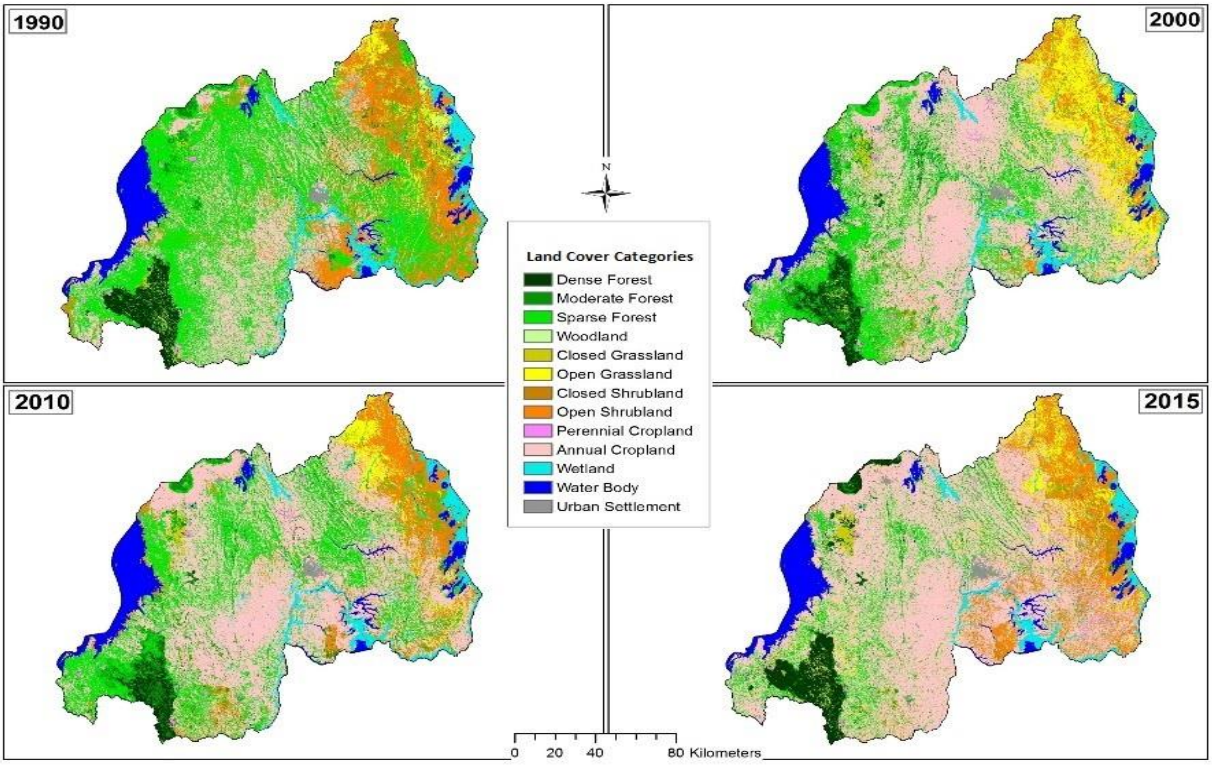
RWANDA
NATURAL CAPITAL ACCOUNTS - LAND

March 2018



WAVES

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Acknowledgements

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[1] This NCA effort for land began in 2014, working closely with officials from the Ministry of Natural Resources (MINIRENA) and Rwanda Natural Resources Authority (RNRA). In early 2017, RNRA was replaced by three specialized bodies: Rwanda Land Management and Use Authority, Rwanda Water and Forestry Authority, and Rwanda Mines, Petroleum and Gas Board. Recently, the Ministry of Natural Resources was divided into a Ministry of Environment and a Ministry of Lands and Forestry. Key technical staff have continued to support the process during this transition.

Executive Summary

Rwanda is keen to grow our economy and wisely manage our natural resources that contribute to economic development. The Economic Development and Poverty Reduction Strategy 2 and the National Strategy for Transformation aim to ensure that development in Rwanda protects the environment and builds resilience to threats posed by climate change, while sustaining economic, social, and cultural growth. Natural Capital Accounting is an approach for analysing trends and trade-offs in the use of the country's land, water, minerals and ecosystem assets. Natural Capital Accounting can add value in the development planning process, inform economic and statistics departments, and raise attention on economically important natural resource sectors. In contrast, Gross Domestic Product is a traditional measure of economic performance, but does not yet fully cover the underlying wealth and natural assets that sustain income.

In Rwanda, land is the basis for agriculture and rural livelihoods, but it faces pressures from population growth, the need for jobs, and rapid urbanization, as well as vulnerability to changes in climate, weather extremes and rainfall patterns. Natural Capital Accounts for land can provide information about the land assets, changes in land use and land cover, land availability and productivity, as well as potential for and constraints to agricultural growth, a key pillar of Rwanda's development agenda. Land Accounts can add value in sustainable development planning by providing indicators and trend analysis to track performance targets for sustainability, land allocation, service delivery, and productivity. Land accounts can help to clarify and compare economic values generated by land in competing uses and how changes in land use may affect land asset value. When integrated with other sectoral data, land accounts can also provide insights about potential effects on water use and food production. NCA can also contribute to accountable governance by increasing the quality, credibility, and consistency of the statistics and analyses that support national development plans and targets.

Natural Capital Accounts follow the principles of the System of Environmental Economic Accounting, applying similar principles and standards as the System of National Accounts. This important feature allows data on land, water, and other resource uses like energy and environmental outcomes to be directly linked to information on economic activity, value-added, and employment for each sector. Land accounts are a tool for monitoring and analyzing assets and changes in land use, land cover, and land value and provide consistent data and evidence to inform both policies and potential investments, e.g., the impacts of urbanization, the sustainability of agriculture, and the extent of habitats for biodiversity conservation.

Our institutions are pleased to issue this first Natural Capital Accounting analysis on land issues. Key findings on assets and changes in land use, land cover and land values are outlined here.

Land Uses and Changes. Rwanda's Land Administration Information System (LAIS) covers 11 million parcels and 2.07 million hectares of land. LAIS is an excellent resource that was designed to improve land registration and tenure practices, but also allows analysis of changes over time in the economic uses of land. LAIS records agriculture as the largest share of land use across the country, followed by Forestry, Residential, and Livestock. Analysis of land use changes shows

that from 2014 to 2015, the Residential and Agriculture land uses gained the most area, while Livestock, Research/Scientific, and Economic lost the most. However, these losses were quite small, less than 2,000 ha overall. Most of these changes are due to administrative re-classification of land that had previously been unallocated to a specific land use. Actual changes from one land use category to another are relatively minor, but there are movements of land into residential uses. For example, the LAIS does not show major movement from agricultural into commercial, economic, or urban land uses.

Land Parcel Sizes. Most land parcels are quite small, less than one-tenth of one hectare – and the distribution is highly skewed toward small sizes. Nearly 70 % of land is in parcels less than 0.2 hectares in size. Only 3.0 % of land is in parcels greater than one hectare – and only 0.6 % of land is in parcels greater than two hectares. Plots in the Eastern Province are about twice as large as the national average, while plots in the Northern are about 60 % of the national average. Parcels classified as agricultural are among the smallest, along with commercial, economic, industrial, and residential parcels. Land uses with larger parcels include those for administrative, livestock, and research/scientific purposes. Interestingly, agriculture parcels declined in average size by around one-half of a percent, while residential parcels saw a slight increase of 0.6 %. Analysis of changes in parcel sizes may be premature for a period with only two years of data. This issue can be explored in greater depth after more years of data are analyzed.

Long-Term Land Cover Change (1990 – 2015). Land cover categories are analyzed through remote sensing of biophysical properties of the land. (In contrast, land use categories defined in LAIS are based on location, value, size, and other administrative characteristics.) Over the 25 years of this analysis, Rwanda has experienced a decline of woodland and an increase in cropland, with the most notable period of change during 1990 to 2000, during which Rwanda experienced war and major movements of people and resettlement of people with land for agricultural purposes (as for example taken from Akagera). This trend was very noticeable in the Northern and Eastern Provinces. Dense forest declined by half from 1990 to 2015, while sparse forest has increased, particularly after 2000. The area of settlements has doubled over this period, but remains a very minor feature of the landscape, at about one percent of Rwanda's overall area.

Recent Land Cover Changes. Looking at the period from 2010 to 2015, the greatest change was in loss of sparse forest coupled with an increase in annual crop land, open grass land, and open shrubland. This continues a long-term trend in Rwanda as more land has been brought under cultivation at the expense of remaining lightly forested areas, potentially contributing to runoff and soil loss. However, the area of closed grass land, shrubland and perennial crop land also increased over this period, possibly indicating an increase in trees on farms and in agricultural landscapes, as communities reclaim degraded areas, plant trees, and engage in agroforestry. The area of wetlands decreased by about 13,000 ha, which is about 13 % of the total area in wetlands that existed in 2010. The continuing loss of wetlands confirms a concern noted in the Rwanda State of Environment and Outlook Report (REMA, 2015). On the positive side, this period saw an increase in dense forest with a nearly equivalent decrease in moderate forest, which may indicate that remaining forest areas are being protected enough to enable a transition from moderate to dense tree cover. The area in settlements increased from about 21,000 to 36,000 ha, a 74 %

increase. Settlements, however, cover only 1.4 % of Rwanda's overall land area, even though they host an increasing share of the population.

Value of Transactions. In a step toward developing monetary asset accounts for land, the report analyzes the distribution and values of 15,000 parcel transactions. This showed a wide range of sizes and values across provinces. Kigali City, Western, and Northern Provinces had quite small transactions, averaging about one-tenth of a hectare, while the Eastern Province had transactions averaging over four-fifths of a hectare. Generally, parcels in urban districts have higher transaction values, with Kigali being higher than other provinces. Most transactions involved agricultural, livestock, and residential land uses. Transactions involving agriculture and livestock land uses had lower values per hectare than residential or commercial land uses. Residential land uses represented about three quarters of the total value transacted, but less than 20 % of area transacted. Most residential transactions took place in Kigali. More work is needed to separate the value of land from the value of developments and buildings on the land.

Implications and Further Steps. The report reviews issues and trends on Rwanda's land assets and discusses possible implications for development planning. It offers suggestions that may improve institutional coordination and data collection and quality in the future. For example, land use and cover information can inform land-use planning from local to national scale. Land use and cover accounts can also inform Rwanda's efforts to build climate resilience, reduce deforestation, and increase forest cover. When fully compiled, the series of Natural Capital Accounts on land, water, minerals and ecosystems can be used in combination with other data sources and modeling approaches to analyze key policy and development planning issues in an integrated framework. Regarding coordination and data sharing, there is a need for standard approaches for linking data systems across ministries and sectors so that they are more compatible, enabling better analysis by integrating data from multiple sources and sectors.

The NCA approach asks that we work together across sectors and institutions to produce consistent, reliable data to support economic assessments and sound policy formation. Through the process of developing these accounts, we have learned a lot, built inter-agency collaboration, and established systems for sharing data across institutions and sectors. Though we have made great strides, more can be done to harmonize data sharing systems, improving compatibility and streamlining data collection systems. Achieving our national economic growth goals will require the wise use of our land, water, minerals and ecosystems. Natural Capital Accounting is a tool that can inform our national development planning process, as well as our national climate change strategies. Natural Capital Accounts will be an important source for developing and tracking indicators of progress toward sustainability. Our institutions plan to update and publish natural capital accounts documents regularly in the future so that they become a resource for analysts, students and policy makers working toward sustainable development solutions.

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Acronyms and Abbreviations

DG	Director General
EDPRS	Economic Development and Poverty Reduction Strategy
GDP	Gross Domestic Product
GDSA	Gaborone Declaration on Sustainability in Africa
ha	hectare
ICT	Information and Communications Technologies
ISIC	International Standard Industrial Classification
IPCC	Intergovernmental Panel on Climate Change
LAIS	Land Administration Information System
LTRSP	Land Tenure Regularisation Support Programme
MINECOFIN	Ministry of Finance and Economic Planning
MINILAF	Ministry of Lands and Forestry
MINIRENA	Ministry of Natural Resources
MOE	Ministry of Environment
NCA	Natural Capital Account
NST	National Strategy for Transformation
NISR	National Institute of Statistics of Rwanda
PDF	Portable Document Format
RBM&E	Result Based Monitoring & Evaluation
RCMRD	Regional Centre for Mapping of Resources for Development
RDB	Rwanda Development Board
REDD	Reducing Emissions from Deforestation and Forest Degradation
REMA	Rwanda Environment Management Authority
RLMUA	Rwanda Land Management and Use Authority
RNRA	Rwanda Natural Resources Authority
RMPGB	Rwanda Mines, Petroleum and Gas Board
R-PP	Readiness Preparation Proposals
RRA	Rwanda Revenue Authority
RWFA	Rwanda Water and Forestry Authority
SDGs	Sustainable Development Goals
SEEA	System of Environmental Economic Accounting
SNA	System of National Accounts
SNAPP	Science for Nature and People Partnership
UN	United Nations
UPI	Unique Parcel Identifier
USGS	United States Geological Survey
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WBG	World Bank Group
WCS	Wildlife Conservation Society

CHAPTER I: Introduction and Overview

Rwanda is engaged in developing Natural Capital Accounts, guided by a Steering Committee led by the Ministry of Environment and Ministry of Lands and Forestry (formerly Ministry of Natural Resources), and its associated agencies, and including members from the Ministry of Finance and Economic Planning (MINECOFIN), National Institute of Statistics of Rwanda (NISR), Ministry of Infrastructure, Ministry of Agriculture, Rwanda Development Board, the Wildlife Conservation Society, and others. Natural Capital Accounting (NCA) brings together information on how natural resources are contributing to the economy – information on resource stocks and flows, uses and users, scarcities and potentials – to help improve development decisions. NCA is an extension of the System of National Accounts that helps to describe the economy's use of natural assets, such as land, water, forests, and minerals. The approach helps to integrate natural resources into economic analysis and can provide a broader picture of development progress than standard measures, such as Gross Domestic Product (www.wavespartnership.org).

1.1 Rwanda's Development Context and Natural Capital Accounting

Rwanda's Second Economic Development and Poverty Reduction Strategy (EDPRS 2) recognizes environment and climate change as cross cutting issues that require mainstreaming sustainability into productive sectors and reducing vulnerability to climate change. The EDPRS 2 sees land as a key resource for both rural livelihoods and new production. (MINECOFIN, EDPRS 2 2013 - 2018).

The EDPRS 2 emphasizes environment and natural resource management, with a key focus on land. Rwanda aims to have an efficient system of land administration and land management that secures ownership and promotes investment in land for socio-economic development and poverty reduction. EDPRS 2 aims to ensure that development in Rwanda proceeds in a manner that protects the environment and builds resilience to threats posed by climate change while sustaining support to economic, social, and cultural growth. It promotes policies that secure and provide water of adequate quantity and quality for all social and economic needs, for generations to come, with all stakeholders participating in decisions affecting its management. It also proposes improving the mining sector so that it may contribute optimally and sustainably to Rwandan growth (MINIRENA, 2013). The emphasis on poverty eradication and environmental sustainability is likely to continue as Rwanda embarks on the planning process for its upcoming National Strategy for Transformation and Prosperity.

In line with the goals of EDPRS 2, Rwanda has devised several strategies and initiatives pertaining to environmental improvement and climate change adaptation. For example, the Green Growth and Climate Resilience Strategy (2011) defines upstream planning requirements needed to mainstream climate-related interventions and development programs. Rwanda has adopted a roadmap for domestication and implementation of the Sustainable Development Goals (SDGs), which highlight economic development, environmental sustainability, and social inclusion. As part of this, Rwanda has developed an analysis of gaps in policy and indicators for

measuring progress, as well as plans for establishing relevant baselines (MINECOFIN, 2016). Rwanda is also committed to actions that, in the face of climate change, increase resilience and reduce emissions. The country has established a national environmental fund, FONERWA, and is accessing adaptation, mitigation, and resilience funding from all possible international sources, including the Global Environment Facility, multilateral development banks, and specialized climate funds, such as the Forest Carbon Partnership Facility, the Forest Investment Program, and the Pilot Program for Climate Resilience. Rwanda is also developing a Results-Based Monitoring and Evaluation System as a tool for efficiently monitoring and assessing performance against development targets, and for helping to identify trade-offs or potential constraints. Natural Capital Accounts will be a relevant and important source for choosing indicators and tracking progress against baselines under many of these initiatives.

Natural Capital Accounting can add value in Rwanda's national development planning process by raising attention to economically vital natural resource sectors and by providing consistent, reliable data to support economic assessments and sound policy formation that takes cross-sectoral issues into account. NCA can help to identify trade-offs or potential constraints as Rwanda grows. NCA can also contribute to accountable governance by increasing the quality, credibility, and consistency of the statistics and analyses that support national development plans and targets.

In 2012, Rwanda signed the Gaborone Declaration on Sustainability in Africa (GDSA), agreeing to use natural capital accounting as a tool to inform national sustainable development. GDSA encourages countries to collect and monitor information across ecosystems, agriculture, fisheries, and human well-being, to provide information at multiple scales that allow actors to make decisions with a better understanding of both the environmental and economic impacts and consequences. In 2013, Rwanda joined the Global Partnership on Wealth Accounting and Valuation of Ecosystem Services (WAVES) and accessed World Bank technical assistance to support its NCA efforts. Based on early scoping efforts in 2014 and 2015, the Government determined to focus its NCA preparation on land, water, and mineral accounts. The Government is also collaborating with the Wildlife Conservation Society and a consortium of partners with funding from the Science for Nature and People Partnership (SNAPP), as described later.

1.2 Land, Agriculture, and Economic Issues

Rwanda has a small surface area, steep, hilly terrain, and very high population density (about 414people/km^2, based on population data from the Rwanda Poverty Profile Report (NISR 2015) and area data from the Land Administration Information System. See table at the end of this section). The high population density and the country's reliance on agriculture for livelihoods is a key issue for management and conservation of land and watersheds. Unsustainable farming practices on steep slopes and deforestation have resulted in extensive erosion and siltation, compromising the ecosystem services critical for Rwanda's food and energy security. With an average GDP growth rate of seven % per year in the past five years, Rwanda has reduced poverty from about 57 % to 39.1%, with a significant reduction in rural areas, where 93.2% % of Rwanda's poor live.

Agriculture provides about 33%% of GDP, 80 % of employment, and 45 % of export revenues (mostly tea and coffee) (NISR 2015). However, steep terrain, limited land, and a lack of modern technology pose serious constraints for agricultural development. Overexploitation of land, high dependence on biomass for household energy needs (used by 80 % of the population), and increasing urbanization (at 4.4 % per year) create significant pressure on natural resources, notably land, water, and forests. Over 60 % of households cultivate less than 0.7 ha, and 30 % cultivate less than 0.2 ha. Over 70 % of the cultivated land surface has slopes of greater than 10 %. This results in high levels of erosion and surface runoff into waterways. Erosion causes loss of soil, nutrients, and organic matter that translates into annual economic losses of US$34 million, or almost 2 % of GDP equivalent (REMA, 2009).

Rwanda's high dependence on traditional rain-fed agriculture makes it highly vulnerable to changes in temperature and rainfall. Climatic factors—exacerbated by a loss of forest and vegetative cover—and steep slopes result in various shocks and stresses on already perturbed ecosystems. Increased intense rainfall, flash floods, landslides exacerbated by erosion (caused by agricultural practices on steep slopes and deforestation for fuel wood), and a lack of adequate drainage have a significant impact on agricultural production (and hence food security), infrastructure, and electricity generation.

Population pressures and inheritance practices have resulted in increasing fragmentation of land parcels, which leads to inefficient agriculture and households with holdings that are too small to support them. Through EDPRS 2, the government promotes an agricultural development strategy that aims to increase productivity to achieve food security and improve rural incomes. Weak economic prospects in traditional agriculture contribute to rural-urban migration. Increasing urbanization requires land to be available for priority development projects, but also highlights the need for better zoning practices, especially ones that increase green areas for improved quality of life and policies that limit urban sprawl. There is a need for high quality data and monitoring systems to help in assessing competing land uses and managing land resources sustainably.

Figure 1 (page 3) is a map of land cover and change in Rwanda from 1990 to 2015. Chapter III analyzes the data behind these maps in greater detail. Population density by province is reported in the table below using data from the Population Census and land area data recorded in Rwanda's Land Administration Information System (LAIS). This system is explained in further detail in Chapter II, which focuses on analysis of land use changes. Table 1 (on page 4) shows population and density across the provinces of the country.

Figure 1: ***Land Cover and Land Change in Rwanda, 1990-2015***

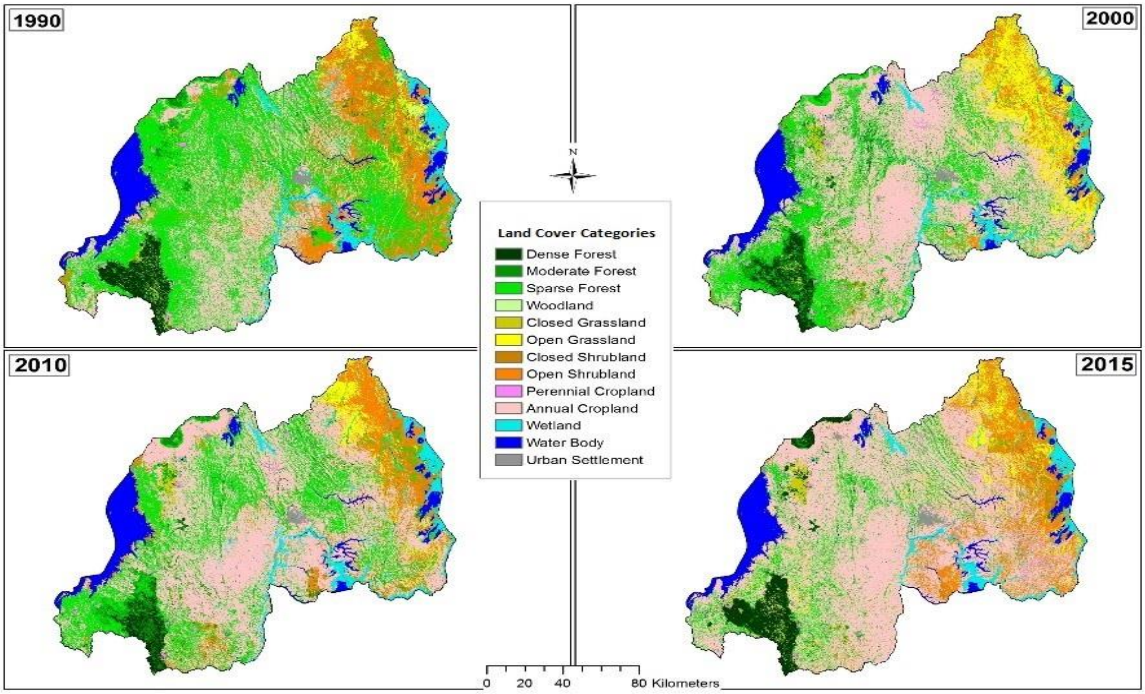


Table 1: ***Rwanda Population Distribution and Density (using LAIS Area), 2012***

Location	Population 2012	Urban Share	LAIS Area* (ha) 2014	Population / Ha
RWANDA	10,515,973	16.5%	2,069,548	5.1
Kigali City	1,132,686	75.9%	69,761	16.2
South	2,589,975	8.9%	536,556	4.8
West	2,471,239	12.2%	403,493	6.1
North	1,726,370	9.3%	302,369	5.7
East	2,595,703	7.2%	757,369	3.4
* LAIS Area does not include water bodies, national parks, and roads *Source: NISR: POPULATION & HOUSING CENSUS, Nov 2012. Annex 1.*				

1.3 Natural Capital Accounting for Land: Rationale

The System of Environmental Economic Accounting (SEEA) provides the international statistical standard for environmental-economic accounts (SEEA UN Statistical Division, 2012. http://unstats.un.org/unsd/envaccounting/seea.asp). Environmental-economic accounts follow the same principles and standards as the System of National Accounts, which reports on the level of economic activity and employment for each sector. Environmental accounts are designed to use the same sector classification as the National Accounts, so that data on land, water, and environmental outcomes can be linked to information on economic activity, value-added, and employment for each sector. The SEEA framework highlights that land is central to

environmental-economic accounting. Land accounts consist of physical asset accounts (stocks of land), physical flow accounts (changes in land use and cover), and monetary accounts (values of land). Land accounts are a tool for monitoring and analyzing changes in land use, land cover, and land value and provide consistent data and evidence to inform both policies and potential investments, e.g., the impacts of urbanization, the sustainability of agriculture, and the extent of habitats for biodiversity conservation. Rwanda's LAIS provides an excellent data source for the development of land accounts.

In Rwanda, land is the basis for agriculture and rural livelihoods, but it faces pressures from population growth, the need for jobs, and rapid urbanization. Natural capital accounts for land can add value in planning for sustainable development by providing indicators and trend analysis to track performance toward targets for sustainability, land allocation, service delivery, and productivity. Land accounts can inform policy making about land availability and productivity, as well as potential constraints to agricultural growth, which is a key pillar of Rwanda's development agenda.

Land accounts can help Rwanda to track and compare trends concerning the economic values of land under different uses and to assess potential trade-offs systematically. Although sectoral level planning exists, better information and data sharing would help to ensure that individual sectoral targets do not contribute to cross-sectoral tensions or competing demands for the same land. Land trend information can also provide insights about potential implications of land use change on water usage or food production.

Land accounts can help to clarify and compare economic values generated by land in competing uses and how changes in land use may affect land value. Land accounts can help in the analysis of questions related to the impacts of land use change on productivity of key crops, production of fuel wood, or pressure on water resources (when linked to water accounts). Land accounts also help in the comparison of market values for land in different regions or under different uses. Land accounts contribute to understanding how sectors compare in terms of land use per value of output or intensity of use, or longer-term projections of productivity, resource use, or potential bottlenecks in land availability for national development objectives. Land accounts are an essential basis for an integrated approach, where land, water and ecosystem accounts can be used together in planning and assessing development trajectories. Rwanda's efforts to develop ecosystem accounts are described in Box 1, page 6.

1.4 Organization of the Document

This document represents Rwanda's first effort to compile Natural Capital Accounts for Land, based on data up to 2015. The data and tables in the report are available from NISR and the Ministry of Environment.

Box 1. Ecosystem Accounts Development by WCS / SNAPP Consortium

In 2015, the Wildlife Conservation Society and a consortium of partners under the Science for Nature and People Partnership (SNAPP) set up an Expert Working Group to support Rwanda's development strategy and international initiatives in natural capital accounting. Its aim is to support policymaking that factors in Rwanda's natural capital in a multi-disciplinary fashion to address challenges in nature conservation, economic development, and human well-being. This effort includes a valuation of natural capital and an assessment of ecosystem services—as well as a special focus on Nyungwe Forest National Park and the Rugezi wetlands—with the goal of integrating the value of ecosystem services into the System of National Accounts.

As with the land, water, and mineral accounts being prepared with the support of the WAVES Global Partnership, these efforts focus on the government's key priorities as outlined in EDPRS 2 and Vision 2020. The ecosystems, land, and water accounts are expected to be used in an integrated manner to improve the understanding of the contribution of natural resources and ecosystem services to the economy.

Further integration of the work on land, water and ecosystems can yield multiple insights, including on the value of land, alternative land use options around protected areas, impacts of land degradation on critical ecosystems and ecosystem services, costs and benefits of conservation easements around protected areas, impacts on water funds – all of which will be useful in Rwanda's development planning process. Collaboration toward greater integration of the land, water and ecosystem accounts is being facilitated through technical working groups and through Rwanda's NCA Steering Committee, which guides all related initiatives.

This document reports on land use, land cover, and the monetary value of land (interim results only). Each of these aspects provides a different perspective on issues and challenges. Land Use Accounts can provide consistent information to assess trends in uses of land across sectors, especially competing uses and their associated trade-offs. Land Cover Accounts improve the ability to understand and monitor changes in forest cover, agricultural activity, and urbanization, and the ability to estimate and model changes in ecosystem services, such as water run-off, sedimentation, carbon sequestration, and similar indicators. Monetary Accounts can indicate how and where land values are changing and what factors contribute to these changes. Eventually, comprehensive land accounts can inform decisions on issues related to land conservation and restoration, agricultural development and crop choices, planted forest and agroforest development, and soil erosion and fertility, among other issues.

Chapter II discusses land use and change during the period 2014 to 2015. Chapter III reports on land cover and change for the years 1990, 2000, 2010 and 2015. Chapter IV provides introductory information on the value of land parcel transactions in 2014 and 2015. Chapter V summarizes issues and implications that arose during the development of the land accounts. The Government of Rwanda expects to update these land accounts at regular intervals. Stakeholder comments will be helpful to guide future refinements of the data and analysis.

