Climate Smart Agriculture and Sustainable Intensification: Assessment and Priority Setting for Rwanda

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Feed the Future Sustainable Intensification Innovation Lab

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Abbreviations

AGRA – Alliance for a Green Revolution in Africa

AGRIFOP - Agribusiness Focused Partnership Organization

ASIP-2 – Agricultural Sector Investment Plan

AVRDC – The World Vegetable Center

CGIAR - Consultative Group of International Agricultural Research

CIAT – International Center for Tropical Agriculture

CIP – Crop Intensification Program

CIP/CGIAR – International Potato Center

CSA – Climate Smart Agriculture

DERN – Development Rural du Nord

EDPRS-2 – Economic Development and Poverty Reduction Strategy

FAO – Food and Agriculture Organization

FtF – Feed the Future

GCM – Global Climate Model (Global Circulation Models)

GDP – Gross Domestic Product

GoR – Government of Rwanda

Ha or ha - Hectare

IFDC – International Fertilizer Development Corporation

IFSM – Integrated Farm System Model

IITA - International Institute for Tropical Agriculture

IMBARAGA - Rwanda Farmers Federation

IPCC – Intergovernmental Panel on Climate Change

MINALOC - Ministry of Local Government

MINAGRI - Ministry of Agriculture and Animal Resources

MINIRINA - Ministry of Natural Resources

NGO – Nongovernmental organization

NSCCLCD – National Strategy on Climate Change and Low Carbon Development

RAB – Rwanda Agricultural Board

RNRA - Rwanda Natural Resource Authority

RCP – representative concentration pathways

SASHA – Sweet potato Action for food security and health in Africa

SEI – Stockholm Environment Institute

SI – Sustainable Intensification

SIIL – Sustainable Intensification Innovation Lab

SWOT – Strengths, Weakness, Opportunities, and Threats

T or t - tonnes

USAID – United States Agency for International Development

YWCA - Young Women's Christian Association of Rwanda

ZOI – Zones of Influence

Summary:

This report provides background information to support the design for 'Climate Smart Agriculture and Sustainable Intensification' (CSI and SI) activities in Rwanda. We provide the results of a SWOT (Strengths, Weakness, Opportunities and Threats) analysis in which a wide array of stakeholders participated. We summarized data and discussion about the status of agriculture in Rwanda. The population of Rwanda is poor, often malnourished, and mostly employed in agriculture. Past investment in promoting agricultural growth is showing significant benefits as crop yields have been increasing, but further research for improvements and wide-scale adoption of improved farm management practices are needed to accelerate the pace of change. Climate change and climate variability are threats to agricultural productivity that need to be considered, but, given the relatively good climatic conditions in Rwanda, they do not appear to create an unsurmountable problem. We propose a number of key areas that need attention to make Rwandan agriculture more 'climate smart and sustainable'. Improving soil fertility management for higher productivity is the most important; along with other that include: better data management to allow the development and use of decision support tools; integrated water management, particularly to increase infiltration of excess water; improved system for the development of locally adapted high quality seeds; increased integration of livestock and vegetable production, and small scale mechanization. Capacity building, knowledge sharing and communication platforms need to be improved for better coordination and partnership building. Gender and nutrition should be an integral part of all research and development activities. Opportunities for selected value chains and geographies are presented. Our analysis and observations suggests that successful investments in CSA and SI could not only have a positive effect on productivity, but also on economic, environmental, health, and social outcomes.

1. Introduction:

The economy of Rwanda is highly dependent on the success of agriculture. About 80% of the population is directly or indirectly engaged in agriculture, and it also provides employment to >70% of the labor force (Rwanda Development Board, 2015). There has been a strong decline in poverty in Rwanda over the past decade, but the majority of the population engaged in agriculture still has an income below the poverty line and is food and nutritionally insecure (NISR, 2012; World Bank, 2015). The situation is often worse for female-headed households. Thus, increasing agricultural productivity is key to success of Rwanda's economy and the well-being of its population. The increases in production need to come from the existing farm land, as the population density (449 persons' km^{-2}) is very high and there is limited or no additional land that could be used for agriculture in Rwanda (FAO, 2015).

There are ample opportunities to increase agricultural productivity in Rwanda (Cantore, 2011). The yield gap (the difference between attainable and actual yields) if very high (70%) for most of the cereal and legume crops, and also still considerable for the root and tuber crops (Niyitanga, 2015). While there is ample opportunity to improve farm productivity and income of smallholder households this is not always easy. Most agricultural land is on hillsides, has a low soil fertility and is prone to degradation (Clay et al., 1998). Virtually all agriculture in Rwanda is rainfed, and hence vulnerable to conditions of unfavorable rainfall. Climate change and concomitant increases in climate variability increase production risk and are thus a further challenge to increasing agricultural productivity and profitability (Stockholm Environment Institute, 2009).

Practices that can increase food production from existing farmland while minimizing the negative impacts on environment are referred to as 'climate smart agriculture' (CSA) and/or sustainable intensification (SI). Sustainable intensification aims at producing more food, more efficiently, while protecting the environment and promoting positive social and economic outcomes. Climate smart agriculture adds to that by aiming at strengthening the resilience of agricultural systems to climate variability and climate change, and, where appropriate, at reducing greenhouse gas emissions from agriculture. SI and CSA both contribute to food security and range of developmental goals.

The goal of the USAID/Rwanda Feed the Future (FtF) Project is to expand economic opportunities in rural areas, with a focus on the agriculture sector as the platform for delivering those opportunities. FtF programs of USAID are endeavoring to integrate climate change adaptation and mitigation strategies into near and longer-term investments. Due to the vulnerability of the smallholders to climate change related factors, these interventions will also need to build smallholder farmers' resilience to changing weather patterns and, where possible, to reduce greenhouse gas emissions. The USAID/Rwanda Mission's considers climate change adaptation and reduction of greenhouse gas emissions associated with economic development, and agriculture and food security as a factor in investment prioritization. In doing so, USAID/Rwanda FtF activities will explore opportunities to improve soil fertility, climate change adaptation, resilience to weather variability, and efficiency-based mitigation of greenhouse gas emissions (either in absolute or relative terms, i.e., reducing emissions per unit product) while supporting improved nutrition and income generation by smallholder farmers. As such, the next generation of USAID/Rwanda FTF activities intends to be holistically climate smart.

The FtF Sustainable Intensification Innovation Lab (SIIL) was asked to conduct a SWOT analysis with input from major stakeholders in Rwanda and provide strategic thematic areas which would be critical to consider for a CSA program.

In this report we briefly synthesize the current literature and knowledge gathered during the initial scoping study in Rwanda. This assessment summarizes what is known about climate change, climate variability, vulnerability of agricultural and natural resources systems, and identifies knowledge gaps and determine opportunities for CSA and SI. The assessment provides data on value chains that the mission focusses on (maize and beans); and on other value chains where significant gains in food security and nutrition might be made.

2. Goal:

The main goal of this assessment was to document and inform USAID/Rwanda about CSA and SI opportunities that fits its overarching strategy of designing sustainable, market-oriented interventions designed to reduce poverty and improve nutrition.

3. Objectives:

Objective 1: Synthesize existing knowledge on CSA and SI, identify knowledge gaps, thematic areas for interventions by stakeholders input (SWOT analysis and literature review).

Objective 2: Use geospatial tools to map current status of agriculture (important crops), climate, soils, nutrition, identify vulnerable geographical areas and potential zones of influence (ZOI) where CSA and SI can be implemented.

To meet above mentioned goal and objectives, we conducted a literature review and conducted SWOT analysis by inviting several stakeholder (23 different organizations) to a workshop designed to understand their needs and collaboratively develop thematic areas that are most important to address food and nutritional security of smallholder farmers in Rwanda.

The specific activities, methods and results are briefly documented and summarized.

4. Activities, Description and Results:

4.1. Activity 1: Conduct a literature review to identify and summarize GoR strategic plans, and past activities that document needs and importance of CSA and SI.

The available peer-reviewed journal articles and documents by the Government of Rwanda (GoR) strongly prioritize agriculture as a key area of importance and investment for its Vision 2020. Government of Rwanda (GoR) developed its second Agricultural Sector Investment Plan (ASIP-2; 2013 through 2018) along with the second Economic Development and Poverty Reduction Strategy (EDPRS-2), both of which clearly identifies agriculture as one of the six pillars of Vision 2020 with a goal of developing ‘productive high-value and market-oriented” agriculture by 2020. The EDPRS-2 targets annual GDP growth of 11.5% and reduction in poverty to less than 30% of the population. In 2011, 45% of the population lived below the poverty line, down from 57% in 2006. The strategic plan for the transformation of agriculture (PSTA-3, 2013 to 2018) operationalizes the EDPRS-2 targets. The plan defines four specific objectives: (i) support SI and diversification of cropping and animal husbandry effectively; (ii) support farmers and their organizations to improve accessibility, affordability and efficient use of quality inputs and agricultural support services; (iii) improve agricultural value chain development through an enabling environment for agricultural investment and business of smallholder farmers; (iv) increase the institutional capacities at central- and local government to support implantation of the sector strategy and ensure social and environmental sustainability.

The effect of climate change on agriculture sector was reviewed as a part of process of developing a National Strategy on Climate Change and Low Carbon Development (NSCCLCD) for Rwanda (Agricultural Sector Working Paper – Cole et al., 2011). This working paper identified a range of climatic hazards that are likely to increase vulnerability of agriculture sector over the next four decades. These primarily included: increased rainfall variability; increased temperatures; rising oil prices; rising food prices; steep rises in inorganic fertilizers costs; and population growth resulting in high demand for food, land and water. The authors discussed a range of adaptation and mitigation strategies that could be implemented. These items were broadly put into to two programmatic areas: (a) sustainable intensification of small-scale farming; and (b) agricultural diversity in local and export market. Main actionable items under SI were: climate smart agriculture; resource recovery and reuse; fertilizer enriched products; push-pull – integrated pest management strategies; while items under agricultural diversity were: expansion of crop varieties; expansion of local markets; expansion of manufacturing; and expansion of exports. The NSCCLCD identified few big wins that cane make significant impact on mitigation and adaptation and economic impact in the context of agriculture. The top three identified were; (a) reduced dependency on inorganic fertilizer; (b) improving irrigation infrastructure; and (c) agroforestry. While most of these recommendations are sound, the notion that crop productivity can be increased using no or at current levels of inorganic fertilizer (<5 kg/ha) is difficult.

Extreme weather has caused serious economic losses in the past (SEI, 2009). The agricultural sector has been particularly affected by floods (for e.g. 1997; and 2006 through 2009) and droughts (e.g. 1999, 2000 and 2005). Given that future climates are likely to be more variable, and that extreme events will become more common (or more extreme), the vulnerability of agricultural to such fluctuations is likely to increase. A key priority for climate change adaptation in Rwanda would therefore to increase the ability to cope with extreme climatic events (SEI, 2009), but that is a tall order.

Overall the main thematic areas identified by SEI (2009) fit into the broader framework set by the Government of Rwanda (GoR) which identified soil conservation, irrigation, mechanization, soil fertility, seed development, research and technology transfer, extension and market infrastructure are key areas of investment.

4.2. Activity 2: Determine availability of past data on climate (temperature and rainfall) from meteorological stations in Rwanda, assemble readily available data, and analyze for past trends.

Rwanda is located in east central Africa between 1° and 3° South. It has an elevation between 900 and 4500 m above sea level, with a median elevation of 1600 m. Due to its high elevation the climate of Rwanda is relatively temperate for a country in the tropics. The annual average temperature is between 14 and 23°C, and annual precipitation is between 850 and 1800 mm for 99% of the country. The peaks of the volcanoes are considerably colder and wetter.

The eastern part of the country is warmer than the central and western part (Figure 1). Due to its location near to the equator, monthly temperatures are very stable, but they are slightly higher in the months of August through September (when precipitation is low).

Precipitation shows clear seasonality with a dry season (<30 mm per month; June through August; Figure 2); followed by a first wet season (>125 mm per month; October and November); second medium dry season (about 80 to 120 mm per month; December through February) and second wet season (> 125 mm per month; March through May). The monthly variation in precipitation in space and time is an important determinant of crop production patterns as is average temperature (elevation).

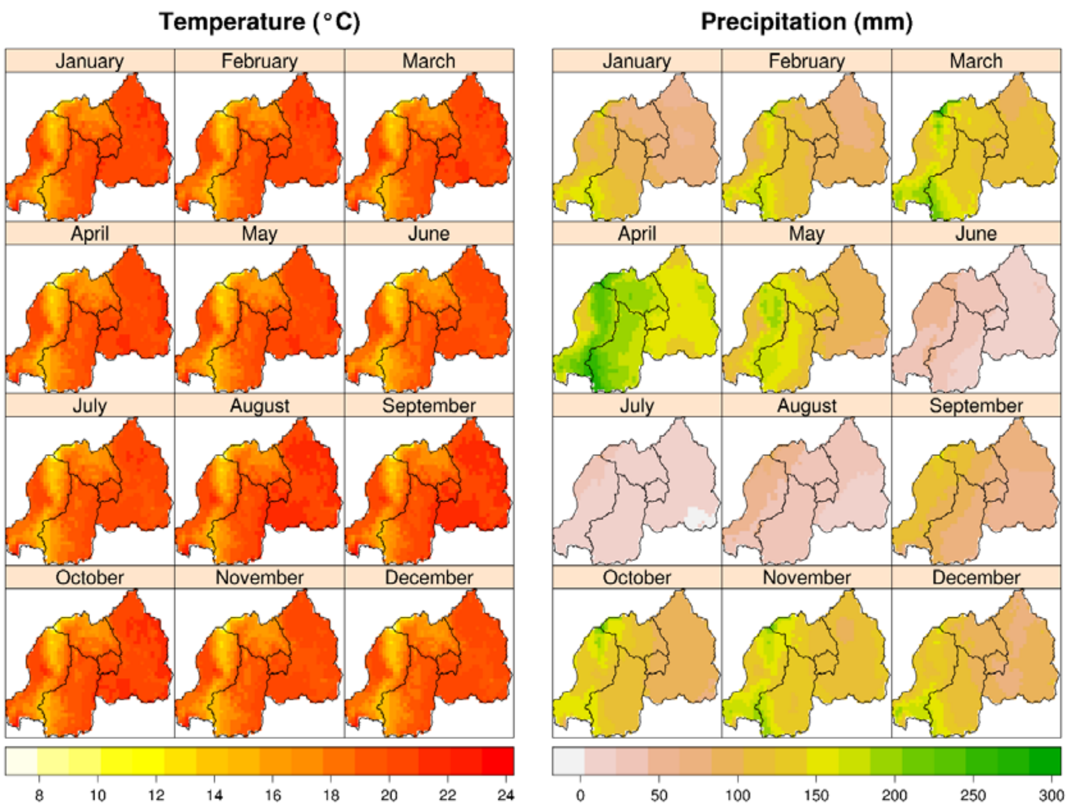

Figure 1. Mean monthly temperature (°C); and total monthly precipitation (mm) (average for 1950 to 2000) in Rwanda. Monthly temperature does not change much over the year, but monthly precipitation follows seasonal pattern with two distinct dry seasons, each followed by a wet season. Source: www.worldclim.org.

