



Ministry of Environment



REPUBLIC OF RWANDA

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Forestry Research Strategy and Guidelines for Rwanda (2018-2024)

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Acknowledgements

The forestry research strategy (2018 - 2024) was developed with the support of the International Union for Conservation of Nature (IUCN). It is a result of a consultative effort between the Ministry of Lands and Forestry, Ministry of Agriculture and Ministry of Environment with Government parastatal institutions, research and high education institutions, civil society organisations, private sector and community working in forestry. The Ministry of Lands and Forestry thank particularly Dr. Adrie Mukashema for the elaboration of this forestry research strategy; staff of Rwanda Water and Forestry Authority (RWA), World Resources Institute (WRI), Rwanda Development Board (RDB), Rwanda Agricultural development Board (RAB), Rwanda environmental Management Authority (REMA), and Food and Agriculture Organisation (FAO) - Rwanda office for their valuable inputs and review of the final document.

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Foreword

Research in forestry is a strategic component at the heart of sustainable forest production, utilisation and biodiversity conservation. Knowledge and evidences produced by forestry research are critically needed to sustain forest management and to efficiently use of the national forestry resources, now and in the future.

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A continued provision of improved forestry reproductive material adapted to particular agro-ecological conditions is required to meet the demand for forest products. The loss of genetic diversity in forests reduces the option for sustainably managing resilient forestry in the face of adverse environments and changing climate. The science that will be delivered under this strategy will support the management of our forests, woodlands and trees to ensure they make a significant and long-term contribution to national priorities. It will generate solutions for how greater resilience to climate change can be achieved, how the benefits from forests we all enjoy today will continue for future generations, and how wood and timber products can play their role in a sustainable, low carbon and resource-efficient economy.

This research strategy has been prepared with a variety of stakeholders, including government agencies, non-governmental organisations and private sector consultations to identify priority areas of research that will support the implementation of the National forestry policy and related strategic plans. Forestry research strategy is an integral part of the overall forestry sector strategic plan (FSSP, 2018 – 2024) and its goal of strengthening forest institutions through research and education in order to sustainably manage Rwanda's forests for the current and future needs of Rwandan society.

Rwanda is signatory to United Nations conventions, agreements and international treaties related to forestry sector. The implementation of this research strategy will be an opportunity for Rwanda to fulfill national obligations as well as the international commitments with informed decisions, plans and best practices. High quality research outputs made available to forestry managers and practitioners will positively impact their working attitudes as they with be equipped with the accurate information they need to perform their task of managing forestry resources of the country.

The value of this strategy will also be in the collaboration and partnership working between Ministry of Lands and Forestry, Ministry of Agriculture Ministry of Environment, Ministry of Commerce and Ministry of Education through their agencies in charge of research and education; local, regional and international organisations, private sector and community to generate and share knowledge in forestry science.

This is the first time the Government of Rwanda has produced forestry research guidance specifically for forestry researchers. I therefore call for stakeholders to support the implementation of this strategy, which reflects the research priorities identified for sustainable forestry in Rwanda. It has flexibility to accommodate changing demands over time, it commits to interdisciplinary science through effective collaboration to achieve high impact, and it is innovative in its approach to using new channels of communication to allow the results of its science to be shared as widely as possible.

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Ministry of Lands and Forestry



1. Introduction

Forestry research will enable Rwanda to ensure sustainable management of forest resources, creation of new woodlots with improved tree species, adoption of agroforestry systems where appropriate and plantation of tree resources in other land uses are based on selected and diversified species; and that the natural capital of its forests and trees continues to be valued both for business and protection of the environment, as well as for the vital services and long-term benefits to Rwandan society and the national economy.

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1.1 Rationale

Rwanda's forests contribute greatly to the national economy. In the fiscal year 2016/17, the contribution of forestry to the GDP was estimated to be US\$365 billion (i.e. 5% of the total GDP)¹. This economic value though is not fully quantified, but translated into tangible assets like wood consumption (construction, sawing, domestic and industrial energy), fruit sales, erosion control etc. and in ecosystem services such climate, quality of landscape, tourism, recreation etc., forests and trees are now highly valued for the role they play in providing these benefits. They are better integrated with other land uses, providing a safe habitat and network for biodiversity, supporting the rural industries while at the same time, maintaining the climate of Rwanda. Healthy forests, woodlands and trees can help to provide clean water from well-managed supplies, resilient ecosystems and good air quality. In towns and cities, they play a key role in cooling, mitigating temperature rises, and encouraging the population to be healthy and active.

It is expected that by 2020, Rwanda's population will climb from 12 million registered in 2017 to 13.5 million² and towards 26 million by 2050³ of which about 35% will live in Kigali city and in the towns of Rwanda. This will put substantial pressure on Rwandan forests for wood construction and wood energy.

Climate change and global warming due to greenhouse gas emissions is a reality. The climate of Rwanda is expected to change towards a warmer and wetter climate by 2050. An increase of temperature by 0.35°C and of rainfall by 40mm per decade are projected^{4,5}. In order to deliver the Paris agreement to limit the global temperature rise to 1.5°C above pre-industrial levels, we must both reduce greenhouses gas (GHG) emissions and remove excess carbon from the atmosphere by planting more forests and by maintaining the good health of existing forestry resources in the country. Although Rwanda, has one of the lowest emissions in the world, continuous deforestation to meet the timber and energy demands by a growing population, coupled with uncontrolled forest land use change to agricultural and human settlements⁶, will put large part of Rwandan land into degradation and the cost of inaction will be higher than the cost of action in due time.

Land productivity is among the top national priority for food, energy and resources for industry. Transforming Agriculture from more traditional approaches to modern and mechanised land management require a greater understanding of the value, scale and nature of the trade-offs to ensure that policies are complementary and are not delivering unintended consequences.

The new threats and challenges to Rwanda's forests today demand new information about species choice, woodland management and restoration, land use and management, pest epidemiology and control. There is a need to ensure that the resilience and adaptability of forest ecosystems to the changing climate is understood, and considered essential for the continuance of the crucial services that forests provide to Rwandan society.

Today, Rwanda has about 704,997 hectares of land with forest and shrubland cover, equivalent to 29.6% of the country, of which 17.7% are plantation forests and 11.9% are natural mountain forests and Savannah shrubland protected in national parks, including Nyungwe forest in south-west, Gishwati & Mukura forests in central-west, Volcanoes forest in north and Akagera savannah shrub in east.

6 Rwanda natural capital accounts -land (2018)

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National Institute of Statistics of Rwanda (2017). Gross domestic Product (GDP) 2016/2017.
 Rwanda Vision 2020

Green Growth and Climate Resilience: National Strategy for Climate Change and Low Carbon Development, (GGCR, 2011)

⁴ McSweeney, R., & Semafara, J. N. (2011). Rwanda's Climate: Observations and Projections (pp. 44).

⁵ Muhire, I., & Ahmed, F. (2015). Spatio-temporal trend analysis of precipitation data over Rwanda. South African Geographical Journal, 97(1), 50-68.

For Woodlands, *Eucalyptus* sp. is the dominant species making up more than 90 % of all plantations in the country, and it continues to dominate the landscape in plantations and woodlots. They are grown mainly in farm woodlots or on boundaries and environments ranging from semi-arid (e.g. suitable for *Eucalyptus camaldulensis*) to sub-humid (e.g. suitable for *E. globulus*). *Pinus* plantations count for approximately 6 percent of the plantations making it the second most significant exotic plantation species in the country⁷. 6

Belgian missionaries introduced Eucalyptus into Rwanda in the early 1900's in the course of responding to the increased demand for fuel and construction wood. In 1933, large blocks of eucalypts were established at the arboretum of Ruhande, in Huye, South Province, where seeds were produced. The arboretum grew to later include introductions other species of eucalyptus during 1989-1990 from the Australian Tree Seed Centre (CSIRO). To date 69 species of eucalypt have been planted in the arboretum of Ruhande. Mainly from this arboretum, seeds and seedlings were distributed throughout Rwanda, and further propagation probably occurred as wild seedlings. Currently, eucalypts are very widespread in Rwanda, and mainly managed as coppice stands with a 3 to 15 year cutting cycle. To date, many eucalypts have escaped from farms and are growing 'wild' and unmanaged across urban and rural landscapes.

Forests in Rwanda face a number of challenges that need in-depth understanding and well-informed solutions in order to ensure the sustainability of the forest sector. These challenges include (but not limited to):

- The low productivity of woodlots: More than 50 percent of forest plantations are at the end of their productive life. Primarily, it is Eucalyptus stumps that are exhausted due to short rotations, and in the last three decades, the average annual growth of eucalyptus productivity drastically dropped up to 1.56 m³ per hectare⁸.
- 2. Low species diversity: Tree cover in Rwanda has been dominated by a small number of Eucalyptus species. The major species found in woodlots and plantations of Rwanda include Eucalyptus grandis, E. saligna, E. globulus, E. camaldulensis, E. tereticornis, E. microcorys, E. maculata, and E. maideni⁹. Eucalyptus has

been so far irreplaceable given its multiple roles in Rwanda. Relying on it, however, constitutes a real threat to sustainability of Rwanda's forestry sector, for example in the case of an outbreak of diseases or pests that affects Eucalypts, while native species are at low numbers; In addition some sections of the general public object strongly to eucalypts being in the landscape, because of perceived negative effects related to water supply, biodiversity, and food production. There is a need of improved knowledge of the net impacts (positive and negative) of eucalypts for improved management, regulation and valueadding from the eucalypt wood resource.

- 3. Rwanda has limited and generally poor genetic material for trees. Seeds are collected either from the old arboretum or from other eucalyptus plantations established for multi-usage without proper management, therefore the quality of forest genetic material generally need to be improved.
- 4. High dependence on fuel wood for cooking results in over-cutting of Rwanda's forest plantations. The overcutting of woodlots is a major cause of forest degradation which calls for alternative source of cooking energy as well as improved sustainable fuel wood production.
- 5. Changes from forest to other land uses: primarily to satisfy the needs of a growing population, to date reaching 12 million people in 2017 on 26,338 km², and which is expected to double by 2050. About 68 percent¹⁰ of population relies on subsistence farming as their main job, using about 13,718 km² of the country's land¹¹, which puts pressure on the country's remaining biodiversity ecosystems, whether forested, savanna, or wetland. Sustainable forest management should be effectively integrated with other rural and urban land uses through cross-cutting country policies.
- Indigenous trees which are scattered across agricultural land are uprooted despite these trees being protected under the ministerial order No008/MINIRENA/2015 of 18/06/2015 establishing a list of protected trees in Rwanda. Hence research will help us to establish fieldbased "gene banks" for threaten indigenous trees to ensure future availability of their genetic material for breeding and seed delivery for <u>sustainable</u> and resilient forestry ecosystems.

⁷ CGIS-NUR, 2012. Rwanda Forest Cover Mapping using Aerial Orthophotos covering Rwanda territory, in collaboration with Ministry of Natural Resource and RNRA, and under the support of PAREF.NL2 project.

Rwanda Natural Resources Authority (2016). Natonal Forest Inventory. Technical report. Kigali- RNRA, 184p.