CHAPTER II: Land Use and Changes

2.1 Land Administration Data and Analysis

The Government of Rwanda promotes a national land tenure regularization program and has established a Land Use Development Master Plan (Republic of Rwanda 2011b). The Master Plan provides national guidelines for the better use and management of land and supports the rational, efficient, equitable and sustainable use of the country's limited land resource. The country's land program aims to ensure that all rightful landholders receive legally valid land title documents and seeks to minimize disputes over land ownership. To support the implementation and management of this comprehensive land registration program, the Government developed the Land Administration Information System (LAIS), which was put into place in 2012. LAIS aims to systematize land registration and maintains up-to-date data and records on land parcels, size, location, ownership, and other factors. The system is maintained and updated regularly as land transactions are recorded. The current LAIS built on and replaced the Land Tenure Regularisation Support Programme (LTRSP), which began in 2009 and ran until January 2013.

LAIS covers 11 million parcels of land, or 2.07 million hectares (ha). All owned parcels have been registered and efforts continue to improve and refine their description and classification. LAIS land use information originates from the field observation made during the LTRS Program and updates are informed by land use plans. As of March 2012, 97 % of the land in the country had been demarcated and adjudicated (Warnest et al. 2012). Rwanda's national territory is 2.49 million ha, including inland water bodies (160,508 ha), natural parks (258,067 ha), and areas of public infrastructure, such as roads. These areas are not included in LAIS, because they are not part of the national land registration system. These areas are mentioned in summary tables for the sake of completeness, but they are not analyzed in detail.

LAIS is the primary data source for the development of the Natural Capital Accounts for Land, particularly the land use data analyzed in this chapter. LAIS data for the period of 2012 to 2015 was examined in the course of developing these accounts. However, due to differences in the precision of early records from when LAIS was initiated, the years 2012 and 2013 were not included in this analysis due to issues of coverage and consistency. Although all land parcels are registered, not all have been fully classified into specific sectors. Before 2014, the share of parcels with land use categorized as "unclassified" was relatively high and the main changes in records in those years were related to the regularization and final categorization of these parcels into specific land uses; LAIS also had incomplete coverage of all provinces. Thus, before 2014, many changes appearing in the LAIS database were related to the administrative process of updating the classifications, not actual changes happening on the ground.[2]

Through campaigns and fieldwork beginning in 2014, the Government's land team succeeded in reducing the share of unallocated parcels—with further reductions in 2015—so that there now

[2] To examine issues of land use changes prior to 2014, analysts could develop a sample of parcels from 2012 and 2013 (excluding 'unclassified' land use) to compare with the 2014-15 coverage. This sampling analysis could provide some insights into land use change over a longer period, if desired in specific areas.

exists a more consistent basis for tracking land use changes and trends over time. For these reasons this Land Accounts document reports results for 2014 and 2015 and discusses land use changes within that period. With improving data and methods in place for continuing analysis, future Land Accounts will have a longer data time series available for analysis of trends. Additional information on methodology is included in Annex B.

2.2 Land Uses and Changes, National Level, 2014 and 2015

LAIS records agriculture as having the largest share of land use across the country, followed by Forestry, Residential, and Livestock. This section summarizes overall land use changes as recorded during 2014 and 2015 in LAIS, which tracks data on land use, ownership, location, and parcel size for about 2.07 million hectares of Rwandan land. LAIS includes 13 land use categories, including the one for unclassified areas (which are being progressively re-allocated to the 12 main land uses). For ease of presentation, and based on analysis of the data in LAIS, this report focuses on the six categories that make up 98 % of land use, shown in Table 2 (on page 8, at right). The remaining seven land use categories are grouped into "others." These "other" seven land uses represent only 2.2 % of all land uses, including: Administrative, Commercial, Economic, Fishing, Research/ Scientific, Social and Culture, and Tourism. The primary data tables, land use change matrices and annexes available for download include all the LAIS categories. Some of the figures and tables in this report are simplified to allow greater focus on the main land uses and how they are changing. The table at right summarizes the categories presented in this report and their relation to the primary LAIS categories.

Table 2: ***Major Land Use Categories and Share of Total Land Use in Rwanda, 2014***

LAIS Land Use Categories	Share of Total Land Use
Agriculture	60.6%
Forestry	9.3%
Industrial	0.2%
Livestock	5.7%
Residential	8.5%
Unclassified	13.5%
"Others"	2.2%
"Others" combines: Administrative, Commercial, Economic, Fishing, Research/ Scientific, Social and Culture, Tourism	

Table 3 (on page 9) and Source: Land Administration Information System

Table 4 **(on page 9), summarize net positive and negative changes in land use for 2014 and 2015.** On the following pages, the Land Use Change Matrices for each year allow examination of land use changes among categories. The organization and compilation of these land use change matrices (for the whole country and at the provincial and district levels for 2014 and 2015) is an important milestone towards implementing the Land Accounts. The matrices show the changes in land use for each year, mapping changes from one category to another. These tables will be available for download with the final publication.

Table 3: ***Rwanda Land Use Change by Land Use Category, National Level, 2014***

	Area & Change Measures	Agriculture	Forestry	Industrial	Livestock	Residential	Unclassified	Others	Totals
National Level-2014	Opening 2014	1,242,363	190,612	3,490	120,445	157,742	309,262	45,634	2,069,548
	Closing 2014	1,251,181	193,406	3,370	118,583	159,817	297,509	45,683	2,069,548
	Net Changes (Ha)	8,818	2,794	-120	-1,862	2,075	-11,753	49	0
	Net Changes (%)	0.710%	1.466%	-3.444%	-1.546%	1.315%	-3.800%	0.107%	0

Source: Land Administration Information System

Table 4: ***Rwanda Land Use Change by Land Use Category, National Level, 2015***

	Area & Change Measures	Agriculture	Forestry	Industrial	Livestock	Residential	Unclassified	Others	Totals
National Level-2015	Opening 2015	1,251,181	193,406	3,370	118,583	159,817	297,509	45,683	2,069,548
	Closing 2015	1,253,305	193,429	3,218	118,579	176,013	279,285	45,720	2,069,548
	Net Changes (Ha)	2,124	23	-152	-4	16,196	-18,224	37	0
	Net Changes (%)	0.170%	0.012%	-4.522%	-0.003%	10.134%	-6.126%	0.082%	0

Source: Land Administration Information System

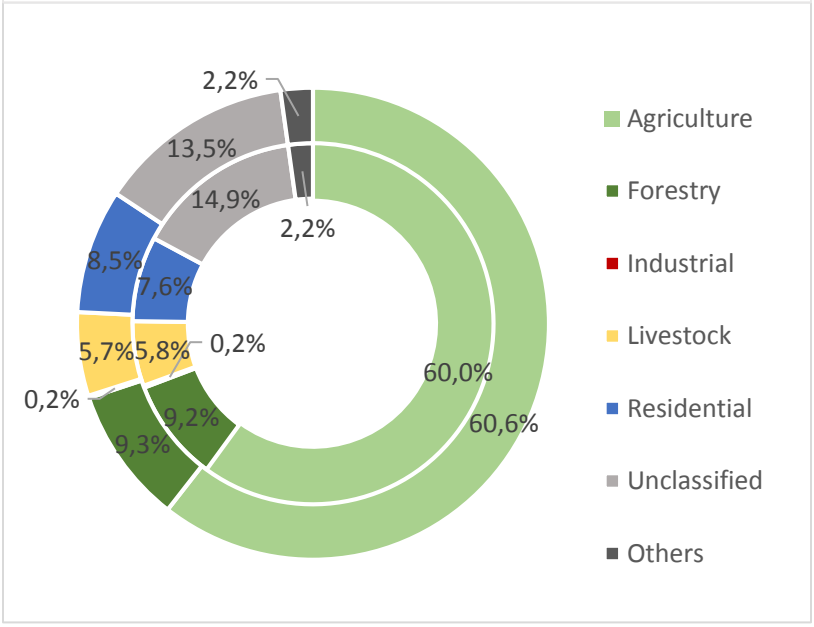
Analysis of the tables above and of the land use change matrices on the following pages indicates that from 2014 to 2015 the land uses that gained the most additional area were Residential and Agriculture. The smallest gainers were Fishing and Tourism, which are grouped into the "others" category. The land uses that lost area over this period were Livestock, Research/Scientific, Industrial and Economic. However, these losses were quite small, less than 2,000 ha overall.

The tables show that there are relatively large changes in administrative designation from unallocated to other uses. Most land that was unallocated in 2013 was re-categorized into agriculture, residential, or forestry in 2014, with further changes in 2015.

Regarding actual changes in land use from one category to another the Land Use Change Matrices show that these are relatively minor. For example, the LAIS data does not show major movement from agricultural land uses into commercial, economic, or urban land uses. However, it is important to note that LAIS tracks land records, but may not match clearly with what is observed in parcels on the ground. Land classified as residential may have more or fewer buildings and construction. Likewise, land classified as agricultural may have buildings or residences constructed on a portion of the parcel. LAIS was designed to improve land registration and tenure, not primarily to record or analyze the economic uses of land. It is, however, an excellent tool for many kinds of analysis.

Land Use Shares. Figure 2 (on page 10, at right), shows each land use category's share of area in 2014 and 2015. In LAIS, about 70 % of Rwanda's land is in agriculture and forestry uses. While residential and industrial land uses are changing rapidly, they currently represent relatively small shares of overall land use. Later in the chapter, these administrative classifications of land use will be compared with biophysical land cover data based on remote sensing and interpretation. This can give some indication of how closely LAIS administrative classifications track with observable land cover information. For example, actual forest cover as measured by remote sensing can be expected to be higher than reported in LAIS, because national protected areas are not recorded in LAIS, and because, within LAIS, some tree-covered areas may be designated as agriculture or commercial land uses. An analysis of forest cover (distinct from land use) from different sources, and based on differing definitions, is provided in Section 3.2 on page 36 of this report.

Figure 2: ***Overall Land Use, National Level: Opening Stock 2014, Closing Stock 2015***



Physical Asset Accounts. Table 5 (on page 11) shows the land use data in the SEEA format for land asset accounts. This format shows the aspiration to complete a physical asset table in future versions of this report. It will be useful in future iterations to distinguish between changes due to the classification of previously unclassified land use and changes that represent genuine change in land use. With additional years of data – and particularly, after the unclassified areas have been reclassified – it will be more relevant and feasible to track expansions, reappraisals, and regression.

Table 5: ***Physical Asset Accounts for Land Use, National Level, 2015 (in hectares)***

		Additions to stock (ha)				Reduction in stock (ha)					
Land Use	**Opening stock of resources (ha)**	**Managed Expansion (a)**	**Natural Expansion (a)**	**Upward reappraisals (a)**	**Total additions to stock (ha)**	**Managed Expansion (a)**	**Natural Expansion (a)**	**Upward reappraisals (a)**	**Total reductions in stock (ha)**	**Closing Stock of resources (ha)**	**Net Change (ha)**
Administrative	6,908				6				394	6,520	-388
Agriculture	1,251,181				9,501				7,377	1,253,305	2,124
Commercial	8,340				120				96	8,364	24
Economic	10,615				60				128	10,548	-68
Fishing	119				8				-	127	8
Forestry	193,406				922				899	193,429	23
Industrial	3,370				189				341	3,218	-152
Livestock	118,583				1,308				1,312	118,579	-4
Research/Scientific	10,413				47				109	10,351	-62
Residential	159,817				16,657				461	176,013	16,196
Social and culture	8,361				506				61	8,806	445
Tourism	927				86				8	1,005	78
Unclassified (b)	297,509				315				18,539	279,285	-18,224
Totals	**2,069,548**				**29,726**				**29,726**	**2,069,548**	-

Source: Rwanda Land Administration and Information System 2015.
Note: (a) These classes have not been populated due to lack of data on the reasons for change. The headings have been included to show the categories to be covered in a more complete physical account table; (b) No land use information available.

Land Use Change Matrix. The Land Use Change Matrices for 2014 (Table 6, on page 13) and 2015 (Source*: Land Administration Information System*

Table 7, on page 13) are shown on the following pages. These matrices are an important milestone in the development of the land accounts. These matrices show changes from one land use into another. These tables, on the following pages, include the full set of 13 land uses available in LAIS. All LAIS land use categories appear on the horizontal and the vertical axes. The table shows the opening stock by land use category at the left. Beginning at the left-most column, and continuing across the row, the table shows net increases (positive numbers) and net decreases (negative numbers) from each other land use category moving across the row to the right. The right column records the total net change for the category. The final column indicates the closing stock of land in the category (opening stock plus net change) at the end of the period. Take "agriculture", in the second row, as an example. In 2014 the category begins with 1.2 million ha, loses (negative) 1,251 ha to forest, and gains (positive) 10,657 ha from the "unclassified" category.

The sum of rows should equal the sum of columns such that all land use changes flow from one category and end up in another category, such that the net change is zero for the whole country. The diagonal band of blank, grey cells across the table indicates where the land use is mapped to itself, hence no net change. As additional years are considered in the land use accounts, these land use change matrices will be an important analytical tool for examining the dimensions and directions of land use change in Rwanda.

Table 6: ***Land Use Net Change Matrix, National Level, 2014 (in hectares)***

Land Use	Opening stock, area(ha) time 1	RWANDA LAND USE CHANGE MATRIX 2014 Net increases (positive numbers) and decreases (negative numbers) from other land uses, time 1 to time 2															Closing Stock - Opening Stock	Closing stock, area (ha) time 2	Net change
		Administrative	Agriculture	Commercial	Economic	Fishing	Forestry	Industrial	Livestock	Research/ Scientific	Residential	Social and culture	Tourism	Unclassified (a)	Inland water bodies	Nature parks	Infrastructure			
Administrative	6,713.88			-0.02	0.06		-14.93			11.22	2.95	-1.44		196.38				194.20	6,908.08	194.20
Agriculture	1,242,362.94			2.34	150.12		-1,246.63	495.51	-103.61	76.11	-1,182.54	-29.78	-1.16	10,657.45				8,817.82	1,251,180.76	8,817.82
Commercial	8,311.50	0.02	-2.34		1.55		-1.31	-5.47	9.95	0.26	-7.00	-7.13		40.39				28.92	8,340.42	28.92
Economic	10,754.16	-0.06	-150.12	-1.55			1.79	-0.90			-3.16	-10.77	-0.48	26.24				-139.00	10,615.16	-139.00
Fishing	121.24													-2.07				-2.07	119.16	-2.07
Forestry	190,611.82	14.93	1,246.63	1.31	-1.79			-5.48	-26.48	1.48	-44.94	-6.00	0.13	1,614.05				2,793.82	193,405.64	2,793.82
Industrial	3,490.43		-495.51	5.47	0.90		5.48		5.44		-1.19			359.21				-120.20	3,370.23	-120.20
Livestock	120,444.78		103.61	-9.95			26.48	-5.44			73.42			-2,050.25				-1,862.13	118,582.65	-1,862.13
Research/Scientific	10,689.80	-11.22	-76.11	-0.26			-1.48				1.09	18.15		-207.42				-277.24	10,412.55	-277.24
Residential	157,741.69	-2.95	1,182.54	7.00	3.16		44.94	1.19	-73.42	-1.09		-33.06	-7.75	954.50				2,075.05	159,816.74	2,075.05
Social and culture	8,190.75	1.44	29.78	7.13	10.77		6.00			-18.15	33.06		1.80	98.00				169.83	8,360.58	169.83
Tourism	852.46		1.16		0.48		-0.13				7.75	-1.80		66.67				74.14	926.60	74.14
Unclassified (a)	309,262.12	-196.38	-10,657.45	-40.39	-26.24	2.07	-1,614.05	-359.21	2,050.25	207.42	-954.50	-98.00	-66.67					-11,753.13	297,508.99	-11,753.13
Total LU (demarcated)	2,069,547.58	-194.20	-8,817.82	-28.92	139.00	2.07	-2,793.82	120.20	1,862.13	277.24	-2,075.05	-169.83	-74.14	11,753.13	-	-	-	0.00	2,069,547.58	0.00
Inland water bodies	160,508.42																		160,508.42	
Nature parks	258,066.60																		258,066.60	
Infrastructure																				
Total area Rwanda	2,488,122.60																		2,488,122.60	

Source: Land Administration Information System

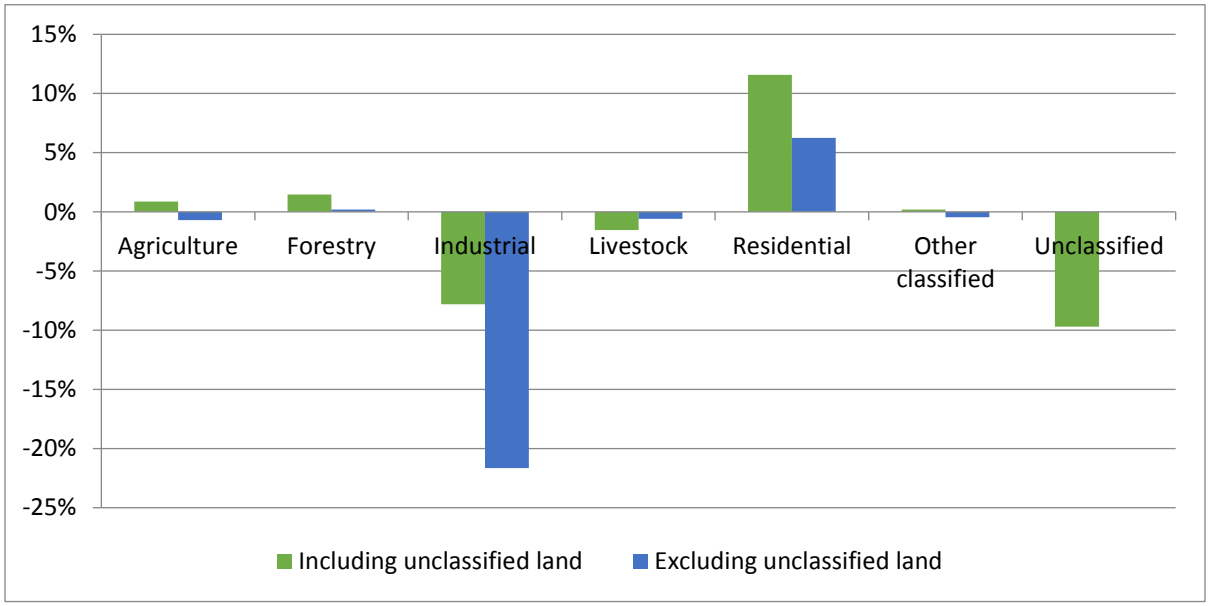
Table 7: ***Land Use Net Change Matrix, National Level, 2015 (in hectares)***

Land use	Opening stock, area(ha) time 1	RWANDA LAND USE CHANGE MATRIX 2015 Net increases (positive numbers) and decreases (negative numbers) from other land uses, time 1 to time 2															Closing Stock - Opening Stock	Closing stock, area (ha) time 2	Net change
		Administrative	Agriculture	Commercial	Economic	Fishing	Forestry	Industrial	Livestock	Research/Scientific	Residential	Social and culture	Tourism	Unclassified (a)	Inland water bodies	Nature parks	Infrastructure			
Administrative	6,908.08		3.40	-1.24							-7.48	-0.11	-67.54	-315.44				-388.41	6,519.67	-388.41
Agriculture	1,251,180.76	-3.40		-4.46	76.92		-24.85	262.49	-283.14	-19.34	-6,578.49	-97.61	-1.66	8,797.65				2,124.11	1,253,304.87	2,124.11
Commercial	8,340.42	1.24	4.46		1.92		2.24	-2.29	2.74		-54.02	1.92		65.70				23.91	8,364.33	23.91
Economic	10,615.16		-76.92	-1.92			-2.03				-44.27	-0.93		58.42				-67.65	10,547.51	-67.65
Fishing	119.16													7.75				7.75	126.91	7.75
Forestry	193,405.64		24.85	-2.24	2.03			-0.51	-26.57	-4.64	-815.45	-7.44	0.89	852.12				23.04	193,428.68	23.04
Industrial	3,370.23		-262.49	2.29			0.51		0.44	0.31	-14.94	-2.08		123.56				-152.40	3,217.83	-152.40
Livestock	118,582.65		283.14	-2.74			26.57	-0.44			-1,216.85			906.40				-3.92	118,578.73	-3.92
Research/Scientific	10,412.55		19.34				4.64	-0.31			-76.10	-18.80		9.69				-61.54	10,351.01	-61.54
Residential	159,816.74	7.48	6,578.49	54.02	44.27		815.45	14.94	1,216.85	76.10		-77.71	1.39	7,464.62				16,195.90	176,012.64	16,195.90
Social and culture	8,360.58	0.11	97.61	-1.92	0.93		7.44	2.08		18.80	77.71		1.08	241.19				445.03	8,805.61	445.03
Tourism	926.60	67.54	1.66				-0.89				-1.39	-1.08		12.36				78.20	1,004.80	78.20
Unclassified (a)	297,509.01	315.44	-8,797.65	-65.70	-58.42	-7.75	-852.12	-123.56	-906.40	-9.69	-7,464.62	-241.19	-12.36					-18,224.02	279,284.99	-18,224.02
Total LU (demarcated)	2,069,547.58	388.41	-2,124.11	-23.91	67.65	-7.75	-23.04	152.40	3.92	61.54	-16,195.90	-445.03	-78.20	18,224.02	-	-	-	0.00	2,069,547.58	0.00
Inland water bodies	160,508.42																		160,508.42	
Nature parks	258,066.60																		258,066.60	
Infrastructure																				
Total area Rwanda	2,488,122.60																		2,488,122.60	

Source: Land Administration Information System

Rate of Change in Land Use. Figure 3 (on page 14, below) shows the rate of change by land use category. It shows that the efforts by the Government's Lands and Mapping Department continue to decrease the area of unclassified land; this area declined by almost 10 % from the beginning of 2014 to the end of 2015. Of the land where the use has been classified, agriculture accounts for some 70 %, a percentage largely unchanged during the two years covered by these accounts. However, while other sectors' share of overall land use remained small in most cases, residential land use has experienced rapid growth over the two-year period. Some of this was due to the reclassification of previously unclassified land (about 5 % of the total). There was also a 6 % change when only including already classified land in the analysis. Industrial land use is a small share of the total, but the rate of change over the two-year period is substantial: a tenth of the land designated for industrial land use at the beginning of 2014 had been reallocated to other land uses by the end of 2015. Even if reclassification of previously unclassified land is included, this sector's overall land use shrank during the period.

Figure 3: ***Rate of Change by Land Use Category, Beginning in 2014 – Ending in 2015***



Based on the land use change matrices for the two years, the "unclassified" category is the main source of additions of area to other land uses. Apart from shifts away from the "unclassified" land category, the main change during 2014 was that agricultural land uses were being reclassified into forestry and residential use. The main change during 2015 was agricultural, forestry, and livestock land uses being reclassified into residential use. The impacts on the source sectors was minor in both years but, given the small initial size of the residential sector, these changes led to a relatively large increase in land classified as residential.

2.3 Land Uses and Changes, Provincial Level, 2014 and 2015

Overview. This section provides tables and graphics that describe the state and change of land use by province (Table 8 for 2014, on page 16, below; Table 9 for 2015, on page 17). This analysis is derived from the land use change matrices that are available at the national and regional levels. These detailed matrices can be found as annexes to the main document and are available for download from the NISR and Ministry of Environment websites.

Table 8: ***Rwanda Land Use Change by Land Use Category, Provincial Level, 2014***

		Land Uses (defined by LAIS)							
Province	**Area & Change Measures**	**Agriculture**	**Forestry**	**Industrial**	**Livestock**	**Residential**	**Unclassified**	**Others**	**Totals**
Kigali City-2014	Opening 2014	39,942	5,065	217	1,041	10,123	10,045	3,328	69,761
	Closing 2014	38,816	4,990	282	953	10,390	10,922	3,407	69,761
	Net Changes (Ha)	-1,126	-75	65	-88	267	877	79	0
	Net Changes (%)	-2.8%	-1.5%	30.2%	-8.4%	2.6%	8.7%	2.4%	0.0%
Southern Province-2014	Opening 2014	326,781	63,465	299	1,156	29,421	111,233	4,200	536,556
	Closing 2014	335,621	65,459	516	1,198	30,191	99,033	4,537	536,556
	Net Changes (Ha)	8,840	1,994	217	42	770	-12,200	337	0
	Net Changes (%)	2.7%	3.1%	72.4%	3.6%	2.6%	-11.0%	8.0%	0.0%
Western Province-2014	Opening 2014	234,049	52,620	2,715	7,097	36,884	55,953	14,175	403,493
	Closing 2014	236,588	52,269	2,294	6,415	36,448	55,780	13,701	403,493
	Net Changes (Ha)	2,539	-351	-421	-682	-436	-174	-475	0
	Net Changes (%)	1.1%	-0.7%	-15.5%	-9.6%	-1.2%	-0.3%	-3.3%	0.0%
Northern Province-2014	Opening 2014	212,386	31,012	85	1,145	17,534	37,022	3,187	302,369
	Closing 2014	211,939	31,006	87	1,161	18,529	36,416	3,231	302,369
	Net Changes (Ha)	-447	-6	2	16	995	-605	44	0
	Net Changes (%)	-0.2%	0.0%	2.5%	1.4%	5.7%	-1.6%	1.4%	0.0%
Eastern Province-2014	Opening 2014	429,205	38,450	174	110,006	63,780	95,009	20,744	757,369
	Closing 2014	428,217	39,682	191	108,856	64,259	95,357	20,806	757,369
	Net Changes (Ha)	-988	1,233	16	-1,150	479	348	62	0
	Net Changes (%)	-0.2%	3.2%	9.3%	-1.0%	0.8%	0.4%	0.3%	0.0%

Source: Land Administration Information System

Table 9: ***Rwanda Land Use Change by Land Use Category, Provincial Level, 2015***

		Land Uses (defined by LAIS)							
Province	**Area & Change Measures**	**Agriculture**	**Forestry**	**Industrial**	**Livestock**	**Residential**	**Unclassified**	**Others**	**Totals**
Kigali City-2015	Opening 2015	38,816	4,990	282	953	10,390	10,922	3,407	69,761
	Closing 2015	38,955	5,005	372	1,015	11,515	9,373	3,526	69,761
	Net Changes (Ha)	139	15	89	62	1,125	-1,549	119	0
	Net Changes (%)	0.4%	0.3%	31.7%	6.5%	10.8%	-14.2%	3.5%	0.0%
Southern Province-2015	Opening 2015	335,621	65,459	516	1,198	30,191	99,033	4,537	536,556
	Closing 2015	343,305	66,342	561	1,313	34,709	85,702	4,625	536,556
	Net Changes (Ha)	7,683	882	45	115	4,518	-13,331	88	0
	Net Changes (%)	2.3%	1.3%	8.7%	9.6%	15.0%	-13.5%	1.9%	0.0%
Western Province-2015	Opening 2015	236,588	52,269	2,294	6,415	36,448	55,780	13,701	403,493
	Closing 2015	232,118	51,703	1,971	5,262	46,915	52,086	13,439	403,493
	Net Changes (Ha)	-4,470	-565	-323	-1,153	10,467	-3,694	-262	0
	Net Changes (%)	-1.9%	-1.1%	-14.1%	-18.0%	28.7%	-6.6%	-1.9%	0.0%
Northern Province-2015	Opening 2015	211,939	31,006	87	1,161	18,529	36,416	3,231	302,369
	Closing 2015	212,200	31,064	108	1,175	18,575	35,960	3,287	302,369
	Net Changes (Ha)	261	59	21	14	46	-457	56	0
	Net Changes (%)	0.1%	0.2%	23.9%	1.2%	0.2%	-1.3%	1.7%	0.0%
Eastern Province-2015	Opening 2015	428,217	39,682	191	108,856	64,259	95,357	20,806	757,369
	Closing 2015	426,728	39,315	206	109,814	64,299	96,164	20,843	757,369
	Net Changes (Ha)	-1,489	-368	16	958	40	807	37	0
	Net Changes (%)	-0.3%	-0.9%	8.1%	0.9%	0.1%	0.8%	0.2%	0.0%

Source: Land Administration Information System

Figure 4 (on page 18) shows the total hectares recorded in LAIS, by province, for each land use at the end of 2015. Agricultural land use dominates in all provinces, even Kigali City. The Eastern Province is the largest and has the highest amount of agricultural and livestock land uses. The Southern and Western Provinces have a larger land area allocated to forestry. The Eastern Province has relatively more land allocated to livestock.