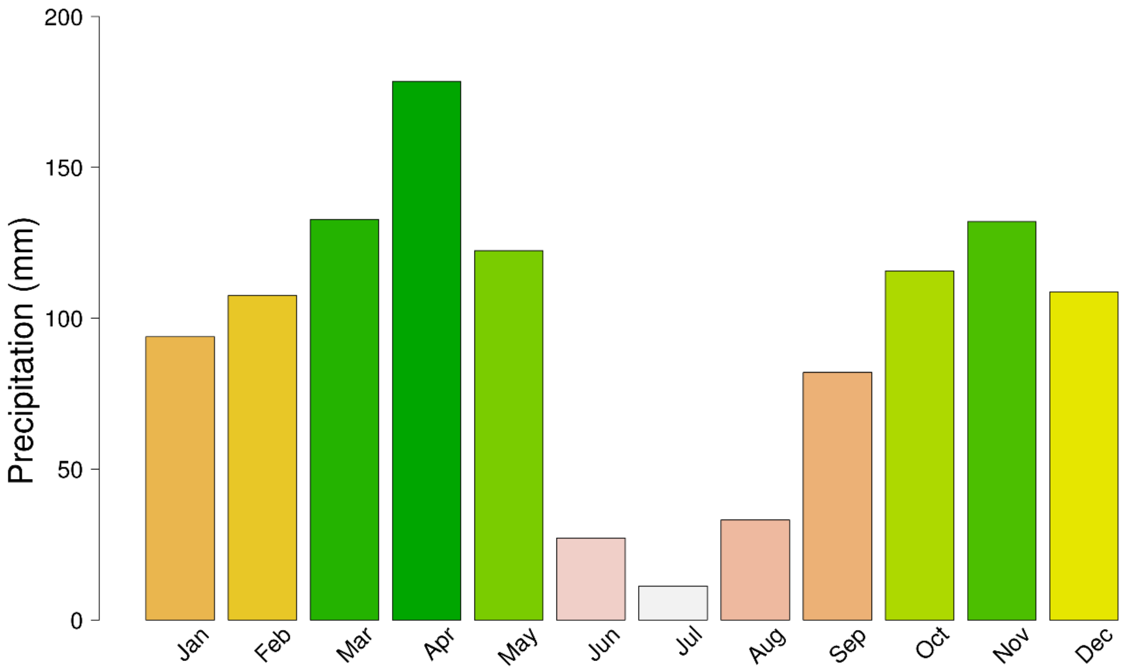

Figure 2. Total monthly precipitation (mm) (average for 1950 to 2000) in Rwanda. Source: www.worldclim.org.

There are not many reliable long term climate records for Rwanda. Many of the older weather stations were discontinued, or hiatus in their records. The Rwanda Meteorology Agency may have more records than what is publicly available, but unfortunately they do not make their data available to the public. Records from Kigali airport and from the CRU TS data set (based on space-time interpolations from stations in Rwanda and surrounding countries), suggest that there has been a strong period of warming since 1980. The average temperature in Rwanda was about 19°C between 1960 and 1980, but has increased at a rate of 0.04 °C per year (1°C over 25 years). This rate of warming exceeds climate change projections for this region which is about 2°C between the baseline (1960-90) and 2050 (i.e. 75 years) under high (but perhaps realistic) greenhouse gas emission scenarios. Therefore, it might be that the warming trend will slow down over the coming two decades, but that temperatures continue to go up. It may also be that the warming observed is biased, and that some of the warming in Kigali is caused by the by the ‘urban-heat’ island effect due to expansion (and increased air pollution) of Kigali.

There has been an increasing trend in annual mean temperature, in contrast there was no discernible trend in rainfall (Figure 3).

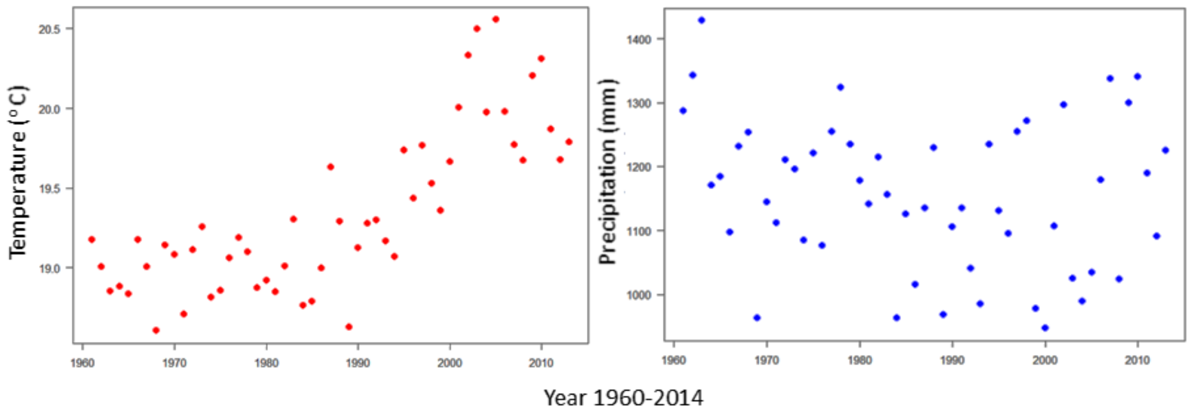

Figure 3. Mean annual temperature (°C) and precipitation (mm); from 1960 to 2014 in Rwanda. There has been a significant increases in mean annual temperature in recent decades (from 1980 onwards). The year to year variation in precipitation is in the order of 200 mm (15%).

4.3. Activity 3: Use downscaled GCM data for different emission scenarios to project future changes in climate and climate variability for various periods (2020-2050).

Description and Results:

Future climate projections are often generated using Global Climate Model (also called General Circulation Models). These models depend about assumptions about the future concentration of atmospheric greenhouse gases. These depend on future human behavior and are thus unknown, hence different scenarios are used (lower and higher emissions). GCMs simulate global weather for different heights in the atmosphere at small time steps (e.g. hourly). To allow for reasonable fast computation the world is divided into limited spatial units making the output very coarse (2 to 3° Longitude and Latitude; one degree is about 110 km).

Downscaling techniques can be used to obtain higher spatial resolution data. We used a straightforward approach to downscaling, the ‘delta-method’. In this method the change in climate as projected by a GCM is assumed to relatively stable over space interpolated to a higher resolution. These high resolution changes in climate are then applied to high resolution observed climate data to generate high resolution spatial data of future projections under different scenarios.

The RCP (representative concentration pathways) scenarios has been accepted by the IPCC (Intergovernmental Panel on Climate Change) for its fifth assessment report. RCP represents four possible greenhouse gas concentration trajectories corresponding to increases in global radiative forcing from pre-industrial times to end of this century (2.6, 4.5, 6.0, and 8.5 W/m^2). We have generated high resolution downscaled GCM data for different RCP for different time periods. These data suggest that there will likely be significant warming across Rwanda over the next decades, but that precipitation will not change much (Figure 4). The data from the highest, but unfortunately most realistic, emission scenario (RCP 8.5) for short term projection (2050) show increases in mean temperature in the range of 2 to 2.5°C (data are the mean of eight different GCMs). The projections also show slight increase in mean annual precipitation (about

50 to 100 mm). However, this slight increase in precipitation will be more than negated by increased temperature which will result in higher water demand by crops (evapo-transpiration). Detailed data on other scenarios and time scales are available at www.gfc.ucdavis.edu/profiles/rst/rwa.html

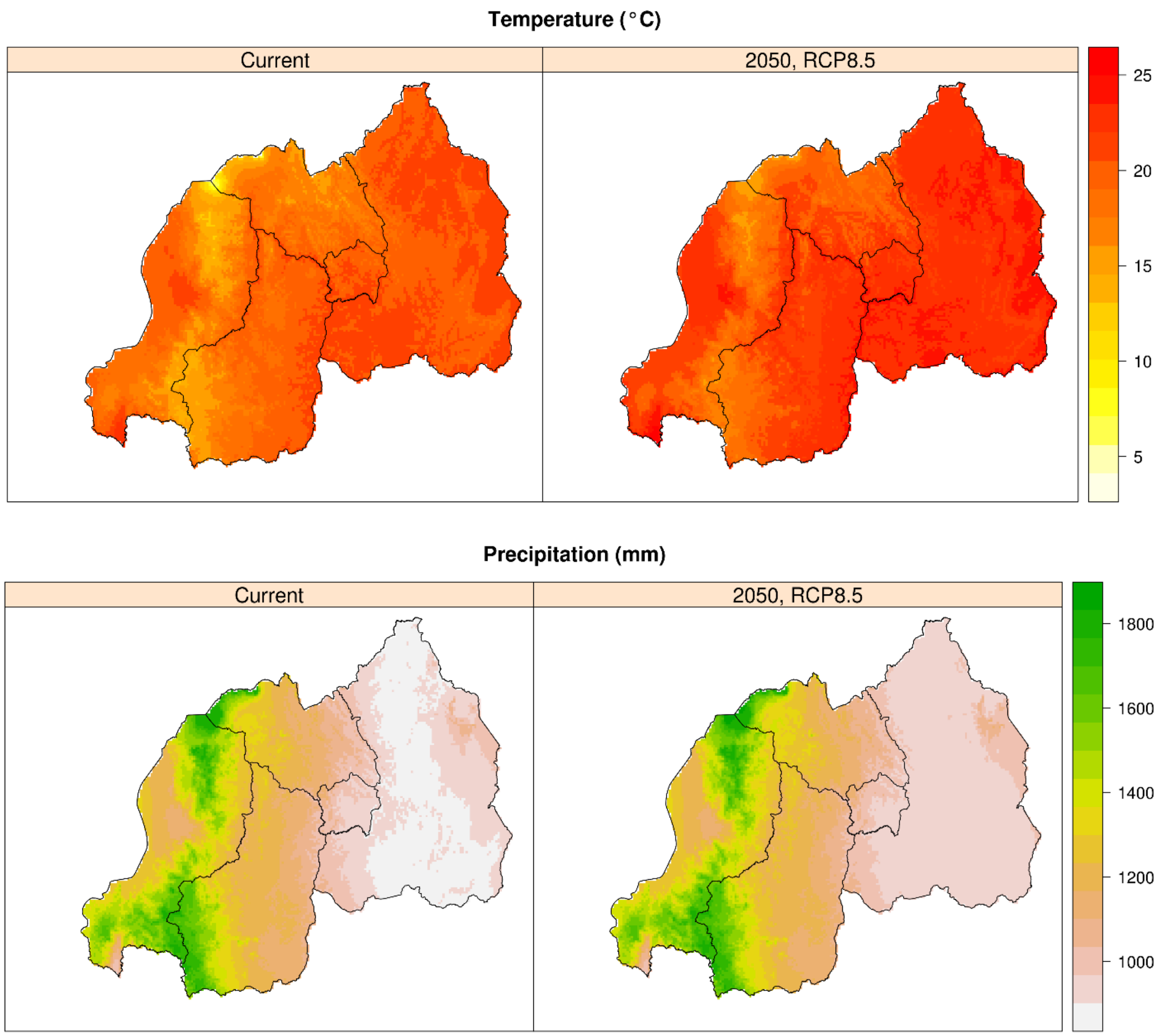

Figure 4. Mean annual temperature (°C) and total precipitation (mm) for "current" (average conditions for 1950-2000) and by 2050, according to with RCP8.5 scenario. Data is averaged of eight different global climate models.

(Source: CMIP5 – Coupled Model Intercomparison. www.cmip-pcmdi.llnl.gov).

4.4. Activity 4: Conduct detailed SWOT (strength, weakness, opportunities and threats) analyses on understanding of climate smart agriculture and sustainable intensification with active partnership of local organizations (national research centers, universities, government agencies, non-governmental agencies).

Description and Results:

We held a two-day workshop inviting all stakeholders to participate in an interactive meeting to assess Strengths, Weaknesses, Opportunities and Threats (SWOT) of various components of CSA and SI. The meetings were designed to identify existing knowledge, identify gaps, identify thematic areas, determine priorities, identify geographical focus, identify stakeholders and their roles, and create partnerships for collaboration. In addition, we were also interested in identifying needs in capacity building, gender, and nutrition.

