of landscape change: issues of scale, resolution and interpretability', *Ecological Indicators*, 2/1-2: 3–15.

Laux, P., Jäckel, G., Tingem, R. M., and Kunstmann, H. (2010), 'Impact of climate change on agricultural productivity under rainfed conditions in Cameroon—A method to improve attainable crop yields by planting date adaptations', *Agricultural and Forest Meteorology*, 150/9: 1258–1271.

Lerner, A. M., and Eakin, H. (2011), 'An obsolete dichotomy? Rethinking the rural-urban interface in terms of food security and production in the global south', *Geographical Journal*, 2011: 1–10.

Levy, Y., and Ellis, T. J. (2006), 'Towards a Framework of Literature Review Process in Support of Information Systems Research', in C. Roberts and J. Whatley (eds.), *Proceedings of the 2006 Informing Science and IT Education Joint Conference* (Salford), 171–81.

Lin, Y.-P., Chang, C.-R., Chu, H.-J., and Cheng, B.-Y. (2011), 'Identifying the spatial mixture distribution of bird diversity across urban and suburban areas in the metropolis: A case study in Taipei Basin of Taiwan', *Landscape and Urban Planning*, 102/3: 156–163.

Loewenstein, N. J., and Loewenstein, E. F. (2005), 'Non-native plants in the understory of riparian forests across a land use gradient in the Southeast', *Urban Ecosystems*, 8/1: 79–91.

Lowder, S. (1986), *The geography of Third World cities* (Totowa, NJ).

Luck, G. W., and Smallbone, L. T. (2010), 'Species diversity and urbanisation: patterns, drivers and implications', in K. J. Gaston (ed.), *Urban ecology* (Cambridge; New York), 88–119.

Luck, M., and Wu, J. (2002), 'A gradient analysis of urban landscape pattern: a case study from the Phoenix metropolitan region, Arizona, USA', *Landscape Ecology*, 17: 327–339.

Lynch, K., Binns, T., and Olofin, E. (2001), 'Urban agriculture under threat', *Cities*, 18/3: 159–171.

Lynch, K., Maconachie, R., Binns, T., Tengbe, P., and Bangura, K. (2012 (in press)), 'Meeting the urban challenge? Urban agriculture and food security in post-conflict Freetown, Sierra Leone', *Applied Geography*, 2012 (in press).

Maeyer, M. de, Sotiaux, A., and Wolff, E. (2010), *Comparison of standardized methods (object-oriented vs. per pixel) to extract the urban built-up area*: *Example of Lubumbashi (DRC)* (Ghent).

Mandere, Nicodemus Mandere, Ness, B., and Anderberg, S. (2010), 'Peri-urban development, livelihood change and household income: A case study of peri-urban Nyahururu, Kenya', *Journal of Agricultural Extension and Rural Development*, 2/5: 73–83.

Mander, Ü., Müller, F., and Wrbka, T. (2005), 'Functional and structural landscape indicators: Upscaling and downscaling problems', *Ecological Indicators*, 5/4: 267–272.

Manshard, W. (1977), *Die Städte des tropischen Afrika* (Berlin; Stuttgart).

Martine, G. (2008) (ed.), *The new global frontier*: *Urbanization, poverty and environment in the 21st century* (London; Sterling, VA).

Mathieu, R., Aryal, J., and Chong, A. K. (2007), 'Object-Based Classification of Ikonos Imagery for Mapping Large-Scale Vegetation Communities in Urban Areas', *Sensors*, 7/11: 2860–2880.

Matuschke, I. (2009), *Rapid urbanization and food security*: *Using food density maps to identify future food security hotspots* (Beijing).

Maxwell, D. (1995), 'Alternative food security strategy: A household analysis of urban agriculture in Kampala', *World Development*, 23/10: 1669–1681.

Maxwell, D. (1999), 'The Political Economy of Urban Food Security in Sub-Saharan Africa', *World Development*, 27/11: 1939–1953.

Maxwell, D., and Armar-Klemesu, M. (1998), *Urban agriculture: introduction and review of literature* (Accra).

Maxwell, D., Levin, C., Armar-Klemesu, M., Ruel, M., Morris, S., and Ahiadeke, C. (2000), *Urban livelihoods and food and nutrition security in Greater Accra, Ghana* (Washington, DC).

Maxwell, D., and Wiebe, K. (1999), 'Land Tenure and Food Security: Exploring Dynamic Linkages', *Development & Change*, 30/4: 825–849.

Mayhew, S. (2004), *A dictionary of geography* (Electronic edition, Oxford; New York). <www.oxfordreference.com/view/10.1093/acref/9780199231805.001.0001/acref-9780199231805>, last access: 03 July 2012.

Mazengo, M. C., Simell, O., Lukmanji, Z., Shirima, R., and Karetti, R. L. (1997), 'Food consumption in rural and urban Tanzania', *Acta Tropica*, 68/3: 313–326.

McDonnell, M. J., and Pickett, S. T. (1990), 'Ecosystem Structure and Function along Urban-Rural Gradients: An Unexploited Opportunity for Ecology', *Ecology*, 71/4: 1232–1237.

McDonnell, M. J., Pickett, S. T., Groffman, P., Bohlen, P., Pouyat, R. v., Zipperer, W. C., Parmelee, R. W., Carreiro, M. M., and Medley, K. (1997), 'Ecosystem processes along an urban-to-rural gradient', *Urban Ecosystems*, 1/1: 21–36.

McGarigal, K. (2008), *Landscape Metrics for Categorical Map Patterns* (Amherst, MA).

McGarigal, K., and Marks, B. J. (1995), *FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure* (Portland, OR).

McGregor, D. F. M., Simon, D., and Thompson, D. A. (2006) (eds.), *The peri-urban interface*: *Approaches to sustainable natural and human resource use* (London ; Sterling, VA).

McIntyre, N. E., Knowles-Yánez, K., and Hope, D. (2008), 'Urban Ecology as an Interdisciplinary Field: Differences in the use of "Urban" Between the Social and Natural Sciences', in J. M. Marzluff, E. Shulenberger, W. Endlicher et al. (eds.), *Urban Ecology* (Boston, MA), 49–65.

McKinney, M. L. (2002), 'Urbanization, Biodiversity, and Conservation', *BioScience*, 52/10: 883.

McKinney, M. L. (2008), 'Effects of urbanization on species richness: A review of plants and animals', *Urban Ecosystems*, 11/2: 161–176.

Ministry of Lands and Human Settlements Development (1998), *Moshi Master Plan 1995 - 2015* (Dar es Salaam).

Mizock, L., Harkins, D. A., and Morant, R. (2011), *Researcher race*: *Social constructions in the research process* (Charlotte).

Molua, E. L. (2006), 'Climatic trends in Cameroon: implications for agricultural management', *Climate Research*, 30: 255–262.

Montgomery, M. R. (2007), *Cities Transformed*: *Demographic Change and Its Implications in the Developing World,* 2007 (Stony Brook, NY).

Montgomery, M. R. (2008), 'The Urban Transformation of the Developing World', *Science*, 319/5864: 761–764.

Moshi Municipal Council (2010), *District Agricultural Development Plans 2010/2011* (Moshi).

Mougeot, L. J. A. (1994a), 'African City Farming from a World Perspective', in A. G. Egziabher, D. Lee-Smith, D. Maxwell et al. (eds.), *Cities feeding people*. *An examination of urban agriculture in east Africa* (Ottawa), 1–22.

Mougeot, L. J. A. (1994b), *Urban Food Production: Evolution, Official Support and Significance,* Cities Feeding People Series, Report 8 (Ottawa).

Mougeot, L. J. A. (1996), 'Introduction: An improving domestic and international environment for African urban agriculture', *African Urban Quarterly,* 11/2-3: 137–152.

Mougeot, L. J. A. (2000), 'Urban Agriculture: Definition, Presence, Potentials and Risks', in N. Bakker, M. Dubbeling, S. Gündel et al. (eds.), *Growing cities, growing food*. *Urban agriculture on the policy agenda ; a reader on urban agriculture* (Feldafing), 1–42.

Mougeot, L. J. A. (2005), *Agropolis*: *The social, political, and environmental dimensions of urban agriculture* (London; Sterling, VA).

Mougeot, L. J. A. (2006), *Growing better cities*: *Urban agriculture for sustainable development* (Ottawa).

Mousavi, S. R., and Eskandari, H. (2011), 'A General Overview on Intercropping and Its Advantages in Sustainable Agriculture', *Journal of Applied Environmental and Biological Sciences*, 1/11: 482–486.