Figure 4: ***Overall Land Use – Provincial Comparison, Closing Stock 2015***

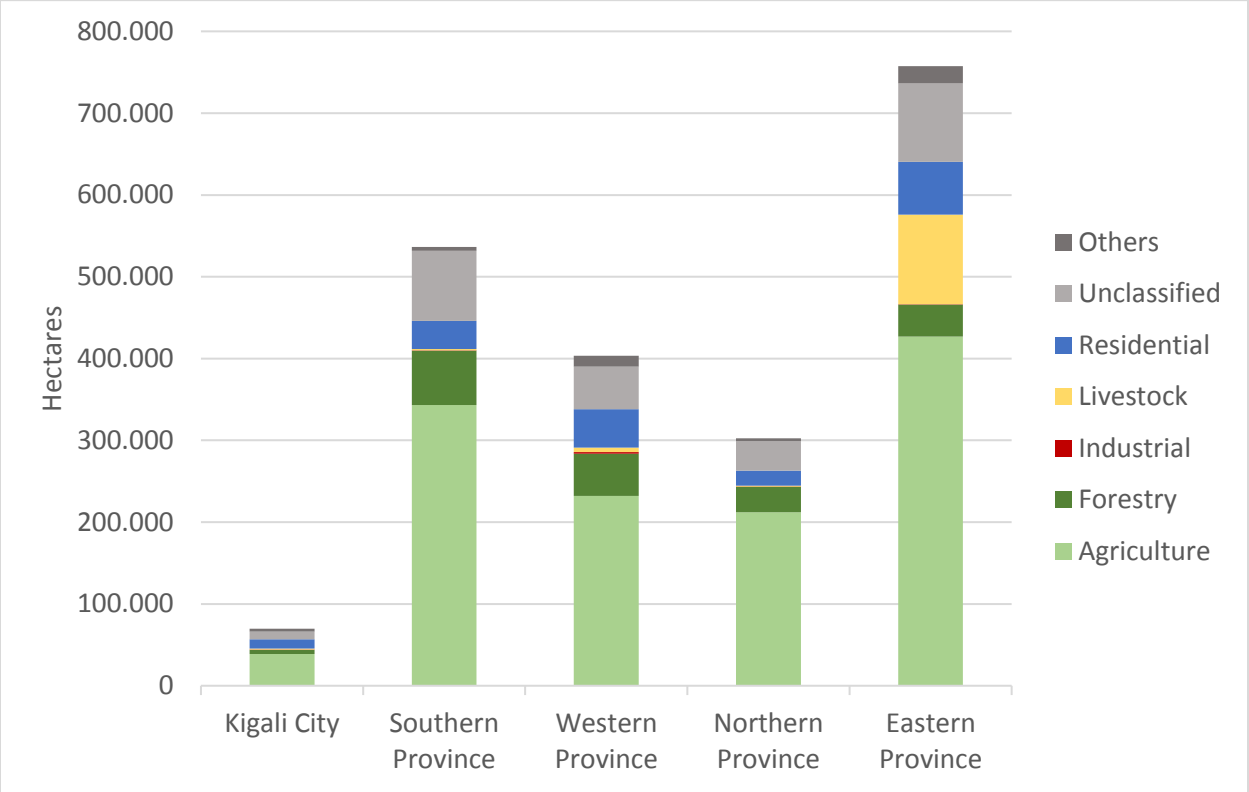
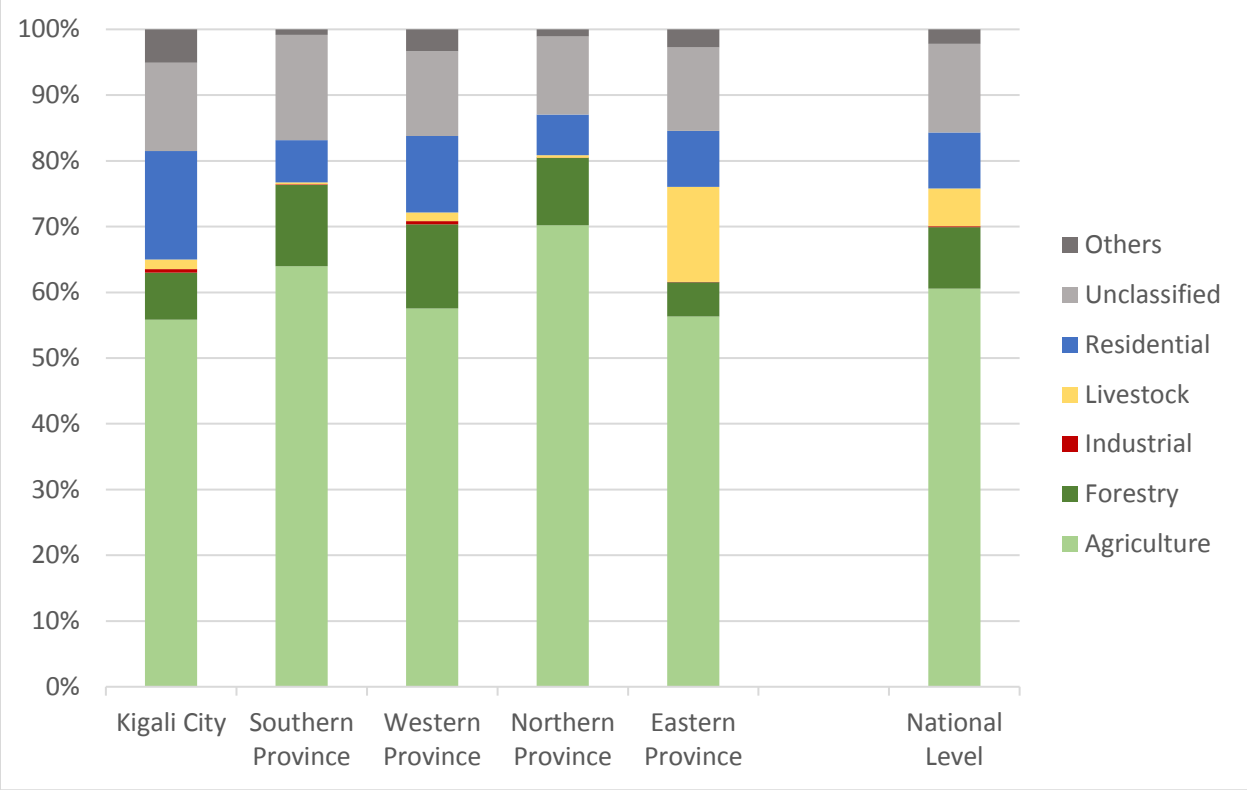


Figure 5 (on page 19) shows these data in shares. This analysis offers a different perspective, shedding additional light on the situation in Kigali City, which has a smaller land area relative to the other provinces. Kigali has a greater share of its land allocated to residential area, as would be expected from a major city, but, surprisingly, maintains substantial land usage in agriculture and forestry. There is only a small portion of land allocated to "industrial" land use, reflecting that these types of activities do not use large areas of land. Note the light grey area of "unclassified" land. This indicates that 10 to 15 % of the land registered in LAIS is still in the process of being assigned a land use. As this classification process is completed, the understanding of land use across Rwanda will improve and this analysis can be updated.

Figure 5: ***Overall Land Use Shares, National and Provincial Level Comparison, Closing Stock 2015***

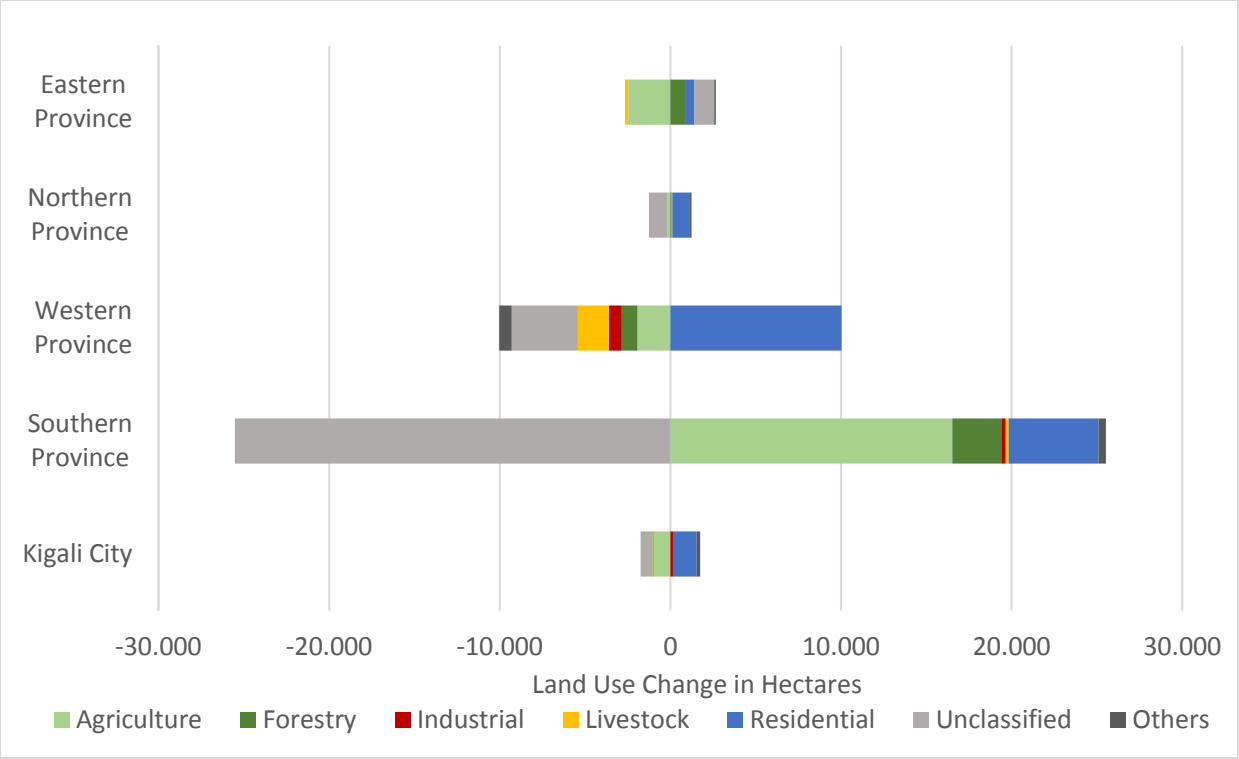


Designation of Unclassified Areas/Parcels. The "unclassified" group is an important category when considering land use change, as reported in these tables and in the overall land use change matrix. Most recorded "changes" are not physical shifts from one land use to another, but administrative moves from an unclassified state into a classified, or known, state based on examination of the case. The following figure, Figure 6 (on page 20) shows, by province, where land use shifts are coming from (negative numbers) and where they are moving to (positive numbers). Most changes in the land use designations in LAIS result from parcels moving from an unclassified condition to a known land use category.

From the beginning of 2014 to the end of 2015, about 30,000 hectares were reclassified in LAIS from the “unclassified” category to a known land use designation. Of these, 25,500 hectares – or 85 % – were in the Southern Province. These hectares were reclassified mainly as Agriculture (65 %), Residential (21 %) and Forestry (11 %). Thus, most of the net changes in land uses recorded in LAIS can be explained by this large effort to designate unclassified areas into a known land use, particularly in the Southern Province in 2014 and 2015. Other provinces may have already been relatively complete in prior years. A larger area of agricultural and forestry land was reclassified in 2014 (almost 11,000 ha), while more residential land was reclassified in 2015 (4,500 ha). This reclassification process is part of the ongoing agenda of the Land Department at the Rwanda Land Management and Use Authority (and formerly under RNRA).

Figure 6 also shows that some areas have been reclassified from an existing land use into another, with small amounts in the Eastern and Western Provinces. These changes may reflect actual physical shifts in land use, but they are small (less than 10,000 ha in total) relative to the administrative reclassifications that have been discussed.

Figure 6: ***Net Changes in Land Use, National and Provincial Levels, 2014-2015***



Province Level Discussion. Based on an examination of the Physical Asset Accounts for Land Use for 2014 and 2015, the following brief findings can be summarized. Additional detail within provinces and at the district level can be found in the annexes and documentation on the website. Table 10 (on page 21) starts off by showing land use shares at the national and provincial levels for year 2015.

Table 10: ***Land Use Shares - National and Provincial Level, 2015***

	Agriculture	Forestry	Industrial	Livestock	Residential	Unclassified	Others	Total
Kigali City	55.8%	7.2%	0.5%	1.5%	16.5%	13.4%	5.1%	100%
Southern Province	64.0%	12.4%	0.1%	0.2%	6.5%	16.0%	0.9%	100%
Western Province	57.5%	12.8%	0.5%	1.3%	11.6%	12.9%	3.3%	100%
Northern Province	70.2%	10.3%	0.0%	0.4%	6.1%	11.9%	1.1%	100%
Eastern Province	56.3%	5.2%	0.0%	14.5%	8.5%	12.7%	2.8%	100%
National Level	60.6%	9.3%	0.2%	5.7%	8.5%	13.5%	2.2%	100%

Kigali City. Despite the urban character of Kigali, greater than half of its area is classified as agricultural land use. Adding in forestry and livestock land uses brings the share to almost two-thirds. These proportions remained largely unchanged during 2014 and 2015. Another 16.5 % of the land is classified as residential and 13 % is unclassified. The main change in land use in the province during 2014 and 2015 was agricultural land being reclassified as residential. Residential land use represents only one-sixth of all land use in Kigali, but it is the fastest growing category. This increase is due to two changes. First, about 8 % of the additions came from re-categorization from the unclassified group. Second, about 6 % of the addition came from reclassification of existing land uses.

Southern Province. In Southern Province agriculture represents about 64 % of land use, while forestry represents another 12.4%%. Only 6.5 % of the land was classified as residential at the end of 2015, with another one-sixth of the land remaining to be classified. This province saw very small land use changes in 2014, apart from previously unclassified land becoming classified as agricultural or forest land. The same types of reclassifications were important in 2015, but this year also saw residential areas expanding, with sizeable tracts of agricultural and unclassified land being reclassified to residential. Total residential land area increased by 2.6% in 2014 and another 15% in 2015 (see Table 9) – about a third of this consisted of reclassification from existing land uses and the remainder was due to classification of previously unclassified land. Due to these two types of changes, Southern Province has a slightly faster growth rate in its residential area than Kigali Province.

Western Province. In Western Province, more than two thirds of the land is classified as agriculture or forestry. This province saw the fastest changes in land use, with several percentage points of the province's overall area being reclassified during the period. Growth in the area of residential land accounted for most of the change in land use: about 4,500 hectares were moved from agriculture into residential use and 3,700 hectares of unclassified land were reclassified as residential. This means that the province's residential land use increased by 28 % from its base of about 36,000 ha. These changes took place during 2015, as its residential land area shrank slightly during 2014. Western Province had the fastest growth rate in residential land use in the country

during this period, as well as accounting for over half of the country's increase in residential land use in total hectares.

Northern Province. Northern Province saw only small land use changes during the period. Over two-thirds of the land in the province is classified as agricultural, and neither share nor area changed noticeably during the period. Other than some agricultural and unclassified lands being reclassified as residential, there were few shifts in land use over the period. Even with these reclassifications, growth in residential land was the second lowest in the country after that of Eastern Province.

Eastern Province. The Eastern Province also saw only small changes in land use during 2014 and 2015. Agriculture dominates the province, with agricultural and livestock land uses accounting for over 70 % of all land use. Eastern Province has over 100,000 ha designated to livestock, or about ten times more than all the other provinces combined. Land in the unclassified group increased somewhat during the period, mostly owing to large livestock areas becoming re-designated. Although some agricultural land was reclassified for forestry during 2014 and much unclassified land was reclassified to specified uses, overall land use patterns remained largely unchanged. This includes residential land use, which remained largely unchanged during 2014 and 2015—the only province for which this was the case.

An analysis of land use change at the provincial and district levels can be found in Annex A. The Annex presents tables for all provinces and districts and examines district level changes in land use for each province, illustrating the power of this approach and the breadth of information contained within the LAIS database.

2.4 Analysis of Changes in Parcel Size

Rwanda has ongoing policies aimed at combating land fragmentation by maintaining or increasing average plot size, particularly in the agriculture sector. Although this is not the main thrust of the work on Natural Capital Accounting, the LAIS database lends itself to analysis of a wide range of land-related questions. Recognizing that the two-year period of this Land Accounts document does not allow analysis of long term trends, an early analysis was conducted to explore trends by location and type of land use.

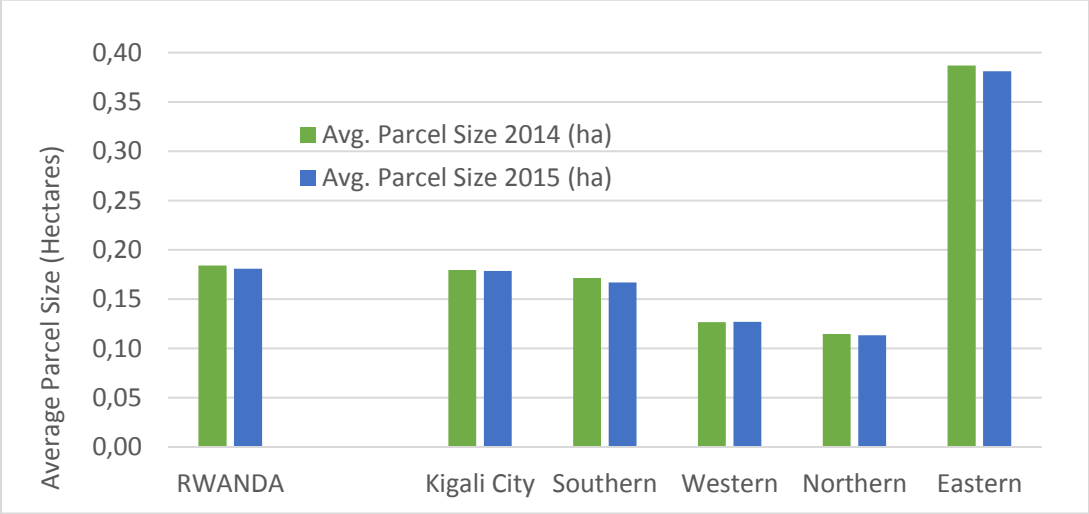
Analysis by Location. The following table (Table 11, on page 23) shows that average parcel sizes are small across all of Rwanda. However, plots in the East are about twice as large as the national average, while plots in the North are about 60 % the size of the national average.

Table 11: ***Average Parcel Size by Province, 2014 and 2015***

Location	No. of parcels 2014	Area (ha) 2014	No. of parcels 2015	Area (ha) 2015	Avg. parcel size 2014 (ha)	Avg. parcel size 2015 (ha)
RWANDA	11,121,853	2,045,643	11,420,044	2,066,577	0.184	0.181
Kigali City	382,666	68,659	390,368	69,707	0.179	0.179
Southern	2,957,960	506,693	3,217,749	536,529	0.171	0.167
Western	3,163,374	400,037	3,157,138	400,783	0.126	0.127
Eastern	1,984,698	768,048	1,986,619	757,298	0.387	0.381
Northern	2,633,155	302,205	2,668,170	302,260	0.115	0.113

Figure 7 (page 23, below) illustrates the same data in graphic form, showing the wide range in average values across provinces. Average parcel sizes saw a slight decline in most places and at the national level over this very brief period of analysis; Western Region experienced a very small increase in average parcel size.

Figure 7: ***Average Parcel Size by Province, 2014 and 2015***



At the district level, in the figure below, specific differences can be seen across areas. Though overall average parcel size decreased at the national level and in four of five provinces, only 18 of 30 districts experienced a decline in average parcel size. In 11 of 30 districts the change in average parcel size from 2014 to 2015 was less than one-tenth of a %. Because parcel size is an interest of the Government, particularly as it pertains to the agriculture sector, this issue can be examined with a longer time series, when the 2016 LAIS data becomes available. Urban districts are indicated by an asterisk. Without statistical analysis, visual inspection of the graphic seems to indicate districts now have smaller parcel sizes, though this does not seem to be consistent across all of Rwanda's provinces (e.g., Rubavu and Rusizi in Western Province).

To investigate how parcel size varies across the country, we analyzed the frequency distribution of area according to size classes of parcels. Figure 8 (on page 24) and Figure 9 (on page 25, below)

are histograms showing the share (percentage) of each province's area that falls into 16 size classes, from quite small up to two hectares and above for the agriculture land use. The figure shows that most land is in parcels that are quite small, less than one-tenth of one hectare – and the distribution is highly skewed toward small parcel sizes. Across all provinces, the vast majority of land is in very small parcels: Nearly 70 % of land area is in parcels less than 0.2 hectares in size. On average for the whole country, only 3.0 % of land is in parcels greater than one hectare – and only 0.6 % of land is in parcels greater than two hectares in area. Kigali and the Eastern Region have more land in slightly larger parcels, but the distribution is still generally skewed toward very small parcels. The share of area in parcels above one hectare is larger in the Eastern Province (8.7 %) and in Kigali (3.5 %). The Northern (0.9 %) and Western (1.2 %) provinces have very limited shares of land in parcels greater than one hectare. Figure 10, also on page 24, shows average parcel size for each District, comparing 2014 and 2015. The distribution of area by size class has not changed appreciably over this period.

Figure 8: ***Distribution of Area by Parcel Size Category for Agriculture Land Use, Opening of Year 2014***

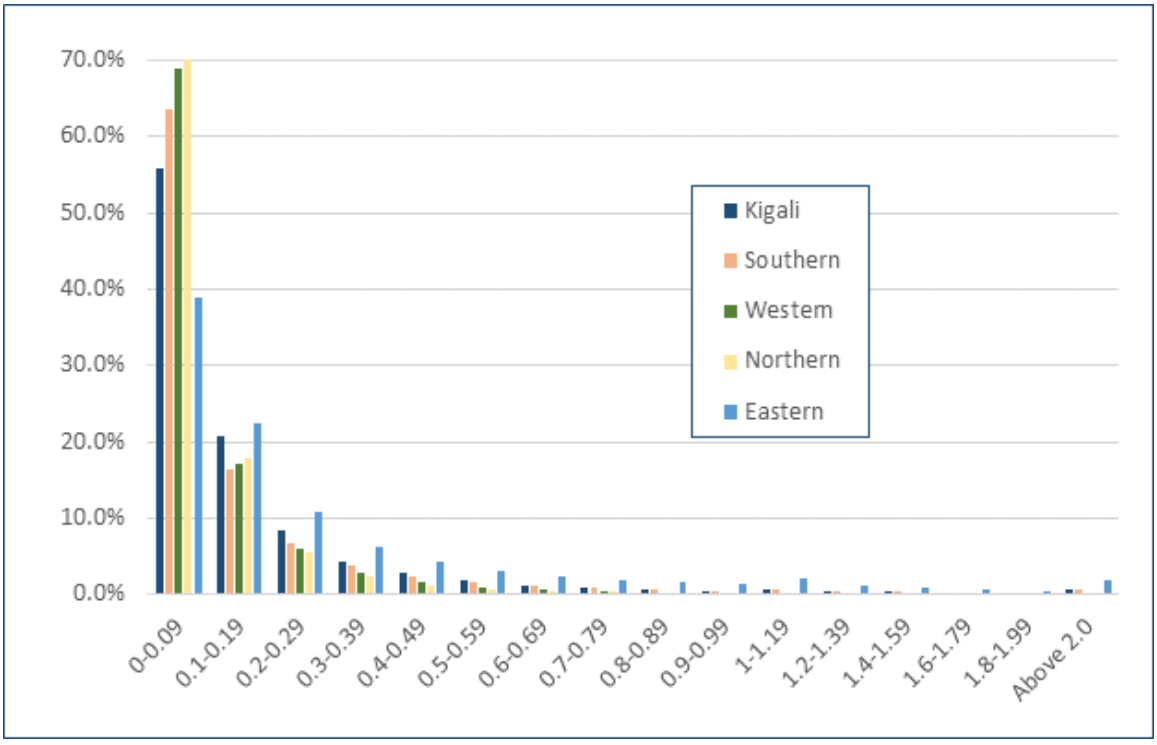


Figure 9: ***Distribution of Area by Parcel Size Category for Agriculture Land Use, Closing of Year 2015***

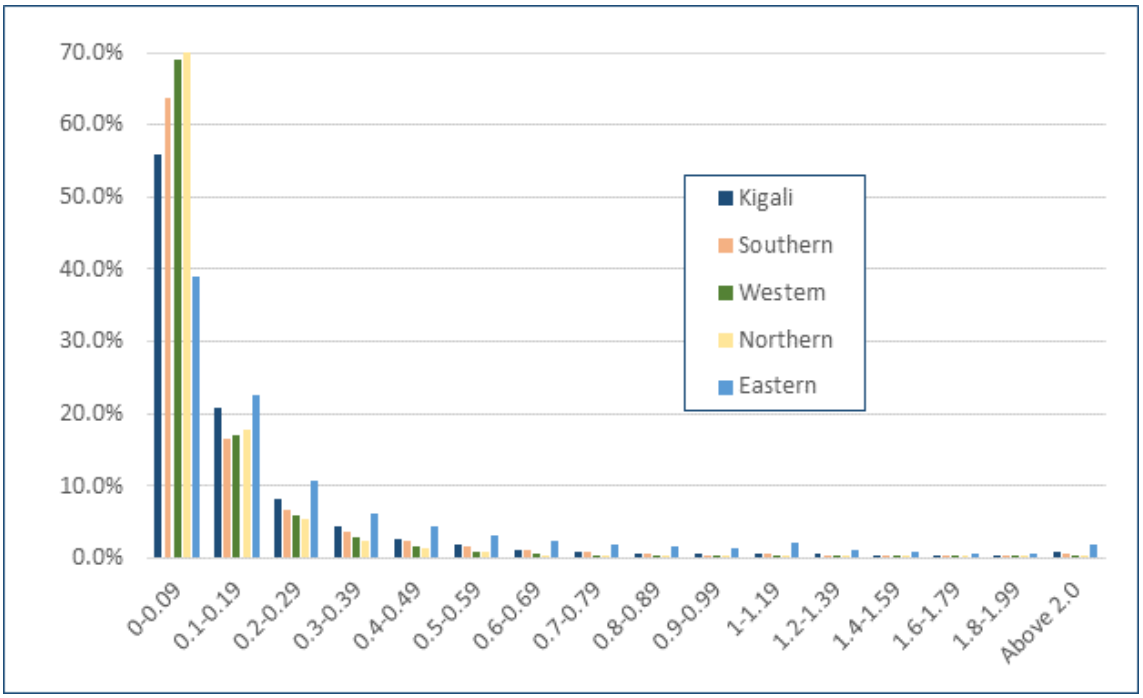
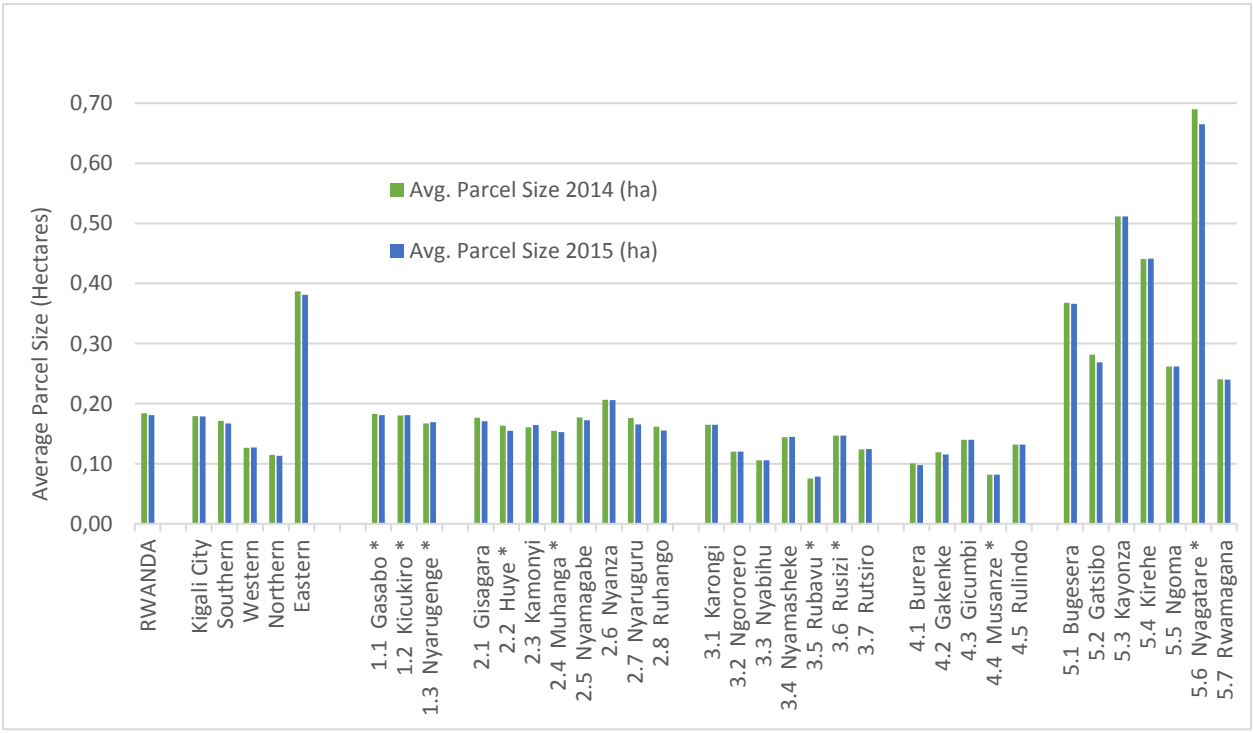


Figure 10: ***Average Parcel Size by District, 2014 and 2015***

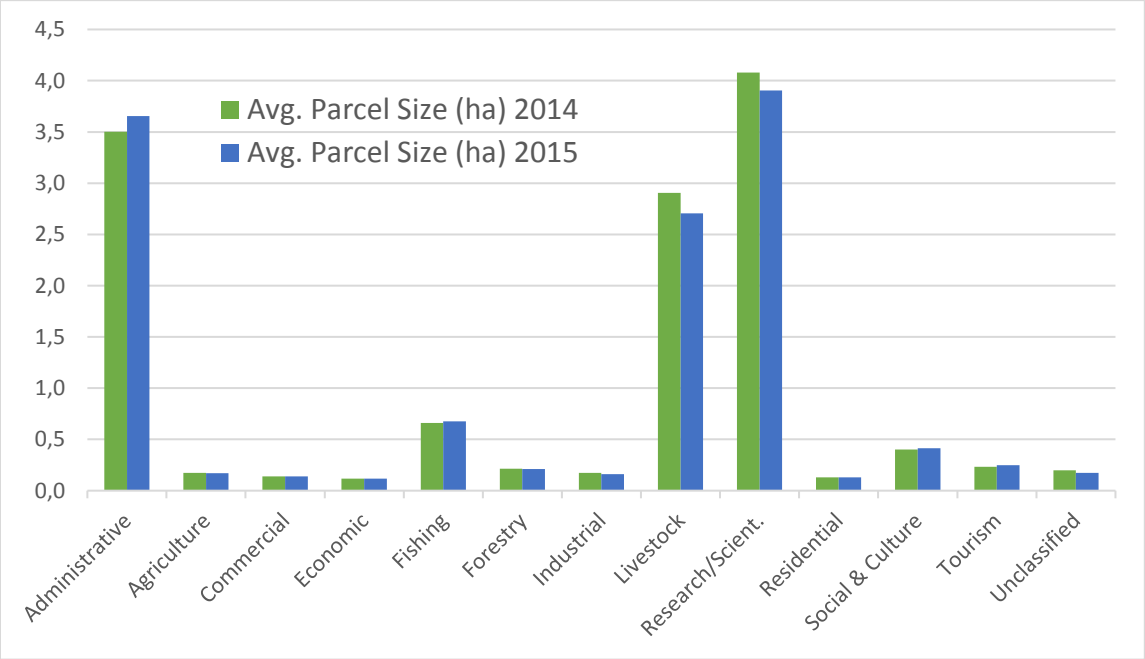


Analysis by Land Use. The analysis of parcel size for different categories of land use found that the average size of LAIS parcels varied substantially by land use, both in size and rate of change; see Table 12 (on page 26, at right) and Figure 11 (page 27). Parcels classified as agricultural, for example, are among the smallest, along with commercial, economic, industrial, and residential parcels. Land uses with larger average size parcels include those for administrative, livestock, and research/scientific purposes. Of the 13 land use categories tracked in LAIS, seven had an average parcel size that was decreasing over this two-year period, while the other six increased in average size. Interestingly, agriculture parcels declined in average size by around one-half of a percent, while residential parcels saw a slight increase of 0.6 %. These findings deserve deeper analysis—of land uses by province and district—so that it may be possible to determine whether these changes are the result of reclassifications (for example if many smaller agricultural parcels or a small number of large administrative or tourism parcels were newly designated). Additional analysis could help to identify which areas are experiencing more rapid changes than others, for example those due to urbanization.