⁹ Hurley B, Nambazimana, A, Kayumba, I (2017). assessment of insect pests of eucalypts in rwanda. FAO-Rwanda. 29p.

¹⁰ National Institute of Statistics of Rwanda (NISR), EICV 4

¹¹ Government of Rwanda (NISR, Ministry of Environment and Ministry of Lands and Forestry), Natural Capital Accounts for Land, March 2018.

 Limited institutional capacity–numbers of personnel and access to requisite forestry knowledge and skills – has not advanced at a pace sufficient to manage the forestry resources of the country and advance the science of forestry – a goal that has been set for the forestry sector for several decades.

Nevertheless, over the last three decades, forestry and agroforestry research has produced some knowledge on matching tree species with sites (agroecological zones) through selecting appropriate forestry and agroforestry tree species and their suitability zones¹², however, tree technology and innovation, from planting material to timber and nontimber value chains and usage, have not advanced. In agroforestry especially, more work remains to be done to increase tree species diversification with high economic and land productivity restoration potential to ensure farmer adoption of agroforestry-based farming systems.

Forests, agroforestry and tree-based research aim to address a set of livelihood and environmentaloriented challenges. Livelihood -oriented challenges include poverty, food, and energy scarcity. Environmental-oriented challenges are concerned with land degradation, climate change, deforestation, and wildlife habitat and biodiversity loss. These challenges are interconnected, and need to be addressed using integrated and community participatory approaches to accelerate adoption and therefore demonstrate impact on ground.

Forestry research requires a broad scope of activity. It must be forward-looking to anticipate long-term challenges, strategic to inform emerging policy issues, and technical to support new and more efficient forestry practices. It has to address the implications for forest and woodland ecosystems from a changing climate – whether from an increase in extreme weather events such as storms and flooding or long-term temperature changes – and the challenges of novel forestry pests and diseases brought by global trade and the movement of natural products and other goods between countries. In 2017, an assessment of the insect pests of eucalypts was conducted in Rwanda by FAO¹³ identified five major invasive insect pests of eucalypts. On the first order of infestation comes the bronze bug (*Thaumastocoris peregrines*) with 88% of infected tree leaves, and next with Eucalyptus gall wasp (*Ophelimus maskeli*) with 58% of infected tree leaves. Other insect pests include the red gum lerp pysllid (*Glycaspis brimblecombei*), the Eucalyptus snout beetle (*Gonipterus* sp.), and the bluegum chalcid (*Leptocybe invasa*). This assessment recommended further investigation and research on pathways of introduction of Eucalypts insect pests in Rwanda, including close monitoring of borders and collaborating with neighbouring countries on issues relating to cross-border invasive pests.

This forestry research strategy is therefore designed to ensure that forests, woodlands, agroforestry and other trees in Rwandan landscapes are healthy, and are properly managed to be able to maximise their contribution to key areas of sustainability through research into:

- 1. The maintenance of a diverse, healthy and resilient environment;
- 2. The efficient use of timber and other ecosystem services to maintain and improve economic competitiveness;
- The improved conservation of biodiversity, protection of water catchment and diversification of non-timber forest products;
- 4. The agricultural land protected against erosion and degradation;
- 5. The people's enjoyment of the countryside, both rural and around city and towns.

Forestry research strategy finally intends to guide the public, private, and other institutions that are currently or potentially working in forestry research on national challenges in the forestry sector where research would play a major role in providing knowledge. It encourages the use of integrated and participatory approaches to dealing with the increasing threats to Rwanda's forests and woodlands, and emphasises the need for an effective evidence base to inform decisions, particularly when addressing emergencies. It has an end goal to inform decision making and the formulation of adapted action plans and highlights the need for policy reformation when necessary.

It is also recognised that conducting and availing results from forestry research to the public can be expensive and time consuming. Many scientific advances such as tree breeding come at a cost.

Essences ligneuses recommendées dans les plantations forestières et agroforestières au Rwanda avec cartes d'aptitudes par zones agrobioclimatique du Rwanda.

¹³ Hurley, B., Nambazimana, A., Kayumba, I. (2017). Assessment of insect pests of eucalypts in Rwanda. Technical report, FAO-Rwanda.

Maintenance of field-based 'gene banks', seed stands and orchards is equally demanding in terms of labour and cost, possibly a reason why these technologies have not advanced in Rwanda. This strategy is therefore elaborated to reiterate the crucial need for research in forestry, and to bridge the existing gap between the management of forest resources of the country and the knowledge and quality of forestry reproductive material required for sustainable forestry in Rwanda.

Finally, revisiting the existing forestry research governance and the current structure of innovative financing mechanisms in this strategy is to ensure a continued flow of funds to forestry research. Lastly, robust performance monitoring and the uptake of forestry research outputs for sustainable management of forestry resources in Rwanda are essential to the future of forestry in Rwanda.

1.2 Structure of the strategy

The introductory section provides a vision for how the forestry science commissioned under the strategy and guideline will deliver real benefits to Rwandan society, and details the five key outcomes it is focused on delivering. This strategy consists of six main sections:

Section 1 introduces the need for a forestry research strategy in Rwanda in order to produce knowledge and evidence for positive change towards sustainable forest and land management as well as for environmental protection.

Section 2 sets out the context within which the strategy will operate.

Section 3 details the five outcomes that the strategy will deliver. Each outcome is set within a brief context and the broad forestry research areas to consider.

Section 4 sets out the forestry research commissioning process and governance structures for the development of future forestry research programmes, together with improved procedures for quality assurance and peer review.

Section 5 addresses the ways in which forestry research will be communicated, and how communication will be used to improve knowledge exchange and ensure the greatest impact from the forestry science.

Section 6 sets out the baseline measures and the qualitative and quantitative assessment criteria that will be used to evaluate the outcomes-based approach and the success of the strategy in achieving its objectives.

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1.3 Outcomes of the forestry research strategy

Goals for forest management are varied, and thus impact tends to be greatest when research is interdisciplinary. The focus of this forestry research strategy on outcomes rather than disciplines is intended to encourage the interdisciplinary approach. Forestry research programmes commissioned under the strategy will be integrated from the start to ensure that synergies are achieved among social, biological and physical sciences to deliver more effective impacts. The strategy also recognises the crosscutting links between themes such as economics, social science and forestry science, and these will be reflected in the future forestry research programmes.

Forestry research commissioned under this strategy will deliver five key outcomes that will:

- Provided the evidence base for the delivery of resilient natural forest ecosystems to enhance multiple benefits for society and biodiversity conservation.
- 2. Provide the knowledge to deliver healthy forests and woodlots management to meet the growing needs for timber and non-timber forest products.
- 3. Provide the knowledge to deliver adequate agroforestry systems as a component of sustainable land management, agricultural landscape restoration and biodiversity conservation in agricultural land.
- Provide the evidence base to allow the forestry sector to deliver a wide range of benefits from forests and trees, to support sustainable economic growth.
- Result in changes to policy and practice through implementation by informed and engaged stakeholders, access to a high-quality skill base of forest researchers, and effective leverage to provide additional resources to increase the evidence base.

These outcomes are strongly influenced by the strategic priorities outlined in the forestry policy and sector strategic plan of 2018-2024.

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1.4 Key values assumed in the strategy

A key driver for the strategy will be collaboration and partnership between the Ministry of Lands and Forestry, Ministry of Agriculture and Ministry of Environment with their respective parastatal institutions, research and high education institutions, civil society organisations, the private sector and communities to generate and share knowledge in forestry science.

Relationships and collaboration with government researchers and other stakeholders will be built on trust and openness to facilitate effective knowledge exchange.

1.5 How the forestry research outcomes will be delivered and evaluated

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1. Strategic outcomes

Forestry research will provide:

- 1. An evidence base for the delivery of resilient natural forest ecosystems and biodiversity to enhance multiple benefits for Rwandan society and beyond
- 2. The knowledge to deliver healthy forests and woodlots through management practices that meet the growing needs for timber and non-timber forest products
- 3. The knowledge to deliver adequate agroforestry systems as a component of sustainable land management, agricultural landscapes restoration and agro-biodiversity conservation
- 4. An evidence base for the forestry sector to deliver a wide range of benefits from forests and trees, to support economic growth
- 5. Changes to policy and practices through implementation by informed and engaged stakeholders, increased number of highly-skilled forest researchers, and effective use of evidence base to leverage for resources to increase innovation in forestry

Delivered by	Measured by		
Forestry research programmes	1. Deliverables		
	2. Evidence to inform credible and effective policy and strategic plans.		
	3. Robust standards and operational guidance to support sustainable forest management.		
	4. Effective and timely knowledge exchange.		
	5. Internationally recognised research.		
	6. Effective models supporting sound decision making.		
	7. Effective models supporting cross-cutting agendas.		
	8. Enhanced qualifications and skill sets.		
2. Evaluation			
Contextual baseline measures	Direct assessment criteria (indicators)		
1. National Forest Inventory (2016)	Qualitative		
2. Forest Landscape Restoration Opportunity Assessment for	 Independent biennial review of impacts. Stakeholder feedback collected through a range of social media tools. 		
Rwanda (2014) 3. Rwanda Forest Cover Map (2012)	Quantitative		
	 Number of peer-review publications and citations. Number of international conference papers presented by forest scientists. Metrics on how forestry science delivered under the strategy translates into policy documents, and good practice guidance. Leverage achieved by Ministry or Forestry Authority funded research programmes. Metrics on the extent of collaborative working. 		
	programmes.5. Metrics on the extent of collaborative working.6. Number of PhDs or MSc researchers supported under the strategy.		

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2. The context for the strategy

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Forestry research underpins the aspirations of Rwanda forestry policy and related strategic plans, enabling Rwanda to implement the regional and international conventions to which is committed. Forestry research strategy is designed to provide the evidence base to support the delivery of those aspirations and commitments.

2.1 Rwanda forestry policy aspirations

Rwanda forestry policy aspirations are the following:

- 1. The capacity of Rwanda's forest sector institutions and personnel will be enhanced and maintained to match the requirements of managing the country's forest and forest land resources.
- 2. Rwanda's capacity to access or produce high quality and diversified forest tree seedlings to meet forest land afforestation, post-harvest reforestation and degraded forest land restoration targets will be fully developed.
- 3. Private sector actors will be encouraged to increase their business activities in Rwanda's forest sector starting from the point of establishing and maintaining forests up to the transformation and sale of forest products.
- 4. Appropriate forest regulatory instruments, licensing, production and transformation practices will be formulated to increase forest biomass fuel production and consumption efficiency.
- 5. Biodiversity and ecosystem services and values will be maintained and enhanced in accordance with national and international programmes and targets to which Rwanda is committed.
- Procedures will be implemented to support participation and decision making in Sustainable Forest Management planning and implementation by relevant stakeholders to ensure proper benefit sharing from proposed forest development activities.
- 7. The use of agroforestry techniques and tree species will be enhanced to contribute to increasing overall forest resource output and agriculture land productivity.