This workshop was done in active participation and collaboration with two Consultative Group of International Agricultural Research (CGIAR) centers (CIAT, International Center for Tropical Agriculture; and IITA, International Institute for Tropical Agriculture). About 26 different organizations were identified to be key stakeholders for this activity in Rwanda. Each institution was asked to send at least one participant. There was a positive response and about 35 representatives from 24 different organizations participated in SWOT analyses (listed below). This makes the results more representative and also captures thoughts of all organizations. The names of participants and their affiliations are provided in Annex 1.

1. Rwanda Agriculture Board (RAB)
2. Ministry of Local Government (MINALOC)
3. Ministry of Natural Resources (MINIRINA)
4. Ministry of Agriculture and Animal Resources (MINAGRI)
5. Rwanda Environment Management Authority (REMA)
6. Rwanda Natural Resource Authority (RNRA)
7. Rwanda Meteorology Agency – Meteo Rwanda
8. Musanze District Representative
9. Kamonyi District Representative
10. Rwanda Farmers Federation (IMBARAGA)
11. Agribusiness Focused Partnership Organization (AGRIFOP)
12. The Rwanda Cooperative Agency
13. National Cooperative Federation of Rwanda
14. Private Sector Federation – Chamber of Agriculture
15. Seed Co – Rwanda
16. Clinton Climate Change Initiative
17. World Vision

18. SNV – Netherlands Development Organization
19. IBISUBIZO Cooperative (active in Musanze District)
20. Gardens of Health
21. Global Communities (USAID Rwanda implementing partner)
22. CIP – International Potato Center (CGIAR Center)
23. IITA – International Institute of Tropical Agriculture (CGIAR Center)
24. CIAT – International Center for Tropical Agriculture (CGIAR Center)

In brief, a SWOT analysis is a methodology that is commonly used in strategic program planning. It provides a simple framework for an entity to scan both the internal and external environment as shown in the matrix below (Figure 5). The SWOT analysis provides information that is helpful in matching the entity's resources and capabilities to the environment in which it operates. It also acts as a filter to reduce the information generated through the exercise to a manageable number of key issues.

As the name implies, a SWOT analysis consists of four categories: strengths, weaknesses, opportunities, and threats. These categories can further be defined as either internal or external factors. Strengths and weaknesses are often internal to an entity. Opportunities and threats tend to be external factors, often beyond the control of the entity/organization, that impact and/or influence operations. The following matrix presents the components of the SWOT analysis.

SWOT Matrix	**Competitive Advantages**	**Institutional Challenges**
Internal Factors	**Strengths** What do we well? Areas that are healthy, vibrant and positive?	**Weaknesses** What do we do less well? Areas of weakness we encounter
External Factors	**Opportunities** Needs; Trends we can take advantage of? What is changing in the community?	**Threats** Issues (rules, regulations or other items) that limits action What is changing that will impact us?

Figure 5. Strengths, Weakness, Opportunities and Threats (SWOT) matrix indicating meaning of terms.

During the SWOT exercise, each participant received colored sticky notes (Post-Its), three for each SWOT category. The participants were instructed to work individually (or sometimes together in teams) and write down three strengths, weaknesses, opportunities, and threats on the sticky notes, representing each of the four SWOT quadrants. Once all of the quadrants were complete, participants were asked to group like ideas and then label each "cluster." The title for each cluster was developed through discussion amongst all participants. The participants reflected on the outcomes of their activities and agreed that the clusters were representative of the assets, opportunities, and challenges as it relates to sustainable intensification. The facilitators at all three sessions reminded the participants that the purpose of the exercise was to generate ideas and feedback, not to come to a consensus on any particular item or issue. Rather, it was entirely conceivable that an issue could be identified in multiple categories (i.e., be both a strength and a weakness). As such, all ideas posted on the walls were documented and are included in the results section.

Definition of CSA:

Participants were not provided with any definition of the CSA. Rather, all participants were asked to define CSA as it means to them, their organization and for Rwanda. The majority of participants had a good grasp of the question and defined CSA in their own words which was representative of their thoughts. There were large differences among various stakeholders. Some of the specific thoughts that were captured are listed below. Full details of all definitions are provided in Annex 1.

- Crops that are adapted to local climate
- Crop diversification
- Adaptation of new crop varieties (stress tolerant)
- Making agriculture (farming systems) more resilient to climate
- Maximize productivity using adaptation and mitigation strategies
- Practices with low carbon emissions
- Use of climate information tools
- Increasing yield and sustainability
- Increase income by using services of skilled agro-dealers (high input efficiency)
- Water conservation
- Restoration of soil fertility
- Use of local inputs (including recycling)
- Increase nutrition food (nutrition sensitive agriculture)
- Reducing food waste
- Increasing farmers capacity

SWOT Analyses for CSA:

There after each of the participants was asked to list various components of SWOT as it relates to CSA on the respective colored Post-Its (green for strength; orange for weakness; yellow for opportunity; and pink for threat). Selected items in each of the categories are summarized below (Figure 6). All of the completed Post-It notes were placed on a wall so that everyone could see (Figure 7). At the end all participants were given time to discuss and add to the list if necessary.

Strengths:	**Weaknesses:**
1. Existence of climate / soil data	1. Soil erosion
2. Presence of agricultural seasons	2. Poor soil fertility
3. Availability of output market	3. Lack of access to water
4. Rural infrastructure network	4. Limited information sharing/access
5. Strong government policies	5. CSA difficult to mechanize
6. Strong institutions	6. Inadequate coordination
7. Active population and skilled labor	7. Small landholdings
8. Adaptive farmers and culture	8. Lack of nutritious food
Opportunities:	**Threats:**
1. Harvesting water / irrigation	1. Erratic rainfall, weather, pests & diseases
2. Linkage of farmers to markets	2. Price fluctuations
3. Restoring measures for soil fertility	3. High levels of soil acidity
4. Accessibility of information possible	4. Limited ICT tools / awareness for CSA
5. CSA funds and Guarantee funds	5. Money inflation
6. Harmonization of policy/practice on CSA	6. Changes in policies
7. Collaboration – building partnerships	7. Land scarcity and high population growth
8. Multi-cropping opportunities	8. Limited crop varieties

Figure 6. Summary of Strengths, Weakness, Opportunities and Threats (SWOT) items for CSA in matrix.

Figure 7. Strengths, Weakness, Opportunities and Threats (SWOT) analyses about CSA. All items listed and posted for further discussion and clustering.

Clusters / Concepts for CSA:

After the list of the all SWOT components – groups were asked to analyze data to create cluster which form similar concepts (Figure 8). The list of various clusters were as follows:

1. Access to funding
2. Data and information
3. Environment
4. Food and nutrition
5. Land issues
6. Market issues
7. Policy
8. Supporting institutions and stakeholders
9. Sustainable soil fertility
10. Technology innovations

Figure 8. Clustering of various SWOT items into topics with similar concepts.

Definitions of SI:

Participants were not provided with any definition of the CSA. Rather, all participants were asked to define SI as it means to them, their organization and for Rwanda. The majority of participants had a good grasp of the question and defined SI in their own words which was representative of their thoughts. There were large differences among various stakeholders. Some of the specific thoughts that were captured are listed below. Full details of all definitions are provided in Annex 1.

- Produce more while preserving natural resource base
- Increasing yield per unit area to ensure food security but protecting environment
- Obtaining optimum yield without damaging environment
- Way of increasing food production from same land and decreasing environmental issues
- Emphases on climate adaptation focused on information delivery
- CSA should be maintained and sustained in an insensitive manner
- Sustainable government policies
- Process of implementation / innovation policies in various sectors
- Shaping existing knowledge for longer-term
- Longer term program that are sustainable and limits environmental hazards
- Putting policy to improve and control disaster including gender issues
- Sustainable scale up of interventions
- Farmers must have ownership and willingness to participate actively
- Intensification (meaning more inputs) is in contraction with limited resources

SWOT Analysis of SI:

Selected items in each of the category (Figure 9) for SWOT of SI are summarized below.

Strengths:	**Weaknesses:**
1. Willingness of farmers and stakeholders	1. Lack of appropriate knowledge about SI
2. Good land for intensification	2. Inadequate coordination among institutes
3. Soil maps available	3. Low level use of climate data / information
4. Water resources available	4. Limited financial resources
5. Community based extension services	5. Soil activity and topography (steep slopes)
6. Agriculture mechanization policy available	6. Lack of appropriate tools
7. Enabling political environment	7. Limited private sector involvement
8. Presence of multiple organizations	8. Lack of modern technologies
Opportunities:	**Threats:**
1. Presence of two rainy seasons	1. Growing population
2. Existence of private sector – inputs	2. Lack of clear communication
3. Value addition to agriculture production	3. Drought and flooding
4. Improve crop yields per unit land area	4. Pests and disease incidences
5. Minimize over exploitation of resources	5. Soil activity and unfavorable topography
6. Diversification of farming systems	6. Sustainable funding for agriculture
7. Opportunities for scaling technologies	7. Small land holding
8. Training of extension services	8. Climate change and climate variability

Figure 9. Summary of Strengths, Weakness, Opportunities and Threats (SWOT) s for SI in a matrix.

Clusters / Concepts for SI:

Similar to that for CSA, after creating the list of all SWOT components – groups were asked to analyze data to create clusters which form similar concepts for SI. These clusters are listed below.

1. Human resources
2. Climate and environment
3. Finances
4. Soil survey and soil fertility management
5. Policy
6. Capacity building

4.5. Activity 5: Synthesize SWOT analyses, inventory of main concepts of CSA and SI, and identification of key strategic thematic areas.

Description and Results:

After formation of the clusters of CSA and SI, all participants were given the opportunity to look into individual items and start thinking about the common thematic area that captures most of the items listed under various categories. The SWOT team did the initial steps of creating these thematic areas which were then discussed if any additional topics are required to be added to the list to capture the thoughts and clusters from both CSA and SI concepts.

The following thematic areas were finally identified:

1. Integrated soil fertility management
2. Integrated water management
3. Crop variety improvement / supporting seed systems
4. Small scale mechanization tools
5. Yield improvement and income generation
6. Adoption of CSA interventions
7. Capacity building
8. Promoting partnerships

In each of the above thematic areas, gender, nutrition, youth, technology and communication were cross cutting areas.

All participants were divided into five groups and each group was asked to discuss specific activities or strategies under each thematic area. It was a rotating and iterative process, in which each group read what the previous group had identified and added anything that was missing. All groups had opportunities to add to each of the topics. Some selected (5) ideas or activities identified under selected thematic areas are listed below. Complete list of items discussed and identified are provided in Annex 1.

Integrated soil fertility management:

- Site specific fertilizer recommendation (based on yield goal)
- Inventory of nutrient use (organic and inorganic sources) and opportunities for integrated nutrient management
- Evaluation and identification of genotypes more responsive to fertilizer and inputs (both organic and inorganic production systems) – including incorporation of legumes in the farming systems.
- Soil amendments (addressing acidity) and use of micronutrients
- Use of hedge rows – agroforestry species/legumes

Integrated water management:

- Rainwater harvesting (for example terracing, tied ridges)
- Raised bed and furrow systems (infiltration, irrigation)
- Survey and mapping of groundwater and water quality
- Improving water retention using CSA (soil cover, increased organic matter, minimum tillage)
- Agroforestry systems for watershed management (multiple purpose, fast growing trees – forage / fodder – value)

Crop variety improvement / supporting seed system:

- Variety selection / breeding for high yield & stress tolerance
- Variety selection / breeding for improved nutrition
- Inventory of nutrition value of various crops / varieties (including indigenous species) and supporting their production.
- Developing and supporting seed systems
- Improving value chain of post-harvest handling and storage

Small scale mechanization and tools:

- Hand operated and gasoline based planting equipment for precision and uniform germination
- Hand operated weeding tools which minimize stain
- Hand operated or gasoline based shellers, cleaners, and milling processing equipment and also opportunities for fortification.
- Use of axial flow pumps for small scale irrigation
- Multiple purpose motor / engines

Yield improvement and income generation:

- Use of high yield and climate resilient genotypes and cash crops
- Development of best management practices (includes agronomy)
- Inclusion of livestock along with crop production
- Home gardening and production of vegetables (at homestead)
- Minimizing losses during harvest and postharvest activities

Adoption of CSA interventions:

- Inventory and assessment of CSA interventions adapted to micro-environments
- Develop tools to assess adoption, enhance adoption of CSA and develop monitoring and evaluation tools for CSA to assess impact
- Develop strategy to provide incentives of CSA technology adopters
- Inclusion of women and youth in CSA approaches
- Enhance collaboration and communication among various stakeholders

Capacity building:

- Training and building capacity of farmers, end-users, researchers and awareness creation about CSA across all stakeholders
- Develop manuals on simple CSA that can be used by extension agents and famers organizations
- Establish CSA demonstration plots across the country where farmers can learn (through farmer field schools)
- Establish knowledge sharing platform for CSA at country level
- Introduce CSA in various levels of formal education (primary, secondary and higher education) and introduce specialization at MS, PhD levels.

Promoting partnerships:

- Enhance partnerships and opportunities for collaboration among various stakeholders (famers, farmer organizations, local and international NGOs, government agencies, public institutions and private sector)
- Mapping stakeholders and their activities at various levels (national, regional and local)
- Enhance public – private partnerships
- Create a conducive environment and policies will enhance partnerships and attracts new partners
- Ensure involvements of all sectors including women, youth and vulnerable groups

4.6. Activity 6: Document Selected Success Stories and Understand Reasons:

All participants were divided into five groups and asked to come up with one "success-story" where a specific intervention was successful. As these were suggested by the group, they often highlighted a project that the organization of at least one group member has been working on. This may have created some bias and the list should not be taken as our choice of the best success stories for all of Rwanda. The following were the five success stories identified by the group.

Project Name: Correction of acidic soils through use of lime and ISFM inputs.