Table 12: ***Average Parcel Size by Land Use, National Level, 2014 and 2015***

Land Use Category	Avg. parcel size (ha) 2014	Avg. parcel size (ha) 2015	Percent change
Administrative	3.501	3.655	4.38%
Agriculture	0.173	0.172	-0.51%
Commercial	0.139	0.140	0.48%
Economic	0.118	0.117	-0.41%
Fishing	0.662	0.675	1.97%
Forestry	0.213	0.211	-0.78%
Industrial	0.172	0.162	-5.81%
Livestock	2.906	2.704	-6.94%
Research/Scient.	4.080	3.906	-4.27%
Residential	0.131	0.131	0.59%
Social & Culture	0.401	0.414	3.17%
Tourism	0.232	0.250	7.82%
Unclassified	0.199	0.172	-13.21%

Figure 11: ***Average Parcel Size by Land Use, National Level, 2014 and 2015***



CHAPTER III: Land Cover Change (1990-2015)

3.1 Overview of Land Cover Data and Sources

In addition to the parcel-level data available in LAIS, Rwanda's Natural Capital Accounts for Land will benefit by providing an overview of the biophysical condition of land and what is growing on it. Fortunately, remote sensing capabilities are increasing regularly and several systems and institutions have produced land cover information for this report at different levels of detail.

Rwanda has worked together with the Regional Centre for Mapping of Resources for Development (RCMRD)[3] to create land use and cover maps for 1990, 2000, 2010, and 2015 (work unrelated to the Natural Capital Accounting initiative). These data are in the public domain and can provide useful background analysis and information on long-term trends. The WCS, SNAPP, and USGS effort to develop ecosystem accounts has already relied on these land cover datasets developed for Rwanda; See Box 2, next page.

The RMLUA is improving its capabilities in remote sensing analysis and mapping, and in the future will be able to link the comprehensive information in LAIS to an institutional capacity for mapping and analysis at different geographic scales. Most of the prior land cover maps are available only for specific periods that pre-date the establishment of LAIS. The 2015 land cover map, however, was developed as part of this NCA effort. This effort contributed to the capacity building Rwanda needed to be able to produce and update land cover maps on a more regular basis. The analysis in this chapter now includes the 2015 data, so that land cover can be compared over a 25-year period using consistent classification procedures through the same institution. In future versions, it will be useful to improve consistency of the linkage between LAIS and the land cover data, with geographic representation and mapping applications.

3.2 National Level Land Cover Analysis - 1990, 2000, 2010, and 2015

The land cover categories employed in remote sensing analysis are different from the land use categories defined in LAIS. Land cover analysis is based on categories that can be identified—visually or through algorithms—using remote sensing. These categories are based on the biophysical properties of the land. In contrast, land use data in LAIS is based on location, value, size, and other variables that are important in land administration, but may not always be directly observable (e.g., ownership). Thus, there is not complete congruence between land use (Chapter II) and land cover (Chapter III).

[3] RCMRD, based in Kenya, was established as an inter-governmental organization to supply spatial analysis and mapping and capacity building services to member countries, including Rwanda. Its mission is to promote sustainable development in member States through generation, application, and dissemination of geo-information and associated ICT technologies, products, and services.

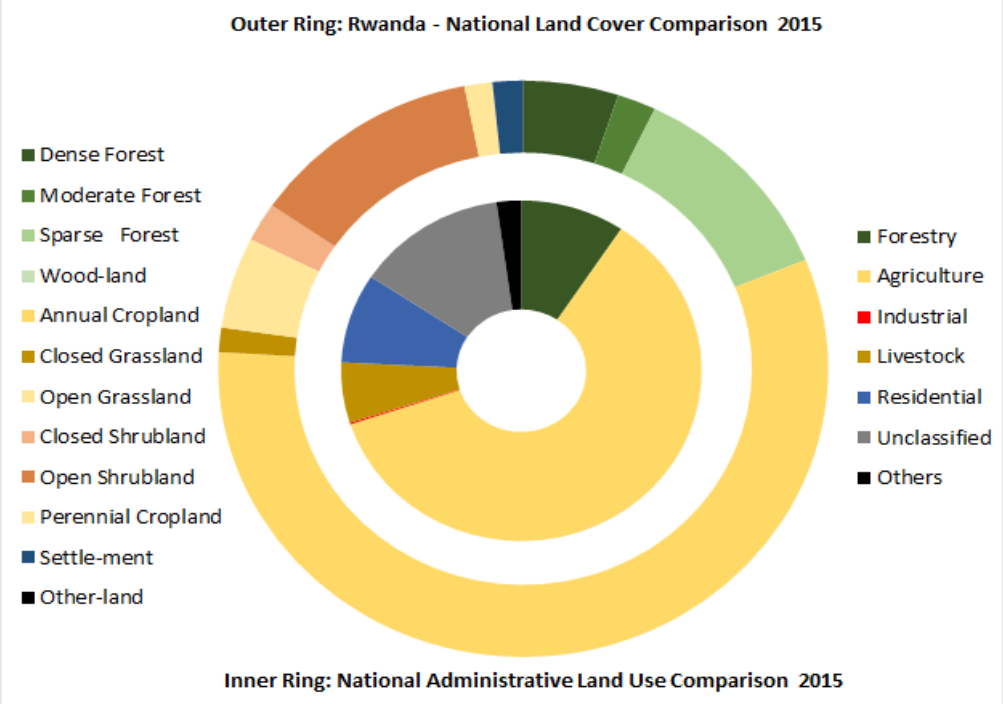
Box 2. Beyond Land Cover: Ecosystem Accounts & Modeling Results

Major development policy issues in Rwanda that are based on natural capital and that can be addressed in the ecosystem accounting framework include: food security through expanding irrigated agriculture to increase productivity; expanded power production through increased hydropower and possibly the mining of peat from wetlands; and meeting the growing need of households and business for municipal water supply. Addressing competing needs in a sustainable manner depends on land use/land cover and the generation of key ecosystem services, such as carbon storage, water flow, and sediment flow. The team designed alternative scenarios for modeling future land use options and the provision of ecosystem services under different development options.

Using land cover data generated by RCMRD, the team quantified carbon storage, sediment regulation, and water yield in Rwanda for the years 1990, 2000, and 2010. They calibrated the water yield model using year 2010 Tropical Rainfall Measuring Mission (TRMM) precipitation data, RCMRD land cover data, and stream gage data for seven watersheds in Rwanda. Results show that many ecosystem services declined from 1990 to 2000, but then rebounded, although to a lesser extent, from 2000 to 2010 (carbon and soil erosion, but not quick flow and local recharge). Preliminary results for 2015 based on recently generated land cover for that year indicate a further decline in ecosystem services, driven largely by continued forest loss. Patterns differ across the country depending on how key model inputs vary in space (e.g., climate, land cover, elevation, soils, vegetation).

Differences in land cover and land use designations for 2015 presented in Figure 12, page 29. This comparison is only illustration. Differences are expected, not unusual.

Figure 12: ***National Land Cover and Administrative Land Use Comparison, 2015***



RCMRD reported on this analysis in March 2016 noted (citing earlier work at RCMRD/SERVIR, 2012) that the land cover classification scheme relies on guidelines from the IPCC - Intergovernmental Panel on Climate Change (IPCC, www.ipcc.ch/). These guidelines help to ensure that country specific mapping standards can be rolled back to higher level IPCC categories. The highest level (or minimum detail) IPCC land cover categories are identified in Rwanda as Schema 1 and coded from 10 to 70, as in the table below.

IPCC provides for nationally-agreed sub-classification categories at a finer level of detail, identified in Rwanda as Schema II. The following sub-classification scheme was agreed upon by Rwanda's national team in consultative sessions in 2012. Level 2 classifications can be subdivided further to level III or IV, but this was not done for this analysis. The following table illustrates the Level I and Level II land cover categorization used in Rwanda, the basis for the land cover analysis and comparison across decades.

10 - Forestland	01 Dense Forest
	02 Moderate Forest
	03 Sparse Forest
30 – Grassland	31 Closed Shrub land
	32 Open Shrub land
	33 Closed Grassland
	34 Open Grassland
40 – Cropland	41 Perennial Cropland
	42 Annual Cropland
50 – Wetland	51 Wetland
	52 Water Body
60 – Settlement	
70 - Other Land	71 – Other Land

The following table (Table 13, page 30, below) and figure (Source: Regional Centre for Mapping Resource for Development

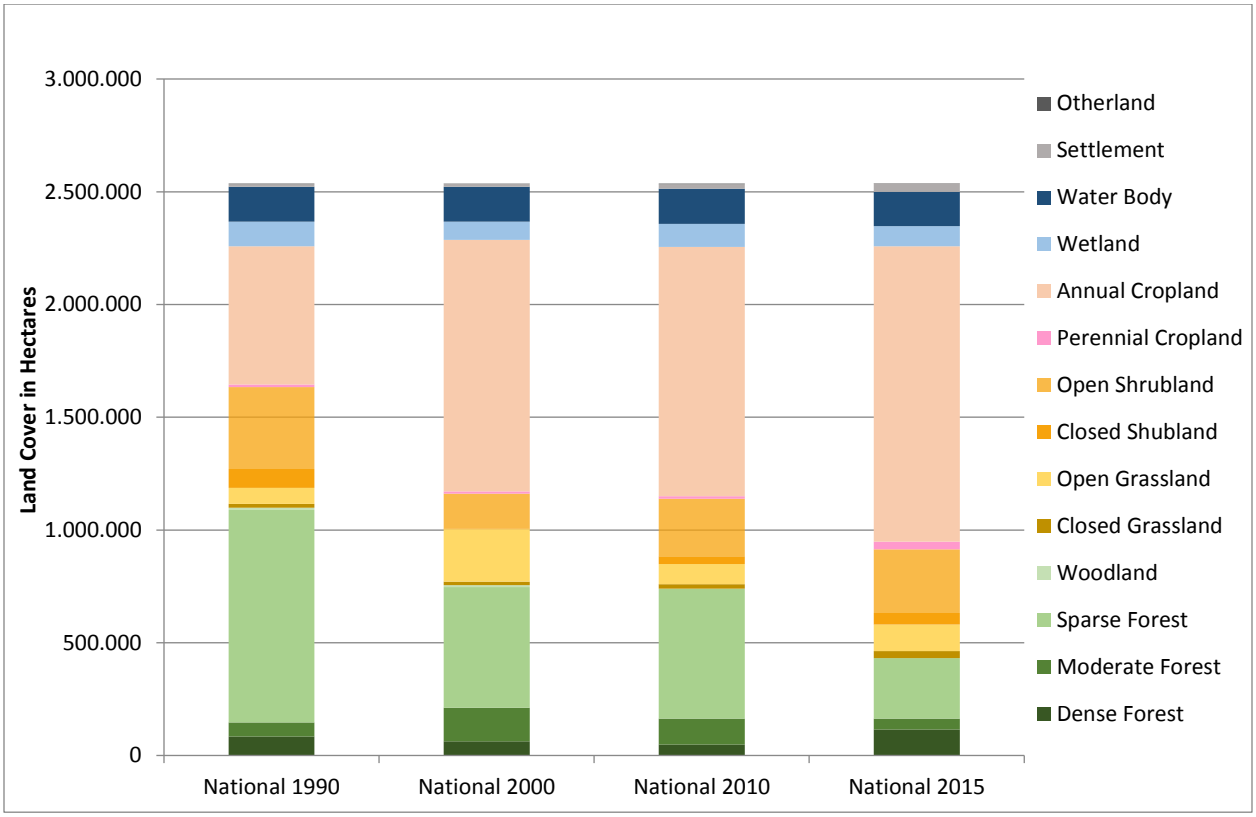
Figure 13, page 31) show the areas, in hectares, for various types of land cover, such as moderate forest, open grassland and wetland.

Table 13: ***National Land Cover Comparison, 1990, 2000[4], 2010, and 2015 (in hectares)***

	Dense Forest	Moderate Forest	Sparse Forest	Woodland	Closed Grassland	Open Grassland	Closed Shubland	Open Shrubland	Perennial Cropland	Annual Cropland	Wetland	Water Body	Settlement	Other land	Grand Total
National 1990	84,151	62,891	942,347	9,922	16,867	71,168	83,465	362,945	10,694	613,527	109,838	153,643	11,633	3,560	2,536,653
National 2000	63,081	148,949	535,085	7,967	15,826	233,408	1,901	154,484	11,036	1,115,204	80,956	153,716	13,843	1,197	2,536,653
National 2010	48,298	114,669	575,873	472	20,907	88,060	34,416	255,806	10,995	1,105,713	102,689	155,294	20,945	2,515	2,536,653
National 2015	115,762	47,237	269,210	-	31,446	117,687	49,937	282,607	34,058	1,310,704	88,773	152,300	36,344	587	2,536,653

Source: Regional Centre for Mapping Resource for Development

Figure 13: ***National Land Cover Comparison, 1990, 2000, 2010, and 2015***



The figure and table illustrate changes over a long time scale, as well as the specific history of Rwanda. In general, there has been a decline of woodland and an increase in cropland. However, this change is most noticeable in the period from 1990 to 2000, which includes the Genocide events and those land use changes associated with movements of people and repatriation of refugees. While the area of dense forest has declined by half over the 20-year period of this analysis, the

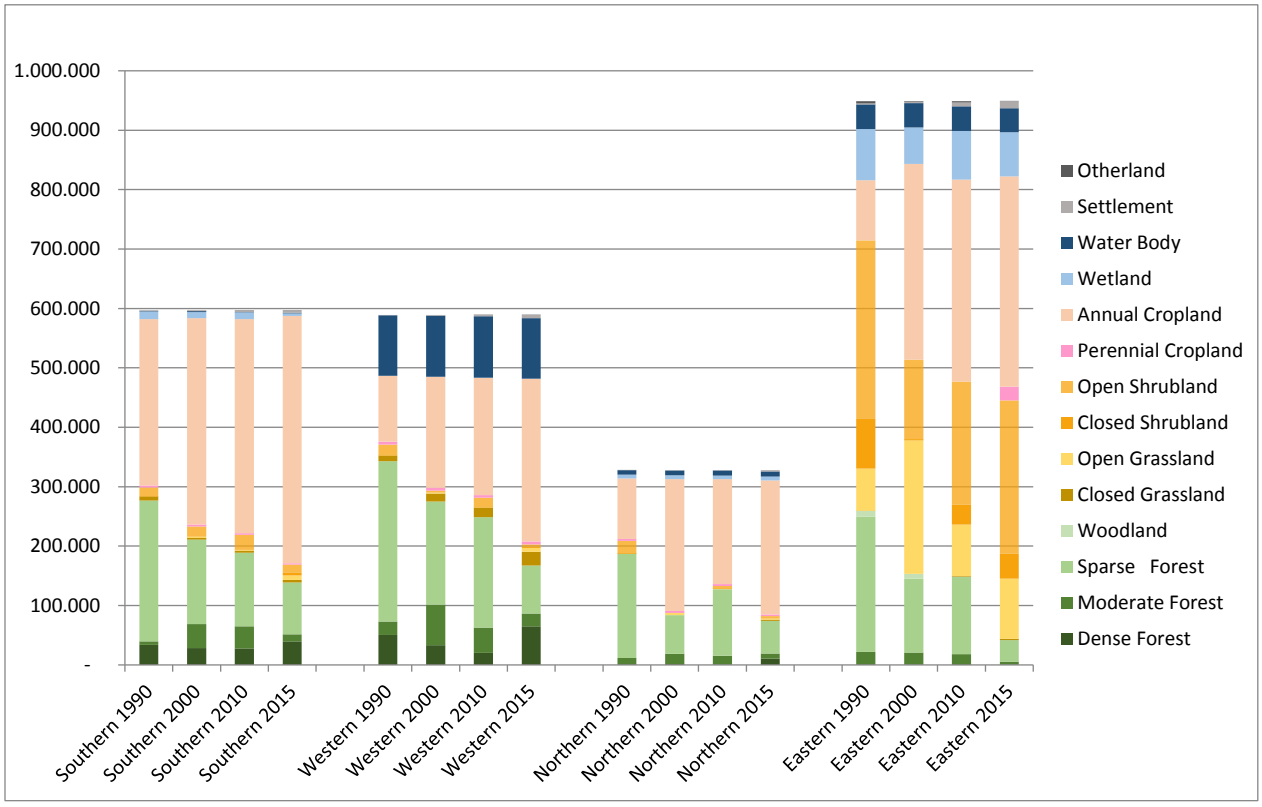
[4] Note that data for 2000 show large changes for specific land cover categories: moderate forest, woodland, open grassland, closed shrubland, and wetland. For example, wetland area declines by 25% from 1990 to 2000, then returns to near its 1990 value in the next decade. The specific regional locations of these discontinuities are discussed in the next footnote with provincial data. These data come from RCMRD database and were not reanalyzed for this report.

area of sparse forest has increased, particularly after 2000. The area of settlements has doubled over this period, but remains a very minor feature of the landscape, at about one percent of Rwanda's overall area. Clearly, since 2010 the change in land cover has continued. The area of cropland, both annual and perennial, has grown predominantly at the expense of sparse forest.

3.3 Provincial Level Land Cover Analysis - 1990, 2000[5], 2010, and 2015

The following table (*Table 14*, page 33) and figures (Figure 14, below; and Figure 15, on page 34) illustrate the same land uses (by color) for the four provinces and Kigali City. This yields a more nuanced view of land cover changes over time. The first graphic shows total areas of land cover in hectares; the second shows shares of land in each land cover.

Figure 14: ***Land Cover Change, by Province, 1990, 2000, 2010, and 2015***



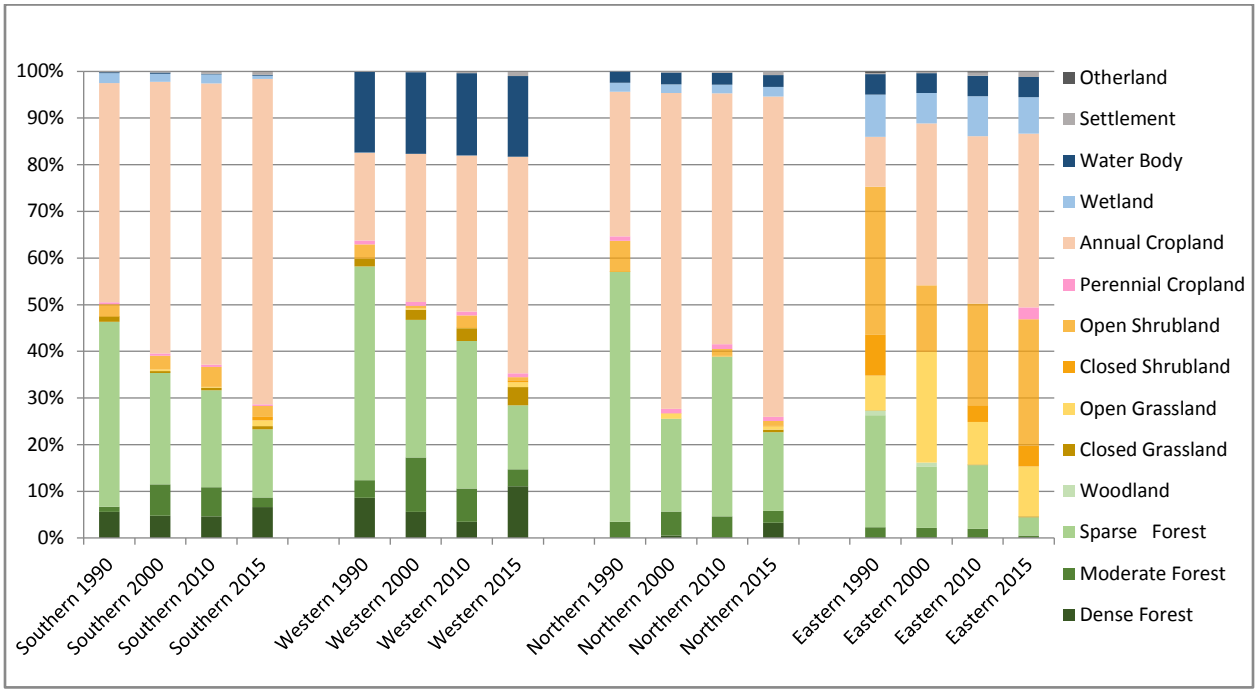
[5] Figures provided from the RMCRD analysis are currently undergoing verification and cross checking. Some figures for 2015 bear further examination and this is ongoing in dialogue with RCMRD. Note that some figures for the year 2000 analysis show discontinuity. At the province level, in 2000, there appear to be large changes in the Western Region for open grassland and open shrubland); in the Northern Region for sparse forest, open grassland, and open shrubland; and in the Eastern Region for open grassland and closed shrubland. These data are available from the RCMRD website and were investigated and commented upon in this report, but not re-analyzed from raw data.

Table 14: ***Land Cover Change, by Province, 1990, 2000, 2010, and 2015 (in hectares)***

PROVINCE	Dense Forest	Moderate Forest	Sparse Forest	Wood-land	Closed Grassland	Open Grassland	Closed Shrubland	Open Shrubland	Perennial Cropland	Annual Cropland	Wet-land	Water Body	Settle-ment	Other-land	Grand Total
Kigali 1990	-	1,019	32,011	-	1	31	5	7,546	-	19,274	4,565	904	8,145	-	73,501
Kigali 2000	10	2,673	29,028	106	-	1,020	-	26	-	29,194	2,445	682	8,315	-	73,501
Kigali 2010	-	1,939	24,041	6	1	16	269	2,346	-	32,014	3,522	616	8,730	-	73,501
Kigali 2015	27	669	9,131	-	27	586	88	4,267	447	41,299	3,577	633	12,743	7	73,501
Southern 1990	33,556	6,266	236,920	-	6,777	-	18	15,416	2,801	280,352	12,714	1,215	985	-	597,020
Southern 2000	28,311	40,193	142,488	65	2,624	1,934	-	17,555	3,052	347,560	10,334	1,442	1,462	-	597,020
Southern 2010	27,664	37,283	123,844	-	3,561	654	489	25,322	3,043	359,929	11,310	747	2,820	354	597,020
Southern 2015	39,679	11,900	87,304	-	4,153	7,466	4,686	13,639	2,282	416,532	4,085	941	3,968	384	597,020
Western 1990	50,595	22,202	270,256	-	9,726	2	106	18,072	4,720	110,828	210	101,895	591	-	589,202
Western 2000	33,017	68,685	173,555	-	13,202	1,697	-	3,057	4,758	187,180	153	102,836	1,063	-	589,202
Western 2010	20,492	42,121	186,197	-	16,181	299	128	15,839	4,727	197,220	41	103,822	1,999	137	589,202
Western 2015	65,197	21,524	80,719	-	23,038	6,252	2,338	3,884	4,875	273,820	15	101,818	5,616	104	589,202
Northern 1990	-	11,412	175,623	-	356	2	40	21,485	3,173	101,708	6,237	7,870	185	-	328,091
Northern 2000	1,651	16,805	65,429	14	-	3,643	-	105	3,225	222,020	6,154	8,282	763	-	328,091
Northern 2010	134	15,045	112,265	-	-	316	292	4,873	3,225	176,478	6,204	8,298	960	-	328,091
Northern 2015	10,711	8,276	55,351	-	1,873	2,301	470	3,248	2,944	225,319	6,682	8,397	2,518	-	328,091
Eastern 1990	-	21,993	227,538	9,922	7	71,133	83,296	300,427	-	101,365	86,112	41,760	1,727	3,560	948,839
Eastern 2000	91	20,593	124,585	7,782	-	225,115	1,901	133,742	-	329,249	61,870	40,474	2,240	1,197	948,839
Eastern 2010	7	18,281	129,525	466	1,165	86,775	33,238	207,426	-	340,072	81,613	41,810	6,437	2,024	948,839
Eastern 2015	147	4,867	36,705	-	2,356	101,083	42,355	257,568	23,510	353,733	74,414	40,511	11,498	92	948,839

Source: Regional Centre for Mapping Resource for Development

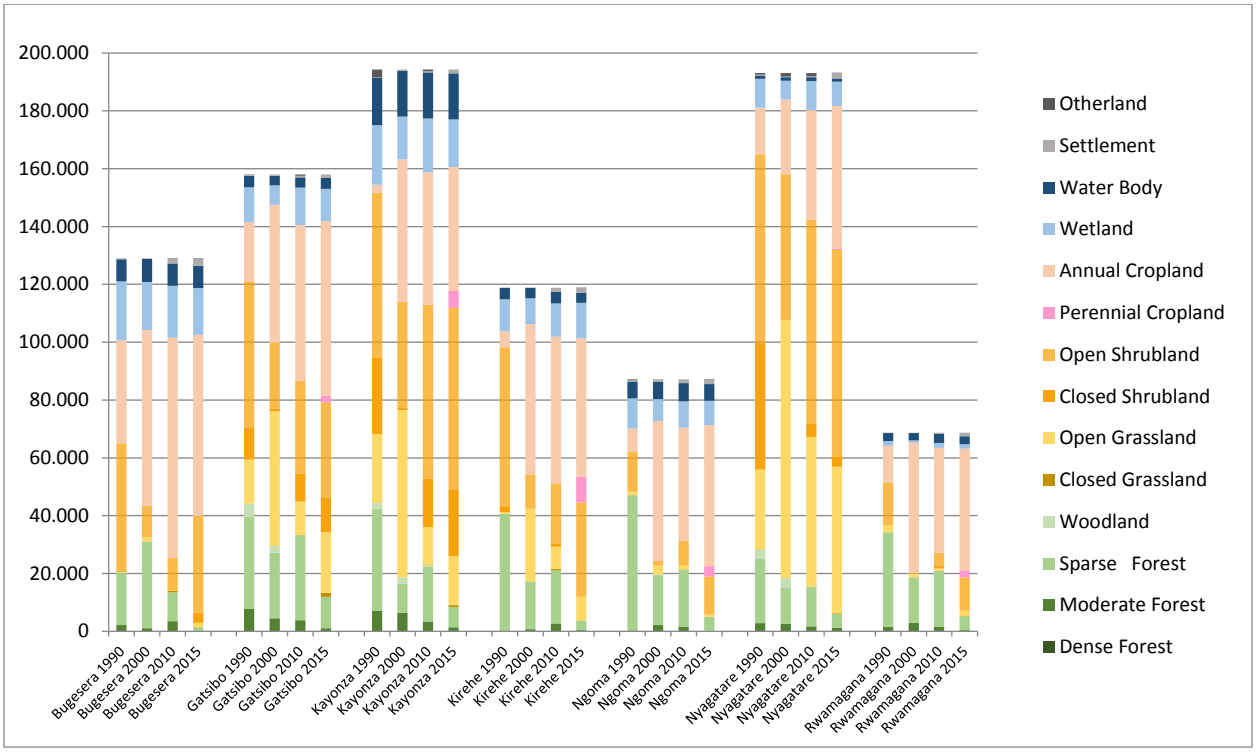
Figure 15: ***Land Cover Change in Shares, by Province, 1990, 2000, 2010, and 2015***



Across all provinces, the figures show an increasing share of land cover in crops and grasslands and a decline in moderate and sparse forests. This trend was very noticeable in the Northern and Eastern Provinces between 1990 and 2000, reflecting the genocide and resettlement of people in those areas during the 1990s. These social and demographic changes resulted in loss of forests and expansion of grazing and cropping land. The trends are relatively dramatic and uniform in the Southern, Western, and Eastern Provinces. In the Northern Province, there is a dramatic increase in annual cropland in 2000 at the expense of forested land. The data show a rapid reversal of this situation by 2010. The specific events (and possible data interpretation issues) that lead to this apparent major change in direction of land cover change need to be investigated further.