Moustier, P. (1999), ‘Complémentarité entre agriculture urbaine et agriculture rurale’, in O. B. Smith (ed.), *Agriculture urbaine en Afrique de l'ouest*. *Une contribution á la sécurité alimentaire et á l'assainissement desvilles* (Ottawa), 41–55.

Moustier, P., and Danso, G. (2006), ‘Local Economic Development and Marketing of Urban Produced Food’, in R. van Veenhuizen (ed.), *Cities farming for the future*. *Urban agriculture for green and productive cities* (Ottawa, Silang, Philippines), 174–195.

Mubvami, T., and Mushamba, S. (2006), ‘Integration of Agriculture in Urban Land Use Planning and Adaptation of City Regulations. Case Studies: Abidjan, Beijing, Valadares’, in R. van Veenhuizen (ed.), *Cities farming for the future*. *Urban agriculture for green and productive cities* (Ottawa, Silang, Philippines), 53–86.

Muzzini, E., and Lindeboom, W. (2008), *The Urban Transition in Tanzania*: *Building the Empirical Base for Policy Dialogue* (Washington, DC).

Myint, S. W., Gober, P., Brazel, A., Grossman-Clarke, S., and Weng, Q. (2011), ‘Per-pixel vs. object-based classification of urban land cover extraction using high spatial resolution imagery’, *Remote Sensing of Environment*, 115/5: 1145–1161.

National Bureau of Statistics (2011), *Tanzania in figures 2010* (Dar es Salaam).

National Bureau of Statistics, and Kilimanjaro Regional Commissioner's Office (1998), *Kilimanjaro Region*: *Socio-Economic Profile* (Dar es Salaam).

National Bureau of Statistics, and Ministry of Finance and Economic Affairs (2010), *Statistical Abstract 2009* (Dar es Salaam).

Ndenecho, E. N., and Akum, K. H. (2009), ‘Spatio-temporal analysis of micro financing for agricultural innovation diffusion in Mezam division, Cameroon’, *International NGO Journal*, 4/3: 57–65.

Ngowi, H. P. (2005), ‘Private Sector Delivery of Urban Services: Benefits, Obstacles and Ways Forward for Public Transport Service in Dar Es Salaam City, Tanzania’, *Eastern Africa Social Science Research Review*, 21/1: 97–117.

Niñez, V. (1985), ‘Introduction: Household gardens and small-scale food production’, *Food and Nutrition Bulletin*, 7/3: 1–5.

Njoh, A. (2003), ‘Urbanization and development in sub-Saharan Africa’, *Cities*, 20/3: 167–174.

Nkwi, W. G. (2011), *Sons and daughters of the soil*: *Land and boundary conflicts in North West Cameroon, 1955-2005* (Bamenda, Cameroon).

Nowak, B., and Schulz, B. (2009), *Taschenlexikon tropischer Nutzpflanzen und ihrer Früchte* (Wiebelsheim).

Nsiah-Gyaabah, K. (2004), ‘Urbanization Processes - Environmental and Health effects in Africa. Panel Contribution to the PERN Cyberseminar on Urban Spatial Expansion’. <www.populationenvironmentresearch.org/papers/Nsiah-Gyaabah_contribution.pdf>, last access: 10 October 2012.

Nugent, R. (2000a), ‘The impact of urban agriculture on the household and local economies’, in N. Bakker, M. Dubbeling, S. Gündel et al. (eds.), *Growing cities, growing food*. *Urban agriculture on the policy agenda ; a reader on urban agriculture* (Feldafing), 67–98.

Nugent, R. (2000b), ‘Urban and Periurban Agriculture, Household Food Security and Nutrition. Discussion paper for FAO-ETC/RUAF electronic conference "Urban and Periurban Agriculture on the Policy Agenda"; August 21 - September 30, 2000’. <www.fao.org/urbanag/Paper1-e.htm>, last access: 3 August 2012.

Nyambod, E. M. (2010a), ‘Environmental Consequences of Rapid Urbanisation: Bamenda City, Cameroon’, *Journal of Environmental Protection*, 01/01: 15–23.

Nyambod, E. M. (2010b), ‘Geographic Information Systems as a Tool for Participatory Land Administration. Matrix: Bamenda City, North West Region of Cameroon’, Master Thesis (Brussels, Vrije Universiteit Brussel).

O’Brien, G., O’Keefe, P., Meena, H., Rose, J., and Wilson, L. (2008), ‘Climate adaptation from a poverty perspective’, *Climate Policy*, 8/2: 194–201.

Okafor, F. C. (1986), ‘Land use dynamics and planning problems in a rurban fringe environment’, *Land Use Policy*, 3/3: 221–229.

Olayiwola, A. M., Eludoyin, A. O., and Ekecha, A. E. (2011), ‘Land Use Change in the Mezam Division of the North-West Province, Cameroon From Landsat Imageries (1988 And 2001)’, *Ethiopian Journal of Environmental Studies and Management*, 4/1: 49–55.

Oluoch, M. O., Pichop, G. N., Silué, D., Abukutsa-Onyango, M. O., Diouf, M., and Shackleton, C. M. (2009), ‘Production and Harvesting Systems for African Indigenous Vegetables’, in C. Shackleton, M. Pasquini, and A. W. Drescher (eds.), *African indigenous vegetables in urban agriculture* (London; Sterling, VA), 145–76.

Oppenheim, A. N. (1992), *Questionnaire design, interviewing, and attitude measurement* (New ed., London; New York, NY).

Panel on Urban Population Dynamics, Montgomery, M. R., Stren, R., Cohen, B., and Reed, H. E. (2003), *Cities transformed*: *Demographic change and its implications in the developing world* (Washington, DC).

Park, R., Burgess, E. W., and McKenzie, R. D. (1925), *The City* (Chicago).

Pasquini, M., Assogba-Komlan, F., Vorster, I., Shackleton, C., and Abukutsa-Onyango, M. (2009), ‘The Production of African Indigeneous Vegetables in Urban and Peri-Urban Agricultre: A Comparative Analysis of Case Studies from Benin, Kenya and South Africa’, in C. Shackleton, M. Pasquini, and A. W. Drescher (eds.), *African indigenous vegetables in urban agriculture* (London; Sterling, VA), 177–223.

Payne, G., Durand-Lasserve, A., and Rakodi, C. (2008), *Social and economic impacts of land titling programmes in urban and peri-urban areas*: *International experience and case studies of Senegal and South Africa*, Final Report submitted to Ministry of Foreign Affairs, Government of Norway; Swedish International Development Agency (SIDA); Global Land Tools Network, UN-Habitat, C. Marx, M. Rubin, and S. Ndiaye.

Petković, J. (2007), ‘Traditional Values and Modernization Challenges in Forming Urban and Rural Culture’, *FACTA UNIVERSITATIS - Series Philosophy, Sociology, Psychology and History*, 6/1: 23–39.

Place, F., and Hazell, P. (1993), ‘Productivity Effects of Indigenous Land Tenure Systems in Sub-Saharan Africa’, *American Journal of Agricultural Economics*, 75/1: 10–19.

Porter, E. E., Forschner, B. R., and Blair, R. B. (2001), ‘Woody vegetation and canopy fragmentation along a forest-to-urban gradient’, *Urban Ecosystems*, 5/2: 131–151.

Porter, G., Lyon, F., and Potts, D. (2007), 'Market institutions and urban food supply in West and Southern Africa: a review', *Progress in Development Studies*, 7/2: 115–134.

Potter, R. B., and Lloyd-Evans, S. (1998), *The city in the developing world* (Harlow, Essex, United Kingdom).

Potts, D. (2012), *Whatever happened to Africa´s rapid urbanisation?,* Counterpoints (London).

Pouliot, M., and Treue, T. (2012 (in press)), 'Rural People's Reliance on Forests and the Non-forest Environment in West Africa: Evidence from Ghana and Burkina Faso', *World Development*, 2012 (in press).

Qian, J., Zhou, Q., and Hou, Q. (2007), 'Comparison of pixel-based and object-oriented classification methods for extracting built-up areas in aridzone', in International Society for Photogrammetry and Remote Sensing (ISPRS) (ed.), *Proceedings of the ISPRS Workshop on Updating Geo-spatial Databases with Imagery & The 5th ISPRS Workshop on Dynamic and Multi-dimensional GIS*, 163–171.

Rakodi, C. (1999), *Poverty and Wellbeing in the Peri-Urban Interface of Developing Country Cities: A Review*, DFID NRSP Programme Development Report PD070 (Hemel Hempstead).

Rakodi, C., McCallum, D., and Nunan, F. (2002), *Sustainable urbanisation*: *Achieving agenda 21* (Nairobi).

République du Cameroun (2010), *La population du Cameroun en 2010*: *3e RGPH* (Yaoundé).