To implement these forestry policy aspirations, the forestry sector strategic plan (FSSP) has been formulated, and one of its outcomes will focus on improving forestry education and research capacity in Rwanda (FSSP, outcome 1.6). FSSP calls for collaboration with national and international research institutions to ensure access to the results of forest research – and the development of research programmes that are tailored to Rwanda's forest sector needs. This forestry research strategy describes the needs and sets out the guidelines and framework in which research in forestry will operate.

Forestry research will be guided by the common purpose and principles outlined in the forestry policy, namely stimulating economic growth, maximising well-being, and protecting our environment while promoting private sector management of public forests without negatively affecting the benefits for future generations.

The strategy also sets out quality standards for appraisal and approval process of forestry research, both fundamental and applied research. The strategy covers natural forests, plantation forests, agroforestry systems, urban trees or any other tree outside forests.

2.2 Alignment with other related strategies and commitments

Sustainable forestry practice is increasingly being required to integrate effectively with other rural and urban land uses and it must operate at a range of different scales. The public forest estate is diverse – ranging from large, productive, managed woodlands to small, natural, semi-natural woodlands with high biodiversity value. Private forests are from small scale woodlots to scattered trees in agricultural land (agroforestry).

This strategy will contribute to a distinct range of priority areas defined in forestry and environment strategies. It will help to address current and emerging challenges on cross-border issues such as biodiversity, plant health and climate change.

Forestry research will reflect wider issues outlined in the vision 2020, in the Sustainable Development Goals 2030 (SDGs), as well as in the Green Growth Strategy for Climate Change and Low Carbon Development 2050 (GGCRS).

 The vision 2020 stressed the issue of increased climate change consequences including floods, the cost of lives and resources resulting in from landslides and droughts that adversely affect agricultural output. It calls for Rwanda to put in

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place strategies to mitigate the impact of climate change by focusing on developing eco-friendly policies and strategies in all sectors of the economy and by promoting green growth.

- GGCRS formulates an action programme for sustainable forestry, agroforestry and biomass energy. Forestry related sub-programmes (12) cover:
 - a) enhancing forest germplasm
 - b) enhancing silviculture practices
 - c) improving forest management for degraded forest resources
 - d) a joint Forestry and Agriculture strategy for agroforestry.
 - e) Improving the use of biomass energy through sustainable charcoal production techniques.

GGCRS sub-programme 11 calls for effective protection and sustainable management of protected areas. This will be possible by maximizing the community involvement and benefit sharing as well as establishing participatory Payments for Ecosystem Services (PES) schemes.

- 3 The United Nations development agenda entitled "Transforming our world: the 2030 Agenda for Sustainable Development" known as SDGs was entrusted to Rwanda the Africa host of the Sustainable Development Goals Centre – which is expected to drive innovation and research towards achievement of the SDGs in Africa. The SDGs which are linked to the sector are ultimately fully reflected in the Rwanda Forest Sector Strategic Plan 2017-2022 that derives from the revised National Forestry Policy (2017). There two major SDGs directly related to forestry: Goal 13 which calls for actions to combat climate change and its impacts and Goal 15 which deals with: 1) protection and restoration of terrestrial ecosystems 2) promotion of sustainable management of forests, 3) combating desertification, 4) halting and reversing land degradation and biodiversity loss.
- 4. Rwanda's comprehensive National REDD+ Preparation Proposal (RPP) calls for systematic studies to assess the background, level and impact of drivers of deforestation and forest degradation.
- 5. The National Tree Reproductive Materials Strategy (2017-2026) recognises the importance of research in producing high quality tree reproductive material for sustainable forestry. Particularly, TRM strategy calls for research in TRM value chain. The production of high genetic quality TRMs cannot be achieved without research to produce practical tools and recommendations on suitable high quality TRMs

such as seed sources, collection, processing, storage, and testing. TRM strategy also encourages the conservation of tree biodiversity. The focus shall be on *ex-situ* and *in-situ* conservation¹⁴ to be able to conserve high value exotic and indigenous tree genetic resources for the supply of high quality reproductive materials for use in forestry and agroforestry programmes in the future.

- The new strategic plan for agricultural 6. transformation in Rwanda (PSTA-4), an instrument implementing the National Agriculture Policy 2004 in its current revision (NAP 2018), has a particular focus on improved agriculture food system's skills and knowledge, resilience and sustainable intensification, food security and nutrition and incomes. PSTA-4 promotes the development of soil and water conservation as part of integrated watershed management programs, considering that the most successful approaches are those involving local communities, especially in reconciling the use of crop, livestock, and trees. PSTA-4 also encourages the investments in hill slopes soil and water conservation and agroforestry (tree belts, contour belts) and non-tree measures (grass trips, contour bunds, planting of fodder grasses on bunds/ridges, use of permanent, perennial vegetation on contours), integration of trees on farm plots, tree belts, protective forests etc.). The choice of trees to be used needs site-specific research and experimentations.
- 7. The Bonn Challenge (2011) is a global aspiration to restore 150 million hectares of the world's deforested and degraded lands by 2020. In 2011, Rwanda made its pledge to the Bonn Challenge to restore 2 million hectares of degraded forests and agricultural land. This represents proportionally the highest national commitment to the challenge. To implement this commitment, in 2014 an assessment was carried out to determine the restoration needs and where they are needed. The following four restoration opportunities¹⁵ were identified:
 - Agroforestry represents the largest opportunity for restoration across Rwanda.
 Of the 2.4 million hectares of land in the country, more than 45% (1.1 million hectares) is potentially suitable for agroforestry.
 Implementing agroforestry on steeper sloping land offers the greatest restoration opportunity with approximately 30% of the country (705,000 hectares).

¹⁴ Ex-situ conservation means the conservation of biological diversity outside its natural habitat. In the case of tree genetic resources, this may be in seed genebanks, in vitro genebanks or as live genebanks.

¹⁵ Ex-situ conservation means the conservation of biological diversity outside its natural habitat. In the case of tree genetic resources, this may be in seed genebanks, in vitro genebanks or as live genebanks.

- b) Improving management of woodlot and timber plantations interventions focuses on improving and intensifying fuel wood and timber production. Approximately 11% of the total land area of Rwanda (256,000 hectares) is potentially suitable for improved management of eucalyptus woodlots and plantations and 17,849 hectares occupied by pine plantations have long attained their growth cycle and need for harvesting plan and renewal for the continued productivity of land allocated to pine.
- Restoring natural forest through buffers and enrichment planting of degraded forests inside parks and reserves represents a relatively small (1% of the total country land area), but is vitally important for maintaining these ecosystems and the services they provide.
- d) Creating protective forest to prevent erosion on the many steeply-sloped ridges and hillsides and to protect rivers and wetlands from the harmful effects of erosion, and creating 20m-buffer zones of native species around rivers and 50-m buffer around wetlands and water bodies.

2.3 A joint approach

Forest management, agricultural development, research and education institutions will work closely together to assure the communication and uptake of the research results and recommendations. This strategy stimulates forestry education institutions to play a key role in not only producing forestry professionals but also advancing forestry research and publication in Rwanda.

As part of the roadmap to implement the forestry research strategy, the long-standing research relationship between Government, development and education institutions will be formalised through memoranda of understanding (MoU). The MoU concerns (but not limited to) government institutions:

 Rwanda Agricultural development board (RAB) for collaboration in research programmes related to Agroforestry, silvo-pastoralism and agricultural landscape restoration, tree biotechnology and Genbank for the indigenous and threatened species, and forest management tools and practices; 2. Rwanda development Board (RDB) for research related to biodiversity conservation, ecotourism and protection of natural ecosystems;

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- Rwanda Environmental Management Authority (REMA) for research related to Wetlands biodiversity and protected riparian buffers;
- National Industrial Research Development Agency (NIRDA), collaboration will be formalised for wood industry research, timber and Non-timber product development (e.g. medicinal trees);
- 5. Rwanda bureau of standards (RBS) to develop standards, laboratory and certification process of timber and non-timber product export; and
- National Research Commission of the Ministry of Education, the University of Rwanda (UR) and IPRC/ KITABI College of Conservation and Environmental Management (KCCEM) for academic, research and capacity building programmes in forestry, agroforestry and nature conservation.

2.4 Dealing with uncertainty

The outcome-based approach adopted by this strategy will allow uncertainty in a complex environment to be addressed through interdisciplinary thinking and solutions. There are other development agendas such as GHG emissions reduction, renewable energy, and low-carbon urban systems in which forestry has much to offer. Interdisciplinary solutions will help science to make sense of global events such as climatic changes resulting in increasing extreme biotic and abiotic events, to provide some certainty for the long-term decisions which forestry requires.

Forestry is a long-term commitment and research requires an intelligent vision about the forces that will influence Rwanda woodlands over the next 30 years, for example, to enable them to best serve the changing demands society will place upon them. The Government of Rwanda (within regional and global context) is increasingly using 'horizon scanning' through setting up long term vision (2050), enabling policies and strategies, and this need to be supported by evidence and prediction analyses from research and experimentation.

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3. Outcomes

The research commissioned under this strategy will strongly focus on improving the effectiveness of forestry policy and related strategies for the efficiency of their implementation. The research strategy will be cross-cutting and interdisciplinary in nature, and will contribute to the five strategic outcomes outlined in this section.

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3.1 An evidence base for the delivery of resilient natural forest ecosystems and biodiversity to enhance multiple benefits for Rwandan society and beyond

Research commissioned in support of this outcome will be designed to:

- 1. Support the delivery of healthy, multipurpose and resilient natural forests, which will deliver the widest range of benefits.
- 2. Support increased societal use of natural forests outside parks and the services they can provide.
- 3. Support the improved protection and species enrichment for terrestrial ecosystems, and the designed riparian buffers of water ecosystems

3.1.1 Context

In relation to the national forestry cover which is to date 29.6% of the total country land, about 11.9% is natural forests. Natural forests are either managed in accordance with special laws of national parks, or by Ministerial orders protecting relic natural forests scattered across Rwanda. Those regulatory frameworks are:

- Loi N°22/2005 du 21/11/2005 portant creation du Park National de Nyungwe;
- 2. Law N°33/2010 of 24/09/2010 establishing Akagera National Park;
- Volcanoes National Park gazetted in 1934 (Décret du 26/11/1934 fixant les limites du PN d'Albert); and
- 4. Law N°45/2015 of 15/10/2015 establishing the Gishwati-Mukura National Park;
- Ministerial Order N°006/MINIRENA/2015 of 18/06/2015 determining the management of protected state forests not governed by special laws.

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Natural regeneration assessment highlighted interventions designed to both expand and restore Rwanda's intact natural forest ecosystems and biodiversity that are important for cultural and tourism value. Improving biodiversity of the relic forests protected in the Ministerial Order N°006/ MINIRENA/2015 of 18/06/2015 would improve societal and economic value of these forests.

Beside forest ecosystems, wetlands, rivers and water bodies are supposed to be protected against harmful erosion and diverse pollutions. The ministerial order protecting wetlands and swamps¹⁶ calls for 50-m buffers of native species. The choice of species to be used for such purpose need experimental research determining appropriate species and management required for selected species to ensure full protection of water resources of the country and maintenance of its quality.