It is possible to analyze the data at district level, but with a level of detail not appropriate for in this report. An analysis of the Eastern Province is shown here for illustrative purposes (Figure 16, on page 35), indicating that land use change can be tracked at a decadal scale for each district in Rwanda. This type of information has value in spatial planning, assessing development trends, and monitoring the achievement of land use plans over time. It can also identify areas where land cover is changing rapidly, which might deserve further investigation. In the past, land cover analysis has been done infrequently, but, with improvements in technology, it becomes cost effective to conduct it regularly. Updating the analysis every two or three years would be useful for regular monitoring and for comparing the situation on the ground to spatial plans.

Figure 16: ***Land Cover Change, Focus on Eastern Province, 1990, 2000, 2010, and 2015***



Focus on Recent Land Cover Changes. The following figures[6] (16a and 16b, page 35) provide more detail on the latest period of land cover data from 2010 to 2015. At the national level, the greatest change was in loss of sparse forest coupled with an increase in annual crop land, open grass land, and open shrubland. The decrease in sparse forest area was about 307,000 hectares, representing 12 % of Rwanda's land area. The increase in annual crop land was about 205,000 ha, representing 8 % of total area. This continues a long-term trend in Rwanda as more land has been brought under cultivation at the expense of remaining lightly forested areas, potentially contributing to runoff and soil loss. However, it can also be seen that the area of closed grass land, closed and open shrubland and perennial crop land also increased over this period, possibly indicating an increase in trees on farms and in agricultural landscapes, as communities reclaim degraded areas, plant trees, and engage in agroforestry.

The area of wetlands decreased by about 14,000 ha, which is about 14 % of the total area in wetlands at the start of the period in 2010. The continuing loss of wetlands confirms a concern that has been noted previously, for example in the Rwanda State of Environment and Outlook Report (REMA, 2015). The area of water bodies remained roughly the same.

On the positive side, this period saw a substantial increase in the area of dense forest with a nearly equivalent decrease in moderate forest. This change in status of 67,000 ha (2.7 % of total land)

[6] Two minor land uses that occupy very few hectares (Wood-land and Other-land) were excluded from this analysis to improve readability of the figures.

may indicate that remaining forest areas are relatively well cared for and able to transition from moderate to dense tree cover. The area in settlements increased from about 21,000 to 36,000 ha, a 74 % increase. Settlements cover only 1.4 % of Rwanda's overall land area, but host an increasing share of the population.

Figure 16a: Change in Land Cover, National Level 2010 to 2015 (in hectares)

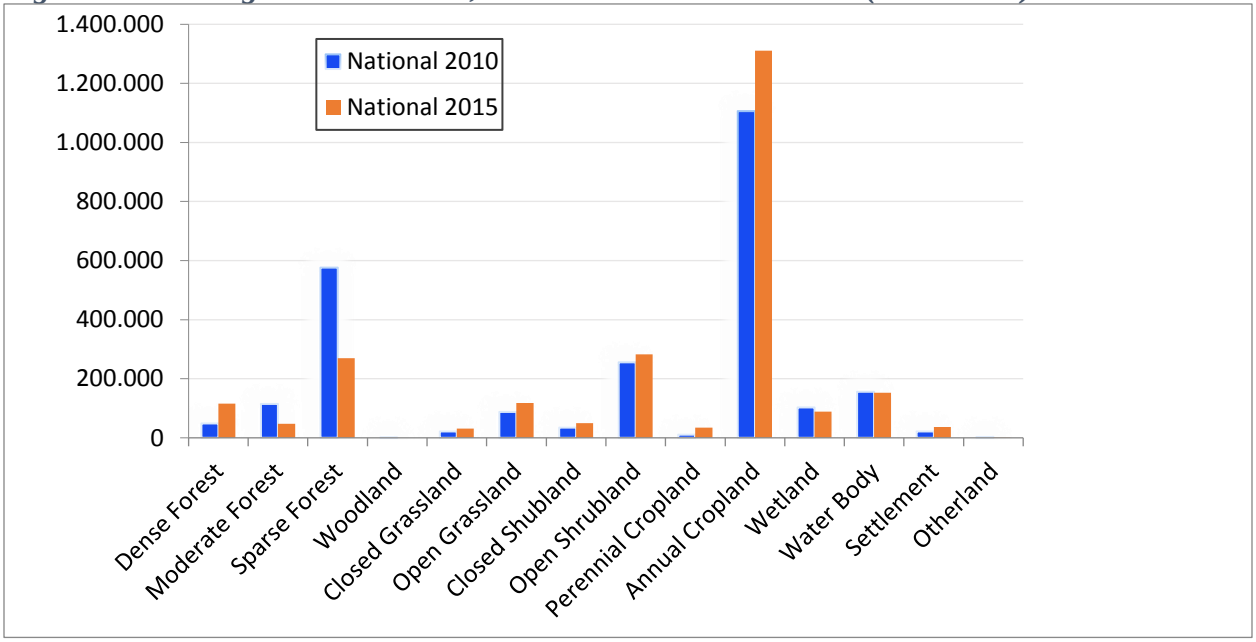
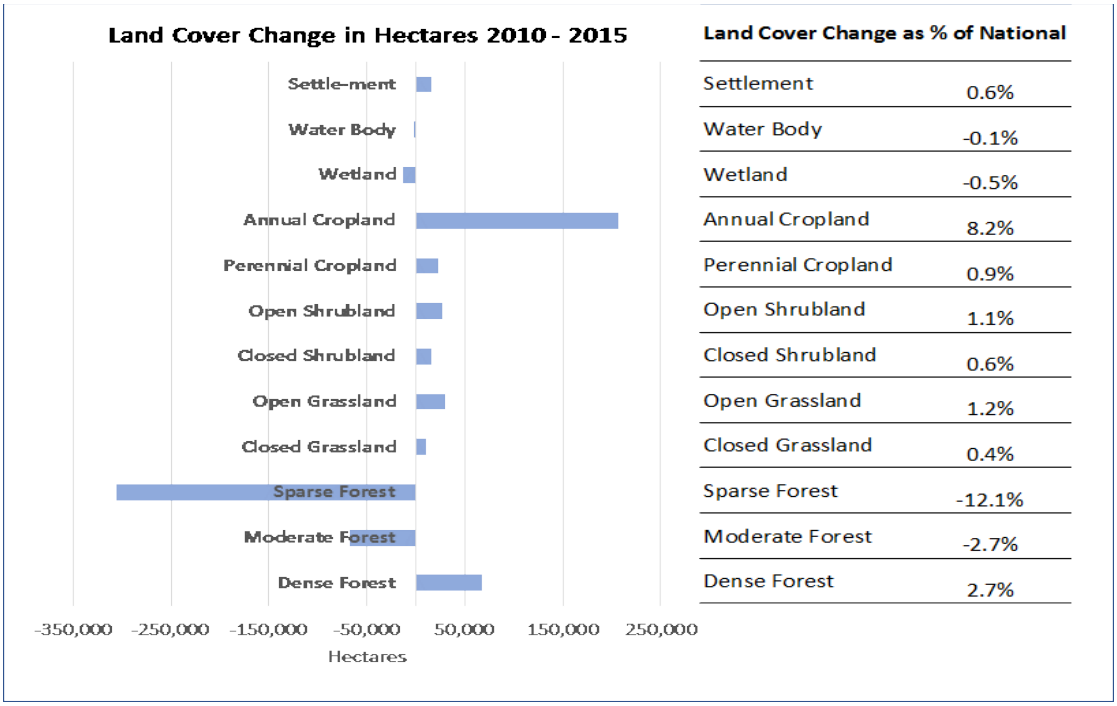


Figure 16b: Change in Land Cover, National Level from 2010 Base to 2015 (in hectares)



Land Cover Change as % of National	
Settlement	0.6%
Water Body	-0.1%
Wetland	-0.5%
Annual Cropland	8.2%
Perennial Cropland	0.9%
Open Shrubland	1.1%
Closed Shrubland	0.6%
Open Grassland	1.2%
Closed Grassland	0.4%
Sparse Forest	-12.1%
Moderate Forest	-2.7%
Dense Forest	2.7%

Focus on Forest Cover. As noted above, data on forest and land cover from different sources and time periods produce differing results. To understand differences in Rwanda's forest cover reported over time, RWFA undertook an "Interpretation of the Forest Cover 2015 Report" in July 2017 (RWFA, 2017). This analysis compared results reported in Rwanda Forest Cover Mapping produced by the Geographic Information Systems and Remote Sensing Research and Training Center of the National University of Rwanda in collaboration with MINIRENA/RNRA in 2012 (CGIS-NUR 2012), Rwanda NCA Project Land Cover Mapping for 2015 (RCMRD 2016) and RCMRD's earlier analysis in 2010, as well as the National Forest Inventory 2015 (RNRA 2016). Some of these earlier forest cover results were also summarized in the 2015 State of Environment Report (REMA 2015). The most recent is the 2015 analysis from RCMRD reported in this section.

The National Forestry Inventory aims at providing quantitative and qualitative information on the wood resources both inside and outside forests. It covers both trees inside forests and trees outside forests in both shrubland and other land. However, it excludes National Parks. The CGIS 2008 analysis, in contrast, considers area covered by shrublands as forests. This result has been used by RWFA as a baseline for examining forest cover change. RCMRD classifies Shrublands separately in a more detailed categorization scheme. The 2015 State of Environment Report lists 29.2 % forest cover and notes that Vision 2020 sets a 30 % target to be achieved. In addition, the two major remote sensing efforts used different imagery and technologies as the basis for classifications and coding: CGIS 2008 used 25cm aerial resolution orthophotos from 2008-9, while RCMRD used 30-meter resolution Landsat imagery from 2015.

These definitional and technological explanations account for most of the differences in results reported in the different publications. RWFA recognizes the need for harmonization of forest cover definitions and descriptions in line with international standards. A step toward resolution of these different results can be achieved in the following table, which shows the results when forest cover and shrubland are aggregated.

Table 14a. Comparison of Forest Cover Results from Several Data Sources

Rwanda Forest Cover Remote Sensing Analysis	**Total Area (Ha)**	**Forest Cover *Excluding* Shrubland**	**Forest cover *Including* Shrubland**
2008 by CGIS	2,531,329	16.31%	26.61%
2010 by RCMRD	2,536,653	29.15%	40.58%
2015 by RCMRD	2,536,653	17.05%	30.15%

The table shows that RMRD's analysis, when adjusted to include shrubland, produces figures closer to expectations based on earlier analyses. Finally, it is worth noting that the RCMRD results from 2010 and 2015 use similar data sources and forest cover definitions, allowing the comparative analyses produced in this section.

CHAPTER IV: Land Transaction Values and Comparisons

This chapter analyzes transaction values from LAIS, an initial step toward developing monetary accounts. This early data analysis provides descriptive statistics and comparisons across districts and sectors that are quite interesting. The results will be more complete and useful for time series analysis when supplemented with LAIS data for 2016 and 2017. However, there are also some discrepancies in the data that indicate a need to scrutinize data quality and consistency so that LAIS records can be improved to support further analysis.

4.1 Overview of LAIS Data on Transaction Values

LAIS is a rich source of data on Rwanda's land transactions and values. In 2014, LAIS recorded 15,500 land transactions involving an area of 4,000 hectares. These are summarized in the table below (Table 15, on page 38, below). The average size of parcels involved in these transactions was about one-quarter of a hectare, with a wide range of sizes across provinces. Kigali City, Western, and Northern Provinces had quite small transactions, on average--about one-tenth of a hectare--while the Eastern Province had transactions averaging over four-fifths of a hectare.

Table 15: ***Summary of Parcel Transaction Data from LAIS, 2014***

LOCATION	No of Parcels Transacted	% of Total	Total Area of Transactions (ha)	% of Total	Total Value of Transactions (M RwF)	% of Total	Province Average Transaction Size (ha)	Province Ave Value/Ha (M RwF)
KIGALI CITY	6,964	45%	677	17%	87,962	62%	0.10	130
SOUTHERN	2,200	14%	446	11%	6,508	5%	0.20	15
WESTERN	1,549	10%	259	6%	8,047	6%	0.17	31
NORTHERN	1,857	12%	216	5%	4,361	3%	0.12	20
EASTERN	2,950	19%	2,421	60%	34,948	25%	0.82	14
RWANDA	**15,520**	**100%**	**4,020**	**100%**	**141,825**	**100%**	**0.26**	**35**

The total value of transactions was 141 billion Rwandan Francs (RwF), with 62 % of that value being transacted in Kigali City. Sixty % of the area transacted was in the Eastern Province; 45 % of all parcels transacted were in Kigali City.

The data analyzed here are for 15,520 formal transactions recorded in LAIS during the study period, representing less than 1.5 % of the 11,000,000 parcels in LAIS. This may appear to be a low rate of transactions, however, note that there may be additional informal transactions that are not recorded, particularly for extremely small parcels that change hands among family members. By law, parcels of less than one hectare cannot be subdivided, so this would limit the registration of very small parcel transactions. One could also expect that residential parcels would be smaller than livestock/agricultural parcels. This could help to explain the low average size for transacted parcels in Kigali, where most transactions occurred, and where there would be more residential, commercial and industrial land uses. The high average value of transactions in Kigali may also occur because there is a high share of parcels with buildings and other higher value developments,

relative to more rural areas. For these reasons, care must be taken in the analysis of transaction data from LAIS.

The average value per hectare of a transaction was 35 million RwF/ha. However, the value for Kigali City was five times higher than in the other provinces. Eastern Province had the lowest average transaction value per hectare at 14 million. The term "average value per hectare" is used instead of the term "land price" for two reasons. First, the transactions include parcels with buildings and parcels that include just land. Developed parcels—those with buildings—should have higher prices than undeveloped agricultural or forest land. The SEEA framework and the System of National Accounts recommend separating the value of buildings and improvements (a form of produced capital) from the value of the land itself (a form of natural capital). Second, in keeping with the SEEA methodology, these average values are calculated as the total amount paid divided by the total area exchanged at the province or district level. Due to the high variability in the quality and value of different land parcels, this calculation is not the same as the average of prices paid per hectare in individual transactions.

High Variability of Transaction Values. An initial examination of the LAIS 2014 data on parcel transaction values revealed differences of orders of magnitude across parcels and provinces. To understand the basis for this variability, a limited statistical analysis was conducted. The following table (Table 16, on page 39, at right) shows the average value per hectare of parcels transacted, along with the minimum value, maximum value, and standard deviation (calculated using Excel formulas). This shows the high variability in the transaction values, even after standardizing on value per hectare. For all of Rwanda, the maximum value per hectare is almost 250 times greater than the average, while the minimum is less than one-tenth of one % of the average. Some of the variation can be explained because LAIS does not distinguish built up parcels from undeveloped land.

Table 16: ***Parcel Transaction Statistical Measures from LAIS***

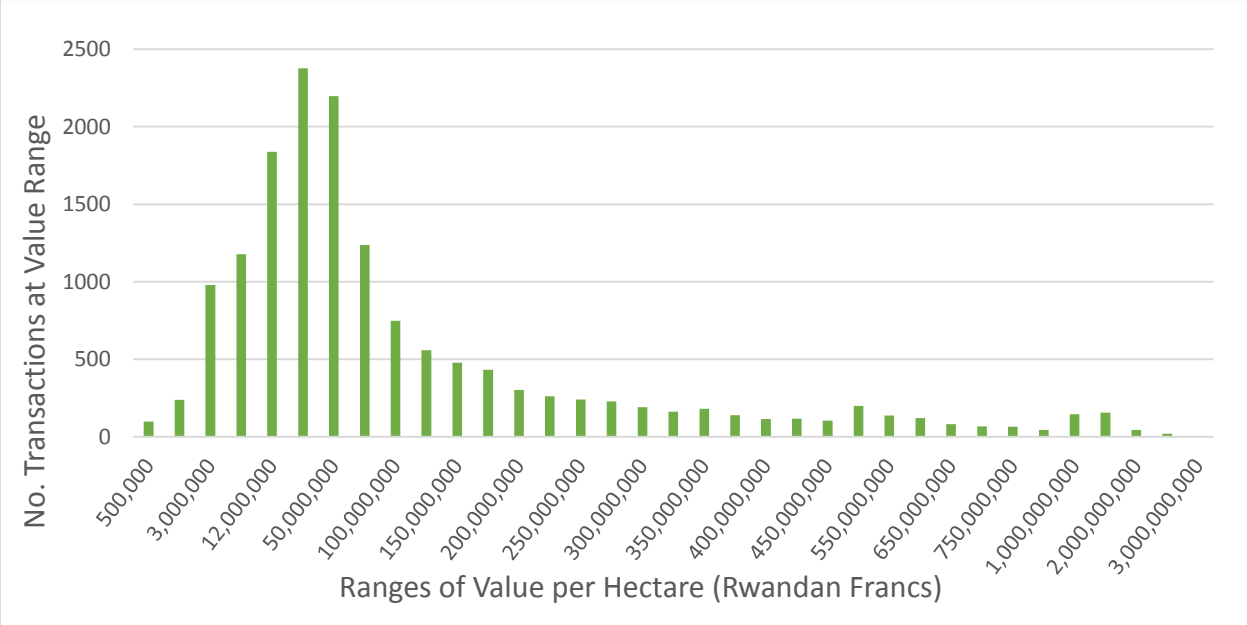
LOCATION	Parcel Ave Value /Ha (M RwF)	Min Parcel Value /Ha (M RwF)	Max Parcel Value /Ha (M RwF)	Std Deviation of Parcel Value /Ha
KIGALI CITY	214	0.10	33,916	643
SOUTHERN	47	0.12	3,449	130
WESTERN	99	0.13	34,476	897
NORTHERN	48	0.14	2,070	117
EASTERN	123	0.02	33,625	799
RWANDA	142	0.02	34,476	629

Still, in a market where most transactions yield values in the range of 20 to 100 million RwF (US$ 25,000 to 125,000) per hectare, it is beyond surprising to see parcels being exchanged for only 100,000 RwF (US$ 125) per hectare, or even as low as 20,000 RwF (US$ 25) per hectare. Equally concerning are parcels in relatively rural areas that are exchanged for more than 30 billion RwF per hectare. These extremely high and low values raise the suspicion of data entry errors and indicate a need for stringent cross checking.

The figure below (Figure 17, on page 40) shows a histogram of the frequency (number) of transactions occurring within the value range on the horizontal axis. Most transactions occurred in

the range of 3 million to 150 million RwF per hectare. This is quite a wide range, but is likely realistic given the diversity of rural, town, and city-based transactions and the fact that developed and farming parcels are grouped together. However, there are also a small number of extreme values at the low and high ends. These extreme values skew the means and variances of the data set and cause concern that they are due to data entry errors (e.g., dropped or added zeroes) rather than realistic land value estimates.

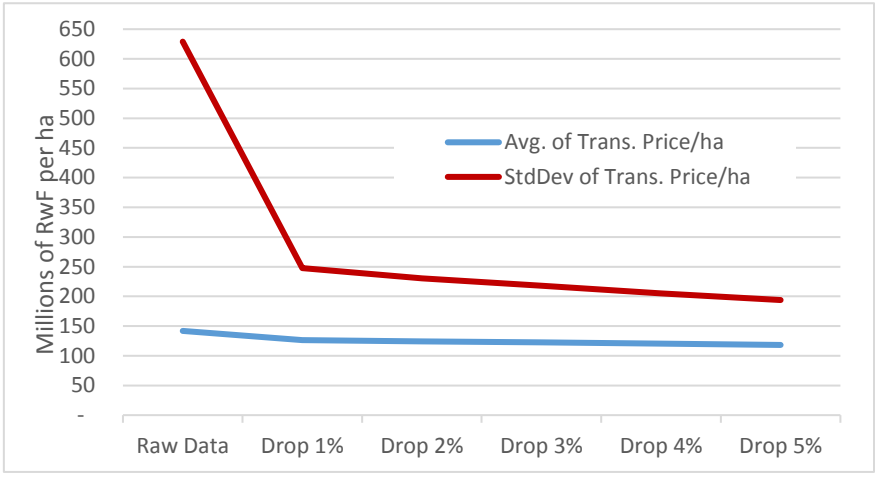
Figure 17: ***Frequency Distribution of Parcel Transaction Values, 2014***



Further analysis found that, indeed, a relatively small number of erratic values may indicate errors in the underlying data, perhaps introduced during data entry from paper records. Because the data set has over 15,000 records, it was assumed that most were not flawed and some process could be developed to screen out extreme outliers, so that the remaining records could still serve as a useful sample of land transaction values. One response would be to use a sampling approach and calculate averages with some substantial subset of the data. However, this would be relatively technical and less useful for preparing natural capital accounts in a regular, replicable, and systematic manner in the future.

As an alternative, the effect of omitting a small percentage of the data points from both the high and low end of the distribution was tested. The resulting effect on the mean and standard deviation of the value per hectare variable is shown in the figure below. Omitting one percent of the extreme low and high values (2 % of the data set overall, or about 300 data points) results in a very substantial (60 %) reduction in the variability of the data, with a much lower effect (about 10 %) on the mean; this can be seen in Figure 18 (on page 41, below). Further, this procedure of omitting a small portion of the extreme values had no major effect on the values at district or province.

Figure 18: ***Average Land Price - Changes as Different Levels of Outliers are Omitted***



Based on these observations, the rest of this analysis proceeds with one percent of the records dropped from each end of the value per hectare distribution. This procedure may provide a useful avenue for analyzing data for 2015, which also has variability issues.

4.2 Land Parcel Transaction Values by Province and District

The table below (Table 17, page 42) summarizes the number, area and value of parcel transactions for 2014 at the national and provincial levels. The graphic on the following page (Figure 19, page 42) summarizes the area and value of transactions at the district level. Together, these data and charts illustrate a reasonably understandable pattern of areas and transaction values changing hands.

In summary, a large area of land is changing hands in both urban areas and the larger provinces. There are higher value land transactions in urban districts (those indicated with asterisk, as in earlier chapters). There is still quite a range of values, but this may make sense when comparing rural and remote areas with urban centers. The largest changes are occurring in areas with the fewest transactions (because a small change in what gets counted has a greater impact on the overall average).

There are some interesting exceptions to these general patterns, such as in Bugesera and Nyagatare in Eastern Province. The "high value urban – low value rural" explanation, as above, would suggest that Nyagatare, which contains one of a handful of secondary cities, should have the highest transaction values in the province. Instead, Bugesera holds this position. This may be explained

by Bugesera's relative proximity to Kigali, leading to parcel transaction values that are higher in the north of Bugesera. These relationships deserve in-depth study, as well as comparison with 2015 and recent years, when those data become available.

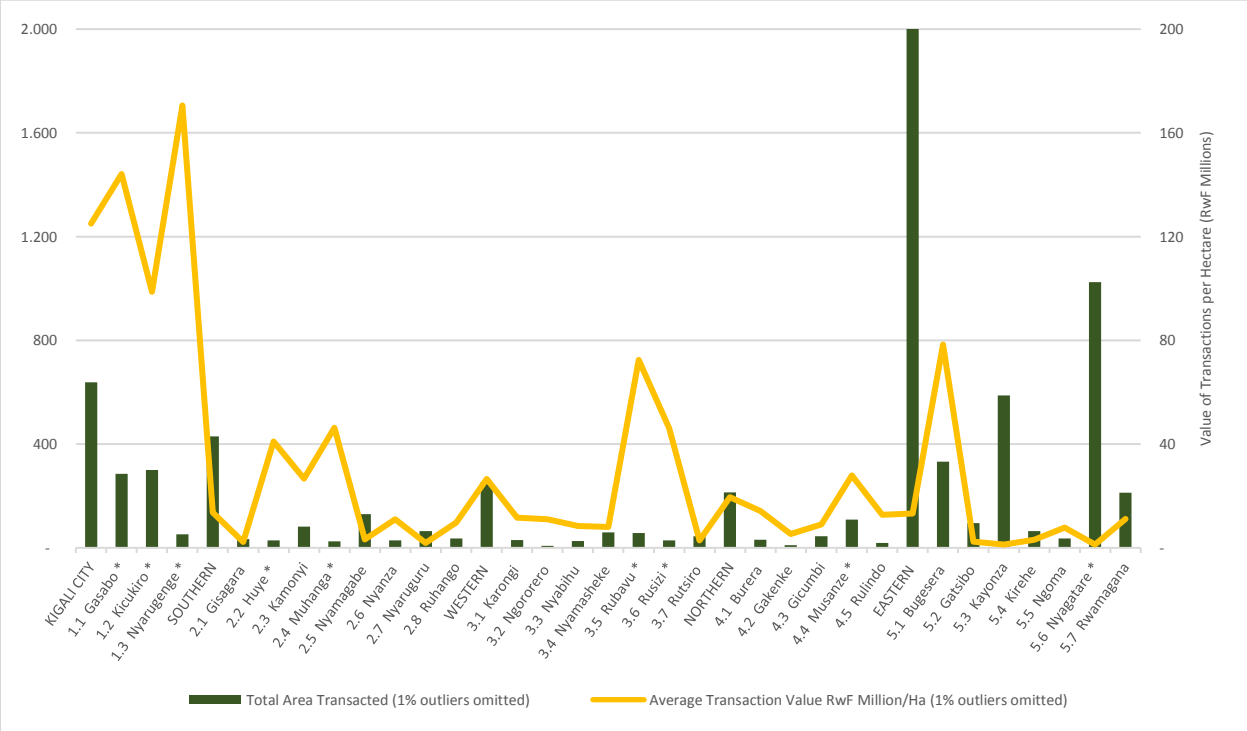
Table 17: ***Summary of Number, Area, and Value of Parcel Transactions, by Province, 2014***

LOCATION	Number of Parcel Transactions	Total Area of Transactions (ha)	Average Value of Parcel Transactions (RwF Million/ha)
KIGALI CITY	6,839	639	125.0
SOUTHERN	2,157	430	13.6
WESTERN	1,505	253	26.6
NORTHERN	1,845	214	19.6
EASTERN	2,838	2,353	13.3
RWANDA	**15,184**	**3,890**	**32.9**

Notes:

- One percent of outliers have been omitted from each end of the distribution as a way of dealing with possible data entry errors leading to high variance in LAIS data.
- This omission of outliers explains the small differences with the descriptive summary data in Section 4.1.