This project was aimed at managing soil acidity which is a major limitation for yield improvements for all crops – cereals, legumes, tubers and banana.

Where: Nyaruguru and Nyamagabe districts

Why:

- The acidity was the most limiting factor
- The project provided quality seed (Irish potato, climbing bean, maize and wheat) with livestock and hedgerows (agroforestry) on contour lines.
- Effective use of bench terraces;
- 20,000 farmers benefited from the project;
- This created high productivity and household food security
- High demand for lime and seeds

Partnerships: AGRA, RAB (implementer), farmer cooperatives

Project Name: SASHA (Sweet potato Action for food security and health in Africa)

This project aimed to assist farmers in improving productivity of orange flesh sweet potato rich in Vitamin A and adding value by processes products.

Where: Turwanyubukene farmer groups, Gakenke Sector, Gakenke District

Why:

- Currently selling planting materials
- Supply roots for Urwibutso enterprise
- They have now increased in their income to pay health insurance, school fees, buying basic planting materials themselves
- Woman can contribute to household expenses
- Land is properly used now with recommended manure erosion control also applied

Partnerships: CIP, RAB, IMBARAGA, YWCA

Project Name: Increasing soil fertility benefits of climbing bean to smallholder

In 2012 the crop intensification program (CIP) cultivated 150 ha of land to grow climbing beans in Remera. The trial was repeated for 6 seasons.

Where: Remera sector, Musanze District.

Why:

- Beans were fertilized by different chemicals and they produced 3 t/ha
- Yield was three fold higher than bush beans using same inputs
- High production provides smallholder farmer an opportunity to feed his family and sell the surplus to the market
- By selling surplus they were able to generate income to meet other family needs while meeting the demand for climbing beans in their communities

Partnerships: AGRA, RAB, local government, Farm cooperatives, CIP

Project Name: Bucket drip irrigation technology

This project was aimed at small irrigation opportunities for small house and farm holds

Where: Nyamagabe, Huye and Nyaruguru Districts (southern province)

Why:

- High rate of malnutrition (stunting > 50%); Land shortage; Drought; High pressure on marshlands; Low household income
- 6 model farmers; Local fabricators / sustainability purpose; Investment costs: $78 per kit; Land size (space): 15 x 5 m
- Yield increased; and household income increased by up to 97%
- Malnutrition rate decreased
- Payback: within one season
- Three seasons of production
- Now 106 smallholder farmers adopting the technology

Partnerships: World Vision Rwanda, Vision Finance Co., Local government, others

Project Name: International Fertilizer Development Corporation (IFDC) fertilizer program

Activities: fertilizer use monitoring, training on appropriate fertilizer use.

Where: Musanze District (all sectors)

Why:

- Increased productivity / food security
- All agro dealers trained
- Increased knowledge of farmers

Challenges:

- Price fluctuations
- Climate

Partnerships: IFDC, IMBARAGA, RAB, DERN, local government, farmer cooperatives

4.7. Activity 7: Map data (sub-divisions, climate, ecology, resources, biophysical and socio-economic conditions, market access, nutrition and health) using geospatial tools.

<u>Description and Results:</u>

<u>Administrative and Topography:</u>

Rwanda is administratively subdivided into 5 provinces and 30 districts (since 2006; Figure 10). These districts are further divided into 416 sectors, 2148 cells and 18820 villages. Prior to 2006 the main subdivisions were 10 prefectures and 142 communes.

Figure 10. Regions and districts in Rwanda.

The country has an elevation between 900 and 4500 m above mean sea level, with a median elevation of 1600 m (Figure 11). Broadly it can be divided into three altitude zones (high altitudes on the west, medium altitude in the central and low altitude zone in the east).

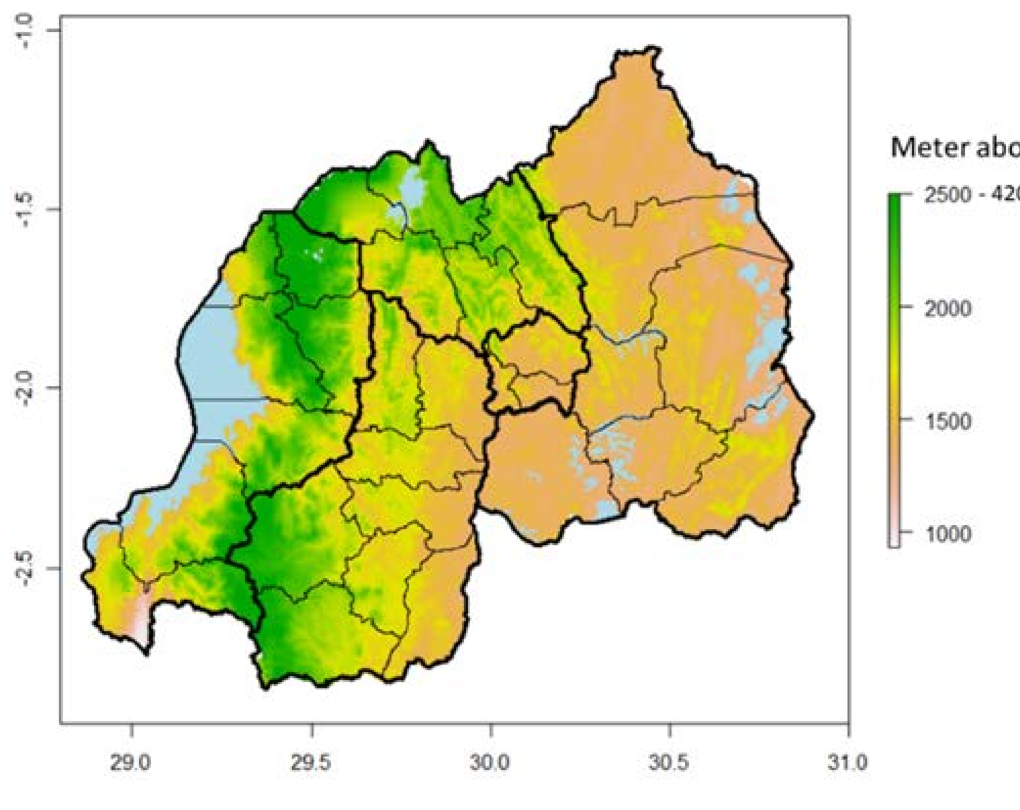

Figure 11. Elevation map of Rwanda.

Climate:

Due to its high elevation the climate of Rwanda is relatively temperate for a country in the tropics. The annual average temperature is between 14 and 23°C, and annual precipitation between 850 and 1800 mm (Figure 3). Climate is generally warmer and drier in the east compared to west.

Agro-Ecological Zones:

Despite its small size Rwanda has large diversity in terms of agro-ecology due to large variability in elevation and the East-West rainfall gradient. The country can be divided into ten agro-ecological zones (Figure 12) which are used in land use planning and agricultural activities (Figure 13). Land use maps are improved and now includes assessment of land degradation and sustainable land management practices.

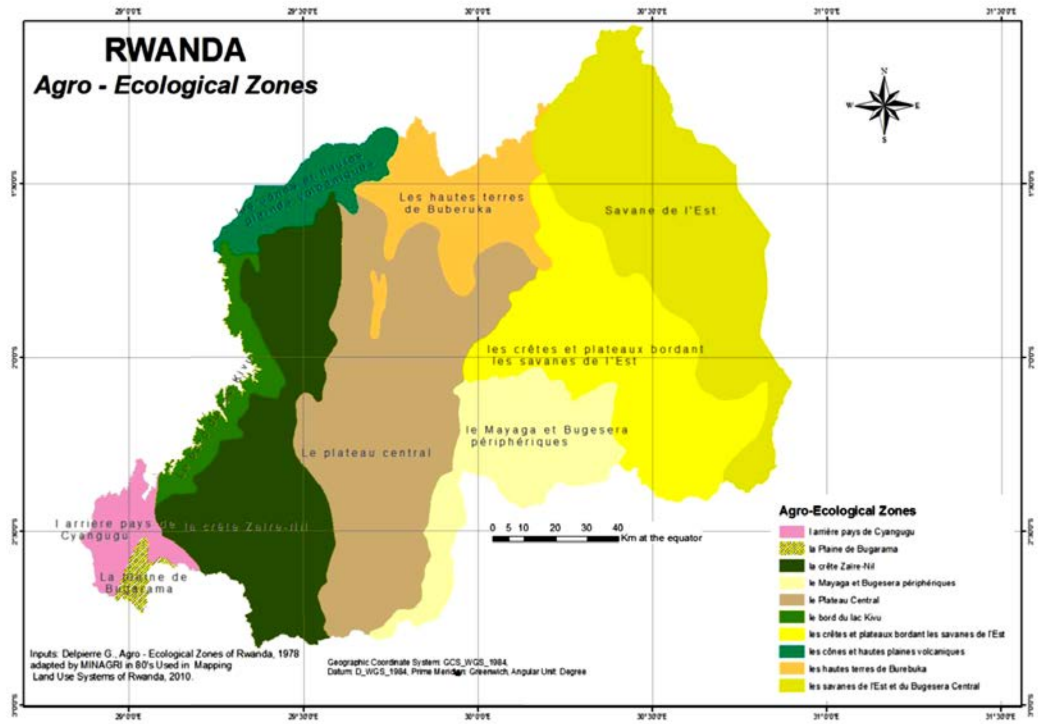

Figure 12. Agro-ecological zones of Rwanda (Source MINAGRI and FAO)

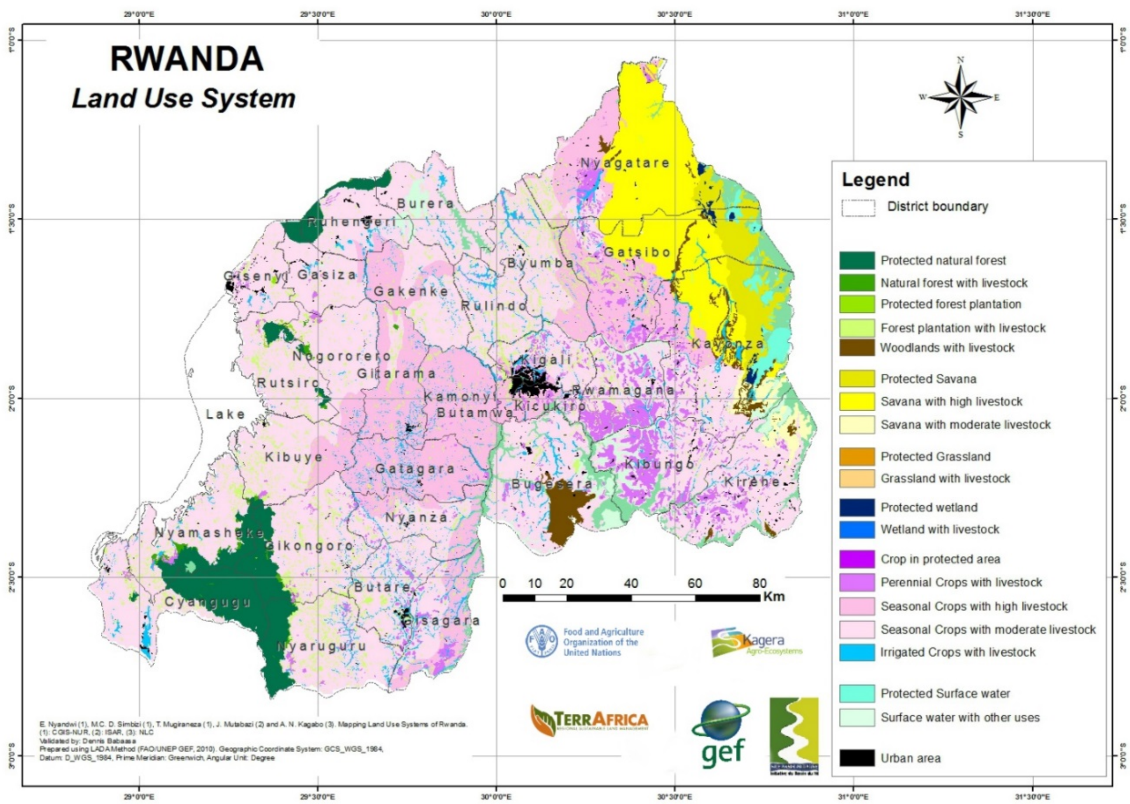

Figure 13. Land use systems of Rwanda (Source MINAGRI and FAO).

Land Availability, Landholding and Soil Quality:

Rwanda is a small country with an area of about 26,338 km^2 with an arable land area of about 1.4 million ha, or 52% of total land area. Recent studies indicate these numbers to be higher with about 70% of total land surface area being directly or indirectly utilized for agriculture and pastures (FAO, 2015; World Bank 2015).

Land holdings of farmers are small with more than 90% having less than 1 ha, and about 50% have less than 0.5 ha (Figure 14).