Rhodes, P. J. (1994), 'Race-of-Interviewer Effects: A Brief Comment', *sociology*, 28/2: 547–558.

Rowhani, P., Lobell, D. B., Linderman, M., and Ramankutty, N. (2011), 'Climate variability and crop production in Tanzania', *Agricultural and Forest Meteorology*, 151/4: 449–460.

RUAF Foundation (2008), 'Environmental benefits'. <www.ruaf.org/node/1716>, last access: 18 July 2012.

Rygaard, M., Binning, P. J., and Albrechtsen, H.-J. (2011), 'Increasing urban water self-sufficiency: New era, new challenges', *Journal of Environmental Management*, 92/1: 185–194.

Sadiki, P., and Ramutsindela, M. (2002), 'Peri-urban transformation in South Africa: Experiences from Limpopo Province', *GeoJournal*, 57: 75–81.

Satterthwaite, D. (2007), *The transition to a predominantly urban world and its underpinnings,* Human Settlements Discussion Paper Series, No. 4 (London).

Satterthwaite, D., McGranahan, G., and Tacoli, C. (2010), 'Urbanization and its implications for food and farming', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365/1554: 2809–2820.

Schellnhuber, H.-J. (1998), 'Part 1: earth system analysis - the concept', in H.-J. Schellnhuber and V. Wenzel (eds.), *Earth system analysis*. *Integrating science for sustainability : complemented results of a symposium organized by the Potsdam Institute (PIK)* (Berlin; New York, NY), 3–195.

Shackleton, S. E., Shackleton, C. M., Netshiluvhi, T. R., Geach, B. S., Ballance, A., and Fairbanks, D. H. K. (2002), 'Use Patterns and Value of Savanna Resources in Three Rural Villages in South Africa', *Economic Botany*, 56/2: 130–146.

Shah, T., Burke, J., and Villholth, K. (2007), 'Groundwater: a global assessment of scale and significance', in D. Molden (ed.), *Water for food, water for life. A comprehensive assessment of water management in agriculture : summary* (London; Sterling, VA), 395–423.

Shannon, C. E., and Weaver, W. (1949), *The mathematical theory of communication* (Urbana).

Simon, D. (1989), 'Colonial cities, postcolonial Africa and the world economy: a reinterpretation', *International Journal of Urban and Regional Research*, 13/1: 68–91.

Simon, D. (2004), 'The changing urban-rural interface of African cities: definitional issues and an application to Kumasi, Ghana', *Environment and Urbanization*, 16/2: 235–248.

Simon, D. (2008), 'Urban Environments: Issues on the Peri-Urban Fringe', *Annual Review of Environment and Resources*, 33/1: 167–185.

Simon, D., McGregor, D. F. M., and Thompson, D. A. (2006), 'Contemporary Perspectives on the Peri-Urban Zones of Cities in Developing Areas', in D. F. M. McGregor, D. Simon, and D. A. Thompson (eds.), *The peri-urban interface. Approaches to sustainable natural and human resource use* (London ; Sterling, VA), 3–17.

Siniscalco, M. T., and Auriat, N. (2005), *Questionnaire Design*, Quantitative research methods in educational planning, No. 8 (Paris).

Smale, M., Byerlee, D., and Jayne, T. (2011), *Maize Revolutions in Sub-Saharan Africa,* World Bank Policy Research Working Paper, No. 5659 (Washington, DC).

Smit, J., and Nasr, J. (1992), 'Urban agriculture for sustainable cities: using wastes and idle land and water bodies as resources', *Environment and Urbanization*, 4/2: 141–152.

Smit, J., Nasr, J., and Ratta, A. (2001), *Urban Agriculture*: *Food, Jobs and Sustainable Cities*, 2001 Edition (New York).

Soini, E. (2002a), *Changing landscapes on the southern slopes of Mt. Kilimanjaro, Tanzania.*: *An aerial photo interpretation from 1961 to 2000.*, ICRAF Natural resource problems, priorities and policies Working Paper Series, No. 1 (Nairobi).

Soini, E. (2002b), *Livelihoods on the southern slopes of Mt. Kilimanjaro, Tanzania*: *Challenges and opportunities in the Chagga homegarden system,* ICRAF Natural resource problems, priorities and policies Working Paper Series, No. 3 (Nairobi).

Sumberg, J. (1997), 'Policy, milk and the Dar es Salaam peri-urban zone: a new future for an old development theme?', *Land Use Policy*, 14/4: 277–293.

Tacoli, C. (1998), 'Rural-urban interactions: a guide to the literature', *Environment and Urbanization*, 10/1: 147–166.

Tacoli, C., and Satterthwaite, D. (2003), *The urban part of rural development*: *The role of small and intermediate urban centres in rural and regional development and poverty reduction* (London).

Tannerfeldt, G., and Ljung, P. (2006), *More urban, less poor*: *An introduction to urban development and management* (London; Sterling, VA).

Tettey, C. (2005), 'Urbanization in Africa in relation to socio-economic development. A multifaceted quantitative analysis', Doctoral dissertation (Akron, The University of Akron).

Thébaud, B., and Batterbury, S. (2001), 'Sahel pastoralists: opportunism, struggle, conflict and negotiation. A case study from eastern Niger', *Global Environmental Change*, 11/1: 69–78.

Tilly, C. (1964), *The Vendée* (Cambridge, MA).

Tindall, H. D. (1987), *Vegetables in the tropics* (Macmillian international college edition; Reprinted., Houndmills).

Tinker, I. (1994), 'Urban Agriculture is Already Feeding Cities', in A. G. Egziabher, D. Lee-Smith, D. Maxwell et al. (eds.), *Cities feeding people*. *An examination of urban agriculture in east Africa* (Ottawa), vii–xi.

Tipple, A. G. (1994), 'The Need for New Urban Housing in Sub-Saharan Africa: Problem or Opportunity', *African Affairs*, 93/373: 587–608.

Todaro, M. P., and Smith, S. C. (2011), *Economic development* (Eleventh edition., Harlow).

Toulmin, C. (2009), 'Securing land and property rights in sub-Saharan Africa: The role of local institutions', *Land Use Policy*, 26/1: 10–19.

Trefon, T. (2009), 'Hinges and Fringes: Conceptualising the peri-urban in Central Africa', in F. Locatelli and P. Nugent (eds.), *African Cities*. *Competing Claims on Urban Spaces* (Leiden), 15–36.

Turner, M. G. (1990), 'Spatial and temporal analysis of landscape patterns', *Landscape Ecol*, 4/1: 21–30.

UN (1992), *Agenda 21*: *Procedures of United Nations Conference on Environment & Development, Brazil, Rio de Janeiro* (Rio de Janeiro).

UN (1999), *Population growth, structure and distribution*: *The concise report* (New York).

UN (2000), *Sustainable agriculture and rural development*: *Report of the Secretary-General. Abendum. Urbanization and sustainable agricultural development* (New York).

UN (2008a), *Demographic Yearbook*: *Annuaire démographique. 2005* (57th edn., New York).

UN (2008b), *Principles and recommendations for population and housing censuses* (2nd edn., New York).

UN (2011), *World Population Prospects. The 2010 Revision*: *Volume I: Comprehensive Tables* (New York).

UN (2012), *World Urbanization Prospects. The 2011 Revision*: *Highlights* (New York).

UNDP (2011), *Human Development Report 2011*: *Sustainability and equity: A better future for all* (New York).

UNDP (2012), *Global Environment Outlook 5 (Geo 5)* (Valetta).

UNEP (2006), *Africa environment outlook 2*: *Our environment, our wealth* (Nairobi).

UNFPA (2007), *UNFPA state of world population, 2007*: *Unleashing the potential of urban growth* (New York).

UNFPA (2011), *State of world population 2011*: *People and possibilities in a world of 7 billion* (New York).

UN-HABITAT (2006), *Meeting development goals in small urban centres*: *Water and sanitation in the world's cities, 2006* (London).

UN-HABITAT (2010), *The state of African cities 2010*: *Governance, inequality and urban land markets* (Nairobi).

United Republic of Tanzania, *National Sample Census of Agriculture 2002/2003*: *Volume Vc: Regional Report: Kilimanjaro Region* (Dar es Salaam).

UN, UNECE, FAO, OECD, World Bank, and Eurostat (2007), *The Wye Group handbook*: *Rural households' livelihood and well-being : statistics on rural development and agriculture household income* (New York, Geneva).

Uuemaa, E., Antrop, M., Roosaare, J., Marja, R., and Mander, Ü. (2009), 'Landscape Metrics and Indices: An Overview of Their Use in Landscape Research', *Living Reviews in Landscape Research*, 3/1: 5–28.