Figure 19: ***Area Transacted and Average Transaction Value, 2014***



The following table (Table 18, page 43) provides the same data at district level in tabular form.

Table 18: ***Summary of Number, Area and Value of Parcel Transactions, by District, 2014***

LOCATION	Number of Parcel Transactions	Total Area of Transactions (ha)	Ave Value of Trans-actions (RwF M/ha)
KIGALI CITY			
1.1 Gasabo *	2,887	286	144.1
1.2 Kicukiro *	3,146	300	98.8
1.3 Nyarugenge *	806	53	170.6
SOUTHERN			
2.1 Gisagara	64	34	2.3
2.2 Huye *	281	29	41.0
2.3 Kamonyi	683	82	26.7
2.4 Muhanga *	268	25	46.4
2.5 Nyamagabe	396	130	3.2
2.6 Nyanza	180	29	11.0
2.7 Nyaruguru	91	65	1.9
2.8 Ruhango	194	36	9.8
WESTERN			
3.1 Karongi	108	30	11.7
3.2 Ngororero	60	8	11.0
3.3 Nyabihu	181	26	8.4
3.4 Nyamasheke	128	59	8.1
3.5 Rubavu *	642	57	72.4
3.6 Rusizi *	250	29	46.2
3.7 Rutsiro	136	45	2.9
NORTHERN			
4.1 Burera	284	31	14.2
4.2 Gakenke	48	10	5.3
4.3 Gicumbi	197	45	9.0
4.4 Musanze *	1,203	110	27.9
4.5 Rulindo	113	19	12.7
EASTERN			
5.1 Bugesera	840	332	78.4
5.2 Gatsibo	108	96	2.4
5.3 Kayonza	352	587	1.3
5.4 Kirehe	119	64	3.1
5.5 Ngoma	144	37	7.8
5.6 Nyagatare *	432	1,025	1.3
5.7 Rwamagana	843	213	11.2

Note: One percent of outliers have been omitted from each end of the distribution as a way of dealing with possible data entry errors leading to high variance in LAIS data.
"*" : Cities & Secondary cities

4.3 Land Parcel Transaction Values by Land Use

This section provides similar analysis and comparisons disaggregated by Land Use (see Chapter II for introduction to LAIS land uses). The table below (Table 19, on page 44) summarizes LAIS 2014 data on number, area, and value of land transactions according to land use. The figure below (

Figure 20, on page 45) highlights the area and value per hectare information for further insight.

The data show that most transactions involved agricultural, livestock, and residential land uses. Transactions involving agriculture and livestock land uses were of substantially lower value per hectare than commercial, residential, or industrial transactions. As in the geographic analysis, these results indicate understandable patterns in the areas and values across sectors, some of which indicate high value, concentrated economic activities, while others less so.

The residential land use has the largest number of transactions and these represent about three quarters of the total value transacted, but less than 20 % of area transacted. As noted above, the majority of residential transactions take place in Kigali.

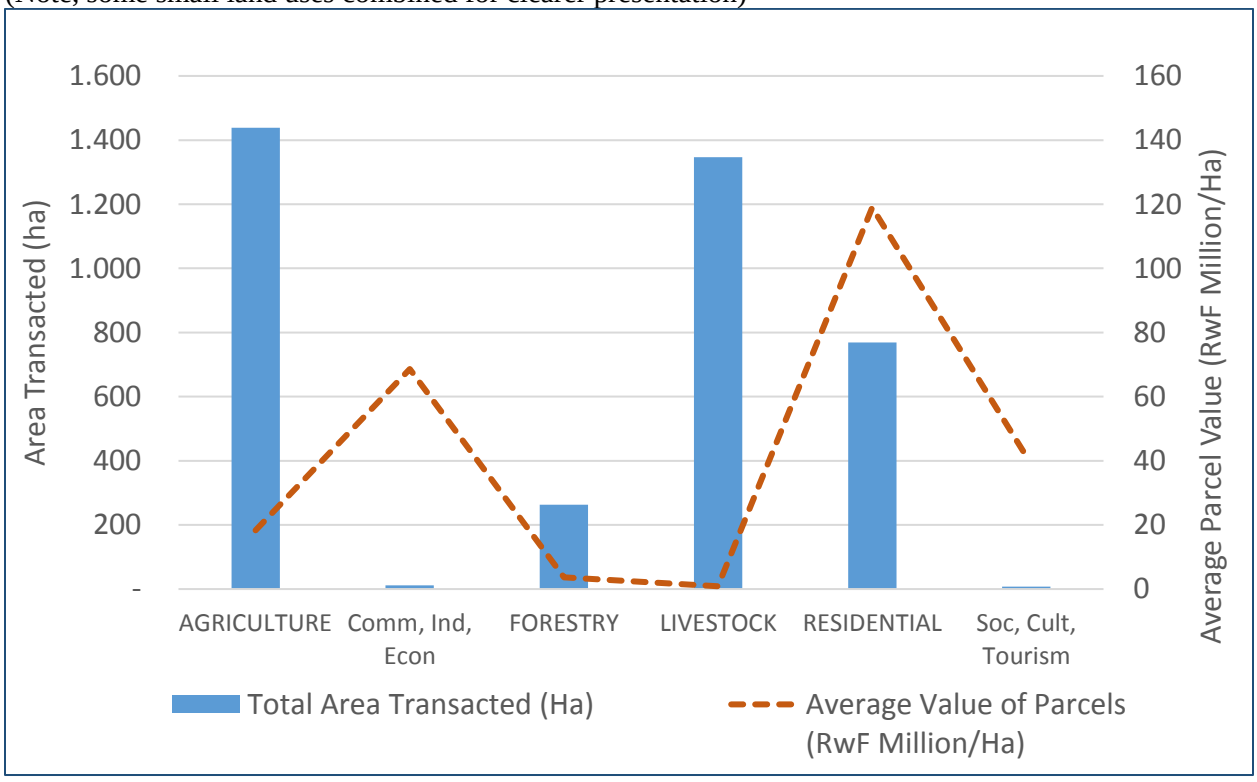
Agriculture and Livestock land uses have relatively large areas transacted (1350 to 1450 ha), but at very different average sizes and values. Agriculture had almost 6000 transactions at an average value of 18 million RwF per hectare, while Livestock had fewer than 180 transactions at an average value of only 0.9 million RwF per hectare. Livestock parcels averaged 7.6 hectares in size, far larger than any other land use, reflecting the extensive nature of this economic activity, but also a relatively low value per hectare. This analysis is provided for each province in Annex C for a more detailed view.

The Natural Capital Accounting approach is useful for providing quantified and disaggregated results that can confirm basic assumptions about the area and value of land transactions. In the long run, the NCA for Land will provide a systematic, consistent, regularly updated data set that can help to deepen Rwanda’s ability to analyze trends and signal disparities.

Table 19: ***Summary of Area and Value of Parcel Transactions, by LAIS Land Use, 2014***

LAIS LAND USE	Total Area Transacted (Ha)	Average Value of Parcels (RwF Million/Ha)	Total Value Transacted (RwF Millions)	Number of Transactions	Average Parcel Size (Ha)
AGRICULTURE	1,438.84	18.28	26,302.46	5,812	0.25
COMMERCIAL	52.04	137.40	7,150.92	207	0.25
ECONOMIC	4.98	11.31	56.30	33	0.15
FISHING	0.03	9.68	0.30	1	0.03
FORESTRY	262.95	3.64	957.52	691	0.38
INDUSTRIAL	6.84	57.32	391.93	37	0.18
LIVESTOCK	1,346.70	0.87	1,173.15	178	7.57
RESIDENTIAL	769.31	118.96	91,516.45	8,202	0.09
SOC. & CULT.	7.72	36.30	280.10	20	0.39
TOURISM	0.31	5.11	1.59	3	0.10
TOTAL	**3,889.72**	**32.86**	**127,830.72**	**15,184**	**0.26**

Figure 20: ***Summary of Area and Value of Parcel Transactions, by LAIS Land Use, 2014***
(Note, some small land uses combined for clearer presentation)



4.4 Areas for Improvement in Preparation for Monetary Account

LAIS provides a systematic data set capable of advancing the understanding of land transaction values in Rwanda. This section indicates some steps that can be taken to improve data quality and prepare for development of complete Monetary Land Accounts. After full quality and consistency checks, the monetary land accounts will be useful for informing land valuation. Land transaction values, once fully validated, can also be compared or used as reference prices for establishing the appropriate range of values for mortgages, fair prices for land transactions in different regions, and compensation, e.g., if lands are expropriated with just compensation in the interest of national development.

Data Quality and External Validation. Some internal data quality issues still need to be investigated and resolved. For example, the issue of extreme values (outliers) can be assessed and corrected by checking the data in LAIS against the original land records, which are stored in the system as PDF files. For 2014, a first check of 300 records would help to determine the scale of the issue and the effort needed to address it, if data entry errors are found. This would be time consuming, but could be managed by engaging students as interns under the supervision of experienced staff. Increased effort and some revisions will also be needed to separate the value of the land from the value of buildings on and improvements to the land.

In addition, some external checks or comparisons could be contemplated to assure that the LAIS data are as robust and realistic as possible. For example, LAIS values per hectare could be compared with mortgage values, as collected by the banking system and Revenue Authority. This may lead to another round of data validation, system compatibility checks, and efforts to improve and harmonize definitions.

Next Steps toward Monetary Land Accounts. An important next step will be to compile all the similar analyses and comparisons for 2015 (and soon, 2016). Next, linking the Land Use categorization to the National Accounts (ISIC codes that underpin sectoral analysis of GDP) will enable comparison of land values from LAIS to other parts of the economy and other sources of economic data on sector performance, jobs, and other trends over time. As noted above, effort will be needed to separate land values from building values, to the greatest extent possible. A sampling approach has been proposed to develop estimators that can aid in this effort.

Rwanda will also need to develop an approach for estimating and projecting the average land transaction values to all parcels to achieve an overall estimate of land values for the country. LAIS provides a sample of 15,500 records for 2014, but there are 11 million parcels in the full data set. Statistical procedures and guidance are available to assist in this effort.

Finally, the effort will involve constructing SEEA format monetary land accounts, including land use value changes. The Land Use Accounts discussed in Chapter II provide an overview of the SEEA formats and data summaries. This complete national estimate data set can then be analyzed and disaggregated using similar approaches as demonstrated in this chapter.

CHAPTER V: Land Accounts: Issues and Implications

This chapter reviews NCA issues and trends and discusses possible implications for Rwanda's development challenges and policymaking. The subsequent sections review findings and lessons learned that are related to coordination and institutional issues, data collection and quality issues, and capacity and technology issues. Suggestions are included that may be relevant for the annual budgeting process, specifically to improve and institutionalize the preparation of natural capital accounts on a regular basis and to mainstream their use into the development planning process.

5.1 Policy and Development Planning Issues

Informing the Land Use Planning Process. Land accounts and the information in LAIS can be used to inform land-use planning (including the distribution of land uses at province and district level, and at even lower levels of administrative organization), plus information on parcel size, ownership, transaction values, and changes in all of these. LAIS contains so much information that it can support a wide range of analyses, however, the challenge is in refining those top-level findings needed by policy makers. Agencies and local governments involved in land-use planning will benefit if detailed results from LAIS can be made available, including linking them with geographic information systems and mapping that can show change over time with high resolution. It would be a useful exercise, for example, to use the land accounts—as presented in this document and in the downloadable annexes—in comparison with the Land Use Development Master Plan, and to examine how land use classifications conform to the recommendations (disaggregated to district or lower level). Specific areas of rapid change or land uses that are not aligned with the Master Plan can be investigated in depth, including through field visits. Now, the land use data, land cover maps, and land use plans are separate in terms of both data requirements and institutional responsibilities. If the three can be integrated in a geospatial framework, this will become a useful tool for checking the consistency of plans with actions on the ground, as well as assessing land use and land cover trends relative to plans.

Land valuation. The NCA for land can be useful for informing the valuation of land, after full quality and consistency checks. LAIS provides a good basis for analysis of land parcel transaction values. These can be compared with mortgage values, as collected by the banking system and Revenue Authority. As noted, land transaction values can help to inform officials on the range of appropriate values for mortgages, land compensation, etc. Revisions may be needed to separate the value of the land from the value of buildings and construction on the land.

Rural development patterns and process. The NCA and LAIS can be used to inform officials of changes in development and settlement patterns, as discussed in Chapters II and III. With additional analysis and mapping information, the LAIS system can be used to report on the development of rural settlements and changes in residential land uses, by district or any other level of geographic detail. LAIS results could also be compared with land cover accounts based on satellite imagery as a means of cross-checking registered land use and actual land cover. This can support the "integrated approach to land-use and human settlements" called for in the EDPRS 2.

This would require a finer scale of analysis than the NCA for land, but the data and systems are available to support this process, should decision-makers find it valuable.

Land parcel size. The LAIS system allows analysis of changes in parcel size by land use and geographic area. The current system has quality data for two years, as shown in Chapter II, so any discussion of long-term trends would be premature at this point. This analysis shows that national averages of parcel size are not a good indicator of what is happening at the regional and district levels, where there have been both increases and decreases in parcel size across different regions and land uses. For some areas, these changes reach 3-5 % over the two-year period examined, which indicates rapid change in parcel size, but in the direction of both increasing and decreasing parcel sizes. This topic may deserve more analysis or case studies of areas with rapid changes to determine if this reflects action on the ground, or artifacts of the LAIS and data quality.

Climate and resilience planning and investment. The land use and cover accounts have great relevance for Rwanda's efforts to build climate resilience, reduce deforestation, and increase forest cover. Rwanda is now engaged in developing a strategic plan for climate resilience and a forest investment plan, with preparation funding from the Pilot Program for Climate Resilience and the Forest Investment Program, both of which are under the umbrella of the Climate Investment Funds (see http://www-cif.climateinvestmentfunds.org/country/rwanda). The land accounts can support analysis of forest cover changes, pace of development, and areas of vulnerability.

Integrated analysis and modeling using land, water, and minerals accounts. When finally compiled, the series of Natural Capital Accounts can be used in combination with other data sources to analyze key policy issues or to support modeling and projections that go beyond the scope of the NCA documents. There is great potential for coordinating analytical efforts with universities and think tanks, as well as for capacity development of faculty and students. Topics of interest could include analysis of impacts of changes in land uses on water supply, agricultural production, and other environmental services. WCS and the SNAPP team have begun this type of modeling work in the context of developing Ecosystem Accounts.

5.2 Coordination and Institutional Issues

This section discusses inter-institutional communication and coordination issues that were encountered during the process of compiling the land accounts. The following suggestions are offered to improve and streamline the process going forward.

Linking data systems across ministries. There is a need for standard operating procedures and rules of the game for linking data systems across ministries and sectors. For example, if all databases included similar identifying information—e.g., LAIS unique parcel identification number, or a taxpayer identification number (from Rwanda Revenue Authority – RRA), or a NISR business enterprise survey identifier—then analysts seeking to compile and analyze information across sectors would have a basis for integrating data from multiple sources and cross referencing data sets. This data linkage will improve efficiency and speed the time needed to produce natural capital accounts going forward, but could also be considered an important contribution to strengthening the system of national accounts, the data available to RRA, the sectoral agencies,

etc. NISR may be an institution that could play a role in establishing data linking and sharing protocols or standard operating procedures for database developers and managers in the future, with an eye toward integration and cross referencing.

Integration and efficiency of data compilation. At the national level, integrating the NCA work into the system of national accounts (SNA) could be strengthened and made more efficient. It would be valuable to update the land and water accounts regularly to establish a time series of indicators for assessing performance and reporting over time to policymakers and the public. The human and financial resources needed for regular updating will depend partly on the frequency of publication, which might be every two years depending on the needs of data users. Developing the accounts up to version one required about 145 weeks[7] of effort over about 18 months, and was estimated based on government staff contributions and the World Bank-sponsored WAVES technical assistance program. Some of this effort was used in building capacity and overcoming data issues, with the result that future iterations should take less effort.

Institutional mandate and focal point for NCA. Rwanda's National Steering Committee for NCA will need to consider the institutional setting for managing and maintaining the natural capital accounts after the development and technical assistance period ends. Technical agencies may have responsibility for production of sectoral data; statistical agencies are often responsible for data quality and consistency; economic and planning agencies may have an important role in the use and application of data from multiple sectors in an integrated framework. Some countries have found that creating a NCA unit within a central, coordinating agency can be very helpful in providing needed convening power. Among WAVES-supported countries, Botswana and Madagascar have this unit located in the Ministry of Finance. Some countries have an overall coordination function, or steering committee, under a lead agency, such as Planning or Finance, with dedicated units within the national statistics authority responsible for producing the accounts. Use of the accounts in policy and planning for development may be mainstreamed into the work of technical and planning agencies. In most WAVES countries, the Ministries of Planning/Finance have been willing to dedicate funds to the production of these accounts because they add value and key information for policy and development planning. The table on the next page provides an overview of how different countries have addressed this issue.

[7] This is a very rough estimate that includes time spent on organizing, preparing, and training across several sectors, not just land accounts. The WAVES Program supplied about 15 weeks of international technical assistance, 40 weeks of senior Rwandan technical assistance, and 90 weeks of data analysis support over an 18-month period, though this effort contributed to both the land and water accounts. Total Government staff participation in trainings, workshops, and production of the tables and accounts documents was probably about equivalent.

NCA Country	NCA Coordination Unit
Guatemala	No, there is not yet a coordinating unit
Costa Rica	Yes, based in the Costa Rica Central Bank
Columbia	Yes, based in the National Administrative Department of Statistics
Botswana	Yes, based in Ministry of Finance
Madagascar	Yes, based in the Ministry of Economy and Planning
Philippines	Yes, based in the Philippine Statistics Authority PMO is in National Economic and Development Authority
Indonesia	No, there is not yet a coordinating unit
*Netherlands	Yes, based in National Statistics Agency
*Australia	Yes, based in National Statistics Agency
	* Developed countries

5.3 Data Quality and Data Collection Issues

The LAIS is a good database system with quality information at parcel level on area, ownership, location, and transactions. It is an excellent basis for the land accounts and it continues to be refined and improved. However, the NCA development process has identified some data quality and consistency issues that could be addressed to improve the completeness and accuracy of land information in the future. The following points indicate areas where refinements to LAIS may be considered. The RMLUA team is already aware of many of these issues.

Transaction values. To streamline the regular, efficient production of analysis relevant to land use change, land values, and the economic contributions of different types of land, it would be helpful to include descriptive information on parcels that undergo market transactions for ownership change. This will allow rigorous analysis of the value of land, as well as the structures or improvements made to the land. Having a better understanding of the price of land in various uses and locations can contribute to analysis of the economic forces behind development and urbanization trends, e.g., agricultural market value chains.

Consistency of definitions. Land use designations are neither consistently, nor narrowly defined, so that in application, there is variability in how parcels are classified. For example, the distinction between the "commercial" and "economic" categories is not clear even to users of the LAIS database. Similarly, the land uses "agriculture" and "livestock" are not well distinguished in application to specific parcels. It will be useful to consider and define the categories of land use precisely and in a manner that allows alignment with other sources of economic and productivity information, for example, the ISIC system employed in the National Statistical Accounts. Such detailed categorization would also allow LAIS information to be readily compared and analyzed in relation to information available from other agencies. This will also allow closer alignment with the procedures and methods recommended in the System of Environmental Economic Accounting (SEEA) for physical and monetary land accounts.

Comparison with real world conditions. Because LAIS is a land administration database there may be places where the actual uses of land on the ground do not match the coding in the database (or, as above, where the coding does not accurately describe the land use, e.g., commercial activities). With the recent District Master Plans in place, the issue of land use change can be

captured in LAIS, assuming that the land use master plan implementation is monitored effectively. However, there may be discrepancies in places where there are only a few land use transactions and in places where the original land use demarcation did not adequately reflect existing land uses. There may be other cases where land sale transactions occur, but are not actually captured in the system; this may be happening in some rural areas. With the land campaign occurring every year and reaching into rural areas, eventually these transactions should be captured in the system. The extent of this discrepancy could be determined through increased field checking on a sampling basis. This might prove resource intensive, but could be considered as a cross check on LAIS over a periodic basis.

Unrecorded transactions. Transactions that are not recorded would not be identified in LAIS. It is difficult to determine how common this issue may be; it is a compliance issue rather than a data quality issue. Surveys could be used with some sampling on the ground to determine if this is an important issue.

Additional land use categories. In terms of data quality improvements for the future, there may be a rationale to add some land use categories to LAIS. These additional categories could help to clarify land usage on the ground in greater detail and to record additional items such as roads, infrastructure, rivers, and protected areas. Mining may be considered as an important enough land use to warrant its own LAIS category. A limited review of 'unique parcel identifiers' of several mining operations indicated that these may be coded as "commercial," "economic," or some other land use. The LAIS team may want to consider merging some categories, specifically "commercial" and "economic," because these do not seem to be well distinguished by either definition or in application by LAIS' users.

5.4 Capacity and Technology Issues

This section discusses the institutional capacity issues and technology challenges that Rwanda faces as it seeks to compile and refine its natural capital accounts. Suggestions are offered to address these issues going forward.

Capacity for regular NCA updating. Current staff of the environment and natural resource agencies, NISR, and other agencies engaged in the NCA process to date have participated in training events and have built their skills through on-the-job work, training events, and workshops. There will, however, be a continuing need for training and expertise to continue to upgrade the government's capacity to systematically handle the NCA over the coming years. The University of Rwanda (UR) will be a useful institution to consider as a source of training on environmental economics, natural capital accounting, and cross-sectoral understanding of water issues, land issues, mining issues, and ecosystem issues. MINIRENA (then) and UR in 2016 established a Memorandum of Understanding for scientific and research collaboration on these topics.

Capacity for analysis of issues and policies based on NCA and LAIS sources. Although the LAIS system is reasonable and comprehensive, the analysis and reporting from the system to management tends to focus on administration and process issues, such as records processed and area covered. Analytical and issue-based reports may be better positioned to provide policymakers with information on important trends, changes in values, or key questions of the day. Currently,

analysis based on the database seems to involve special studies or external researchers, rather than a routine analytical capacity responsive to management questions. The Government may also want to consider commissioning specific studies from research organizations, working in parallel with existing staff of the land department. It could also be reasonable to consider that researchers or organizations that conduct studies using the LAIS database should brief their results to the land unit. The land unit could also consider—if it has not already—to record these research products in an electronic library that the staff can use to respond to important probably policy issues that decision-makers are facing.

Staff skills and time constraints. For the longer-term institutionalization of NCA preparation and maintenance, the government may need to consider time constraints on mid-level government officials tasked with this work, as well as budgets needed for database maintenance, field verification, workshops, and further training. Currently, staff skills are adequate for the task, but there may be future needs as staff turnover. The Government has in place a staff development process where individuals are sponsored for post graduate studies, after which they are expected to remain at the agency for three years. The government also sponsors staff taking short-term courses when there is a need to boost skills in a specific area. Courses in environmental economics, accounting, and statistics should be eligible.

Technology Capacity. As part of updating the land cover maps for Rwanda, RCMRD did an assessment of Rwanda's natural resource agencies' computing and processing capacity. RMCRD found that the unit can handle current requirements, but may need additional capacity to meet future demands. As it pertains to storage, there is sufficient capacity and back up media, but staff keep some data on their computers rather than in a centralized storage unit. Some upgrades to server functioning are expected soon to improve back up / mirroring capacity (and thereby enhance safety). As to internet connectivity, the Government has fiber and 3G connections, which are sufficient for daily activities, but not for handling the large data downloads associated with geospatial data.

Box 3: Next Steps on Ecosystem Accounts

In Rwanda, the contribution of forest ecosystem services to the economy has been underestimated, due to the lack of a practical valuation and implementation approach. Preliminary work on economic valuation of ecosystem services will be informative for Rwanda's policy makers and development planners. However, the current research is based on a few case studies and a few years of data. Continuing compilation of land, water and ecosystem accounts on a regular basis create a longer time series that will enable more informative analysis of trends. Further integration of the approaches, data sets and scenarios analyzed will be important for more comprehensive understanding of NCA implications for economic development. Strengthening collaboration with universities and researchers would provide the government with access to technical expertise and specific skills in economic modeling, biophysical modeling, and resource valuation that can contribute to the development planning process.

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Annexes

ANNEX A: Land Uses and Changes at the District Level

This Annex follows on Section 2.3 of the main report and illustrates the same breakdown of land use changes, but at the district level. This level of analysis allows a closer look at the dynamics within provinces, but in too much detail for the main report. As seen in Chapter II, both Kigali and Southern Province experienced fast rates of change in certain land uses during the 2014-15 period. This Annex presents tables for all provinces and districts and examines district level changes in land use for each province, as an illustration of the power of this approach and of the LAIS database. Districts with secondary cities or urban settings are noted with asterisk. Later analysis could assess statistical significance of differences between urban and rural districts in terms of land uses and change over time.