Various assessments of protected ecosystems have highlighted the benefits that ecosystems do, and can, provide to society – such as the role of safeguarding biodiversity and ecosystem resilience. However, these assessments acknowledge that the evidence base linking changes in ecosystems to human wellbeing is incomplete, and tends to be biased towards assessments based on economic value, largely ignoring less well quantified health values and nonquantified shared social values.

Protecting forest and water ecosystems is a major priority for the country, and this outcome needs to be delivered in a collaborative way across sectors, academia and working closely with stakeholders and communities around protected areas of the country. This Forestry research strategy is developed with consultation by range of government and nongovernment conservation stakeholders. The Forestry management authority will collaborate with RDB and REMA and their partners to deliver this research outcome through memoranda of understanding (see section 2.2).

3.1.2 Research areas

Evidence requirements to deliver this outcome will:

 Develop multidisciplinary tools to help managers maintain or improve forest biodiversity, halting species decline in existing protected areas. Understanding the value of native species, ensure that native species choice for the restoration of degraded natural ecosystems and expansion is based on knowledge and ecological adaptability. Build resilience in native forest ecosystems now and for the future.

- Develop best practices for protecting rare species and threatened species and their habitats through creation of special conservation zones in protected areas, and design connectivity (corridors) and/or adequate measures for their survival and viability.
- 3. Identify appropriate conservation measures that are fit to scale the intensity and risk management of conservancy and match the ecological requirements of the rare and threatened species within and beyond the boundary of the protected area.
- Develop tools for the conservation of tree genetic resources for threatened native species through restoration of degraded native ecosystems to more natural conditions. Establishing *ex-situ* conservation¹⁷ sites to improve the value of the ecosystems at the landscape level.
- Produce a greater understanding of proximate and underlying causes of conversion of relic natural forests to cropland, or to other non-forest land use and recommendations on promising scenarios to stop converting forests and woodlands to other land uses.
- 3.2 The knowledge to deliver healthy forests and woodlots through management practices that meet the growing needs for timber and nontimber forest products

Research commissioned in support of this outcome will be designed to:

- Increase forest cover and woodland productivity to address timber and biomass energy demand in Rwanda
- 2. Sustain investor confidence in forests and woodlands.

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¹⁶ Prime Minister №006/03 of 30/01/2017 drawing up a list of swamp lands, their characteristics and boundaries and determining modalities of their use, development and management

¹⁷ Ex-situ conservation means the conservation of biological diversity outside its natural habitat. In the case of tree genetic resources, this may be in seed genebanks, in vitro genebanks or as live genebanks.

3. Identify new options for forest management to address the threats posed by climate change and pests and diseases.

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- 4. Enable forest management and woodland expansion as part of an integrated approach to sustainable land and water resources management.
- 5. Enable forests to play their part in addressing issues such as flooding, drought and biodiversity loss.

3.2.1 Context

The woodlands of Rwanda have generally low yields. According to the recent national forest inventory (NFI, 2016), the total stock reaches 50m³ per hectare, with a timber volume share of about 22 m³ per hectare, service wood volume share of 15 m³ per hectare and energy wood volume share of 13 m³ per hectare. This low yield is attributed to overcutting leading to poor coppicing, large empty spaces within plantations, and maximum woodland that does not contain any trees taller than 10 cm; a stock of 1.2 m³ is only available per capita in Rwanda. This stock is far below the current demand in wood products and services. Hence there is need for science and innovative measures to deal with a rapidly growing demand in forest products while maintaining forests for other services. It is important that tree seed improvement through breeding and other seed technologies are given its important role it deserves in research. Increasing access to good quality tree seeds has been well detailed in the Tree Reproductive Material (TRM) strategic plan (2018), and the role of research was also mentioned as fundamental. Otherwise, farmers would resort to using wild-collected tree seed with low yield potential resulting to persistent low forest productivity. This research strategy therefore support the TRM strategy, through the supply of knowledge and science needed to establish quality seed stands and orchards for future production of quality basic material and diversity of economic tree species in Rwanda.

Forest and woodland managers and investors, whether public or private, need to have confidence that their assets are sufficiently resilient to deal with the environmental and societal challenges their woodlands are faced with in the course of a long life. More frequent extreme weather events and the recent increase in threats from new forestry pests and diseases require expert and timely science to ensure this confidence is maintained, and the benefits from forests remain sustainable.

Woodland expansion is a significant land-use change component that requires a sound evidence base for effective policy and investment decisions. It can be best delivered through close integration with agriculture policy¹⁸ and settlement policy¹⁹. For example, forestry can complement and support agriculture by reducing carbon footprints and increasing the stability of farms against landslides.

This outcome will deliver the expertise needed by managers to improve the management of forests and woodlands, and to provide a solid foundation for woodland expansion to increase the many benefits woodlands can deliver, for example, but not limited to:

- supporting green growth in a productive a) and sustainable rural economy by increasing the value of natural resources, sequestering carbon and helping to tackle greenhouse gas emissions, and producing timber and biomass to satisfy the current gap in energy demand as outlined in the WISDOM Rwanda (2013)²⁰;
- b) providing places that people and communities value highly and want more of for health benefits and enhanced rural and urban landscapes;
- restoring degraded habitats, developing C) habitat networks and creating mixed native and non-native woodlands to increase biodiversity and support adaptation to climate change;
- helping to manage ecosystem services, d) such as sustainable watershed management, and protection of soil and clean water resources against erosion.

3.2.2 Research areas

Evidence requirements to deliver this outcome will:

Improve tree species variety to optimise forest 1. yields and their subsequent contribution to a balanced the timber and wood energy supply and demand, ecosystem services as well as non-timber forest productivity. One example of decision tools that are provided by this research will the specie's yield increment model and species allometric equations for the improved tree species.

¹⁸ National Agriculture policy (2018) 19

National Human settlement policy (2005) Rwanda Natural Resource Authority (RNRA&PAREF.Be), 2013. Rwanda 20 Supply Master Plan for fuelwood and charcoal (WISDOM Rwanda) Technical report. 151p.

Improve understanding of the impact of invasive pest species²¹ at the ecosystem level, find technically and financially effective ways to anticipate new threats, rapid detection and identification, monitor and improve response²². The ways may include modelling, biosecurity controls and practical measures such as:

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- Horizon scanning to detect and prepare against new pest and disease threats before they arrive;
- Understanding the overall nature, condition and distribution of forest types and species within Rwandan woodlands through the National Forest Inventory, including their silviculture, ecology, growth and yield, and exploring the future opportunities and threats identified; and
- Learning how to manage forests at multiple scales to ensure that they are more resilient to tree health threats through management practices and tree breeding approaches that identify a wider variety of 'threat-proofed' tree species and understand their silviculture including establishment requirements, production cycle and timber qualities.
- Identify methods²³ to successfully increase Rwanda's woodland cover and the percentage of woodlands under recognised forest management plans.
- Evaluate approaches to woodland adaptation and increase resilience, focusing on the composition (species, origin, diversity and stability of ecological communities) and management systems (silviculture and regeneration systems) that effectively address climate change concerns. This should include understanding of forestry from regions that currently experience climates similar to those anticipated in Rwanda in the future.
- 5. Develop a greater understanding of the impact of forestry governance, ownership and customary tenure rights on forest management, including outstanding claims of legal non-compliance, or evidence that the relevant codes of practice and guidelines are not implemented leading to continuous conversion of forest land to other land uses. Recommendations on approaches

to address continuous forest fragmentation and land-use connectivity issues. Develop integrated and interdisciplinary social research across the rural and urban sectors to understand what motivates landowners to take up incentives for forest land-use change.

- 6. Develop multidisciplinary tools to help identify new woodland sites that may offer the best potential to deliver the most ecologically efficient basket of ecosystem services. Quantify the location, scale of delivery and physical benefits of woodland creation and management on ecosystem services. The increasing importance to consider the 'basket' of ecosystem services when evaluating the benefits provided by woodland to society at both landscape and ecosystem scales, such as flood, drought and climate change mitigation and the role of trees.
- 7. Design a forest management tool to effectively maintain the existence of naturally occurring native species and genotypes, and prevent losses of biological diversity in forest plantations.
- 8. Research to better understand the demographics of the forestry workforce to predict future requirements. This is vital to ensure an adequate workforce profile is available to meet future projected timber forecasts and ambitions to expand the forestry sector
- 3.3 The knowledge to deliver adequate agroforestry and silvo-pastoral systems as a component of sustainable land management, agricultural landscapes management and agrobiodiversity conservation.

Research commissioned in support of this outcome will be designed to:

 Ensure that agroforestry plays a significant role in increasing productivity of agricultural land, enhancing resilience of smallholder agriculture to climate change, and reduces GHGs by agricultural activities.

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²¹ Pest species in this context include alien and native insect pests, diseases, vegetation and animals.

²² These include developing practical control measures using integrated pest management and, if necessary, chemical techniques.

²³ This includes understanding landowner behaviour, sensitive silvicultural techniques and improved regeneration techniques.

2. Ensure that agroforestry significantly contribute to wood energy as well as service wood demand in Rwanda.

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- 3. Increase use of agroforestry technologies and innovations by farmers and enhance adoption of agroforestry systems and silvo-pastoralism as appropriate measures of agricultural and pasture management.
- 4. Enable agroforestry to play their part in addressing issues such as landslides, flooding and drought.
- 5. Promote the agro-biodiversity conservation in agricultural land use.
- 6. Produce tailored science-based agroforestry tools for site-specific and effective decision making.

3.3.1 Context

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Agroforestry has multiple benefits such as reducing soil erosion and increasing resilience to heavy rains through improved slope stability; water management and nutrient recycling which improve agricultural production; and carbon sequestration. Although important, the current absence of accurate benchmark data on pilot agroforestry features makes it difficult to assess the effectiveness of existing agroforestry systems that can be scaled up in large-scale agricultural landscapes restoration interventions.

This strategy therefore outline priority areas for research in agroforestry to improve agriculture resilience in agriculture to climate change through tested Climate Smart Agricultural practices (CSA) that both assist in mitigating climate change impact on agricultural productivity, and potentially generate carbon credits.

Fuelwood in Rwanda is assumed to come from forests and woodlands, thus contributing to largescale deforestation²⁴. The role of individual farmed trees in providing woody biomass for energy and other uses is important, National forestry inventory (NFI 2016) estimated about 10,272,751 m³ provided by agroforestry country-wide, which is approximately 80 % the total volume, provided by forest plantations and 7 times higher than the total volume of wood biomass provided by shrubland and savannah. It is estimated that, with an additional woody biomass supply of 1.07 million m³ from agroforestry, the supply would cover about 50.8 % of the 2020 wood biomass

24 Ndayambaje J.D & Mohren J.M.J (2011). Fuelwood demand and supply in Rwanda and the role of agroforestry. Agroforest Syst 83:303–320 gap.²⁵ Support coping strategies undertaken by farmers; promote planting of trees from good seeds in farmlands especially in Eastern Province and on steep slopes of Northern, Southern and Western provinces is a national priority.