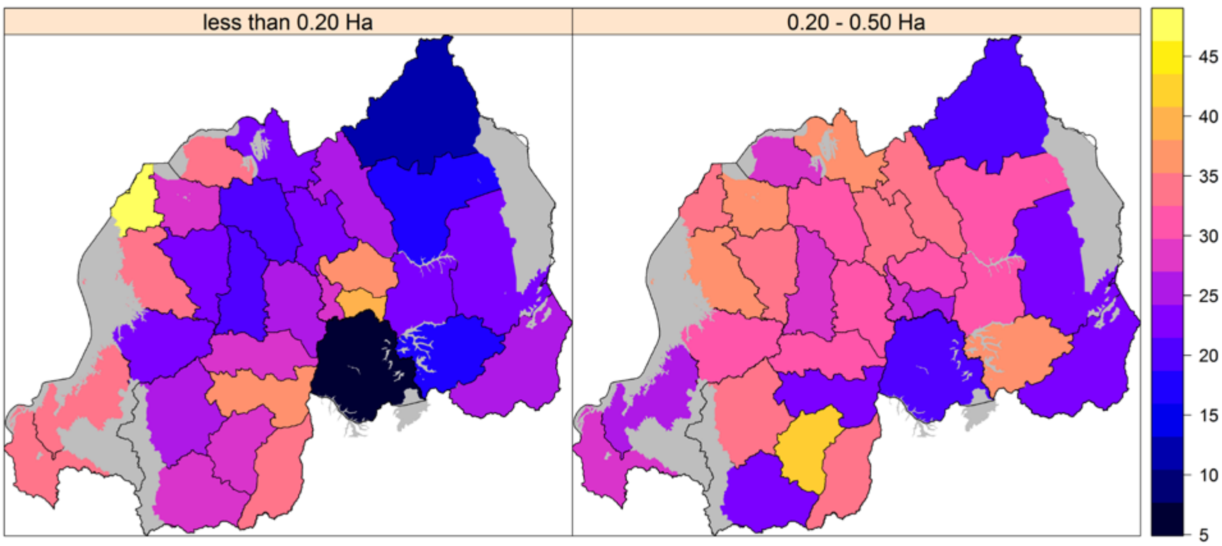

Figure 14. Percentage of agricultural households according to farm size (FAO).

Much of the land (>50% of the arable land area) is prone to erosion due to steep slopes. About 80% of land has slopes that are larger than 6% and about 40% of the land has a slope of 25% or higher. According to FAO about 40% of land is classified as high erosion risk and requires soil retention measures, while only 23% is risk free from erosion. About 75% of soil is highly degraded.

As for soil quality large proportion of land (>70%) suffers from soil acidity (pH< 4.5; Figure 15) often with aluminum toxicity. As expected, pH is lowest in the wetter western part of the country where soils have weathered more. The soil organic matter (SOM) content ranges between 2 and 3% for the majority of land area. SOM is generally lower in the (dryer) eastern part of the country. It is highest in wetter and cooler (high elevation) areas in the west and in the low lying peat land areas in the south. Plant growth, microbial activity, nutrient availability is optimum at a soil pH range of 5.5 and 8. Low pH (acidic soils) negatively influences availability and uptake of several essential nutrients, and also restrict root growth and access to water and nutrient leading to low productivity.

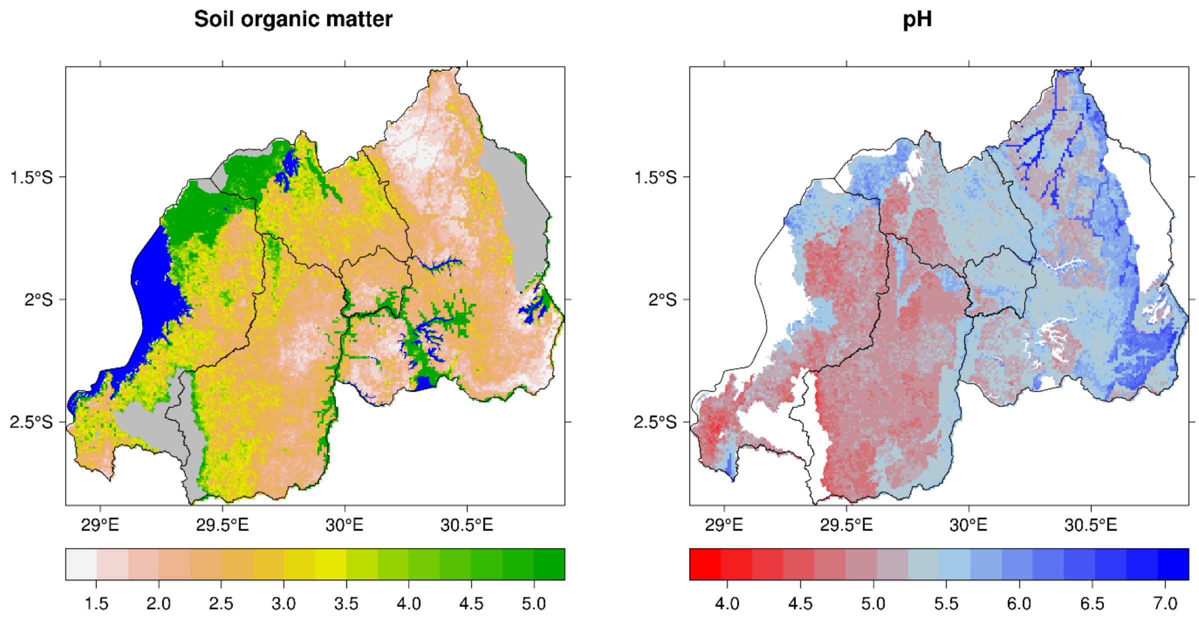

Figure 15. Soil organic matter (%) and soil pH.

<u>*Crop Production:*</u>

There is a high diversity in the crop production in Rwanda (Figure 16). Plantains ranks first in term of total acreage, followed by beans, maize and root and tuber crops (cassava, potato and sweet potato). In terms of acreage planted, there has been significant increase in production of beans (primarily due to increase in climbing beans) and maize. Whereas, the acreage of other crop has remained constant (Figure 16). The productivity of maize and root and tuber crop has strongly increased in the recent years, while not much change was observed in other cereal or legume crops.

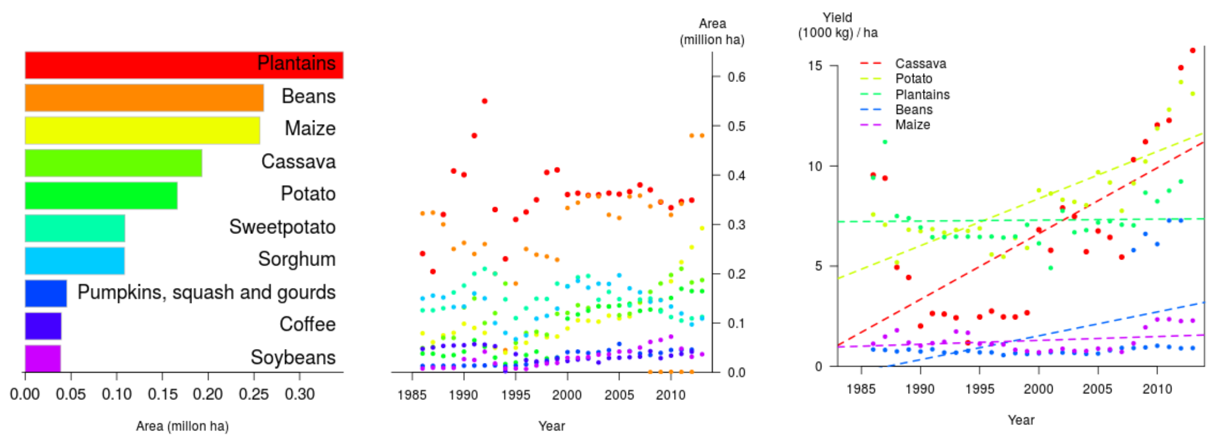

Figure 16. Current acreage and past trends of acreage and yield of important crops.

<u>Current Yield, Potential Yield and Yield Gaps:</u>

Crop yield potential is determined by the genetic potential of a variety, and by the temperature and solar radiation. However, in many cases this potential cannot be reached due to limiting factors (water, nutrients) and yield reducing factors (pests, diseases, weeds). As most crops in Rwanda are rainfed, we considered yield potential as the highest yield that can be attained under rainfed (no irrigation) conditions, but under perfect fertility conditions and in the absence of pests.

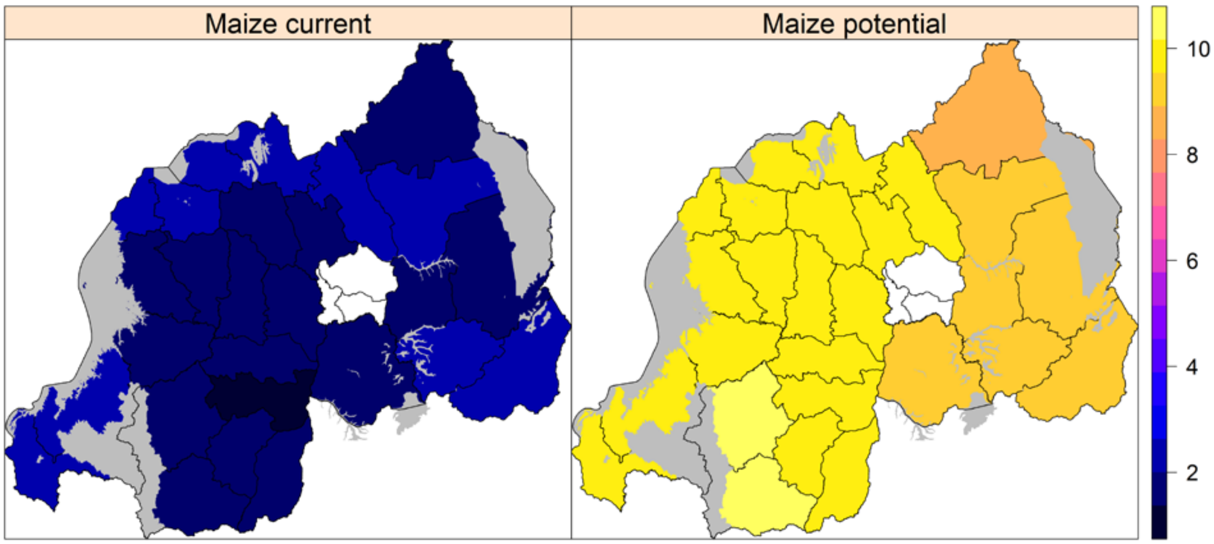

Figure 17. Current yield and potential yield (1000 kg/ha) for rainfed maize in Rwanda.(t/ha).

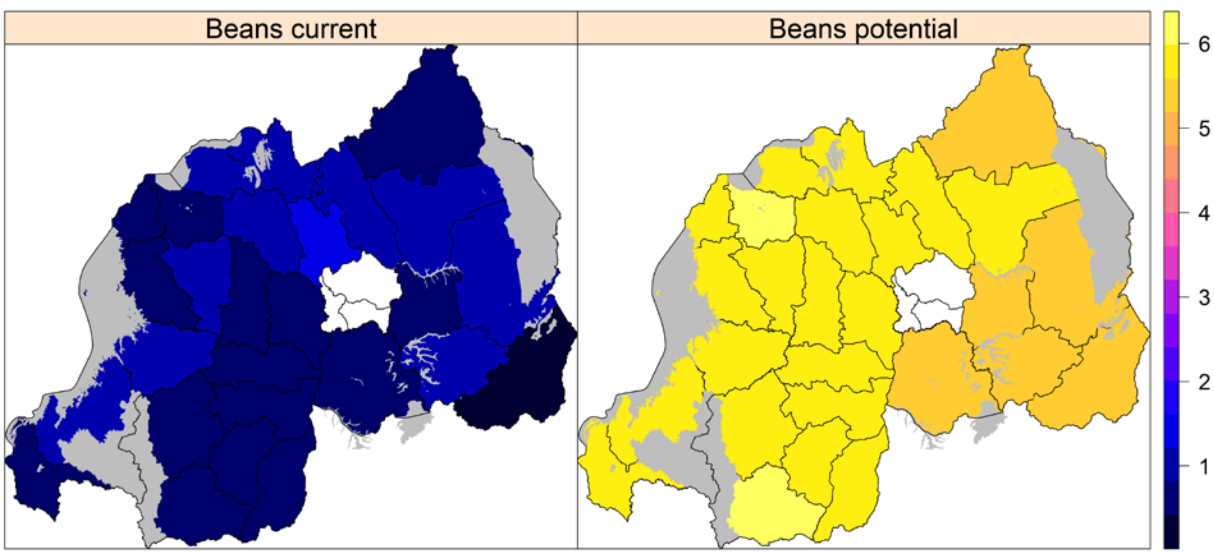

Figure 18. Current yield and potential yield (1000 kg/ha) for rainfed beans in Rwanda

Yield gap is defined as the difference between this attainable (potential yield) and actual (current) yield. Despite recent increases in yield of some crops there are significant yield gaps for major cereals, legumes and tuber crops. Figures 17 and 18 shows the current yield and potential yield for maize and beans in Rwanda. As the figure shows yield potential for both maize and bean in several regions ranges from 8 to 10 t/ha (maize) and 5 to 6 t/ha (beans); while the current yields range between 2 and 4 t/ha (maize) and 1 to 2 t/ha. This suggest there is potential to increase maize and bean yields in the range of 2 to 4 t/ha. Current and potential yield of other crops such as cassava and potato are shown in Annex 2.

Input Use:

Lower yields and larger yield gaps for various cereal, legumes and tuber crops can be generally associated with limited use of improved genotypes, limited use of inputs particular inorganic fertilizer (Figure 19), and sub-optimal management (agronomic practices).There has been an increasing trend in the use of external inputs (particularly use of inorganic fertilizers and pesticides). For example, fertilizer consumption in Rwanda was about 2 k/ha in 2003 which increased to about 10 kg/ha in 2008 and about 32 kg/ha (MINAGRI, Rwanda). The use of fertilizer significantly increases the cost of production and can also have a negative impact on environment if not used judiciously. Care should be taken to ensure that there is balance between productivity increases and protecting environments. Inorganic fertilizer should therefore be used in integrated approaches to manage soil fertility. By combining crop rotations that include legume crops, organic sources of fertilizer (manures, compost, residues).

Rwanda has only about 1% of land under irrigation, and majority of crop production is rain-fed and dependent upon rainfall (see figures in Annex 2). Distance to market access is also provided as figure in Annex 2.