Land Use Change at District Level - 2014

District		Agriculture	Forestry	Industrial	Livestock	Residential	Unclassified	Others
1. Kigali City								
1.1 Gasabo *	Opening 2014	25,561	3,288	147	569	5,056	5,193	1,619
	Closing 2014	25,421	3,275	180	555	5,303	4,984	1,715
	Net Changes (Ha)	-140	-13	33	-14	247	-209	95
	Net Changes (%)	-0.5%	-0.4%	22.4%	-2.4%	4.9%	-4.0%	5.9%
1.2 Kicukiro *	Opening 2014	6,943	537	50	428	3,433	3,030	1,295
	Closing 2014	6,466	548	72	356	3,567	3,423	1,283
	Net Changes (Ha)	-477	11	22	-72	134	393	-12
	Net Changes (%)	-6.9%	2.1%	44.5%	-16.8%	3.9%	13.0%	-0.9%
1.3 Nyarugenge *	Opening 2014	7,438	1,240	19	45	1,634	1,823	413
	Closing 2014	6,928	1,167	29	43	1,520	2,516	410
	Net Changes (Ha)	-510	-73	10	-2	-114	692	-4
	Net Changes (%)	-6.9%	-5.9%	52.7%	-4.7%	-6.9%	38.0%	-0.9%
2. Southern Province								
2.1 Gisagara	Opening 2014	42,734	2,998	9	139	2,855	15,057	343
	Closing 2014	43,133	3,042	9	143	2,870	14,588	348
	Net Changes (Ha)	399	44	0	5	16	-469	6
	Net Changes (%)	0.9%	1.5%	0.0%	3.3%	0.5%	-3.1%	1.6%
2.2 Huye *	Opening 2014	31,549	6,751	10	321	3,562	13,740	972
	Closing 2014	32,952	7,147	13	329	3,685	11,580	1,199
	Net Changes (Ha)	1,404	396	2	8	123	-2,160	227
	Net Changes (%)	4.4%	5.9%	23.4%	2.5%	3.4%	-15.7%	23.4%
2.3 Kamonyi	Opening 2014	41,230	5,583	21	111	3,729	13,493	438
	Closing 2014	42,102	5,619	22	110	3,827	12,475	449
	Net Changes (Ha)	873	36	1	0	98	-1,018	11
	Net Changes (%)	2.1%	0.6%	4.9%	-0.2%	2.6%	-7.5%	2.5%
2.4 Muhanga *	Opening 2014	40,329	7,480	9	90	3,737	10,938	701
	Closing 2014	41,090	7,639	12	93	3,845	9,894	713
	Net Changes (Ha)	761	158	2	3	107	-1,044	12
	Net Changes (%)	1.9%	2.1%	23.1%	3.8%	2.9%	-9.5%	1.7%
2.5 Nyamagabe	Opening 2014	50,208	16,045	228	101	4,065	12,320	583
	Closing 2014	51,214	16,405	437	101	4,100	10,696	597
	Net Changes (Ha)	1,005	360	210	1	35	-1,625	14
	Net Changes (%)	2.0%	2.2%	92.2%	0.8%	0.9%	-13.2%	2.3%
2.6 Nyanza	Opening 2014	42,971	4,164	9	216	4,805	12,392	425
	Closing 2014	44,953	4,367	10	229	5,008	9,955	460
	Net Changes (Ha)	1,982	203	1	13	204	-2,437	34
	Net Changes (%)	4.6%	4.9%	9.1%	6.2%	4.2%	-19.7%	8.0%
2.7 Nyaruguru	Opening 2014	38,355	17,653	9	92	2,704	18,657	529
	Closing 2014	39,734	18,348	10	101	2,756	16,500	553
	Net Changes (Ha)	1,379	694	0	9	52	-2,158	23
	Net Changes (%)	3.6%	3.9%	4.5%	9.5%	1.9%	-11.6%	4.4%
2.8 Ruhango	Opening 2014	39,406	2,791	3	89	3,963	14,635	208
	Closing 2014	40,443	2,893	3	92	4,099	13,346	219
	Net Changes (Ha)	1,037	102	0	3	136	-1,288	11
	Net Changes (%)	2.6%	3.7%	0.0%	3.3%	3.4%	-8.8%	5.1%

Land Use Change at District Level - 2014

District		Agriculture	Forestry	Industrial	Livestock	Residential	Unclassified	Others
3. Western Province								
3.1 Karongi	Opening 2014	43,998	13,092	470	339	4,869	10,178	2,952
	Closing 2014	43,992	13,089	470	339	4,845	10,180	2,983
	Net Changes (Ha)	-7	-3	0	0	-24	2	31
	Net Changes (%)	0.0%	0.0%	0.0%	0.0%	-0.5%	0.0%	1.1%
3.2 Ngororero	Opening 2014	40,855	8,121	874	1,662	5,302	7,615	1,160
	Closing 2014	41,481	8,122	355	1,662	5,123	7,688	1,159
	Net Changes (Ha)	626	1	-519	0	-179	72	-2
	Net Changes (%)	1.5%	0.0%	-59.4%	0.0%	-3.4%	0.9%	-0.1%
3.3 Nyabihu	Opening 2014	25,996	4,586	19	1,520	3,721	9,846	819
	Closing 2014	26,657	4,584	21	1,566	3,990	8,966	725
	Net Changes (Ha)	661	-2	2	45	269	-881	-94
	Net Changes (%)	2.5%	0.0%	9.0%	3.0%	7.2%	-8.9%	-11.5%
3.4 Nyamasheke	Opening 2014	36,871	9,521	158	125	6,111	9,123	4,399
	Closing 2014	38,970	9,546	163	141	6,088	6,998	4,403
	Net Changes (Ha)	2,099	24	5	16	-23	-2,125	4
	Net Changes (%)	5.7%	0.3%	3.0%	12.6%	-0.4%	-23.3%	0.1%
3.5 Rubavu *	Opening 2014	18,866	2,442	107	1,034	3,204	4,590	1,166
	Closing 2014	17,874	2,084	107	292	3,079	7,077	897
	Net Changes (Ha)	-992	-358	1	-743	-124	2,486	-269
	Net Changes (%)	-5.3%	-14.7%	0.6%	-71.8%	-3.9%	54.2%	-23.1%
3.6 Rusizi *	Opening 2014	30,822	5,126	826	98	8,980	7,493	1,497
	Closing 2014	30,829	5,141	919	98	8,913	7,441	1,501
	Net Changes (Ha)	7	16	93	0	-67	-52	4
	Net Changes (%)	0.0%	0.3%	11.2%	0.0%	-0.7%	-0.7%	0.3%
3.7 Rutsiro	Opening 2014	36,640	9,731	261	2,318	4,697	7,108	2,182
	Closing 2014	36,784	9,702	259	2,318	4,409	7,431	2,034
	Net Changes (Ha)	144	-29	-2	0	-288	323	-149
	Net Changes (%)	0.4%	-0.3%	-0.8%	0.0%	-6.1%	4.5%	-6.8%
4. Northern Province								
4.1 Burera	Opening 2014	34,692	4,799	16	156	4,428	10,843	574
	Closing 2014	34,705	4,800	16	160	4,448	10,795	582
	Net Changes (Ha)	13	2	0	4	20	-48	8
	Net Changes (%)	0.0%	0.0%	0.0%	2.5%	0.5%	-0.4%	1.4%
4.2 Gakenke	Opening 2014	50,401	8,525	16	112	3,853	5,854	542
	Closing 2014	50,212	8,516	16	112	4,306	5,590	553
	Net Changes (Ha)	-190	-9	0	0	452	-264	11
	Net Changes (%)	-0.4%	-0.1%	-0.6%	0.2%	11.7%	-4.5%	1.9%
4.3 Gicumbi	Opening 2014	58,260	7,764	12	409	5,370	8,685	832
	Closing 2014	58,135	7,754	12	422	5,634	8,542	834
	Net Changes (Ha)	-126	-10	0	13	264	-142	1
	Net Changes (%)	-0.2%	-0.1%	-0.8%	3.2%	4.9%	-1.6%	0.2%
4.4 Musanze *	Opening 2014	29,466	3,561	37	226	2,309	4,083	649
	Closing 2014	29,452	3,559	39	225	2,391	4,000	666
	Net Changes (Ha)	-14	-2	1	-1	81	-83	17
	Net Changes (%)	0.0%	-0.1%	3.4%	-0.4%	3.5%	-2.0%	2.7%
4.5 Rulindo	Opening 2014	39,566	6,363	4	241	1,573	7,557	590
	Closing 2014	39,435	6,377	5	241	1,751	7,489	597
	Net Changes (Ha)	-131	14	1	0	178	-68	7
	Net Changes (%)	-0.3%	0.2%	26.0%	0.0%	11.3%	-0.9%	1.2%

Land Use Change at District Level - 2014

District		Agriculture	Forestry	Industrial	Livestock	Residential	Unclassified	Others
5. Eastern Province								
5.1 Bugesera	Opening 2014	60,752	2,638	51	661	11,149	15,235	10,100
	Closing 2014	61,073	2,662	58	647	11,225	14,805	10,116
	Net Changes (Ha)	321	24	7	-15	76	-429	16
	Net Changes (%)	0.5%	0.9%	13.6%	-2.2%	0.7%	-2.8%	0.2%
5.2 Gatsibo	Opening 2014	59,799	9,107	14	7,547	12,414	9,589	983
	Closing 2014	59,849	9,112	14	7,570	12,464	9,462	982
	Net Changes (Ha)	50	5	0	23	50	-126	-2
	Net Changes (%)	0.1%	0.1%	0.0%	0.3%	0.4%	-1.3%	-0.2%
5.3 Kayonza	Opening 2014	64,155	7,497	18	33,899	7,528	20,843	1,400
	Closing 2014	62,797	8,720	19	34,029	7,617	20,739	1,418
	Net Changes (Ha)	-1,359	1,223	1	130	90	-104	18
	Net Changes (%)	-2.1%	16.3%	8.2%	0.4%	1.2%	-0.5%	1.3%
5.4 Kirehe	Opening 2014	68,013	6,796	22	11,116	8,478	15,826	4,024
	Closing 2014	68,090	6,798	23	9,097	8,520	17,718	4,028
	Net Changes (Ha)	77	2	1	-2,019	42	1,893	5
	Net Changes (%)	0.1%	0.0%	3.5%	-18.2%	0.5%	12.0%	0.1%
5.5 Ngoma	Opening 2014	54,878	3,409	20	1,435	8,774	9,274	1,073
	Closing 2014	54,905	3,415	21	1,435	8,801	9,208	1,077
	Net Changes (Ha)	27	6	1	-1	28	-66	5
	Net Changes (%)	0.0%	0.2%	6.8%	0.0%	0.3%	-0.7%	0.4%
5.6 Nyagatare *	Opening 2014	79,195	5,231	9	53,321	8,396	16,182	2,091
	Closing 2014	79,128	5,204	9	54,048	8,429	15,500	2,106
	Net Changes (Ha)	-67	-27	0	727	33	-681	15
	Net Changes (%)	-0.1%	-0.5%	0.0%	1.4%	0.4%	-4.2%	0.7%
5.7 Rwamagana	Opening 2014	42,413	3,772	41	2,027	7,043	8,061	1,073
	Closing 2014	42,376	3,771	47	2,030	7,203	7,924	1,079
	Net Changes (Ha)	-38	-1	6	3	160	-137	6
	Net Changes (%)	-0.1%	0.0%	14.1%	0.2%	2.3%	-1.7%	0.5%

Land Use Change at District Level - 2015

District		Agriculture	Forestry	Industrial	Livestock	Residential	Unclassified	Others
1. Kigali City								
1.1 Gasabo *	Opening 2015	25,421	3,275	180	555	5,303	4,984	1,715
	Closing 2015	25,146	3,231	220	558	5,655	4,825	1,797
	Net Changes (Ha)	-275	-44	40	4	352	-159	83
	Net Changes (%)	-1.08%	-1.33%	21.94%	0.63%	6.64%	-3.19%	4.82%
1.2 Kicukiro *	Opening 2015	6,466	548	72	356	3,567	3,423	1,283
	Closing 2015	6,398	537	114	413	4,065	2,886	1,302
	Net Changes (Ha)	-68	-11	42	57	498	-537	19
	Net Changes (%)	-1.06%	-2.02%	58.00%	16.10%	13.95%	-15.69%	1.50%
1.3 Nyarugenge *	Opening 2015	6,928	1,167	29	43	1,520	2,516	410
	Closing 2015	7,410	1,236	37	44	1,795	1,662	426
	Net Changes (Ha)	483	70	8	1	275	-853	17
	Net Changes (%)	6.97%	5.97%	26.35%	3.24%	18.08%	-33.92%	4.14%
2. Southern Province								
2.1 Gisagara	Opening 2015	43,133	3,042	9	143	2,870	14,588	348
	Closing 2015	45,650	3,167	9	184	4,177	10,532	415
	Net Changes (Ha)	2,517	125	0	40	1,306	-4,056	67
	Net Changes (%)	5.8%	4.1%	-0.8%	28.3%	45.5%	-27.8%	19.1%
2.2 Huye *	Opening 2015	32,952	7,147	13	329	3,685	11,580	1,199
	Closing 2015	33,707	7,315	13	336	4,287	10,199	1,049
	Net Changes (Ha)	755	168	0	7	601	-1,381	-150
	Net Changes (%)	2.3%	2.3%	0.0%	2.2%	16.3%	-11.9%	-12.5%
2.3 Kamonyi	Opening 2015	42,102	5,619	22	110	3,827	12,475	449
	Closing 2015	43,386	5,653	22	127	4,585	10,376	456
	Net Changes (Ha)	1,283	34	0	17	758	-2,099	7
	Net Changes (%)	3.0%	0.6%	-0.7%	15.1%	19.8%	-16.8%	1.6%
2.4 Muhanga *	Opening 2015	41,090	7,639	12	93	3,845	9,894	713
	Closing 2015	41,612	7,717	23	115	4,142	8,969	708
	Net Changes (Ha)	521	78	11	22	297	-925	-5
	Net Changes (%)	1.3%	1.0%	94.4%	23.1%	7.7%	-9.3%	-0.7%
2.5 Nyamagabe	Opening 2015	51,214	16,405	437	101	4,100	10,696	597
	Closing 2015	51,249	16,473	441	106	4,795	9,879	607
	Net Changes (Ha)	36	68	3	5	695	-817	10
	Net Changes (%)	0.1%	0.4%	0.8%	4.7%	17.0%	-7.6%	1.7%
2.6 Nyanza	Opening 2015	44,953	4,367	10	229	5,008	9,955	460
	Closing 2015	46,199	4,429	21	237	5,306	8,234	554
	Net Changes (Ha)	1,246	63	11	8	298	-1,721	95
	Net Changes (%)	2.8%	1.4%	117.6%	3.7%	5.9%	-17.3%	20.6%
2.7 Nyaruguru	Opening 2015	39,734	18,348	10	101	2,756	16,500	553
	Closing 2015	40,610	18,613	10	106	2,841	15,220	601
	Net Changes (Ha)	876	265	0	5	85	-1,280	48
	Net Changes (%)	2.2%	1.4%	1.6%	5.0%	3.1%	-7.8%	8.8%
2.8 Ruhango	Opening 2015	40,443	2,893	3	92	4,099	13,346	219
	Closing 2015	40,891	2,976	23	102	4,576	12,292	235
	Net Changes (Ha)	448	82	19	11	477	-1,054	16
	Net Changes (%)	1.1%	2.8%	575.7%	11.9%	11.6%	-7.9%	7.3%

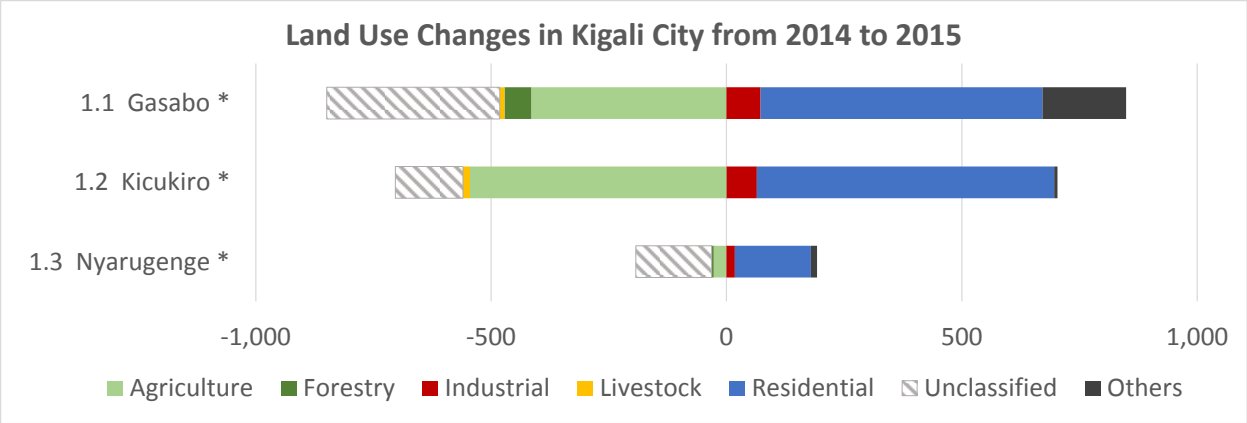
Land Use Change at District Level - 2015

District		Agriculture	Forestry	Industrial	Livestock	Residential	Unclassified	Others
3. Western Province								
3.1 Karongi	Opening 2015	43,992	13,089	470	339	4,845	10,180	2,983
	Closing 2015	44,257	13,128	153	348	5,567	9,515	2,929
	Net Changes (Ha)	266	39	-318	10	722	-665	-54
	Net Changes (%)	0.6%	0.3%	-67.6%	2.8%	14.9%	-6.5%	-1.8%
3.2 Ngororero	Opening 2015	41,481	8,122	355	1,662	5,123	7,688	1,159
	Closing 2015	39,171	7,636	340	456	9,345	7,572	1,068
	Net Changes (Ha)	-2,311	-486	-14	-1,205	4,222	-115	-90
	Net Changes (%)	-5.6%	-6.0%	-4.0%	-72.5%	82.4%	-1.5%	-7.8%
3.3 Nyabihu	Opening 2015	26,657	4,584	21	1,566	3,990	8,966	725
	Closing 2015	25,738	4,523	20	1,584	5,953	8,023	667
	Net Changes (Ha)	-919	-61	-1	19	1,963	-943	-58
	Net Changes (%)	-3.4%	-1.3%	-4.4%	1.2%	49.2%	-10.5%	-8.0%
3.4 Nyamasheke	Opening 2015	38,970	9,546	163	141	6,088	6,998	4,403
	Closing 2015	38,407	9,473	163	144	7,159	6,595	4,367
	Net Changes (Ha)	-563	-72	0	3	1,071	-403	-36
	Net Changes (%)	-1.4%	-0.8%	0.2%	2.0%	17.6%	-5.8%	-0.8%
3.5 Rubavu *	Opening 2015	17,874	2,084	107	292	3,080	7,077	897
	Closing 2015	17,853	2,101	120	284	3,583	6,557	911
	Net Changes (Ha)	-21	17	13	-7	504	-519	14
	Net Changes (%)	-0.1%	0.8%	11.9%	-2.5%	16.4%	-7.3%	1.5%
3.6 Rusizi *	Opening 2015	30,829	5,141	919	98	8,913	7,441	1,501
	Closing 2015	30,431	5,174	916	103	9,617	7,126	1,477
	Net Changes (Ha)	-398	32	-3	4	703	-315	-24
	Net Changes (%)	-1.29%	0.6%	-0.3%	4.3%	7.9%	-4.2%	-1.6%
3.7 Rutsiro	Opening 2015	36,784	9,702	259	2,318	4,409	7,431	2,034
	Closing 2015	36,260	9,668	258	2,342	5,693	6,698	2,019
	Net Changes (Ha)	-524	-34	0	24	1,283	-733	-15
	Net Changes (%)	-1.4%	-0.4%	-0.1%	1.0%	29.1%	-9.9%	-0.7%
4. Northern Province								
4.1 Burera	Opening 2015	34,705	4,800	16	160	4,448	10,795	582
	Closing 2015	34,929	4,826	17	140	4,386	10,617	591
	Net Changes (Ha)	224	25	2	-20	-62	-178	9
	Net Changes (%)	0.6%	0.5%	11.4%	-12.7%	-1.4%	-1.6%	1.5%
4.2 Gakenke	Opening 2015	50,212	8,516	16	112	4,306	5,590	553
	Closing 2015	50,239	8,525	16	120	4,304	5,528	572
	Net Changes (Ha)	28	9	0	7	-1	-62	19
	Net Changes (%)	0.1%	0.1%	0.0%	6.3%	0.0%	-1.1%	3.5%
4.3 Gicumbi	Opening 2015	58,135	7,754	12	422	5,634	8,542	834
	Closing 2015	58,146	7,783	14	430	5,638	8,489	833
	Net Changes (Ha)	11	29	3	8	4	-54	-1
	Net Changes (%)	0.0%	0.4%	23.4%	1.9%	0.1%	-0.6%	-0.1%
4.4 Musanze *	Opening 2015	29,452	3,559	39	225	2,391	4,000	666
	Closing 2015	29,446	3,545	55	233	2,478	3,887	686
	Net Changes (Ha)	-6	-14	17	8	88	-112	20
	Net Changes (%)	0.0%	-0.4%	42.8%	3.5%	3.7%	-2.8%	3.0%
4.5 Rulindo	Opening 2015	39,435	6,377	5	241	1,751	7,489	597
	Closing 2015	39,440	6,386	5	252	1,768	7,438	605
	Net Changes (Ha)	4	10	0	12	17	-51	9
	Net Changes (%)	0.0%	0.2%	-3.4%	4.8%	1.0%	-0.7%	1.5%

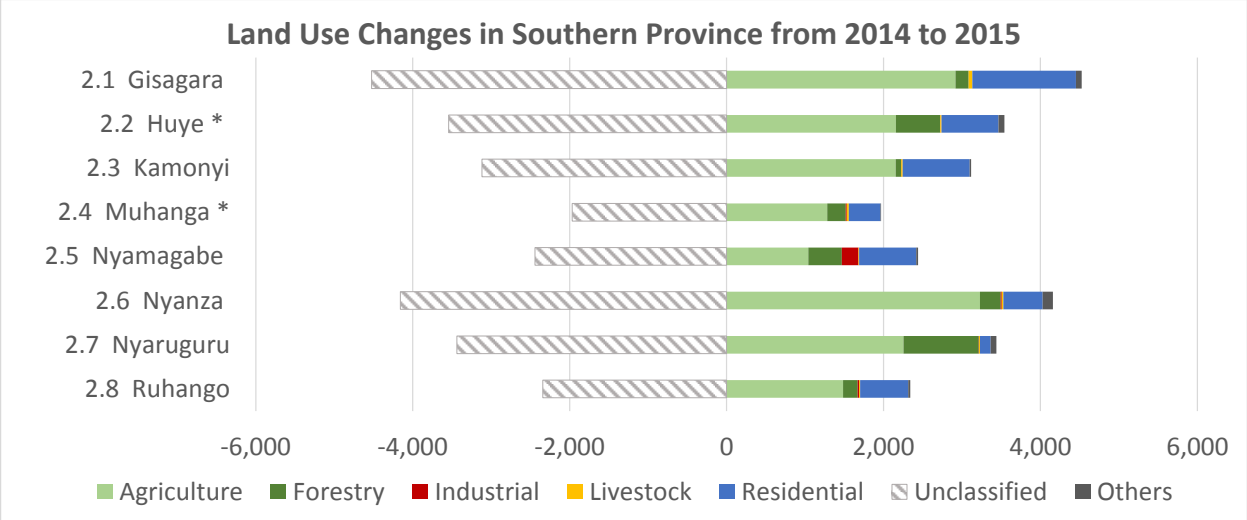
Land Use Change at District Level - 2015								
District		Agriculture	Forestry	Industrial	Livestock	Residential	Unclassified	Others
5. Eastern Province								
5.1 Bugesera	Opening 2015	61,073	2,662	58	647	11,225	14,805	10,116
	Closing 2015	60,930	2,642	73	651	11,483	14,659	10,149
	Net Changes (Ha)	-143	-20	15	4	258	-147	33
	Net Changes (%)	-0.2%	-0.8%	25.9%	0.6%	2.3%	-1.0%	0.3%
5.2 Gatsibo	Opening 2015	59,849	9,112	14	7,570	12,464	9,462	982
	Closing 2015	59,372	9,086	14	7,474	12,207	10,325	974
	Net Changes (Ha)	-477	-26	0	-96	-256	862	-7
	Net Changes (%)	-0.8%	-0.3%	0.0%	-1.3%	-2.1%	9.1%	-0.8%
5.3 Kayonza	Opening 2015	62,797	8,720	19	34,029	7,617	20,739	1,418
	Closing 2015	62,707	8,707	19	34,486	7,637	20,349	1,435
	Net Changes (Ha)	-90	-13	0	456	20	-391	17
	Net Changes (%)	-0.1%	-0.1%	0.0%	1.3%	0.3%	-1.9%	1.2%
5.4 Kirehe	Opening 2015	68,090	6,798	23	9,097	8,520	17,718	4,028
	Closing 2015	68,083	6,796	23	9,174	8,478	17,691	4,030
	Net Changes (Ha)	-7	-2	0	76	-42	-27	1
	Net Changes (%)	0.0%	0.0%	0.0%	0.8%	-0.5%	-0.2%	0.0%
5.5 Ngoma	Opening 2015	54,905	3,415	21	1,435	8,801	9,208	1,077
	Closing 2015	54,928	3,413	21	1,815	8,784	8,817	1,084
	Net Changes (Ha)	24	-3	0	381	-17	-391	7
	Net Changes (%)	0.0%	-0.1%	0.0%	26.5%	-0.2%	-4.2%	0.6%
5.6 Nyagatare *	Opening 2015	79,128	5,204	9	54,048	8,429	15,500	2,106
	Closing 2015	78,411	4,905	10	54,200	8,304	16,490	2,103
	Net Changes (Ha)	-717	-299	2	152	-125	990	-3
	Net Changes (%)	-0.9%	-5.7%	19.4%	0.3%	-1.5%	6.4%	-0.2%
5.7 Rwamagana	Opening 2015	42,376	3,771	47	2,030	7,203	7,924	1,079
	Closing 2015	42,296	3,765	46	2,015	7,405	7,834	1,068
	Net Changes (Ha)	-80	-5	-1	-15	202	-90	-11
	Net Changes (%)	-0.2%	-0.1%	-2.5%	-0.7%	2.8%	-1.1%	-1.0%

A Closer Look at District Level Changes. As noted, Kigali and Southern Provinces experienced relatively large or rapid changes in land use. By looking at district level changes in these provinces, it is possible to see if the land use changes are province-wide trends, relatively localized within the province, or if there is some difference in districts that are urban (denoted with an asterisk in tables and figures). This exercise illustrates the power of the LAIS database for use as an analytical framework to support the natural capital accounts and analysis of land use issues in Rwanda. The format and size of this document does not allow in-depth examination of each district. Provincial and district governments, researchers, and students may wish to pursue this analysis in greater detail. The LAIS database includes information at even finer levels of detail, if there were interest in examining specific areas of land use change to an even greater degree of granularity.

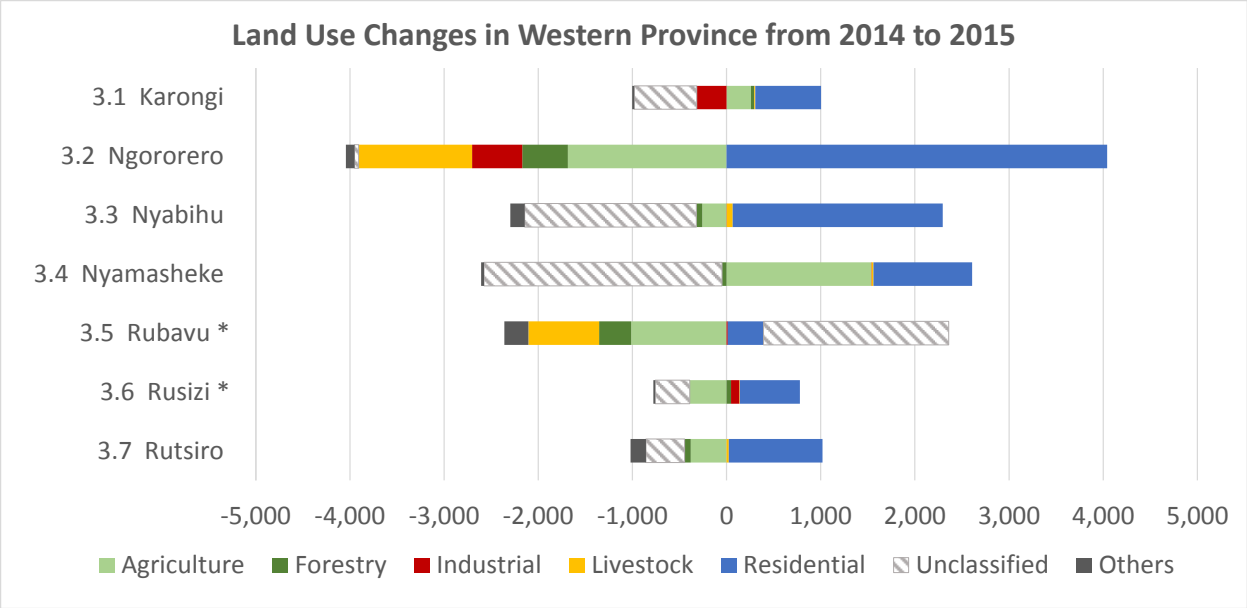
District Level Changes in Kigali City. The following figure illustrates changes in land use for the 2014-15 period for the three districts in Kigali City. This figure shows that about 2,000 ha in Kigali City changed classifications, with most of these changes occurring in Gasabo District and a few changes occurring in Nyarugenge District. In both Gasabo and Kicukiro Districts, there were some reclassifications from unclassified land to known land uses. The main changes, however, were agricultural and forestry land uses into urban and industrial land uses, as might be expected with the rapid urbanization around the capital. Changes in land use classification occurred across the city on about 1,500 out of 70,000 hectares, equivalent to 2.1 % of land.



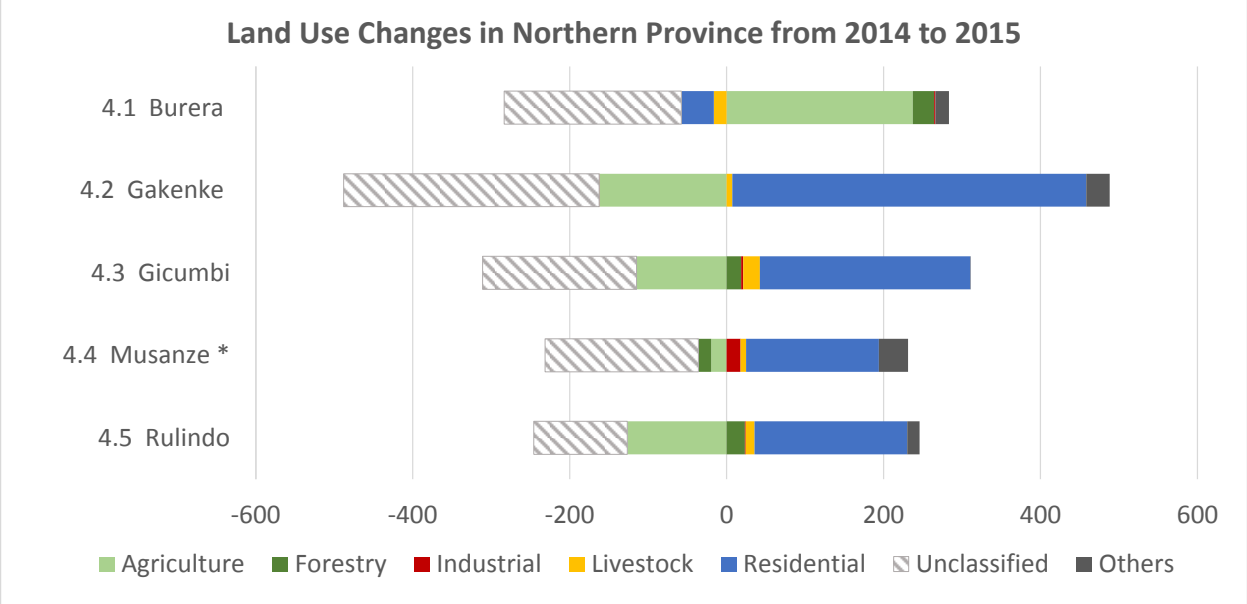
District Level Changes in Southern Province from 2014 to 2015. The following figure illustrates changes in land use for the 2014-15 period for the eight districts of the Southern Province. A substantial amount of land changed classifications, but all of this was from an initially unclassified state. Most reclassifications were into agriculture, residential, and forestry land uses. Most of the changes occurred in Gisagara and in Nyanza Districts, possibly reflecting the locations of land registration campaigns conducted by the RMLUA.