It was also found that the quality of timber wood and service wood produced in agroforestry systems is lower than that in forest plantations or even in shrubland and savannah because trees in agroforestry systems are rather large-crowned single trees, naturally producing a rather short but big-diameter²⁶ making agroforestry biomass best suited for fuelwood or cooking energy than for timber and pole production. More research is needed in this respect to advise on best silvicultural practices and agroforestry tree species that produce service wood in agroforestry systems.

Land clearing practices in Crop Intensification Programs (CIPs) without post conservation measures and climate change exert severe stress on agriculture and threaten local species. Therefore, the methods for the long-term conservation of local species should be developed. Landraces (i.e. local tree species) are a vital genetic resource for future breeding work. Ex-situ Seed banks and collections of local breeds may be appropriate methods for the conservation of threatened native species uprooted in agricultural land.

This strategy therefore promotes scientific advancement on biotechnology in agroforestry, conservation of native tree genetic resources, improving quality timber in agroforestry systems, and enhancing smallholder farmers adaptation and resilience to the impact of climate change. The Agroforestry Strategy²⁷ has a special focus on ensuring that knowledge and practices developed in agroforestry are disseminated and adopted by farmers.

The implementation of agroforestry research will be in partnership with the International Centre for Research in Agroforestry (ICRAF), Rwanda Agricultural Development Board (RAB) and National Agricultural Export Board (NAEB) and the Food and Agriculture Organisation (FAO) and in collaboration with farmers 'associations and cooperatives through the establishment of demonstration plots and farmer field schools.

27 Agroforestry Strategy (2018) is jointly developed by MINILAF and MINAGRI with the support of FAO.

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²⁵ WISDOM Rwanda (2013)

²⁶ National Forestry Invintory (NFI, 2016)

3.3.2 Research areas

Evidence requirements to deliver this outcome will address the adoption of agroforestry practices resulting in improved soil health and water quality; land productivity; and agro-biodiversity, and timber production in agricultural systems. The research will:

- Identify, assess, and prioritize agroforestry technology needs and outcomes to enhance adoption at scale and profitability of agroforestry technologies and innovations;
- 2. Develop integrated and agro-ecological based landscape management models and recommendations on scale-up pathways to achieve the SDGs on sustainable agriculture in Rwanda. Determine types of regeneration cycles appropriate for the landscape values, and for enhancing environmental and economic resilience. These models will help to maintain and/or restore varying mosaic of species at different spatial scales.
- 3. Develop a greater understanding of the impacts and challenges on existing agricultural land uses and management in sustaining water quality and quantity in the catchment areas, and propose mitigation strategies and remedies for those challenges. Provide recommendations on approaches to protect and restore natural water courses, water bodies, riparian zones and their connectivity.
- Develop knowledge and technologies to improve the accounting of the multiple benefits of agroforestry and its contribution to agricultural accounts in the national economy.
- Establish a spatial agroforestry monitoring tool to support the national forest inventory and develop allometric equations and volume tables for selected timber agroforestry trees.

3.4 An evidence base for the forestry sector to deliver a wide range of benefits from forests and trees, to support economic growth in Rwanda.

Research commissioned in support of this outcome will be designed to:

- 1. Improve skills, knowledge and human resource capacity needs in forestry at national level.
- 2. Produce innovative tools for more effective decision making.
- 3. Support a thriving and sustainable rural economy and socio-economic welfare of farmers.
- 4. Ensure that forestry can play a significant role in delivering to the green growth and low-carbon economy of Rwanda.

3.4.1 Context

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The forestry sector has a key role to play in supporting the rural and wider economy by increasing the market and non-market value and benefits of forests. The evidence will therefore provide knowledge for use by policy makers, by forestry and woodland owners and practitioners, and by users of forestry goods and services to bring about this outcome.

The natural capital in woodlands can make a significant contribution to the Rwandan economy from the value that is added to forestry goods and services in addition to providing many public benefits. For example, the wood processing industry is nationally competitive (for example UDUKIRIRO, Electrical pole plant, sawmills etc.), national economy benefits from a wide range of tourism facilities from four national parks, and the aesthetic effects of forests and trees can significantly increase the value of housing, and of land for urban development areas. Research shows how sustainably managed forests and woodlands can help mitigate climate change, provide means of flood management and drought control, and help to cool towns and cities. These are issues of direct relevance to both the rural and urban environments.

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Valuing and accounting for natural capital is a major step in enabling the benefits of forest ecosystem services to be realised in the economy. Natural Capital Accounting pilot assessment started with Land accounts. Work will also continue to incorporate forest ecosystem services values into ecosystem accounts. The Natural Capital Committee was established with the aim to improve understanding of the value of natural capital to help set priorities for actions to support and improve the Rwanda's natural assets.

Rwanda REDD+ readiness proposal (R-PP) has been developed in 2015 to promote incentives for activities relating to reducing emissions from deforestation and forest degradation;

The Forestry Ecosystem Market (FEM) Task Force will be established to set out mechanism and road map for implementation of REDD+ readiness proposal, Natural Capital Accounting - Forest Ecosystem Accounts (NCA-FEA) and payment of ecosystem services (PES). The FEM task force will also explore market opportunities to work on. FEM Task force shall be composed by forestry scientists, economists and statisticians. In collaboration with National Institute of Statistics (NISR), they will design monitoring tool to timely review the increased role of forests and woodlands, and proper account the contribution of Rwanda's forests in the national economy.

3.4.2 Research areas

Evidence requirements to deliver this outcome will:

 Assess the forestry skill gap and advice on capacity building needs for increasing the number of forestry qualification opportunities diploma, degree and high degree level to better position Rwanda forestry sector among important economic sectors of the country. 2. Improve the efficiency of the timber value chain. This will focus on tree breeding in relation to wood and timber properties to develop methods and technologies that deliver market requirements and wider forest products that add most value.

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- 3. Support the forest industry with research to optimise timber growth, recovery and use. This will be delivered through the maintenance of a network of Permanent Sample Plots (PSPs), and by adopting a sustainable multi-benefit forest management approach, which will investigate the potential for alternative silvicultural systems, regeneration and novel tree species.
- 4. Develop forest ecosystem service markets to support economic growth and contribute to averting risks from ecosystem degradation. This will concentrate on understanding the value of rural and urban ecosystem services, whether cultural, social, environmental or economic, and devising mechanisms for their associated evaluation and payment, and developing systems for natural capital accounting, payment of ecosystem services (PES) and REDD+ readiness strategy implementation.
- 5. Develop and use holistic and interdisciplinary tools and models to support decision making in forest, ecosystem and wider land management through agroforestry to achieve sustainable and beneficial outcomes and better understanding between foresters and other parts of society. This will ensure that forestry contributes to the low carbon economy by using data from the National Forest Inventory, linked to financial and yield appraisal through production forecasting. Biomass energy and timber production will be assessed, to allow scenario planning for different management options including the development of renewable energy policy. WISDOM Rwanda (2013) provides planning scenario for cooking energy demand in Rwanda, and a similar work need to be done for Timber demand.

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3.5 Changes to policy and practice through implementation by informed and engaged stakeholders, increased number of highly-skilled forest researchers, and effective use of evidence base to leverage for resources to increase innovation in forestry.

Research commissioned in support of this outcome will be delivered by:

- 1. An interdisciplinary approach to ensure that science and research is fit for purpose, credible and robust.
- 2. Collaboration and partnership to enhance capability and deliver more effective results.
- 3. Stakeholder engagement in the design of research programmes to improve uptake and application of research.
- 4. Mobilisation of forestry resources incentives to strengthen science, innovation and technology adoption in forestry sector.

3.5.1 Context

Green growth strategy for Rwanda (GGCR-2050) has defined the role of excellent research and innovation in making Rwandan society and the economy prosperous.

However, it also identified areas of need, particularly improvements in knowledge exchange and stakeholder engagement to deliver research outputs that respond to society's needs. This Forestry Research Strategy will address areas of need in a number of ways:

- 1. This strategy will greatly involve stakeholders in setting research priorities, and the way in which research knowledge is exchanged.
- 2. It will adopt an interdisciplinary approach to specifying the research programmes to be commissioned.

3. It will focus on the outcomes to be achieved and the impacts to the Rwanda forestry sector, sub-regional ecosystems and beyond.

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4. The strategy will balance the need for highimpact peer-reviewed journal papers, and applied science made available for forestry practitioners through effective dissemination.

The strategy will improve the use of scientific evidence in decision making related to new forestry orientation and revision of policy and strategies as well as contribute to sound plans in forest resources management. It will create an interface between managers and researchers which have been lacking in last two decades.

The strategy acknowledges the important role itself has to play through engaging in forestry research networks in Rwanda, the region and beyond. The strategy will deliver the best value for money as well as excellent and interdisciplinary science. Effective collaboration and partnership will allow the research budget to extend its reach. To date the national budget does not have a specific line for forestry research, but this strategy will create sound reason to have such a line. The Government of Rwanda is considered an important sponsor of this forestry research strategy and with the operational plan developed for this course it will be easy to align other partners and collaborators to contribute to annual research and action plan.

Influence in the context of this strategy is equally about broadening expertise, skills and capability, as it is about funding. Therefore, the Ministry in charge of Forests, through the national forestry authority, will work to promote and facilitate opportunities for collaboration in forestry research programmes with other providers. Strengthening environmental partnerships that bring together pooled resources will deliver much more impact than individual organisations could deliver on their own.

3.5.2 Delivery actions

The actions required to deliver this outcome will include:

1. Establishing national forestry research taskforce to coordinate the implementation of the national forestry research strategy.

 Active engagement with stakeholders in specifying the research programmes and their outputs to deliver the strategic outcomes, and understanding the barriers to behaviour change which will ensure that the results of research are adopted and become part of mainstream activity. 6

- Ensuring academic credibility and career progression by specifying outputs of research projects and programmes, organisation and participation in conferences and workshops.
- 4. Creating support for new skills and capability delivered through the joint research award Scheme to be explored by the Ministry in charge of forests in partnership with the National Funds for Environment and Climate Change (FONERWA). This could be an opportunity that benefits PhD and Masters Research, and could continue through the life of this strategy.
- 5. Support for young researchers to gain experience and qualifications through mentoring and expert supervision. Holding annual seminars to bring together students, supervisors, policy makers and practitioners to provide an opportunity to learn more about postgraduate environmental research being conducted in Rwanda. These will provide opportunities for knowledge exchange that will shape future forestry research.
- 6. Support local forest researchers to conduct their research by means of academic or development programmes, to attend relevant international conferences, to communicate regularly with colleagues abroad, and to keep forestry research in touch with foreign opinion relevant to sustainable forest management in Rwanda. Where feasible, secondments and exchange visits will be used. In addition, visiting scientists

from outside Rwanda will be encouraged to participate in research programmes to bring new perspectives, and share their knowledge and experience with local researchers.