Uuemaa, E., Roosaare, J., and Mander, Ü. (2005), 'Scale dependence of landscape metrics and their indicatory value for nutrient and organic matter losses from catchments', *Ecological Indicators*, 5/4: 350–369.

van Ranst, E., Scheldeman, X., van Mechelen, L., van Meirvenne, M., and Kips, P. (1996), 'Modelling the Land Production Potential for Maize in North-West Cameroon Using GIS', in R. Escadafal, M. A. Mulders, and L. Thiombiano (eds.), *Monitoring soils in the environment with remote sensing and GIS* (Paris), 489–502.

van Veenhuizen, R. (2006), 'Introduction, Cities Farming for the Future', in R. van Veenhuizen (ed.), *Cities farming for the future*. *Urban agriculture for green and productive cities* (Ottawa, Silang, Philippines), 1–18.

van Veenhuizen, R., and Danso, G. (2007), *Profitability and sustainability of urban and peri-urban agriculture* (Rome).

Vandermeer, J. (1989), *The ecology of intercropping* (Cambridge).

von Thünen, J. H. (1910), *Der isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie*, Neudruck nach der Ausgabe letzter Hand (2. bzw. 1. Auflage, 1842 bzw. 1850) (Jena).

Watson, V., and McCarthy, M. (1998), 'Rental housing policy and the role of the household rental sector: Evidence from South Africa', *Habitat International*, 22/1: 49–56.

Webster, D., and Muller, L. (2004), 'The Challenges of Peri-Urban Growth in East Asia: The Case of China Hangzhou-Ningbo Corridor', in M. Freire and B. K. P. Yuen (eds.), *Enhancing urban management in East Asia* (Aldershot, Hants, England; Burlington, VT), 23–54.

Weckenbrock, P. (2010), 'Making a virtue of necessity – wastewater irrigation in a periurban area near Faisalabad, Pakistan. A GIS based analysis of long-term effects on agriculture', Doctoral Dissertation (Freiburg im Breisgau, Albert-Ludwigs-Universität).

White, M. J., Mberu, B. U., and Collinson, M. A. (2008), 'African Urbanization: Recent Trends and Implications', in G. Martine (ed.), *The new global frontier*. *Urbanization, poverty and environment in the 21st century* (London; Sterling, VA), 301–16.

Whitford, V., Ennos, A., and Handley, J. (2001), '"City form and natural process"—indicators for the ecological performance of urban areas and their application to Merseyside, UK', *Landscape and Urban Planning*, 57/2: 91–103.

World Bank (2005), *The Dynamics of Global Urban Expansion* (Washington, DC).

World Bank (2008), *Rising Food and Fuel Prices: Addressing the Risks to future generations* (Washington, DC).

World Bank (2011), *World Development Report 2012*: *Gender equality and development* (Washington, DC).

Zezza, A., and Tasciotti, L. (2010), 'Urban agriculture, poverty, and food security: Empirical evidence from a sample of developing countries', *Food Policy*, 35/4: 265–273.

Zvoleff, A., Kocaman, A. S., Huh, W. T., and Modi, V. (2009), 'The impact of geography on energy infrastructure costs', *Energy Policy*, 37/10: 4066–4078.

Annexe 1 Household questionnaire

A Questionnaire Information

A1 Sample Nr.: _____ A2 Questionnaire Nr.: _____ A3 Interviewer: ______ A4 Interview date: _________

B Location

B1 Ward Name: ___________________________________ B2 Mtaa Name: ___________________________

B3 GPS Unit Nr.: ______ B4 Number of GPS Point: _______

B5 GPS References: a) East: _______________________

b) South: _______________________

Information for the Interviewee *(to be read to the interviewee prior to the interview)*:

Hello, my name is ______________. I work for a research project doing a study on agriculture in Moshi. I am not working for governmental/ municipal institutions.

I would just like to find out a little more about agriculture in Moshi and I would therefore like to ask some questions. Of course, you don´t have to answer any questions you don´t like; And you can stop the interview at any time. There are no "right" or "wrong" answers to the following questions.

This questionnaire is strictly anonymous. Your answers will remain confidential. Your name will not be mentioned in any reports. I cannot offer you anything in exchange for your contribution, apart from my thanks. Your participation and testimony are very important to us and therefore highly appreciated. This interview should take approximately one hour. Do you have any questions? Are you willing to continue?

C Interviewee

C1 Sex: [ ] male [ ] female

C2 Type of housing: [ ] cement bricks [ ] mud bricks [ ] mud

C3 Does the house have electricity: [ ] No [ ] Yes

D Housing situation

D1 How long has your family lived in this house: _______________________ (years/months)

D2 Where did you live before you moved to this house: ____

D2a **If unknown location**: How far away is it from here: ______ kms; ____ minutes/hours by ___________

D3 Do you own this house or rent it: [ ] Own (without certificate) [ ] Own (with certificate) [ ] Rent

[ ] Other: ____

D4 How many rooms are there in total: _____

D5 Does the house have piped drinking water on site: [ ] No [ ] Yes

E Overview household members

	Relation to Head of Household	Age	Sex	Highest education	Kind of activity	Average Income/week
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

Relation to Head of Household:
1 – Head of household;
2 – Spouse;
3 – Son/daughter;
4 – Father/mother;
5 – Grandson/granddaughter;
6 – other relative;
7 – others

Education:
0 – never attended school
1 – in primary school
2 – finished primary school
3 – in secondary school
4 – finished secondary school
5 – receiving tertiary education
6 – finished tertiary education

Kind of activity:
0 – unable to work (too old/sick/disabled)
1 – Government
2 – Private
3 – self-employed (non-farming) with employees
4 – self-employed (non-farming) without employees
5 – unpaid family helper (non-farming)
6 – not working & available
7 – Housemaker/ housewife
8 – Student
9 – Agriculture

E2 Which tribe do you belong to?
[ ] Chagga [ ] Masaai [ ] Mpare [ ] Mburu [ ] Msukuma [ ] Mkurya [ ] Mjita
[ ] Msambaa [ ] Mdigo [ ] Mzanaki [ ] Other: ____________________

F Agriculture – General

F1 Do you grow any staple foods or vegetables: [ ] No [ ] Yes

F1a If **"No"**, why not: 1. ____

2. ____

3. ____

(if **"No"**, proceed to **"Section I"**)

F1b If **"Yes"**, where do you grow it:

	Personalised name	Status of the land	Size of the area		Location (preferably mtaa, otherwise ward)	GPS Point Nr./ Map indication Nr.	Irrigation type	Water source
			count	unit (eg. Acres/ hectares)				
Homestead plot								
Field 1								
Field 2								
Field 3								
Field 4								
Field 5								
Field 6								

Status of the land:
1 – own (without certificate);
2 – own (with certificate);
3 – rented/borrowed;
4 – open land/share-cropped

Irrigation type:
0 – No irrigation
1 – Flooding;
2 – Water hose;
3 – Watering can

Water source:
1 – River;
2 – Lake;
3 – Well;
4 – Canal;
5 – Tap water
6 – Spring
7 – Collected rainwater

F2 Agricultural production overview

		Grown?	Field Code from F3	Nr. of harvests per year	How much do you produce?			How much do you sell?		How big is the area you grow it on?		
					Amount produced (count)	Amount produced (e.g. kg/ bags/ bundles)	Time unit (e.g. month/ season/ year)	Amount sold (count)	Amount sold (e.g. kg/ bags/ bundles)	Area (count)	Area (eg. acres/ hectares)	Change last 10 years/ since living in this house (-/0/+)
Vegetables	Beans											
	Soybeans											
	Peas											
	Tomato											
	Eggplant											
	Cucumber											
	Okra											
	Carrot											
	Chinese Cabbage											
	Kale											
	Amaranthus											
Grain	Maize											
	Millet											
	Sorghum											
Roots and Tubers	Cassava											
	Yam											
	Cocoyam											
	Irish potato											
	Sweet potato											
	Onions											
Others	Plantains											
	Sweet Bananas											
	Groundnuts											
	Sunflowers											
	Rice											

F3 Which of the following plants do you grow?
[ ] Ginger [ ] Garlic [ ] Sesame [ ] Castor seed (Castor beans) [ ] Pumpkins [ ] Pineapple
[ ] Watermelon [ ] Herbs [ ] Sugar cane [ ] Sisal [ ] Coffee [ ] Tea
[ ] others: 1. ___________________ 2. ___________________ 3. ___________________
F4 What kind of inputs do you apply:
[ ] Chemical fertilizer [ ] Manure [ ] Compost [ ] Chemical Pesticides [ ] Improved seeds
[ ] others: ______________________________
F5 What is your main method of working the soil:
[ ] human power [ ] animal power [ ] machine power