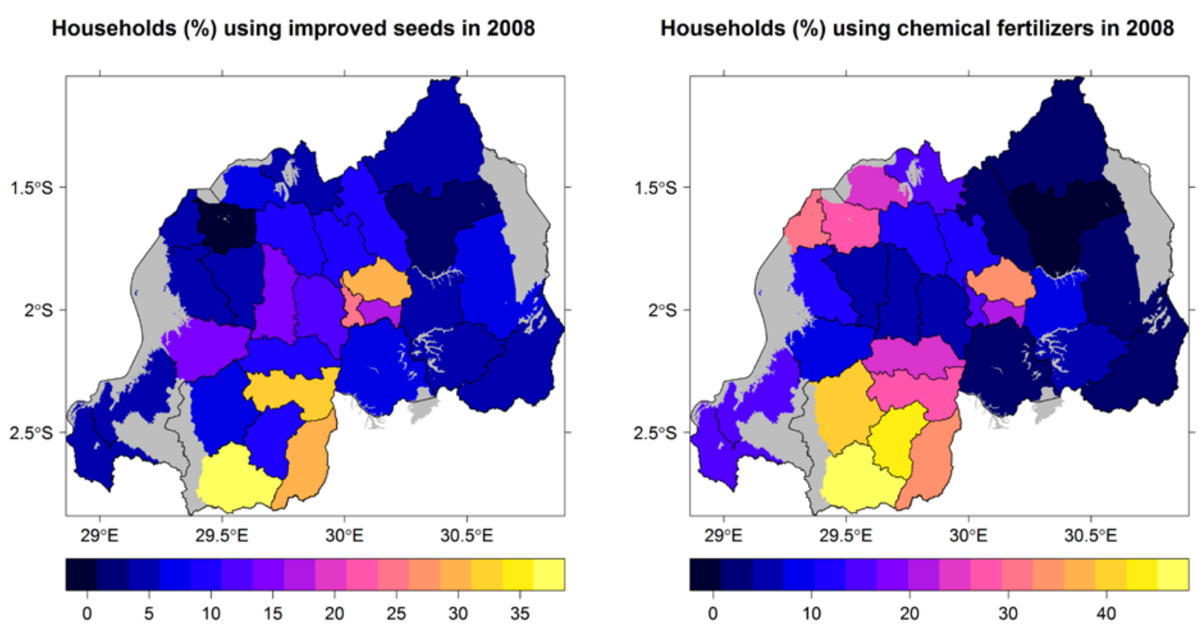

Figure 19. Current yield and potential yield (1000 kg/ha) for rainfed beans in Rwanda

Livestock Production:

Livestock production in Rwanda has seen significant increase in the last two decades (Figure 20) due to return of farmers who came to country with their farmers. The increase of goats has been much larger than for cattle. The cattle numbers increased after 1995 but have now stabilized. This is despite the great desire by many Rwandan households to own a cow (both for milk and as a source of manure); and a government program to promote it. The stagnation in cattle production appears to be related to the scarcity of good quality (forage, feed, feed formulation, composition) and quantity of animal feed, as well a lack of knowledge regarding management (proper animal husbandry, animal health, disease management), In addition, the policy of zero grazing policy adopted by GoR resulted in farmers selling their cattle. Traditionally farming practices include both crop and livestock systems. However, there are opportunities to not only improve awareness but also training and capacity to take advantage of improved practices (e.g. improved forage or fodder; processing of forage or fodder; nutrient recycling from animals to crops) which will allow better integration of crop-livestock and improve productivity of overall farming systems.

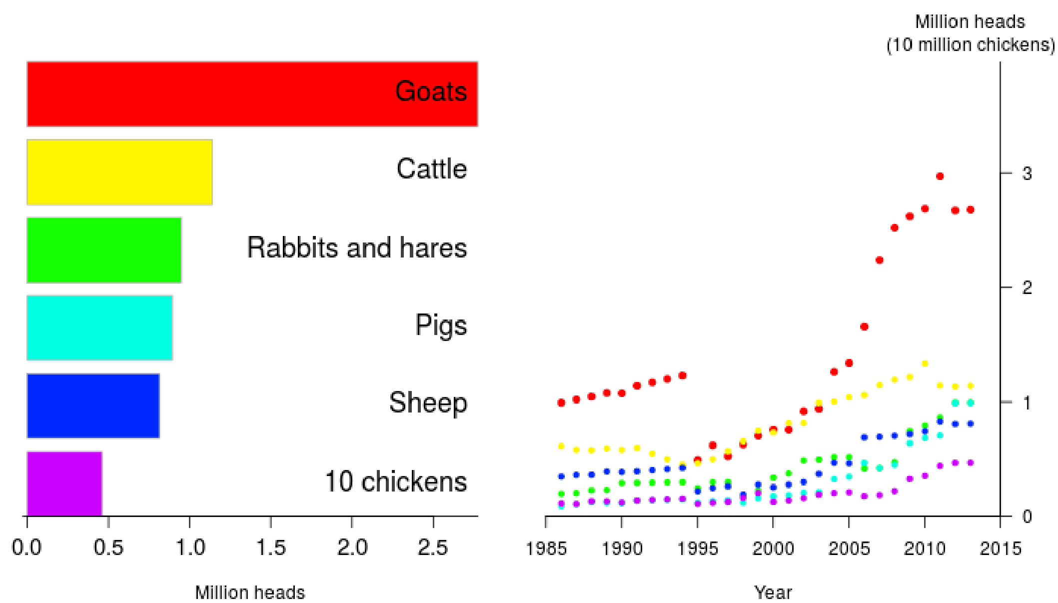

Figure 20. Current numbers and past trend of important livestock species in Rwanda.

Health and Nutrition:

Infant mortality and under-five mortality have strongly decreased over in the last decade. Between 2000 and 2015 infant mortality dropped from 10.7 to 3.2% (deaths per 1000 live births); and under-five mortality dropped from 19.6 to 5%. Height-for-age is a commonly used metric to assess the health of children. Height for age can be expressed as a Z-score (standard score), that is the number of standard deviations away from the mean value in a healthy reference population. A negative Z-score means that a population is has a relatively short height. A Z-score of -2 is often used as the threshold for being ‘stunted’. If the average Z-score in a region is -2 this means that half the children are stunted. The spatial distribution of Z-scores, and also that of the children with anemia shows that there are three regions (South-east, North-West, and South-West) where child health is particularly poor. The reason for this could be complex (including the quality of sanitation and the presence of disease) but malnourishment is likely very important (Figure 21).

In terms of nutrition deficiencies, it was estimated that about 37% of children suffer from some degree of anemia (iron deficiency) (Figure 21). The prevalence of anemia decreases with age, ranging from a high of 66% among children (6 to 11 months) to a low of 21% among children of 48 and 59 months. In terms of distribution it is low around Kigali city (30%) and high in the Eastern (40%), south (40%) and western (35%) provinces.

The Rwandan diet is highly diverse in plant foods, consisting largely of plantains, cassava, beans, potatoes, and sweet potatoes. Consumption of animal source foods is very low, and fat intake is lower than any country in the world (FAO, 2015). Protein consumption is insufficient for about a quarter of the population. There are also some large scale micronutrient deficiencies (Figure 22 and 23). The highest micronutrient deficiencies are in calcium, vitamin A, vitamin B12, vitamin D, selenium, and vitamin E. These nutrients are found in the highest density in animal source foods. The primary dietary source of calcium in Rwanda comes from beans, milk, cassava, and sweet potatoes; and the primary source of vitamin A comes from plantains, vegetables (other), palm oil, offal's, and sweet potatoes. Increasing consumption of animal source foods, especially offal's, meat, fish (whole small, consumed with bones), dairy, and shellfish (though likely impractical for the landlocked country), and red palm oil will reduce micronutrient deficiencies in Rwanda. Given the high consumption of cassava and sweet potatoes, carotenoid-biofortified cassava and orange-fleshed sweet potatoes could have a significant impact on vitamin A status in Rwanda.

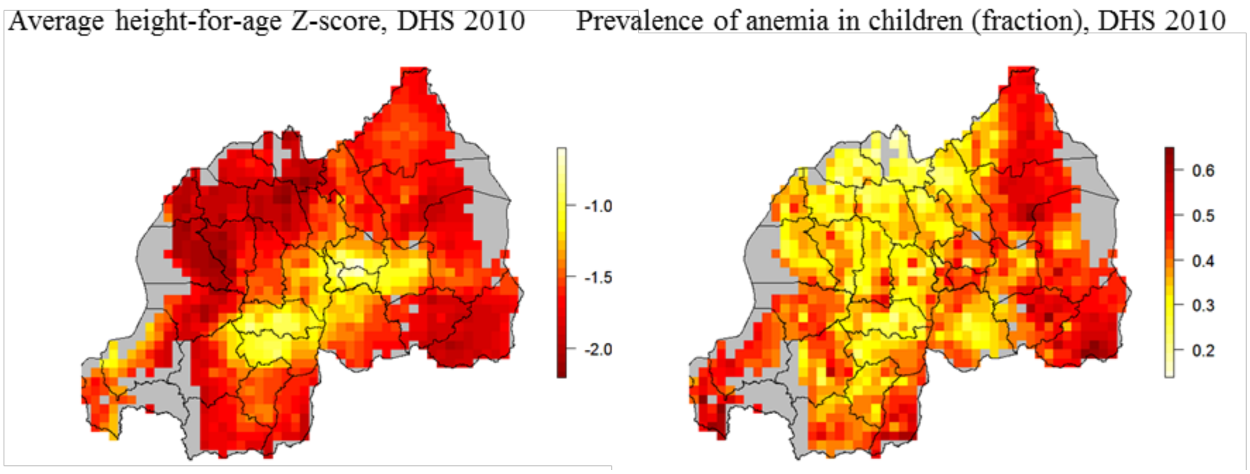

Figure 20. Measures of nutrition status of children based on z-scores and children with anemia. Source: DHS, 2010.

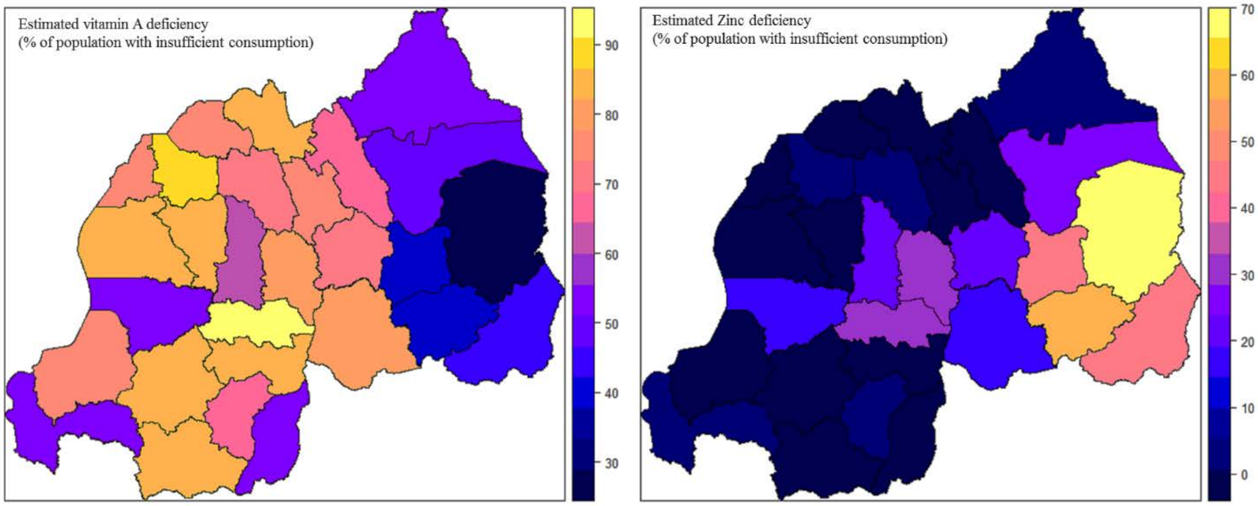

Figure 21. Spatial distribution of the estimated percentage of population below required intake of micronutrients (vitamin A and Zinc).

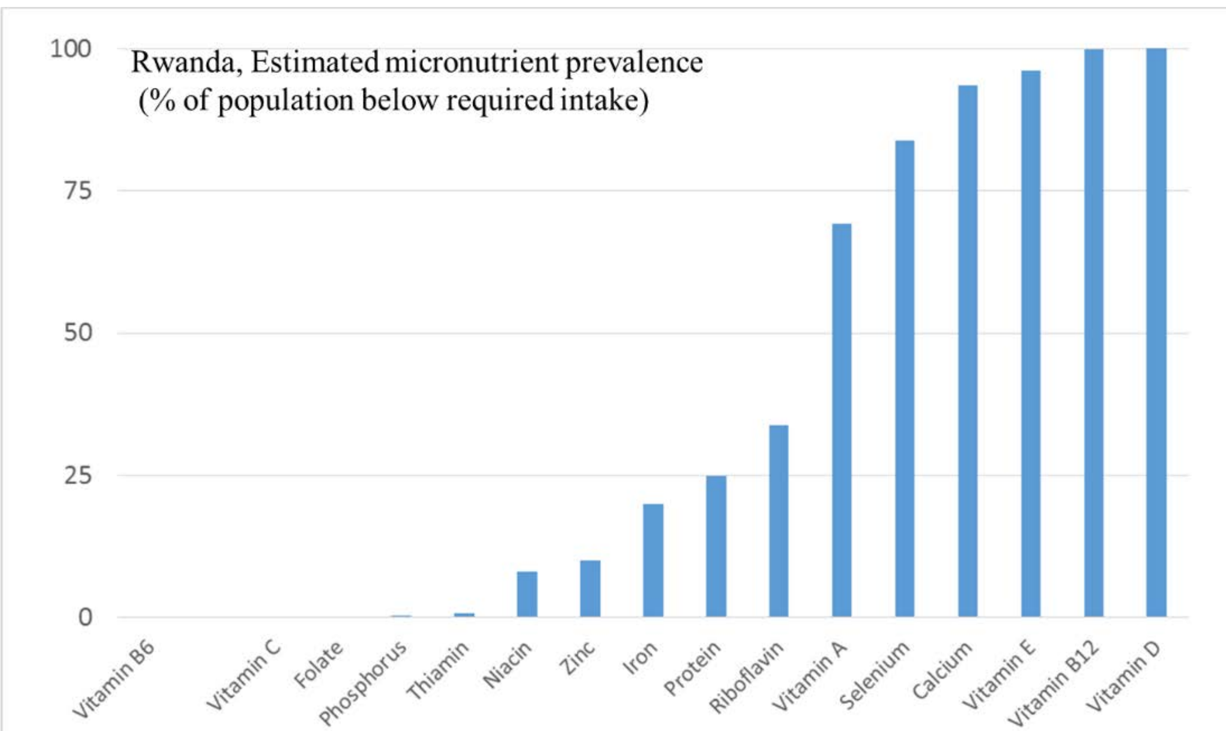

Figure 22. Estimated percentage of population below required intake of micronutrients (deficiency) in Rwanda.