District Level Changes in Western Province from 2014 to 2015. The following figure illustrates changes in land use for the 2014-15 period for the seven districts of the Western Province. About 10,000 hectares changed classifications, with most changes in Ngogorero District. Unlike the Southern Province, the changes in this location were variable, with land transitioning to other land uses, not just those from an initially unclassified state. Almost all of the changes in Ngororero, Nyabihu, Rusizi, and Rutsiro Districts were movements into the residential category of land use.

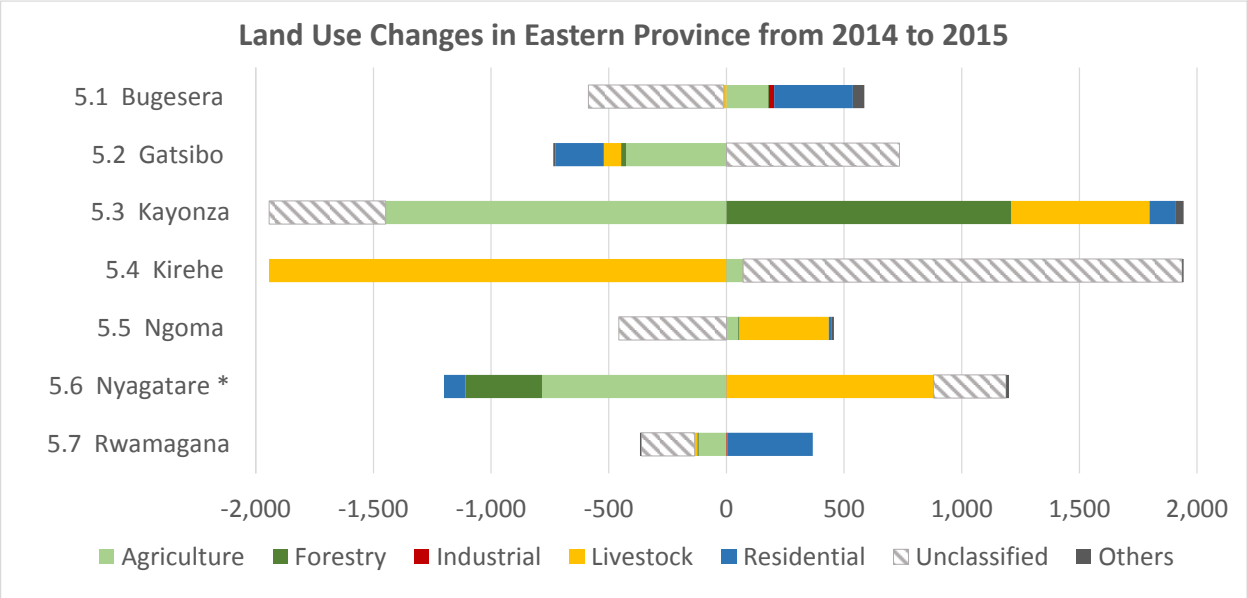


District Level Changes in Northern Province from 2014 to 2015. The following figure illustrates changes in land use for the 2014-15 period for the five districts of Western Province. This figure confirms the earlier statement that land use changes in this province were relatively small during the subject period. Most of the changes were from the unclassified category into residential land use, except in Burera where most of the changes were into agriculture.



District Level Changes in Eastern Province from 2014 to 2015. The following figure shows changes in land use for the 2014-15 period for the seven districts of Eastern Province. Most of the changes to about 4,000 ha occurred in in Kayonze and Kirehe Districts. These districts show relatively greater changes from livestock into unclassified land uses and from agriculture into

forestry than in the other provinces. This might be a candidate for examination of the reasons behind these types of changes. For example, almost all the changes in Kirehe were from livestock into unclassified.



ANNEX B: Methodologies and Definitions

The NCA Rwanda Land Accounts development process followed the System of Environmental-Economic Accounting (SEEA, UNSD 2012). SEEA contains the internationally agreed-upon standard concepts, definitions, classifications, accounting rules, and tables for producing comparable statistics on the environment and its relationship to the economy. The SEEA organizes statistical data—in the same framework as the System of National Accounts—so that consistent descriptive statistics and coherent indicators can be derived to monitor the interactions between the economy and the state of the environment to inform better decision-making.

The land accounts development largely focused on Physical Asset Accounts--land use and land cover--and Monetary Accounts, which are only at the introductory stage at this point. The accounting approach measures the changes in land use or land cover and provides the quantification of stock at different points in time.

1. Physical Asset Accounts

The physical asset accounts were developed mostly from data sourced from the Land Administration and Information System (LAIS). LAIS was introduced in a bid to move from an analog to a digital method of dealing with land transactions, especially by creating a more efficient, cost effective, transparent, and reliable land registration processes. LAIS serves as a digital Land Registry, thus reducing the issue of space needed to keep physical land-related files at the Office of the Registrar of Land Titles. The system came into effect in June 2012 and has information on over 11 million parcels of land across the country. The system is meant to reflect the reality on the ground in terms of land use.

LAIS records and indicates land uses and consequent changes across the calendar year. From the system, one can tell the shifts across the various documented land used changes during the year. The land uses recorded by the system include: Agriculture, Forestry, Residential, Industrial, Livestock, Economic, Research and Scientific, Social and Culture, Commercial, Tourism, Administration, and Fishing. Using the data extracted from the LAIS for 2014 and 2015, the NCA Rwanda Lands Accounts team populated the data into Land Use change matrixes to identify and study trends.

Land Use Change Matrix. The land use change matrix was compiled at national, provincial, and district levels. The Land Use Change Matrix indicates the shifts in land uses between January 1st and December 31st, which makes it possible to study annual trends. Using the land use change matrices—compiled in Excel format—Rwanda's land data can be analyzed from many different perspectives. The physical land use change matrices present the opening and closing stocks of land area for different land uses. They also present the net increase and net decrease of land uses according to the land use or land cover it was converted from (in the case of increases), or to (in the case of decreases). The total net change for each land use or land cover can also be calculated by summing all land use by type for the beginning of the reference period. The closing stock is calculated by summing the opening stock and the total net change in land area for each land use or land cover type. The data can be presented in graphs, charts, and tables for easy comparison.

Land Cover Maps. The land cover maps for Rwanda used in this NCA analysis publication present the land cover types for the country for 1990, 2000, 2010 and 2015. The maps show the trends of major land cover categories such as dense forest, wetlands, settlements, and shrublands, among others, over the given period of the 10 year gaps. The data and tables based on satellite

imagery were obtained from Rwanda GeoPortal, an online platform developed by Rwanda in collaboration with the Regional Centre for Mapping of Resources for Development (RCMRD).

2. Monetary Land Accounts

Physical information needs to be linked to price / value data to compile the monetary land accounts. When this is completed, the land accounts can be linked to other sources of data by sector through the International Standard Industrial Classification code system for economic activities. Existing records in LAIS on land transaction values and fees were considered for 2014 and 2015. LAIS maintains a database of the value of transactions, which includes both the land itself as well as improvements made to the land, such as buildings. Some estimates and comparisons are made in Chapter IV, but these need further analysis and disaggregation to approach the SEEA standard. In particular, the analysis needs to separate the value of land from the value of improvements to the land (e.g., houses, buildings, other construction). Some sampling approaches have been considered, but the full analysis has not been completed and verified. Some suggestions for improvement of data sources and records in LAIS have been recorded in Chapter V.

3. Data Quality

This publication is based on the best available administrative information and satellite imagery that the team could obtain. New analysis has been commissioned as well to extend the time series of land cover analysis. The validation of data accuracy was ensured using the years 2014 as a baseline and 2015 for comparison. Data from previous years was not very reliable as the records in LAIS still showed large numbers of parcels as unallocated, meaning they had incomplete data to support this land use analysis.

4. Coverage and Geography

The data used in the publication covers the entire country: 30 districts and 416 sectors. Based on the users' preferences, the tables and charts from a specific location can be downloaded for additional detailed analysis. The data tables will be available for download after the report and its contents are thoroughly reviewed by the relevant government departments.

5. Data Format

The tables provided have been made available as Microsoft Excel Spreadsheets (.xls), as the Land Accounting aims to follow those standards specified within SEEA.

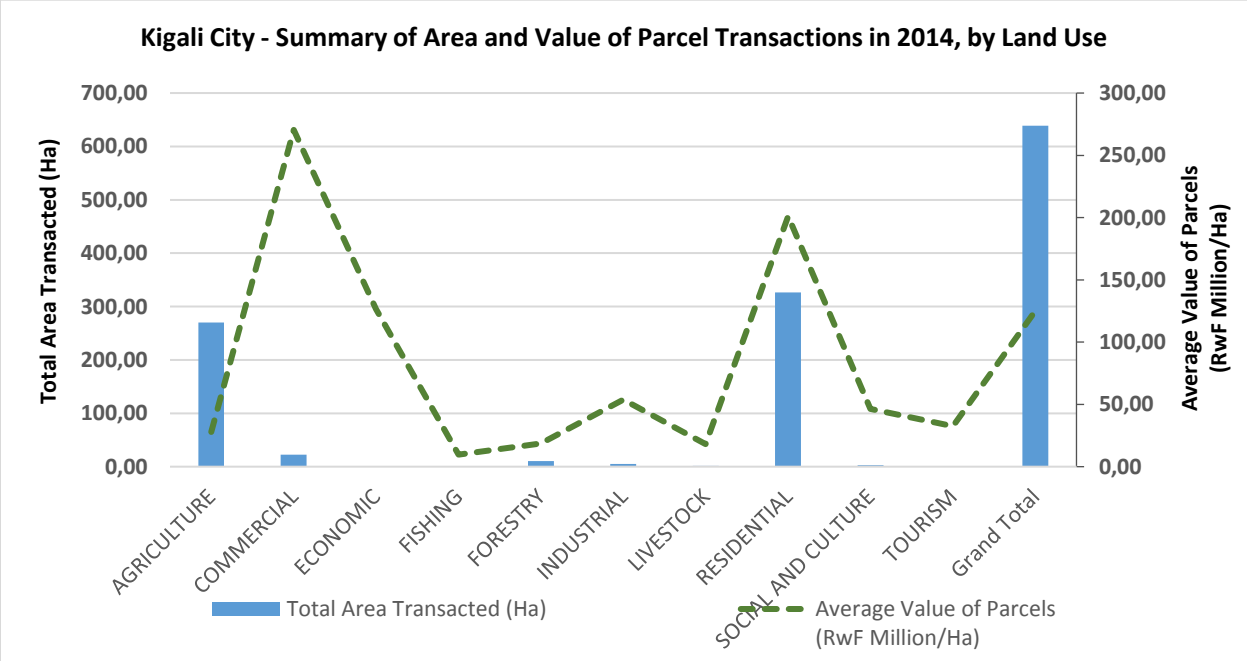
6. Confidentiality

This analysis is based on summarized and aggregated data. There was an effort made to prevent the release of any information that may identify any individuals or organizations, and to ensure that no private information was made public in the process of developing these accounts.

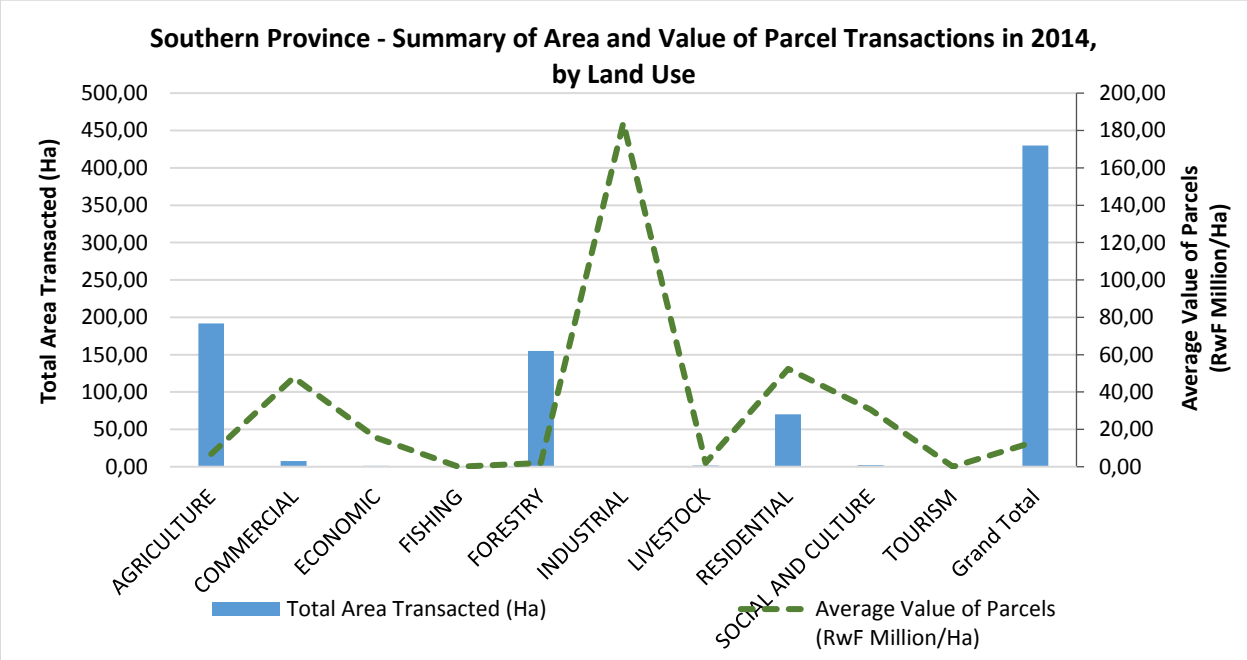
ANNEX C: Area and Value of Land Parcel Transactions by Province, 2014

This Annex provides a summary of the area and value of land parcel transactions in 2014 for each of Rwanda's five Provinces.

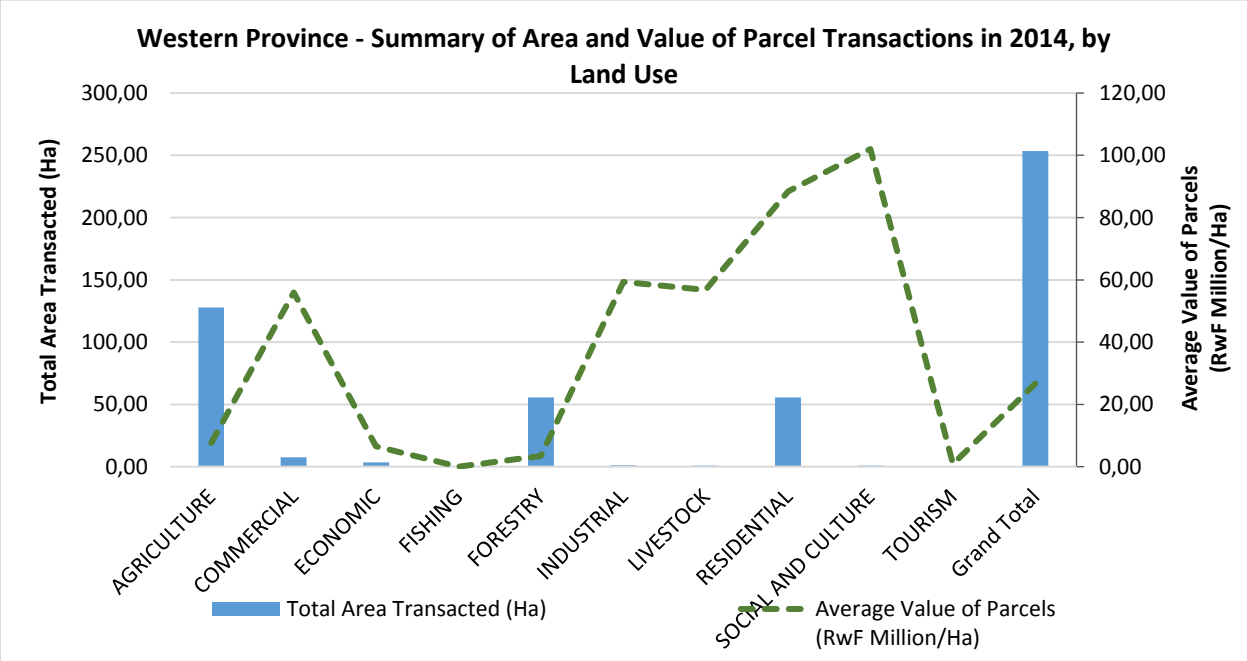
Kigali City - Summary of Area and Value of Parcel Transactions in 2014, by Land Use				
LAIS LAND USE	**Total Area Transacted (Ha)**	**Average Value of Parcels (RwF Million/Ha)**	**Total Value Transacted (RwF Million)**	**Number of Transactions**
AGRICULTURE	269.85	27.76	7,490.79	1,782
COMMERCIAL	22.48	270.41	6,079.49	93
ECONOMIC	0.06	126.61	7.50	2
FISHING	0.03	9.68	0.30	1
FORESTRY	10.78	18.54	199.89	76
INDUSTRIAL	4.87	53.86	262.43	32
LIVESTOCK	1.70	18.02	30.65	8
RESIDENTIAL	326.56	201.03	65,648.14	4,839
SOCIAL AND CULTURE	2.44	46.36	113.00	5
TOURISM	0.02	32.39	0.80	1
Grand Total	**638.80**	**124.97**	**79,832.99**	**6,839**



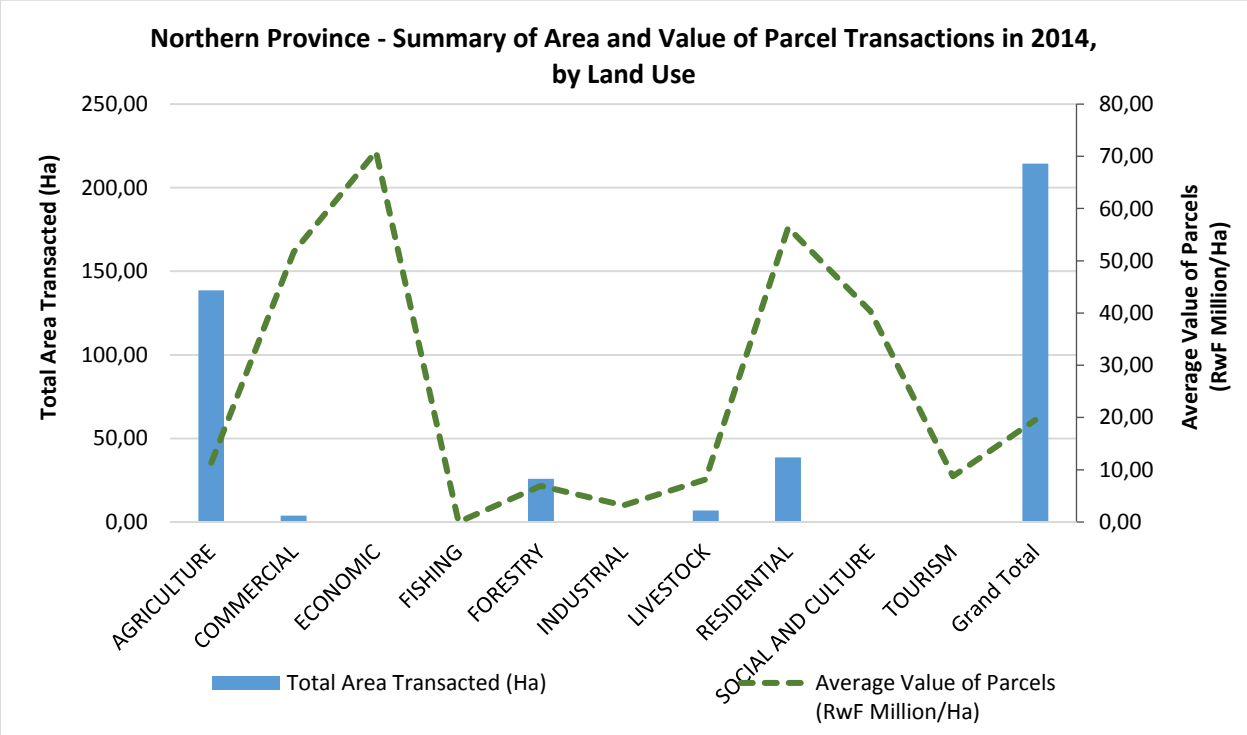
Southern Province - Summary of Area and Value of Parcel Transactions in 2014, by Land Use				
LAIS LAND USE	**Total Area Transacted (Ha)**	**Average Value of Parcels (RwF Million/Ha)**	**Total Value Transacted (RwF Million)**	**Number of Transactions**
AGRICULTURE	191.96	6.90	1,325.37	996
COMMERCIAL	7.67	47.81	366.72	27
ECONOMIC	1.41	15.55	22.00	5
FISHING	0.00	0.00	0.00	0
FORESTRY	154.81	2.12	327.45	301
INDUSTRIAL	0.32	184.11	58.00	2
LIVESTOCK	1.56	1.99	3.10	3
RESIDENTIAL	70.30	52.33	3,678.91	817
SOCIAL AND CULTURE	1.96	30.59	60.00	6
TOURISM	0.00	0.00	0.00	0
Grand Total	**429.99**	**13.59**	**5,841.55**	**2,157**



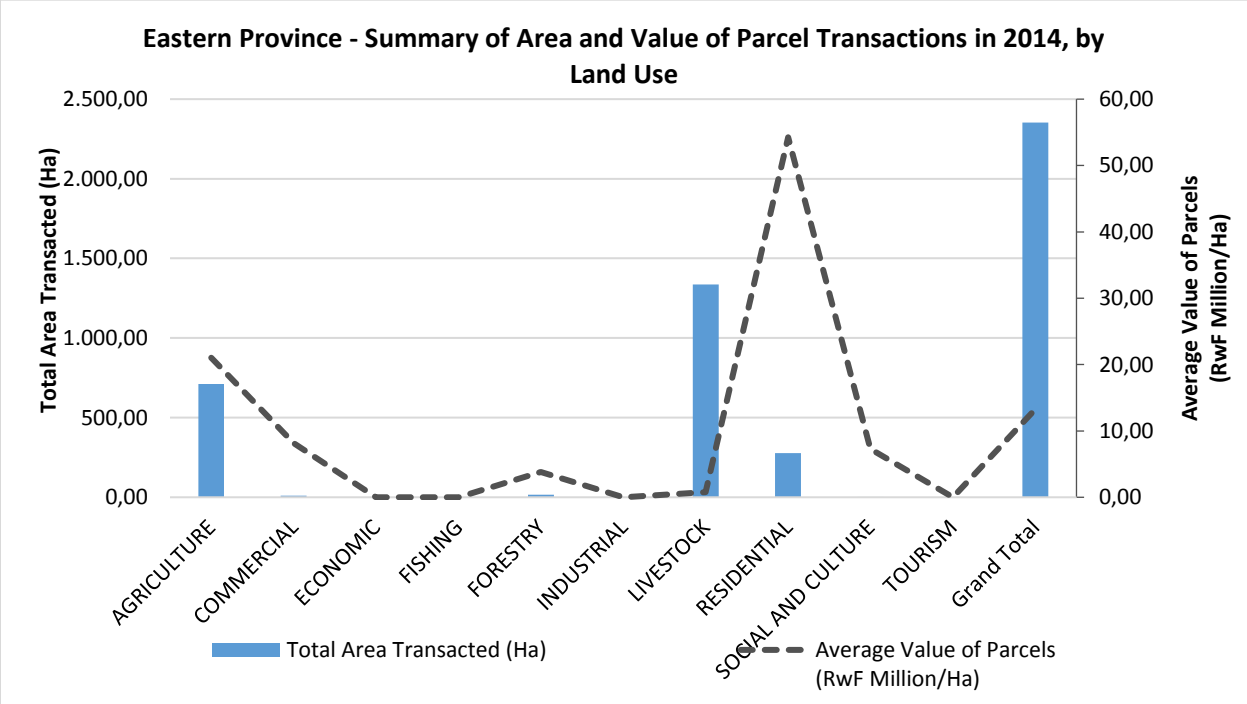
Western Province - Summary of Area and Value of Parcel Transactions in 2014, by Land Use				
LAIS LAND USE	**Total Area Transacted (Ha)**	**Average Value of Parcels (RwF Million/Ha)**	**Total Value Transacted (RwF Million)**	**Number of Transactions**
AGRICULTURE	127.80	7.64	976.96	603
COMMERCIAL	7.60	55.90	424.63	32
ECONOMIC	3.44	6.48	22.30	25
FISHING	0.00	0.00	0.00	0.00
FORESTRY	55.68	3.44	191.27	124
INDUSTRIAL	1.18	59.36	70.00	2
LIVESTOCK	0.98	56.78	55.85	6
RESIDENTIAL	55.70	88.41	4,924.32	708
SOCIAL AND CULTURE	0.80	102.02	81.55	4
TOURISM	0.22	0.87	0.19	1
Grand Total	**253.39**	**26.63**	**6,747.07**	**1,505**



Northern Province - Summary of Area and Value of Parcel Transactions in 2014, by Land Use				
LAIS LAND USE	**Total Area Transacted (Ha)**	**Average Value of Parcels (RwF Million/Ha)**	**Total Value Transacted (RwF Million)**	**Number of Transactions**
AGRICULTURE	138.52	11.35	1,572.61	1,074
COMMERCIAL	3.76	51.69	194.38	40
ECONOMIC	0.06	70.93	4.50	1
FISHING	0.00	0.00	0.00	0.00
FORESTRY	25.77	6.92	178.32	153
INDUSTRIAL	0.47	3.18	1.50	1
LIVESTOCK	6.86	8.16	56.00	13
RESIDENTIAL	38.63	56.33	2,176.07	560
SOCIAL AND CULTURE	0.22	40.34	8.80	2
TOURISM	0.07	8.74	0.60	1
Grand Total	**214.37**	**19.56**	**4,192.78**	**1,845**



Eastern Province - Summary of Area and Value of Parcel Transactions in 2014, by Land Use				
LAIS LAND USE	**Total Area Transacted (Ha)**	**Average Value of Parcels (RwF Million/Ha)**	**Total Value Transacted (RwF Million)**	**Number of Transactions**
AGRICULTURE	710.72	21.02	14,936.73	1,357
COMMERCIAL	10.53	8.13	85.70	15
ECONOMIC	0.00	0.00	0.00	0.00
FISHING	0.00	0.00	0.00	0.00
FORESTRY	15.90	3.81	60.59	37
INDUSTRIAL	0.00	0.00	0.00	0.00
LIVESTOCK	1,335.60	0.77	1,027.56	148
RESIDENTIAL	278.11	54.26	15,089.01	1,278
SOCIAL AND CULTURE	2.30	7.28	16.75	3
TOURISM	0.00	0.00	0.00	0.00
Grand Total	**2,353.17**	**13.27**	**31,216.34**	**2,838**



The WAVES Global Partnership, through the World Bank, supported Rwanda in the preparation of these natural capital accounts for land. The WAVES program aims to mainstream natural capital in development planning and national economic accounts in support of sustainable development.

WAVES core implementing countries include developing countries—Botswana, Colombia, Costa Rica, Guatemala, Indonesia, Madagascar, the Philippines and Rwanda—all working to establish natural capital accounts. WAVES also partners with UN agencies—UNEP, UNDP, and the UN Statistical Commission—that are helping to implement natural capital accounting.

WAVES is funded by a multi-donor trust fund and is overseen by a steering committee. WAVES is grateful to its donors—Denmark, the European Commission, France, Germany, Japan, The Netherlands, Norway, Switzerland, and the United Kingdom.