G Agriculture – Marketing

G1 Where do you sell your products: [ ] don´t sell any (If **"don´t sell any"** products, go to **"Section H"**)
[ ] neighbours/ friends [ ] farmers associations [ ] traders at the market [ ] trade it myself
[ ] other: ____
G2 Did you notice any change in the demand of agricultural products over the last 10 years/ since you live in this house:
[ ] increase [ ] No change [ ] decrease
G2a If **"increase"** or **"decrease"**, did you change anything in your production because of this change:
[ ] No [ ] yes, specify ____
G3 What part of your household income is generated through the sale of food crops?
[ ] nothing [ ] up to ¼ [ ] between ¼ and ½ [ ] between ½ and ¾ [ ] almost all

H Agriculture - Knowledge

H1 Have you ever accessed support from municipal institutions or NGOs supporting agricultural activities in Moshi:
[ ] Never [ ] training [ ] fertilisers [ ] pesticides [ ] seeds [ ] marketing
Other: ____

H2 Do you grow any other crops or trees than you did 10 years ago/ since you live in this house:
[ ] No [ ] Yes (If **"no"**, go to **"H3")**

H2a If **"yes"**, what did you give up growing:	H2b Why did you give up growing it:
1. _________________________________	1. _________________________________
2. _________________________________	2. _________________________________
3. _________________________________	3. _________________________________
4. _________________________________	4. _________________________________
H2c If **"yes"**, what do you grow you haven´t grown before:	H2d Why do you grow it now:
1. _________________________________	1. _________________________________
2. _________________________________	2. _________________________________
3. _________________________________	3. _________________________________
4. _________________________________	4. _________________________________

H3 Is your agricultural production affected by scarcity of water? [ ] No [ ] Yes
I6a If **"yes"**: How are you affected? _________________________________
H4 Are you affected by scarcity of manure? [ ] No [ ] Yes
I7a If **"yes"**: How are you affected? _________________________________

I Agriculture – Changes

I1 Where did you learn on how to cultivate:
[ ] parents/grandparents [ ] school [ ] neighbours/friends [ ] figured out myself [ ] training(s)
I2 Do you or a member of your household take part in activities of a social group/association:
[ ] no [ ] yes

I2a If **“Yes”**:

Type of group	Who in the household	Benefits from participation
Farming Name: ______________________		
Savings group		
Women´s group		
Other: _______________		

I3 What has changed regarding agriculture within the last 10 years/ since you live in this house:

	What kind of change	Positive	Negative	Who/What is responsible for this change?	If **“positive”**: How do you benefit? If **“negative”**: How do you deal with it?
Change 1					
Change 2					
Change 3					

I4 Have you sold any of your arable land within the last 10 years/ since you live in this house:
[ ] No [ ] Yes (If **“no”**, go to **“I5”**)
I4a If **“yes”**,______(count)__________ (unit; eg. acres/ hectares)
I4b If **“yes”**, to whom: [ ] family [ ] neighbours [ ] people from Moshi
[ ] people from outside Moshi [ ] foreigners [ ] municipality
[ ] other: ____

I5 Have you bought any of your arable land within the last 10 years / since you live in this house:
[ ] No [ ] Yes (If **“no”**, go to **“I6”**)
I5a If **“yes”**,______(count)__________ (unit; eg. acres/ hectares)
I5b If **“yes”**, from whom: [ ] family [ ] neighbours [ ] people from Moshi
[ ] people from outside Moshi [ ] foreigners [ ] municipality
[ ] other: ____

I6 Are you affected by scarcity of arable land? [ ] No [ ] Yes
I6a If **“yes”**: How are you affected? _________________________________

I7 How have you been affected by governmental regulations regarding agriculture?
[ ] don´t know any regulations [ ] not affected [ ] plants have been destroyed [ ] punishment
[ ] don’t apply certain inputs [ ] don´t grow specific plants (fill in plants):
1. ___________________ 2. ___________________ 3. ___________________ 4. _________________

J Agriculture - Livestock

J1 What kind of livestock do you have? [ ] none (If **“none”**, go to **“Section K”**)

Livestock	Count	Do you sell them?
Chicken		
Ducks		
Goats		
Sheep		
Cows		
Pigs		

J2 What is the main source of fodder for your animals?
[ ] fodder grown on farm [ ]bought fodder [ ] left over food
[ ] others: ____

K Nutrition

K1 How often in the last week have you been eating the following types of food (fill in numbers):

2. [ ] Ugali [ ]Maharagwe [ ]Mchicha [ ] Chinese [ ] Kabichi [ ] Sukuma wiki [ ] Bamia [ ] Dagaa
3. [ ] Ndizi [ ] Muhogo [ ] Magimbi [ ] Wali [ ] Viazi vitamu [ ]Viazi mvringo [ ] Makande
4. [ ] Nguruwe [ ] Nyama [ ] Samaki [ ] Kuku [ ] Mayai

K2 Generally spoken, what part of your food (non-meat) do you grow yourself:

[ ] nothing [ ] up to ¼ [ ] between ¼ and ½ [ ] between ½ and ¾ [ ] more than ¾

K3 Do you face challenges in providing food for your family:

[ ] never [ ] rarely [ ] sometimes [ ] always

K3a If **"rarely"**, **"sometimes"** or **"always"**, what was the reason for a shortage:

[ ] lack of money [ ] poor harvest [ ] losses after harvest

[ ] others: ____

K4 Has the quantity of food available for your household members changed in the last 10 years/ since you live in this house:

[ ] got more [ ] about the same [ ] got less

K4a If **"got more"** or **"got less"**, what was the main reason:

[ ] more/less money available [ ] sinking/rising food prices [ ] better/worse harvests

[ ] bigger/smaller area under cultivation [ ] relocation of household [ ] family size

[ ] other: ____

L Household - Expenditures

Expenditures	Tsh	Per day/week/month/year/etc.
Rental		
Food		
Water		
Electricity		
Transport		
School fees + all requirements		
Communication		
Fuels		
Kitchen and bathroom supplies		
Clothes		
Medicine		

L2 Are there any other important expenditures you regularily have?

Expenditures	Tsh	Per day/week/month/year/etc.

M Household – General information

M1 Does this household receive regular monetary remittances from people not normally living here:

[ ] no [ ] yes If cash, how much: ____________ Shillings/month

M2 Does this household receive regular income from renting out rooms or land:

[ ] no [ ] yes If yes, how much: _____________ Shillings/month

M3 Does this household receive any welfare grants or government, public pensions or NGOs:

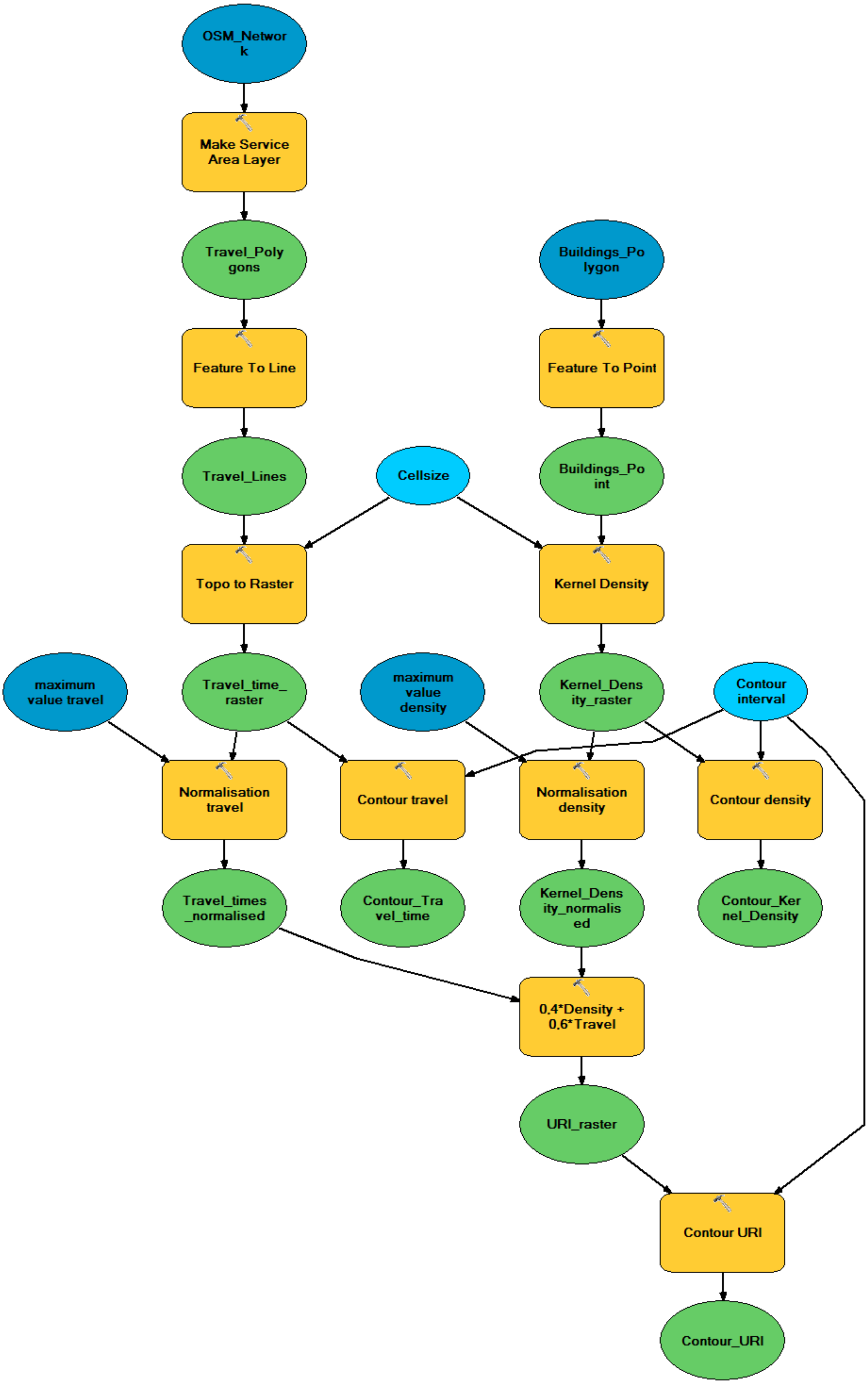
[ ] no [ ] yes If yes, how much: _____________ Shillings/month