4.8. Activity 8: Simulating potential impact of climate change (temperature increase) on important crop value chains.

The major impact of climate change on Rwandan agriculture will likely be due to an increase in temperature and increased incidences of drought due to seasonal shifts in rainfall rather than decreased rainfall (worldclim.org). We simulated the impact of a projected 2°C increase in temperature on yield potential of maize and beans (Figure 24).

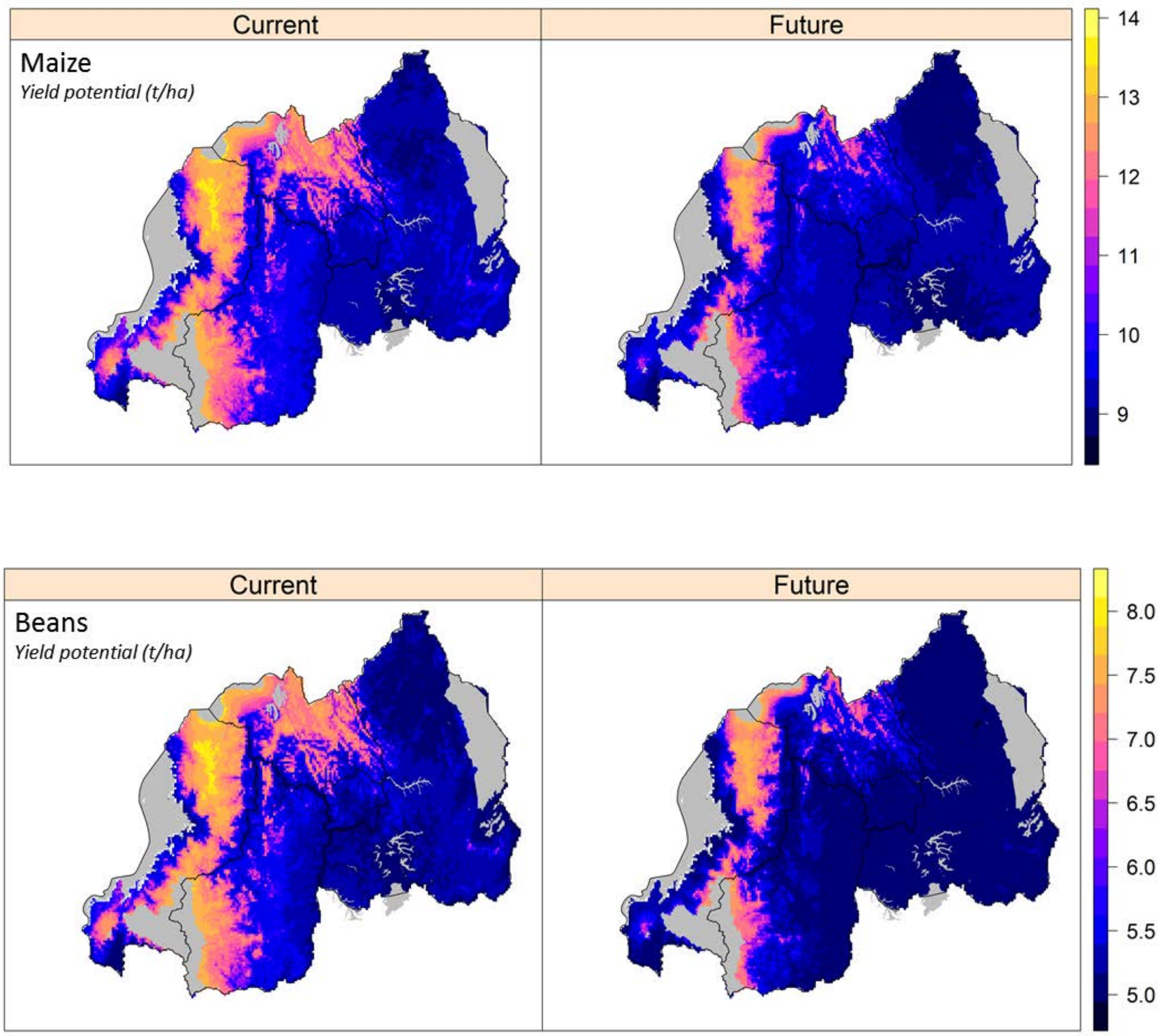

Figure 23.Changes in yield potential of maize and bean with 2°C increase in temperature compared to current yield potential.

Preliminary analysis of comparing potential yield under current and future scenarios suggests shifts in yields. Potential yield decreased generally in eastern regions. However, it is expected that changes in crop management and genetics can compensate for some (but not all) of the negative impacts. Also, declines in yield potential are relatively small as compared to the current yield gap. In other words, while the ‘ceiling’ of maximum attainable crop yield may go down a bit, there will remain ample opportunity to increase productivity.

4.9. Activity 9: Identify priority geographical regions and potential adaptation and mitigation strategies to climate change and with a high potential for SI.

Description and Results:

Considering yield gaps of various crops, malnutrition (stunting) and soil fertility constraints (e.g. soil acidity) allows for identification of zones where problems are most critical, and were opportunities for impactful projects exist.

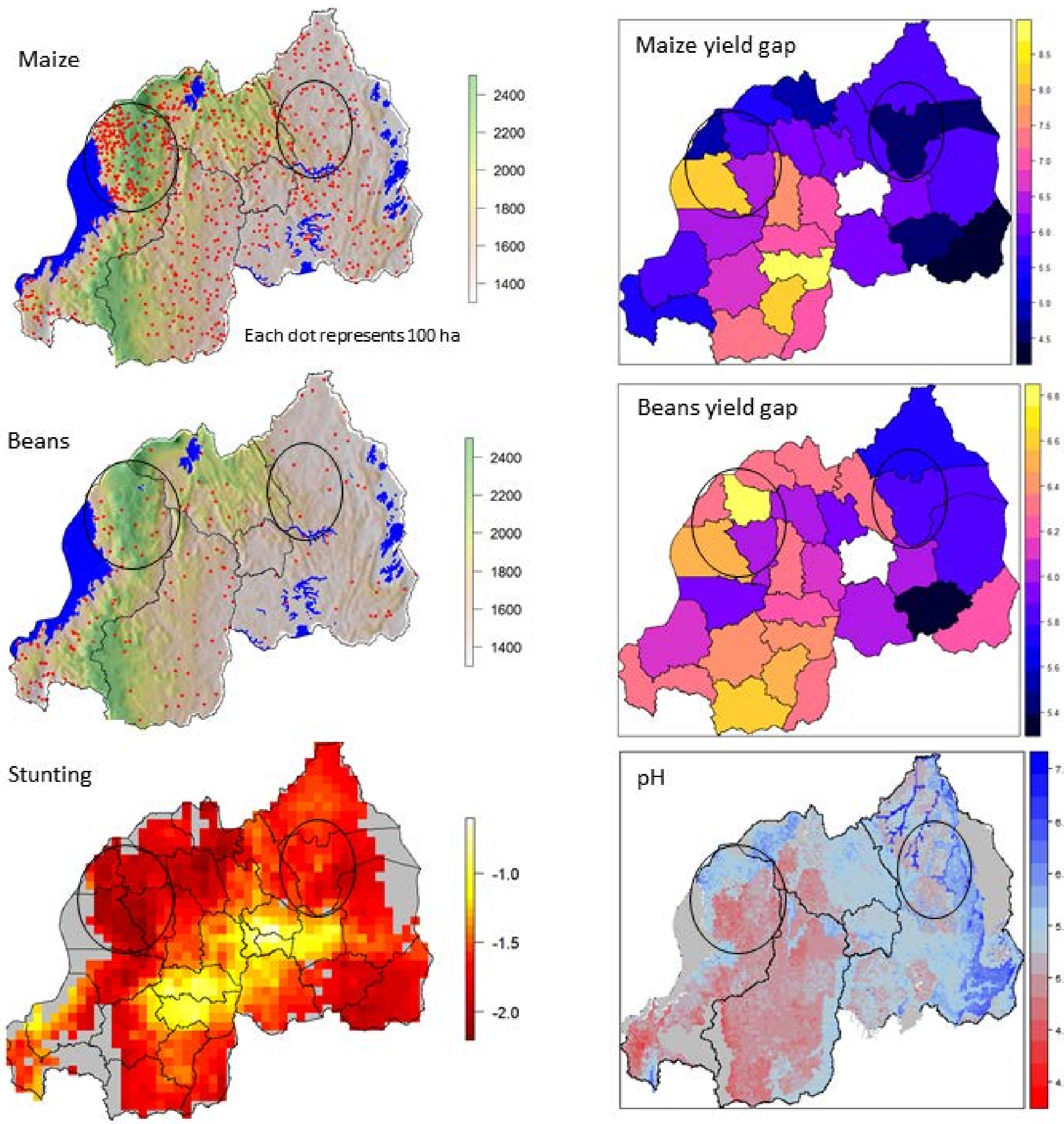

Figure 24.Maps showing current production and yield gaps of maize, stunting and soil pH. The circles on the maps show the potential zones of interest that could be targeted for intervention.

Our initial analysis (using maize as example) shows that there are two general areas of interest (first north-west region; and second north-east region) (Figure 25). The north-west region has lower yields may be associated with lower pH suggesting needs for improved soil and nutrient management practices. While in north-east regions, despite better soil pH and yield are lower due to inefficient crop management practices (for example: planting densities, planting dates, nutrient management, water management, or genotypes). Both of these regions has high rates of stunting and malnutrition. The geographic areas would also remain the same for several other crops and livestock systems. Strategic research and development activities in these geographies would help in enhancing food and nutritional security of smallholder farmers. However, strategic investment in other areas with specific local interventions will be critical to achieve food security for the entire country.

5. Way Forward:

The SWOT analysis and discussion with several stakeholders identified a few items which will be critical as they move forward with CSA and SI interventions. These are addressed in this section and allow for providing some focus.

5.1. Knowledge Gaps and Needs

For implementation of the CSA and SI strategy there must be access to information that can be easily made available to the various stakeholders. Some examples that were highlighted were related to soil and climate information. This information often exists, but is not readily available and assessable to researchers and development agencies.

Some of the critical short-term goals that need to be addressed are listed below. This list is not limited to these items, but it provides some direction for the shorter term.

- Access to soil data-set and information – spatial data (with detailed description)
- Access to climate data-set and information – standard electronic format so that it can be used in decision making tools. There is a network of weather stations in Rwanda. However, these weather stations need to be managed for quality data collection and also networked so that the information is readily available for end-users.
- Baseline inventory and information on various types of fertilizer (types, formulation, mixes) that are being used in various crops. A detailed survey for all crops will provide realistic values to track, that can provide better nutrient management programs.
- There were several interventions that classified as CSA and directly contribute to SI. However, an inventory of these technologies and extent of their use will be critical for baseline formation and to track impact.
- There is clearly a need for basic agronomic management for cereals, legumes and tuber crops. This information should be based on local needs and cannot be generic across the region.
- Several decision support systems are currently available that can be used to simulate what-if scenarios to help determine the impact of intervention. This can also help in identification of geographies for intervention.
- Documentation of social barriers to adoption of previously tried interventions needs to be better understood and used as a learning tool.

5.2. Data Management and Information Systems:

As indicated above there is a need for developing accessible data management and information systems that provide critical agricultural and nutrition data specific for Rwanda. Some of the items that can be made available through such systems are listed above. In brief, some examples include: soil maps, climate data, land holding, variety performance, crop management options, short-term weather and seasonal forecast, and tools that can help with crop selection and land area needed to meet nutrition and income generation programs.

In Rwanda, there is a unique and great opportunity for reaching out to a large number of farmers, through farmers' organizations, cooperatives, agro-dealers, cells phones and ICTs. By making data available and letting different organizations build tools that use these, a tremendous amount of information can be made available. Such opportunities do not exist for many other countries. Thus, Rwanda could serve as pilot study that can be scaled to other countries in the region.

5.3. Important Value Chains:

Most smallholder farmers produce multiple crops and some combination of livestock (from chickens to large animals such as cattle). Thus it is critical that smallholder agriculture be treated as farming systems. However, oftentimes it is important to identify strategic value chains that can help transform farming systems by generating significant yield improvements and income. Such focused programs should address the critical needs of the farming systems.