- Encouraging innovation through forestry researchers working with experts in other sectors, such as, agriculture, natural resources, business and finance etc. to share knowledge, skills and where possible to produce knowledge on crosscutting issues.
- 8. Optimising the efficiency and impacts of research commissioning, partnership working and active liaison with other national and international organisations and government departments will be encouraged to highlight to other sectors, the role that forestry can play in delivering their agendas. This includes developing business partnerships with stakeholders and experts from beyond the forestry sector to develop a network of knowledge and expertise that will foster interdependence between business and environmental ecosystems.
- Improving the levels of co-funding with the devolved forestry administrations and the forestry sector, through making the research agenda more transparent and cross-cutting.
- 10. Developing formal, productive links with professional bodies and academic institutions to generate research synergies, and increasing the uptake of the outputs of commissioned research by offering continuing professional development at organised dissemination events.
- Establishing better connections with professional and trade bodies inside and outside the forestry sector working group to integrate forestry research with research being undertaken in other land uses.

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4. Forestry research governance

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This strategy is designed to accommodate flexibility in addressing future forestry research needs. There is a need to improve the coordination, funding mechanism, implementation of the research and the uptake of recommendations. Much effort will be concentrated on policy briefs and technical baselines with greater stakeholder involvement while encouraging peer reviewed papers.

4.1 Legal and institutional framework

Research on trees, woods and forests is a highly specialised area. In Rwanda, forestry research has been led by "Institut des Sciences Agronomique du Rwanda (ISAR)" for many years until 2010 when agricultural agencies, agricultural research and extension services merged into "Rwanda Agricultural Board (RAB)". This board has been entrusted by the law N°47bis/2013 of 28/06/2013 determining the management and utilisation of forests in Rwanda. In article 45, fundamental forestry research is to be conducted by the national agency in charge of fundamental research which is RAB in the current institutional set up. The law however authorise any other party having the authorization from RAB to also conduct fundamental research in forestry.

Moreover, in article 46, the law assigns the Authority responsible of management and development of forests in Rwanda, currently Rwanda Water and Forestry Authority (RWFA), to conduct applied forestry research related to the role of forests in the national economy and the safeguarding of environment. Other public, private institutions or private operators wishing to conduct the applied research should obtain authorisation from RWFA.

In article 47, the Law says that the results of the research provided under Articles 45 and 46 shall be published through collaboration between the person having conducted the research and the Authority responsible of management and development of forests, in this case RWFA. The law did not distinguish natural forests to forest plantations or woodlands research.

This shared responsibility without clear coordination mechanism however resulted to scattered efforts, coupled with the lack of accountability and knowledge sharing and capacity advancement in the field of forestry science and innovation in Rwanda. Consequently, Rwanda's forests continue to suffer from a number of threats and weaknesses summarized in section 1.1.

Moreover, the research commissioned in the above framework resulted to insufficient uptake of their results and the lack of wide application of the research recommendations. This has also resulted in most of the core capacity being provided by civil society, external experts, and has been long donor-driven research instead of being policy-driven research. The limited involvement of the National authority in charge of the management of forests and the Ministry in charge of forests has in consequence resulted to persistent low capacity of these institutions to sustainably manage forest resources of the country to serve the present without compromising the future.

This strategy therefore, and for the research programmes commissioned under it, calls for a restructuring of public forestry to ensure a strong tie between the unity in charge of management of forests, and forest seed unit with the forestry research unit. An ideal option is that forestry authority contains two main departments: 1) Forestry Research and Seed Production department, and 2) Forestry Management and Monitoring department.

Beside the department in charge of Research in Rwanda Forestry Authority, the Ministry will set up a Forestry Research Committee (or Task force) to ensure the monitoring and the reporting of the progress of its implementation. The committee will be composed by experts, scientists and senior managers from Government and non-Government institutions appointed and formalised under a set of Memoranda of Understanding as outlined in section 2.3. The committee will ensure the strategy is implemented, and the research commissioned under it delivers to the outcomes. The coordination will address short-to-medium-term country research requirements, while accommodating the long-term research needs of Rwandan forestry.

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The committee as a multidisciplinary team will be responsible for:

- Identifying the forestry related issues which need scientific and engineering advice and where public engagement is appropriate;
- 2. Drawing on a wide range of expert advice for cross-cutting issues, particularly when there is uncertainty;
- Assessing the quality of research proposals and approving research outcomes prior to publication;
- Adopting an open and transparent approach to the scientific advisory process and publish evidence and analysis as soon as possible;
- 5. Working collectively to ensure a joint approach throughout government institutions to integrate scientific and engineering evidence and advice into policy making.
- The committee will also ensure that the budget for research reach the recipient institution in a timely manner as per agreed deliverables, and monitor the use of disbursed funds.

4.2 How forestry research will be commissioned

This strategy is developed to be flexible enough to cope with many possible changes to the operating environment, including for example the restructuring of public institutions, national budget negotiation to create the budget line for forestry research, donor alignment and fundraising. However, some key principles underpin the commissioning of forestry research:

- Strengthening the collaboration of public research institutions, civil society and private sector to enable rapid response to emerging issues like disasters and diseases outbreaks.
- 2. Collaborative commissioning of research to access and develop new expertise and capability will complement existing research from other Government and non-Government organisations working in forestry, agroforestry and conservation research.
- Involving external peer reviewers of research proposals and results will ensure that the science to be delivered is of the highest quality and relevant and appropriate to the Rwanda forestry sector.

4. Research proposals shall be explicit about the short-term impacts they are expected to deliver in the application.

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5. Providing opportunity for stakeholders, both public and private, to engage in the formulation of the research briefs to improve the transparency and ownership of results.

4.3 Quality assurance and internal publication

Quality assurance of research proposals and resulting papers through external peer review is the best practice. The Quality assurance will be implemented under this strategy for both research commissioned from public research institutions and from other providers. Peer review in this context will cover the science, methodology and programme outline in the proposal, as well as the innovation that is being commissioned. The rigor of peer review will ensure that the quality and relevance of the science remains high.

The Ministry in charge of forests will establish Forestry Research Committee from academia, and senior managers, external and internal research advisors in the forestry sector. Their main role will be to assess the quality of research proposals and approval of the research outputs prior to publication. This committee does not replace the peer review process by national or international journals. After internal approval by the Forestry Research Committee, the authors and collaborators will have to follow external peer review and publisher instructions for international journal article publications.

Authors' responsibilities for providing research outputs to the national repository system:

The authors shall specify the requirement for the repository manager to avail the publication on a wide scale, to distribute and make available the text of the article, including information on the availability of the underlying data.

- electronic form of the research output;
- underlying data where applicable;
- the right to make to print and publish the research outputs on Ministry website (copyright remains with the authors)

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5. Communication of forestry research outputs

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Communication of research delivered under the strategy is designed to provide the maximum impact for policy development and the delivery of good practice on the ground. Science will be published in ways which provide an accessible knowledge and evidence base for forestry sector of Rwanda. Innovation technology and media communication will be used wherever possible to make access to research outputs. The strategy will adopt a targeted approach to knowledge sharing to improve dialogue and increase stakeholder uptake and adoption.

5.1 Rationale

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Science is not an end in itself. The outcomes of research should inform forestry policy and guide forestry practice to ensure that Rwanda's forests and woodlands are managed as a sustainable and resilient resource.

A strengthened knowledge base is required to allow future decisions to be based on robust, reliable and upto-date evidence. This knowledge base will be open and accessible to stimulate innovation and the development of forest products and services that will benefit to both the forestry sector and the wider society.

Communication will be more than an activity carried out at the end of research programmes. The exchange of knowledge between those who carry out the research and its end users are key issues for this strategy.

The most effective way to strengthen communication is through the direct involvement of the user communities in both the conduct of research and the formulation of research programmes; a knowledge exchange mechanism will be established to achieve this. Direct participation of stakeholders and partners will not only promote shared understanding and collaboration but will also increase the resources available for disseminating insights to as wide an audience as possible and provide feedback for changes to the strategy.

5.2 Audiences and end users

Key stakeholders for research communication activities are policy makers and practitioners, but work will also be done to identify new audiences and end users who can help bring about the changes necessary to deliver the outcomes in this strategy. This will mean improving targeting, and tailoring communications channels to ensure that the right messages reach the right people at the right time.

5.2.1 Working with policy makers

The need for forestry scientists and policy makers to work together has not been greater in the past. Gaps in the two-way flow of policy and science information can lead to key emerging scientific findings not being reflected in government policy and actions in a timely manner and missed funding opportunities. The strategy will improve and build on science to policy activities, identify opportunities and routes that best inform decision making. This will ensure that outputs of research are relevant, fit for purpose and communicated in a timely and accessible way.

5.2.2 Working with forestry practitioners

Based on internationally recognised science and best practice, the government of Rwanda has set out their approach to sustainable forest management in Rwanda through a regulatory framework i.e. forest law and its series of supporting orders and guidelines. The research commissioned under this strategy will continue to support and develop the guidance and other material underpinning the Rwanda's forestry standards to ensure that forest managers and practitioners are able to cope with issues such as the impacts of climate change and pest and disease outbreaks.

5.2.3 Working with stakeholders

Forestry has a wide reach and strong associations with a range of environmental, economic and social agendas, which provide many public benefits. While the Ministry in charge of Forests will continue to work with international, regional and local stakeholders in forestry, agriculture, other natural resources and environment sectors, it also has a strategic commitment to continue to identify wider audiences that can support and benefit from forestry and treerelated research.

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This strategy will therefore seek to engage interests from a range of non-governmental organisations, private sector, companies and those involved in rural, urban and social sustainability – both as end users of research and as generators of knowledge and contributors of knowledge exchanges.

The strategy aims to improve dialogue with external and internal stakeholders by opening channels of communication. It will increase the number of programmes with steering committees and user groups to promote wider involvement of end users in research projects. New technology will be explored to crowdsource ideas and opinions online from a wider range of stakeholders – this will feed into the formulation of research proposals and support innovation.

Commissioned research in this strategy will show the proportion of the budget allocated to communication activities. This will be properly accounted for within the specifications of individual programmes – whether provided by Forest Research or through external organisations – to ensure that dissemination is an integral part of every project. This will help maximise the impact of research.

5.2.4 Working in partnership

The Ministry is committed to working with a wide range of other public institutions, non-governmental organisations, and individuals – to share knowledge and expertise and work towards partnership in communication as well as in research. Key partners in communication are:

- Environmental and climate change partnerships

 making best use of communications networks.
- Educational institutions and professional bodies

 collaboration on continuing professional development.
- Business community effective communication through industry placements, trade articles and the financial press, and making use of stakeholder capacity for wide and effective knowledge exchange.
- 4. Scientific community through the recognised route of published papers.
- General public by encouraging participation in scientific research or 'citizen science' – Engaging citizens in science. Public participation in scientific research is an important new area for this strategy. Volunteers will have the opportunity

to contribute to a wide range of research projects using social media and other webbased technologies. The recording capabilities of smart phones and other mobile devices can be used for efficient, mass data collection.

5.3 Technical communications

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The technical communications team will provide a link between forest scientists and end users of research such as policy makers, managers and practitioners. They will co-ordinate communications about commissioned research and analyse and repurpose outputs to add value to the results and ensure their applicability to target audiences across a wide range of networks throughout Rwanda.