M4 Which of the following assets does your household own (fill in the number of each):

[ ] Car [ ] Motorbike [ ] Bicycle [ ] Plough

[ ] Fridge [ ] TV [ ] Radio/HiFi [ ] Cell phone

Annexe 2 GIS workflow for the calculation of the Urban-Rural Index



Annexe 3 Overview of calculated landscape metrics

Name	Formula	Description
Patch Density	$PD = \frac{n}{A}(10{,}000)$	Number of patches per ha
Patch Richness Density	$PRD = \frac{m}{A}(10{,}000)$	Number of patch types standardised to the ha level. A measure of diversity of patch types
Relative Patch Richness	$RPR = \frac{m}{m_{max}}(100)$	Proportion of the maximum potential richness (in %)
Mean Patch Size	$MPS = \frac{\sum a}{n}(\frac{1}{10{,}000})$	Area occupied by all patches divided by the number of patches (in ha)
Patch Size Standard Deviation	$PSSD = \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left[a_{ij} - \left(\frac{A}{N}\right)\right]^2}{N}}\left(\frac{1}{10{,}000}\right)$	Function of the Mean Patch Size and the difference in size among patches. A measure of absolute variation
Patch Size Coefficient of Variation	$PSCV = \frac{PSSD}{MPS}(100)$	Patch size standard deviation divided by the Mean Patch Size. A measure of relative variability
Shannon's Diversity Index	$SHDI = -\sum_{i=1}^{m}(P_i \circ lnP_i)$	Relative measure of diversity for comparing different landscapes
Percentage of landscape	$\%LAND = P_i = \frac{\sum_{j=1}^{n} a_{ij}}{A}(100)$	Proportion of the landscape occupied by patch class *i* (in %)

Term	Definition
n	Number of patches in the landscape
m	Number of classes present in the landscape
A	Total landscape area in m^2
a	Area of patches in m^2
i	1, …, m classes
j	1, …, n patches

Based on McGarigal and Marks (1995); McGarigal (2008); Howard (2005); Eiden et al. (2000)

Annexe 4 Scientific and local names of crops

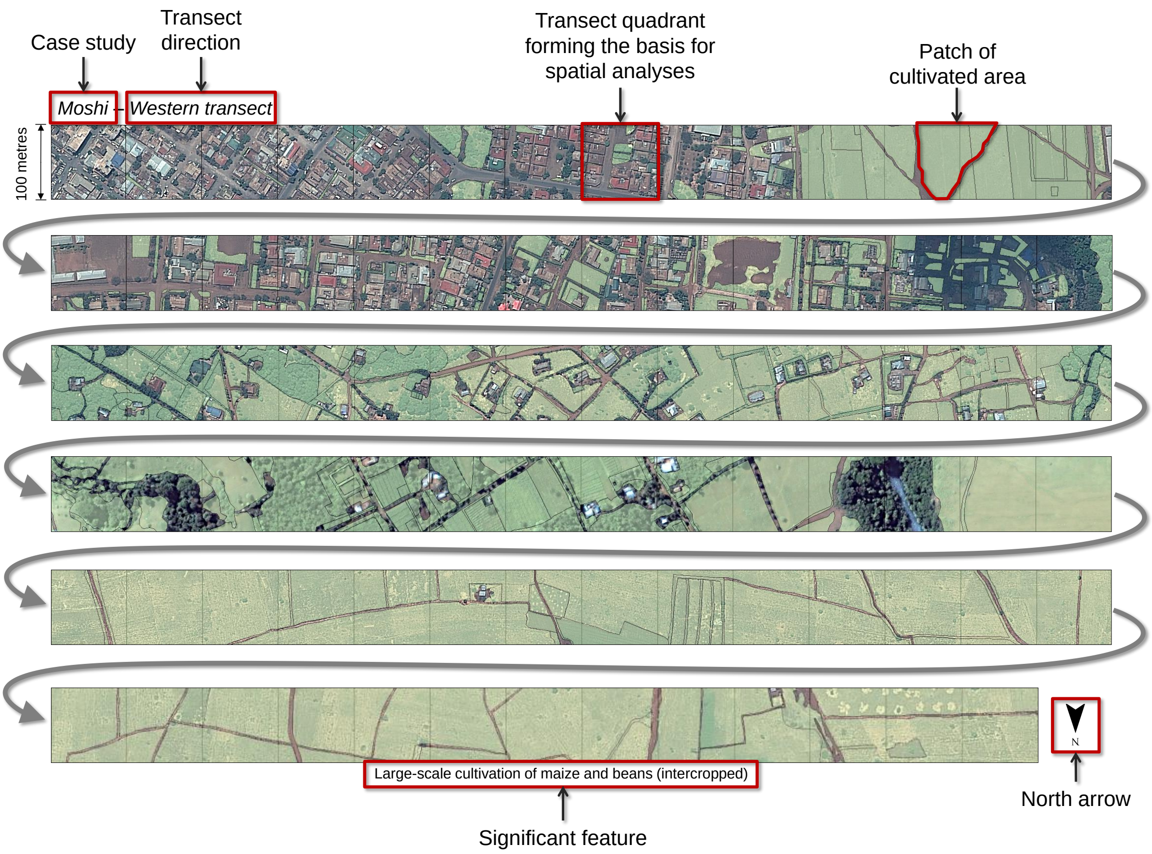
Common name	Latin name	Local name[46]	
		Swahili	Pidgin
Amaranthus	*Amaranthus* spp.	mchicha	green
Banana	*Musa* spp.	ndizi	n/a
Beans	*Phaseolus calcaratus* Roxb.	maharagwe	n/a
Cabbage	*Brassica oleracea* var. *capitata* L.	kabichi	n/a
Carrot	*Daucus carota* L.	karoti	n/a
Cassava	*Manihot esculenta* Crantz.	muhogo	n/a
Chinese cabbage	*Brassica chinensis* L.	chinese	n/a
Cocoyam	*Colocasia esculenta* (L.) Schott.	magimbi	coco
Coffee	*Coffea* spp.	kahawa	n/a
Egg Plant	*Solanum melongena* L.	mbiringani	jargatou
Elephant grass	*Pennisetum purpureum* Schumach.	majani ya tembo	n/a
Garlic	*Allium sativum* L.	kitunguu saumu	n/a
Ginger	*zingiber officinale roscoe*	tangawizi	n/a
Groundnuts	*Arachis hypogaea* L.	karanga	n/a
Huckleberry	*Solanum scabrum* Mill.	n/a	njamajama
Irish Potato	*Solanum tuberosum* L.	kiazi mviringo	irish
Kale	*Brassica oleracea* var. *acephala* L.	n/a	n/a
Maize	*Zea mays* L.	mahindi	corn
Okra	*Hibiscus esculentus* L.	bamia	okro
Onion	*Allium cepa* L.	kitunguu	n/a
Pepper	*Capsicum* spp.	pilipili	n/a
Pineapple	*Ananas Comosus* (L.) Merr.	nanasi	n/a
Pumpkin	*Cucurbita* spp.	boga	n/a
Rice	*Oryza sativa* L.	mpunga	n/a
Roselle	*Hibiscus sabdariffa* L. var. *sabdariffa*	rozela	folere
Sugar Cane	*Saccharum officinarum* L.	muwa	n/a
Sunflower	*Helianthus annuus* L.	alizeti	n/a
Sweet Potato	*Ipomea batatas* (L.) Lam.	kiazi kitamu	potato
Tomato	*Lycopersicon esculentum* Mill.	nyanya	n/a
Watermelon	*Citrullus lanatus* (Thunb.) Matsun & Nakai	tikiti maji	n/a
Yam	*Dioscorea* spp.	kiazi kikuu	n/a

Based on Tindall (1987); Nowak and Schulz (2009)

[46] In some cases, the English name was also used in the local language. Local names were verified by local experts.

Annexe 5 Agricultural and use along the transects

On the following pages, overviews of the spatial changes of agricultural land use along all transects in both case studies are given. The figure below thereby provides an illustrated explanation for easier readability of the transect overviews.

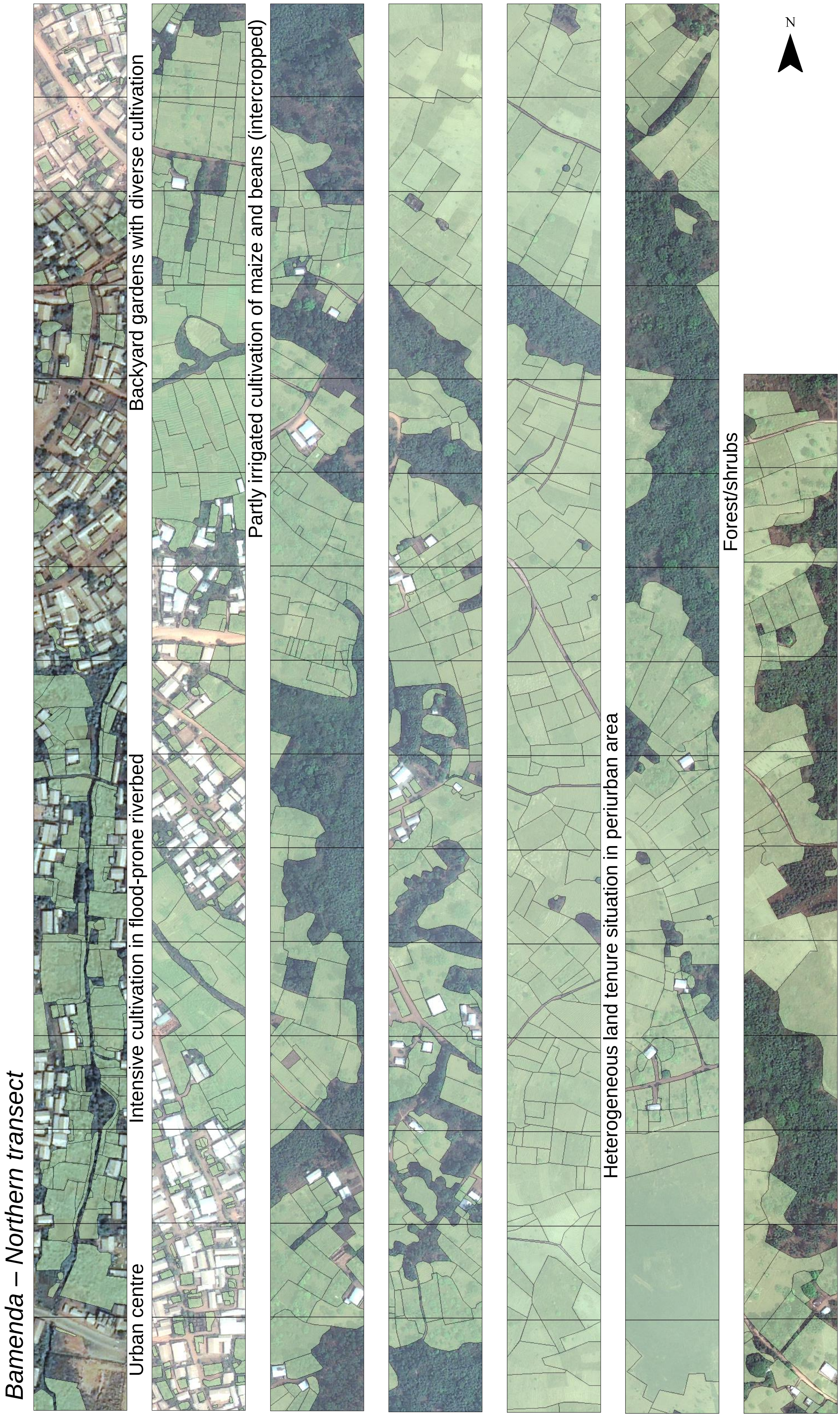



Moshi – Western transect
Staple food production on abandoned airfield
Urban centre
Patches of agroforestry
Large-scale cultivation of maize and beans (intercropped)
N

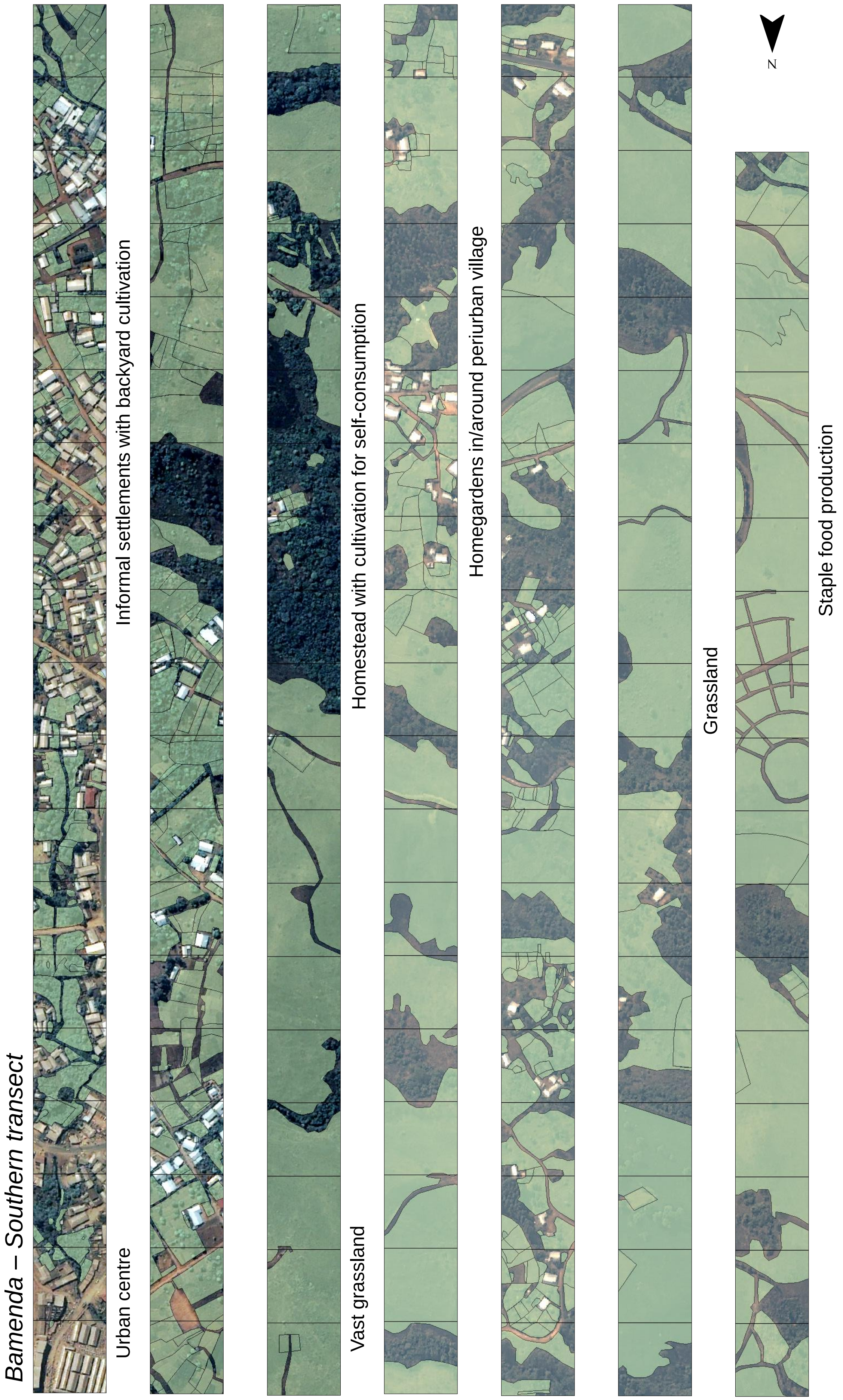

Moshi – Northern transect
Urban centre
Roadside cultivation along Arusha Road
High-income area with grass patches
Grass patches in between school and university buildings
Patches of agroforestry
Backyard cultivation in highly dynamic informal settlement
Staple food production mixed with homegardens (predominantly agroforestry)
Chagga gardens on lower slopes of Mt. Kilimanjaro (agroforestry systems)
N