At the Ministry level, a Strategic Publications task force will be established, making up of forest scientists, technical communication experts and policy advisors who will provide a framework for technical publishing and act as a source of expertise on policy review and good practice in forestry.

5.4 Improving communication channels

A wide range of communication channels will be employed over the period of this strategy to improve the accessibility of forestry research and ensure that key outputs are better targeted towards end users. Effective targeting will involve adapting content and considering whether outputs will be published digitally or in print, or via media, or via face-to-face events and conferences.

5.4.1 Open access publishing

Research outputs produced over the period of this strategy should be published in open access journals. The Ministry of Lands and Forestry will mobilize funds to support high quality peer reviewed articles to be published in open access publication so that such research articles become freely accessible to everyone immediately upon publication. However, it is recognised that there could be significant costs associated with this and so targeted forestry research will continue to be published in appropriate forestry journals.

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5.4.2 Online research archive

An online web portal for forestry research will be made to improve the accessibility of commissioned research. The archive will have a dedicated search facility for all forestry research carried in Rwanda. It will also have options to view current programmes, the latest outputs of research, forest and woodland statistics and datasets with copyright note for users. The site will be supported by links to other research libraries and data repositories in the country.

5.5 Communication of applied research

In addition to the publication of scientific papers, applied research that is fit for purpose and application in everyday practice must be delivered. This requires a balance between the demands for peer-reviewed scientific publication and the need for operational outputs; the commissioning process will therefore be actively managed to ensure an appropriate balance.

The series of research notes will be produced, and will be used to present key research outputs and interim results for policy makers and practitioners in a concise and accessible way. These will replace internal reports and grey literature.

Magazine articles will also be produced for the business and trade press to disseminate information about work programmes and initiatives.

5.6 Guidance and practical outputs

The outputs of research and guidance on good forestry practice will be published in a newsletter for Forestry Standards. The online publications catalogue will be established as the repository for all official publications, which will include all guidance and formal research reports. All publications will be available digitally as eBooks. In some cases and in particular for field guides standards and guidelines, hard copy will be produced.

5.7 Decision support tools

Decision support tools are an effective way of translating research into operational practice. Where this is appropriate they will be developed. One example is the Forest Cadastral System, which underpins the public forest inventory and private sector participation for sustainable management of public forests. Another example is the National Register of forest reproductive materials for forest reproductive material standards. Such tools allow a wider access to forestry services and products.

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5.8 Tailored communication activities

Tailored communication activities are designed to disseminate the results of forestry science to a wide range of stakeholders. Conferences, seminars and workshops, where researchers can talk about their work and results, are well received.

For practitioners, workshops that combine a presentation with a practical demonstration – seminar room with forest excursion – are especially appreciated. These events also increase the opportunity for the feedback of ideas from the field to scientists. These activities supplement traditional approaches, such as published papers and reports, and have proved to be successful in Agriculture sector for example. Such events shall also be organized in forestry.

5.9 Access to information and data

Forestry information and data will be made available to promote innovation by encouraging the re-use of government information and providing easy access to data. This will be encouraged also in private sector and civil society working in forestry sector to share their data with public institutions through memoranda of understanding on data and information sharing.

Along with the implementation of this strategy, Forestry authority will seek to join the national effort on spatial data infrastructure (SDI) or will explore the possibility to upgrade the existing forestry Management Information System (FMIS) to also incorporate module for forestry research data and outputs. This will be designed to facilitate the sharing of spatial information among government and non-government organisations and better facilitate public access to spatial information across the country. Data may be released under arrangements formalized by service level agreement or contracts with confidentiality declarations.

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6. Strategy Evaluation

This strategy employs an outcomes-based approach to research. Evaluation of its effectiveness will include both contextual measures, and direct assessment criteria. Progress on these measures both on qualitative and quantities indicators will be reported annually to the Research Strategy Management Committee and compiled in a published report to reach a wider audience.

6.1 Contextual baseline measures

6.1.1 National Forest Inventory (NFI, 2016)

Accurate and up-to-date information on the size, distribution, composition and condition of Rwanda's forests and woodlands is essential for developing and monitoring policies and guidance to support sustainable forest and agroforestry management. The image-based inventory produced an accurate national forest cover map in 2012 which was made based on digital interpretation of orthophotos covering Rwanda obtained from an aerial photography mission over Rwanda during the summer (July-August) of 2008 and 2009. The ground-based inventory began in 2015 and concluded in February 2016 (NFI, 2016). Both Inventories provide strategic and tactical information, which is relevant to public and private institutions managing or doing business in forestry. Users of forest inventory data include the forestry and timber industries.

The National Forest Inventory (NFI, 2016) reports on the current state of key forest metrics at the national level. Data from the NFI constitutes the baseline indicator metrics and will be used to form a judgment on whether Rwandan forests are healthy, resilient ecosystems that provide a sustainable flow of products and services to society. Metric indicator trends will be collected from established permanent sampling plots (PSPs) for selected species, and will be used to generate annual increment curves and data for growth modeling and characterisation.

The National Forest Inventory (NFI 2016)

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The NFI results for all 30 districts of Rwanda (National Parks excluded) set out the baseline quantitative measures.

- A. In the productive forest plantations (TIF): The overall basal area is 5.3 m² per hectare, while the total volume reaches 50m³ per hectare, with a timber volume share of about 22 m³ per hectare, service wood volume share of 15 m³ per hectare and energy wood volume share of 13 m³ per hectare. These relatively low metrics are attributed to: 1) a significant share of small-diameter coppice forests, 2) a high share of forest areas that are either degraded, with a low crown cover density, and 3) forest areas that do not contain trees larger than 10 cm. With the TIF area of 255,672 hectares, the total country volume of TIF amounts to 12,791,778 m³. With a total population of 10,515,973 people (National census 2012), a stock of forest plantations of 1.2 m³ per capita is available in Rwanda.
- B. In shrubland and savannahs (TOFs): The overall number of trees in shrubland and savannah averages at 58 trees per hectare, with a basal area of 1.8 m² per hectare, and a total volume of 10 m³ per hectare, or one fifth of the volume of forest plantations. Timber volume is 1.8 m³ per hectare, or less than 10% of the timber volume of forest plantations; service wood volume makes up 2.4 m³ per hectare, or approximately one sixth of the service wood volume of forest plantations; energy wood volume is 5.7 m³ per hectare, or approximately half of the energy wood volume per hectare of forest plantations. Although the overall basal area and volume metrics are low, the Rwandan shrubland and savannahs have significant volume reserves amounting to 1,406,351 m³, or approximately 11% of the national forest plantation stock. While shrubland and savannahs are mainly found in the Eastern Province, they offer a minimum of 0.13 m³ per capita.
- **C. Agroforestry and trees on other land cover classes (TOFO):** The 25 tree per hectare average is low due to agro-forestry and other land cover classes' multi-use systems. The overall basal area is 0.9 m² per hectare, while the total volume reaches 7 m³ per hectare, or approximately 70%

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of the volume in shrubland and savannah. Timber volume is approximately 1.3 m³ per hectare, i.e. less than 10% of the timber volume in forest plantations, and even less than in shrubland and savannahs. Service wood volume is about 1.7 m³ per hectare, or approximately 66% of the service wood volume of shrubland and savannah. Wood energy volume is 4 m³ per hectare, or approximately 73% of the energy wood volume per hectare of Shrubland and savannah.

It should be noted that the quality of timber wood and service wood in agroforestry systems is expected to be lower than that in forest plantations and in Shrubland and savannah because the trees in agroforestry systems usually naturally produce large-crowned single trees that are short with wide diameters and tapered, bent stems.. The TOFo area in Rwanda is approximately 1,456,630 hectares (i.e. agricultural land), or a total volume of 10,272,751 m³, which is approximately 80% the total volume of forest plantations and approximately 7 times the total volume of Rwandan shrubland and savannahs. The stock of agroforestry and trees on other land cover classes in the country is approximately 1m³ per capita.

D. Forest productivity in all categories: NFI showed a growth of 1.56 m³ per hectare in forest plantations, or a national production rate of 397,747 m³ per year. Agroforestry systems show an annual growth rate of 0.54 m³ per hectare, or a total of 792,776 m3 per year. In shrubland and savannahs, the annual growth is estimated to be 0.55 m³ per hectare, or 78,209 m³ per year for the country shrubland. National production is approximately 1,268,732 m³ year. With current demand, woody biomass supply is lacking by 200%, despite considerable forestry and agroforestry efforts.

6.1.2 Forest Landscape Restoration Opportunity Assessment for Rwanda (FLR, 2014)

FLR concluded in September 2014 identified five key forestry interventions to restore Rwanda's degraded and deforested land:

- Transforming traditional agriculture to agroforestry systems on steep sloping land and flat or gently sloping land;
- 2. Rehabilitating poorly managed eucalyptus woodlots and plantations located on gentle slopes with improved silviculture with proper tree spacing;

- Rehabilitating poorly managed eucalyptus woodlots and plantations on steep slopes with improved silviculture with proper spacing, erosion control and fire-prevention best practices;
- Restoring deforested protected land in natural forests with native species that are indigenous to the area;
- 5. Establishing and improving the tree diversity of protected forests and on important and sensitive sites such as water and hydropower plant catchments.

The research commissioned under this strategy should establish demonstration plots in different agroecological zones of Rwanda that will serve as field schools for farmers to adopt best practices tested under their ecological conditions. A mid-term (2020) and a long-term (2024) assessment will be carried out on landscape restoration strategies in order to continue supporting the goals laid out in Rwanda's Vision 2050.

6.2 Direct assessment criteria

Direct assessment criteria for the evaluation of the strategy are divided into qualitative and quantitative measures.

Qualitative

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- 1. An independent annual review of the impacts (policy or land-use and management decisions affected) of research commissioned including associated decision support tools.
- 2. Stakeholder feedback on perceptions of the science delivered under the strategy collected using social media tools.
- 3. Independent assessment of science quality by the Forestry Expert Committee on Forestry Science's research programme.

Quantitative

- 1. Number of peer-review publications and citations, through annual collation of research statistics, including both journal papers and technical guidance.
- 2. Number of regional and international conference papers presented by Forest Research scientists.
- 3. Metrics on how science delivered under the strategy translates into policy documents and good practice guidance.
- 4. Leverage achieved by Forestry Authority and Ministry of Lands and Forestry for the funded research programmes, or the annual mobilization of funding through local and international collaboration and partnership.
- 5. Metrics on the level of collaboration (across governmental and non-governmental institutions in both commissioning and delivery of research activities.)
- 6. Number of PhDs and Masters Research projects supported by Forestry Authority and Ministry, with the goal of building capacity and expertise in forestry science.