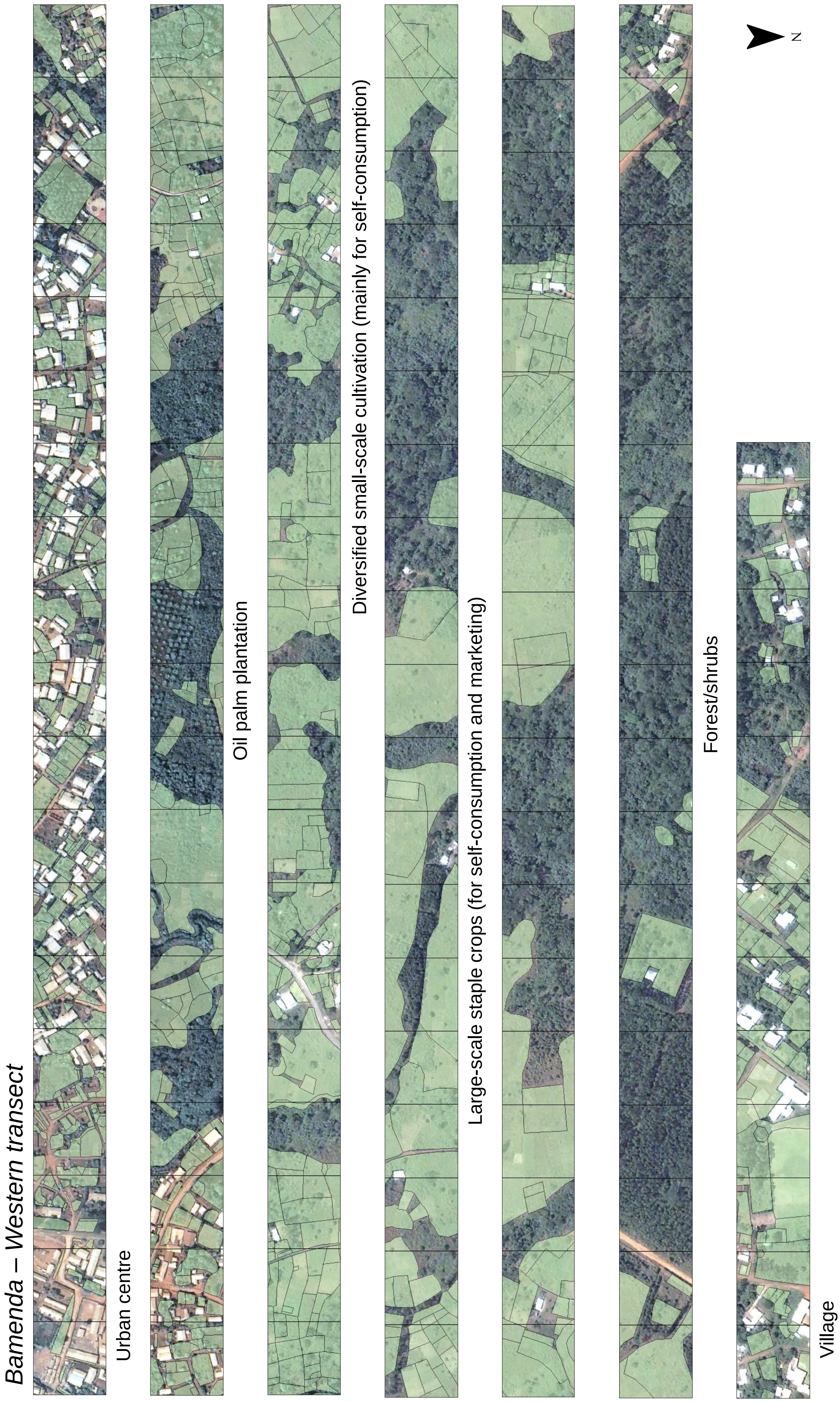

Moshi – Eastern transect
Urban centre
Cultivation along abandoned railway line
Informal settlements with small backyard gardens
River as natural barrier for urban growth
Large-scale cultivation of maize and beans (intercropped) and small-scale backyard cultivation
Periurban village
Higher building density along road to Dar es Salaam
N


Moshi – Southern transect
Urban centre
Semi-legal cultivation on public open spaces
Informal settlement in flood-prone location
Fallow (formerly cultivated area owned by a company)
Large-scale sugar cane plantation (TPC)
N


Bamenda – Northern transect
Urban centre
Backyard gardens with diverse cultivation
Intensive cultivation in flood-prone riverbed
Partly irrigated cultivation of maize and beans (intercropped)
Heterogeneous land tenure situation in periurban area
Forest/shrubs
N


Bamenda – Eastern transect
Urban centre
Redensified old town with hardly any cultivation
Informal settlement with backyard cultivation for self-consumption
Periurban village with diversified cultivation
Staple food production on forest clearings
Forest/shrubs
N


Bamenda – Southern transect
Urban centre
Informal settlements with backyard cultivation
Vast grassland
Homestead with cultivation for self-consumption
Homegardens in/around periurban village
Grassland
Staple food production
N


Bamenda – Western transect
Urban centre
Oil palm plantation
Diversified small-scale cultivation (mainly for self-consumption)
Large-scale staple crops (for self-consumption and marketing)
Forest/shrubs
Village
N

Annexe 6 Photos – Moshi

Photo 1: Moshi's city centre with Mt. Kilimanjaro in the background

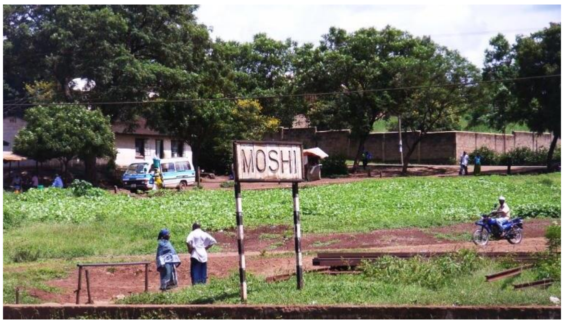


Photo 2: Cultivation of beans next to abandoned railway line

Photo 3: Informal cultivation (beans, groundnuts) on abandoned airfield (WT)

Photo 4: Maize cultivation in a periurban area (NT)

Photo 5: Construction activity in agriculturally dominated environment (ET)

Photo 6: Multiple vegetation layers (beans, banana, trees) in a Chagga garden (NT)

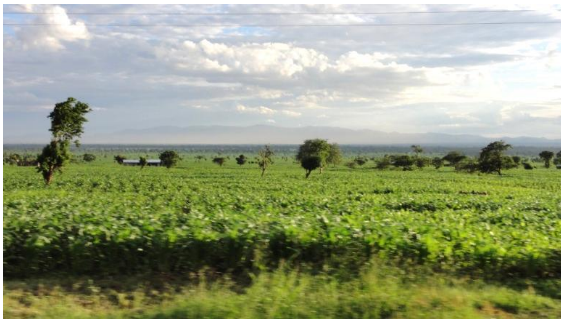


Photo 7: Large-scale maize cultivation in rural setting (ET)

Photo 8: Large-scale market-oriented cultivation of sugar cane (ST)

NT = Northern transect ET = Eastern transect ST = Southern transect WT = Western transect

Annexe 7 Photos – Bamenda

Photo 1: Bamenda as seen from south

Photo 2: Busy street in Bamenda's city centre

Photo 3: Backyard cultivation (beans, banana) close to the city centre (WT)

Photo 4: Cultivation of beans and cocoyam in bags filled with kitchen waste (ST)

Photo 5: Construction activity and heterogeneous land use in periurban area (ST)

Photo 6: Market-oriented vegetable production in periurban area (ET)

Photo 7: Irrigated crop cultivation during dry season in close vicinity to Mezam River (NT)

Photo 8: Irrigated tomato cultivation in periurban area (ST)

NT = Northern transect ET = Eastern transect ST = Southern transect WT = Western transect