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7. Financing strategy and costing

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The biggest constraints to Rwanda's forestry research are human capacity issues and access to finance. Many sources of finance exist to implement this forestry research strategy:

- Rwanda must first create a budget line for forestry research in the national budget under which other funding opportunities should be aligned.
- 2. Ongoing forestry support programmes, as well as those in pipeline, are usually designed to support the national afforestation targets and to provide expertise in developing forestry management tools and practices. It will be possible to negotiate the budget support for research; however this should be done in a proportionate way to avoid diverting scarce resources.
- Though significant, the international forestry funding flowing into Rwanda will not be sufficient to finance the forestry research strategy. Rwanda has yet to fully exploit climate finance opportunities, including its National Climate Change and Environment Fund (FONERWA).
- 4. Payment for Ecosystem Services (PES) offers a potential source of revenue for financing forestry research. Protecting catchments for hydroelectric dams and water supply plants would increase revenues from electricity and water sales. Institutions managing utilities will be approached about allocating part of their budgets to forestry research for sustainable watershed management.

5. Forestry Investment Program (FIP) for Rwanda aims to finance the country's forestry research strategy and actions, including diversification of species for forestry and agroforestry. FIP's research enhances knowledge and practices in agroforestry and stabilisation of landscapes, value chain improvement of agroforestry products, improving tree planting material, and developing guidance for PES implementation in Rwanda. FIP will also finance studies to increase efficiency of timber and charcoal.

Since 2014, Rwanda has been a member of the International Union for Conservation of Nature (IUCN) through Presidential order No 68/01 of 12/03/2014 ratifying the accession of Rwanda to IUCN. This umbrella is important for the Ministry to work closely with IUCN as an expert partner in the implementation of this research agenda. IUCN will be requested to support the Rwanda Forestry Authority to oversee the implementation of this strategy by providing experts who will mentor local researchers. IUCN will also support the mobilisation of resources needed for the first phase of its implementation.

Research areas outlined in this strategy may run beyond the proposed period (2018-2024). The timeline was limited to 2024 because this strategy is part of the country's forestry sector strategic plan (FSSP), which itself contributes to Rwanda's National Strategy for Transformation 2018-2024 (NST 1).²⁸ The proposed funds for implementation of this strategy run through 2024. Proposed mid-term and end-term reviews to assess progress will also establish new research paths to continue supporting the implementation of the National forestry policy and the country's vision 2050.

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²⁸ The NST follows the Economic Development and Poverty Reduction Strategy 2 (EDPRS 2 ending this year, June 2018). It will implement the last two years of Vision 2020 and the first four years of Vision 2050.

#	Research areas and delivery actions per outcome	Cost estimate ('000 US\$)	Duration (2018- 2024)
1	An evidence base for the delivery of resilient natural forest ecosystems and biodiversity to enhance multiple benefits for Rwandan society and beyond	800	7yrs
1.1	Develop multidisciplinary tools and guidance helping managers to maintain or improve forest biodiversity, and halt species decline in existing protected areas.	200	4 yrs
1.2	Develop best practices for protecting rare and threatened species and their habitats.	50	2 yrs
1.3	Identify appropriate conservation measures and ecological requirements of rare and threatened species in other land uses – establish ex-situ conservation sites (live genebank) for threatened native species across agro-ecological zones.	500	6 yrs
1.4	Understand the proximate and underlying causes of conversion of relic natural forests to cropland or to other non-forest land use, and advise on promising scenarios to stop converting forests and woodlands to other land uses.	50	1 yr
2	The knowledge to deliver healthy forests and woodlots through management practices that meet the growing needs for timber and non-timber forest products	1,600	7 yrs
2.1	Improve tree species and variety through breeding and other seed technology to optimise use of quality seeds to enhance forest yields and their subsequent contribution to balanced timber and wood energy, ecosystem services as well as supporting non-timber forest production.	500	7 yrs
2.2	Understand the impact of forestry governance, ownership and customary tenure rights on forest management, including outstanding claims of legal non-compliance, or evidence that the relevant codes of practice and guidelines are not implemented, leading to continuous conversion of forest land to other land uses.	50	1 yrs
2.3	Understand the impact of invasive pest species at the ecosystem level and find technically and financially effective ways of anticipating threats, formulating a response strategy, and identify practical measures to address them.	150	3 yrs
2.4	Advise on best practices to successfully increase forest cover and the percentage of woodlands under recognised forest management plans and certified by Forest stewardship Council (FSC).	500	6 yrs
2.5	Evaluate approaches to woodland adaptation and increasing resilience, focusing on composition (species, origin, diversity and stability of ecological communities) and management systems (silviculture and regeneration systems) that effectively address climate change concerns.	200	3 yrs
2.6	Develop multidisciplinary tools to help identify new woodland sites in Rwanda that may offer the most potential to deliver an ecologically efficient basket of ecosystem services.	100	3 yrs
2.7	Design forest management tool to effectively maintain the existence of naturally occurring native species and genotypes in forest plantations.	50	2 yrs
2.8	Understand the demographics of the forestry workforce to predict future timber forecasts and ambitions to expand the forestry sector.	50	2 yrs
3	The knowledge to deliver adequate agroforestry systems as a component of sustainable land management, agricultural landscapes restoration and agro-biodiversity conservation	680	7 yrs
3.1	Identify, assess, and prioritize agroforestry technology needs and outcomes to enhance adoption at scale and profitability of agroforestry technologies and innovations.	30	6 months
3.2	Develop integrated and agro-ecological based landscape management models and advise on scale-up pathways to achieve the SDGs related to agriculture and food security in Rwanda.	200	3 yrs
3.2	Develop guidance on approaches to protect and restore natural water sources, water bodies, riparian zones and their connectivity.	50	1 yr
3.3	Develop a greater understanding of the impacts of designed agricultural land uses and management on water quality and quantity in the catchment areas, and propose mitigation strategies.	50	1 yr
3.4	Develop the knowledge and technologies to improve the accounting of agroforestry's multiple benefits and its contribution to agricultural accounts in the national economy.	150	3 yrs
3.5	Establish a spatial agroforestry monitoring tool to support the national forest inventory and develop allometric equations and volume tables for selected timber agroforestry trees.	200	5 yrs
4	An evidence base for the forestry sector to deliver a wide range of benefits from forests and trees, to support economic growth	1,250	7 yrs

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#	Research areas and delivery actions per outcome	Cost estimate ('000 US\$)	Duration (2018- 2024)
4.1	Assess the forestry skill gap and advise on capacity building needs for increasing the number of forestry qualification opportunities (diploma, degree and high degree level) to better position Rwanda forestry sector among the country's important economic sectors.	50	6 months
4.2	Explore tree breeding in relation to wood and timber properties to develop methods and technologies that deliver on market requirements and provide forest products that add most value.	500	7 yrs
4.3	Support the forest industry with research to optimise timber growth, recovery and use through establishment and maintenance of a network of Permanent Sample Plots (PSPs) across the country.	350	7 yrs
4.4	Explore and develop forest ecosystem service markets to support economic growth and contribute to averting risks from ecosystem degradation. Develop systems for natural capital accounting, payment for ecosystem services (PES) and REDD+ readiness strategy implementation.	150	4 yrs
4.5	Develop and use holistic and interdisciplinary tools and models to support decision making in forest, ecosystem and wider land management.	100	4 yrs
4.6	Assessment of timber value chain as a basis of elaboration of the Master Plan for National Supply and Demand for wood timber products, similarly to WISDOM Rwanda.	100	1 yr
5	Changes to policy and practices through implementation by informed and engaged stakeholders, increased number of highly-skilled forest researchers, and effective use of evidence base to leverage for resources to increase innovation in forestry	300	7 yrs
5.1	Ensure active engagement with stakeholders in specifying the research programmes and their outputs through sub-thematic working sessions to deliver the strategic outcomes.	75	7 yrs
5.2	Support for young researchers to gain experience and qualifications through mentoring and expert supervision. Holding annual seminars to bring together students, supervisors, policy makers and practitioners to share knowledge and results.	150	7 yrs
5.3	Support local forest researchers to conduct their research through academic or development programmes, relevant international conferences, and regional research workshops.	75	7 yrs
6	Forestry research governance	290	7 yrs
6.1	Establish a national forestry research Committee (FRC) to coordinate the implementation of the national forestry research strategy; ensure operational cost for the Forestry Research Committee (FRC) activities.	70	7 yrs
6.2	Establish and maintain the National Repository System (data, research outputs, etc.). Establish the research web portal and its maintenance (for ongoing research projects, field guide standards and guidelines, policy briefs, etc.)	150	7 yrs
6.3	Quality assurance and internal publication through recruitment of external peer-reviewers to review policy briefs, technical reports and guidance.	70	7 yrs
7.	Communication of forestry research outputs	635	7 yrs
7.1	Communication activities (convening stakeholder meetings, hosting conferences (at least every two years), annual seminars and workshops).	350	7 yrs
7.2	Open access publishing, subscription fees.	50	7 yrs
7.3	Communication of applied research (writing annual magazine articles and research notes for operational outputs).	35	7 yrs
7.4	Develop decision support tools and data management (joining national data infrastructure (SDI), upgrading the existing forestry Management Information System (FMIS) to include the research module.) Establish innovative tools such as crowd-sourcing using mobile phone and telecommunication companies for data collection, information sharing and feedbacks.	200	7 yrs
8.	Monitoring and Evaluation	1,000	6 yrs
8.1	Yield increment monitoring, reporting country wide PSP results and updating the National Forest Inventory (2024).	500	6 yrs
8.2	Evaluate FLR progress and test interventions in different agroecological zones of Rwanda (2020, 2024).	100	6 month
8.3	Forest cover mapping (2020, 2024).	400	2 yrs

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Annex I: Related policies, legislations, strategies and baselines reports

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- 1. National forestry policy (February 2018)
- 2. Forestry Sector Strategic Plan 2018-2024 (February 2018)
- 3. National Tree Reproductive Materials Strategy 2018 2027 (February 2018)
- 4. Guidelines and standards controlling seeds, cuttings and planting stock for forest and tree production in Rwanda (January, 2018)
- 5. National Forest Management Plan 2018- 2024 (NFMP)
- 6. Forest Investment Program for Rwanda (FIP proposal, 2017)
- 7. National forest inventory (2016)
- 8. Rwanda natural capital accounts land (March 2018)
- 9. Forest Landscape Restoration Opportunity Assessment for Rwanda (Rwanda FLR September 2014)
- 10. Green Growth and Climate Resilience: National Strategy for Climate Change and Low Carbon Development, (GGCR 2011-2050)
- 11. Sustainable Development Goals and targets 2030 (SDGs 2015-2030)
- 12. Agroforestry strategy 2018 (under development in collaboration with MINAGRI and FAO)
- 13. REDD+ Readiness preparation (developed 2015, currently under the process of approval)
- 14. Rwanda Supply Master Plan for fuelwood and charcoal (WISDOM Rwanda, 2013)
- 15. Biomass Energy Strategy (BEST, 2008) in current revised form (in collaboration with MININFRA 2018)
- 16. Strategic Plan for the Transformation of Agriculture 2018-2024 (PSTA-4)
- 17. National Agriculture Policy (revised in 2018)
- 18. Law N°47bis/2013 of 28/06/2013 determining the management and utilisation of forests in Rwanda
- 19. Law N°005/2016 of 05/04/2016 governing seeds and plant varieties in Rwanda
- 20. Paris agreement on climate change 2015
- 21. Rwanda vision 2020 (revised in 2012)

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