Our analysis of various value chain crops, yield gaps and potential for yield enhancement and for buy-in from private industries and market opportunities identified some important value chains that merit support. These include:

(a) Maize based farming system: Given the environmental conditions and genetic potential of this crop in different agro-ecological zones, there is ample room for improvement. Several studies have shown significant yield improvement with better agronomy and genetics. In addition, value addition with use of high quality protein and micronutrient fortified maize will address the nutrition needs of the smallholder farmers. There has also been development of several agro-processing industries that create new market opportunities for maize. However, maize should be treated in the context of the farming system and other components of the system should be supported (these include legumes that can be rotated, livestock systems that can supply nutrients and also feed on maize). Opportunities exist for high vitamin A maize and high-quality protein maize.

(b) Bean-based farming systems: In recent years climbing beans have shown significant and rapid yield increases in several regions. Beans provide a significant source of plant protein to the diet of smallholder farmers, and should be an integral part of the farming systems. Inclusion of legumes in the farming systems also leads to biological nitrogen fixation and reduces fertilizer requirement of the cereals crops that follow in rotation. In addition, bio-fortified beans (e.g. high iron bean) will be important for nutrition due to prevalence of high rates of anemia among women and children.

Soybean production is small, and opportunities exist for enhancing production due to the demand from industry. There was large soy-processing industry in Kayonza. This industry is currently not able to meet the raw material need in Rwanda and relies on importing soybeans from neighboring countries.

(c) Home (homestead) Gardens: Designing home gardens for smallholder farmers will provide much needed nutritional security. The focus needs to be dual (both meeting the nutritional needs of the family and also serving as an income generating system). Developing a package of practices (small packets) for systems that includes seeds, along with management decision tools can help this endeavor. Examples are available from other countries in the region. Homestead gardening requires training and capacity building prior to the supply of input or package of practices. Several opportunities exist for scaling of home gardens in larger geographies to have greater impact.

Sweet potatoes are common in home gardens. Production and scaling up of orange fleshed sweet potato (large scale adoption) can overcome the high vitamin A deficiency in the populations (particularly among children under five years).

(d) Integration of livestock: Focus on integration of livestock (all types, from chickens to cattle) can improve protein and several nutrition needs of smallholder farmers (more details provided in later sections).

6. Strategic Intervention Areas by USAID for Research and Development:

Based on the literature review, SWOT analysis, discussion with various partners and field visits the following strategic areas would be critical to address food and nutritional security of smallholder farmers and vulnerable communities including women and children.

6.1. Integrated Soil Fertility Management

Integrated soil fertility management is critical for smallholder farmers for multiple reasons, which primarily include: (a) less dependence on imported high cost fertilizer; (b) provides opportunities to use locally available nutrient sources more efficiently; (c) judicious and combined use of inorganic and organic sources will boost productivity and maintain soil quality and soil health; and (d) provides balance between crop nutrient needs and protecting environment.

It needs to be acknowledged that at present the levels of inorganic fertilizer used by smallholder farmers is low and in many cases insufficient to increase crop yields. Therefore, increased and judicious use of inorganic fertilizers will be required to increase crop productivity.

When used at levels that match the yield goals, there is no need for damage to environment (soil, water or air pollution).

Farmers and extension agents need to be trained in various aspects of use of organic and inorganic sources of fertilizer – particularly in terms of identifying nutrient content of various organic sources (the amounts required to meet the crop needs) and inorganic sources; timeliness of application; method of applications; identification of crops that will respond to organic and inorganic sources; formulation of fertilizer used; and site specific recommendation based on soil and plant analyses.

Knowledge on various types of fertilizer mixes available in the market is critical as they may not be appropriate to meet the crop needs or may have higher sources of a particular nutrient that may not be required. Farmers should also be made aware of the need for use of micro-nutrients in addition and balanced nutrition for each crop based on the cropping systems they use and soil test results.

Integrated soil fertility (nutrient) management approaches will require improvements in current farming systems to better incorporate livestock, crop resides and composting. Incorporation of livestock would also require use of high quality forage or fodder crops to enhance productivity of livestock. Some specific action items identified during the SWOT were listed in previous sections.

6.2. Integrated Water Management

Water is critical for all aspects of agriculture and domestic use in Rwanda. Despite high annual rainfall, due to high slopes, water is not efficiently captured and utilized for crop production. Rwanda has only about 1% of land under irrigation, and majority of crop production is dependent upon rainfall. The annual rainfall comes in two seasons. However, there are also two dry-seasons which makes crop production vulnerable to drought stress. Even slight changes in the pattern of rainfall increases vulnerability of crop production. Similarly, uncertainty of rainfall also makes decision-making difficult and important.

Crop production is threatened by both flooding and dry spells. During high intensity rainfall, crops are damaged by flooding, due to high slopes and lack of proper watersheds and water management. High slopes also cause issues with soil erosion and loss of nutrients. It is estimated that soil losses are in the range of 20 to 150 (t/ha)/year on slopes of about 15 to 50% which are common across the country. In addition, flooding can also lead to improper accumulation of salts if not managed appropriately, leading to degradation of land and natural resources. Therefore, integrated water management (capturing) and providing access to captured water will be critical. Ways to capture water in both downhill marshland systems and hilltop crop production will be required.

Integrated water management at all levels: surface and rain water (storage of rain water, enhancing infiltration), ground water, and water catchments (ponds and canals) can help with sustainable management of water (both in terms of quantify and quality). Collection of water and providing access to smallholder in both lowlands and highlands will increase resilience (minimize risk) of crop and animal production to climate change leading to increased agricultural productivity.

Water management is directly tied into soil conservation and land use programs. Use of soil conservation methods such as plantation of grass strips, plantation of fast growing multi-purpose tress, and incorporation of agro-forestry systems against slopes to increase catchment and also minimize soil erosion.

Capturing rainwater in ponds and planned watershed management can provide opportunities for irrigation. Use of small-scale irrigation (from stored water) may reduce risks associated with agriculture and can help with timely planting and strategic irrigation to avoid stress at sensitive stages of crop production. Rainwater harvesting (ponds) have positive impact on productivity and income (Zingiro et al., 2014); but water and ponds should be managed and constructed appropriately to avoid risk of them becoming breeding grounds for mosquitos and cause issues with malaria and health.

Improved management of water resources can also help with crop diversification, which can provide nutritional security. Selection of appropriate crops, genotypes based on soil type (texture and chemistry) and available water resources will help accommodate efficient use of water. In addition, agronomic practices such as minimum tillage, cover crops, residue management and methods to improve organic matter will improve infiltration and build ground water. Capacity building of farmers, farmer organizations and extension personnel will be critical for proper implementation of integrated water management programs.

6.3. Crop Improvement and Seed Systems

One of the main challenges for improving crop yield is the limited availability of improved genotypes that are not only high yield but also tolerant to biotic and abiotic stresses. Our discussion with stakeholders clearly indicated a lack of research capacity on crop improvement (breeding and genetics) for most crops (with exception of banana) that are important for smallholder farmers. They are currently relying on research from wider regional efforts. This research capacity must be enhanced to meet the growing demand.

In addition, the support of seed systems is one of biggest limitations. Although some efforts are ongoing within the research wing of Rwanda, more commitment and partnership with private companies are needed.

6.4. Farming Systems Approach

Smallholder farmers produce diversity of crops to meet nutritional needs and also to build resilience to year to year variability. Use of diversified farming systems which incorporates mixed crops and varieties (legumes, cereals, tubers, bananas, vegetables and agroforestry) along with livestock not only increases biodiversity but also increases nutrient, water, and pest management. These practices also increase resilience of farming to climate change in terms of both adaptation and mitigation.

Production systems research is required to identify the best mixture of crop for a given soil/topography and for the needs of the smallholder farmers. Some examples include – mixed or intercropping of banana with legumes (climbing beans) or cereals (maize); intercropping of locally grown vegetables crops (for example tomato, onion, beet, leek, cabbage, eggplant, amaranth) into farming systems or home gardens of small holder farmers.

Although systems approaches have much value – some thought must be given to focusing efforts on one or two crop-based systems based on the local need for maximization of return on investments. These value chains can range from maize and bean systems to tuber and banana based farming systems.

Integration of Livestock Production

Livestock is an important asset to smallholder farmers it can provide supplementary income and also meet the nutritional needs of a family. It also provides manure that can be used as an input to crop production (maize, beans, potato, sweet potato and vegetable gardens). Integration of livestock along with crops also leads to efficient use of nutrients by recycling the animal waste into the crop production systems and soil improvement; and feeding animals with forage or fodder crops and biomass. Focus should be on all types of livestock (including cattle, goats, sheep and chickens). Small animals can often serve as insurance against crop failure and provides much needed income and food security. The GoR has initiated a one cow per poor family policy which is helping increase household income and helping other farmers by providing the first-born heifer creating broader impact in selected communities. Opportunities to enhance this program along with better feeding and disease management practices are required to enhance productivity. While cows are certainly preferred by many Rwandans, attention should also be given to other livestock species, particularly goats, sheep and pigs.

Integration of Vegetable Production

Integration of locally grown diverse indigenous vegetables into the farming systems (either at homesteads) or farm level can provide nutrition and additional income to smallholder farmers. There are several species of local varieties with high nutritive value. Identification of these vegetables crops and developing new or improved methods of management practices, and providing seed, along with other inputs to small holder farmers will be beneficial. Lessons can be learnt from such projects in the region (e.g. AVRDC projects).

Creating an awareness program at all levels, from schools to the national level, about the value of indigenous vegetables can create/expand market opportunities and make vegetable production more profitable for smallholder farmers. Similarly, collecting and documenting the nutritive value of these species will also be critical.

6.5. Appropriate Scale Mechanization

Most of the farming practices are conducted by human labor using hand operated implements (mainly hoe). There are several opportunities for small scale mechanization implements which can enhance efficiency of human labor and overall productivity of the production systems. Small-scale mechanization will have a direct impact on the labor provided by women as they contribute to >70% of field operations.

The type of mechanization interventions will primarily depend upon the topography of land. Certainly areas which have high slopes will have limited opportunities that are targeted towards harvest, threshing, shelling and processing, rather than planting. The east of Rwanda has flat lands and rolling hills with low slopes that can allow use of two-wheel tractors or animal traction. Simple tools such as hand operated maize shellers, mechanical gasoline operated grain shellers, seed cleaners, driers and processing mills (agro-processing including flour mills) will improve quality of the produce.

In addition, for efficient utilization of forage and fodder crops mechanical hand or power operated choppers (fodder and forage) can provide opportunity for feed additives and increase nutritional quality and digestibility. All of these activities will decrease human drudgery and increase productivity.

Any mechanization interventions will require development of supply chain and local support systems. In addition, capacity building activities will be required across all levels (farmers through research organizations). Smallholder farmers will need to be linked with markets and provided with training for proper use of equipment. Opportunities for micro-finance and credits will be required to jumpstart such interventions and programs.

6.6. Capacity Building

During the SWOT analysis, there were several capacity building needs identified. These included the development of formal education materials related to CSA and SI for use in formal education. Different materials should be developed for different levels of education, whether primary / secondary/ or higher education. There was also strong support for the idea of graduate training (MS and PhD) specially focused on CSA and SI.

There was also great interest in developing curricula for farmer organizations, and for research and extension agents at various institutions

To accomplish these goals, several possible strategies were also identified, including the creation of a model farm (innovation hubs; research parks) which will showcase various proven technologies (demonstration plots) related to CSA and also serve platform for networking, communication and knowledge sharing. These will also serve as study tours for farmers, extension agents, staff and policy makers that are interested in CSA.

6.7. Building Partnerships / Knowledge Sharing and Communication

For efficient scaling of CSA and SI activities it is critical to build sustainable partnerships and provide avenues for knowledge sharing and develop strategic communication platform among all stakeholders.

There were several stakeholders that were interested in CSA and SI activities. Building partnership among various stakeholders is critical for not only identifying the needs but also exchanging ideas and building on each other’s successes and failures. Partnerships are required at various levels (among and between organizations).

- Farmers or individual
- Among farmers organizations
- Local and regional organization (government and NGO)
- Private sectors

- Public institutions
- Partnership across the complete value chains (e.g. production to processing and markets)
- Policy makers
- Governments (village, local, regional and national)

Facilitation and development of partnerships will require stakeholder orientation, creation of platform and opportunities for interaction and networking (workshops, meeting, and conferences) and active follow up. Partnerships should be built based on mutual benefits and organizations should collaborate and cooperate with each other.

Development of an innovation platform will be one of the ways to build active partnerships. This will require mapping of active organizations, roles, goals, active projects and geographies that will be openly available and accessible (in public domain). There is stronger need for public and private partnerships for long-term sustainability of these platforms.

Several methods exist and are identified for knowledge sharing and communications. The appropriate type of communication strategy will differ with the type of stakeholder and message. Some of the common methods of communication include:

- Remote communication: Traditional correspondence (letters, phone), modern (e-mail, blogs, text messages, internet and social media, websites)
- Workshops: Face to face interactions
- Media: larger audience (radio, TV, movie clips, short videos etc.)
- Formal extension publications: bulletins, pamphlets
- Formal research publications; journal articles, conference abstracts and presentations.

For any activities relate to CSA and SI and farming systems it will be important to develop framework, matrix and measures to quantify the potential impact on various components. The discussion for developing a common framework for SI indicators is continuing. The template of this indicators is provided in Annex 3. Developing a common set of indicators and metrics will be critical. Five domains have been identified across four different scales. These include (i) productivity; (ii) economics; (iii) environment; (iv) social (includes gender); and (v) human (includes nutrition; food security and education). The four scales includes (i) field or plot level; (ii) farm-level; (iii) household level; and (iv) macro-level. Actual metrics for each of these levels are under discussion and will be presented later.

7. Conclusions

Rwanda is a densely populated country. Its population is poor, and often malnourished. Most Rwandese are engaged in agriculture. It is of paramount importance that the agricultural sector further develops to provide income and more food of a higher quality to the growing population. Investments in promoting agricultural growth seem to be paying off as crop yields have been increasing, but further investments are needed to keep this going. Climate change is a threat, particularly as it directly influences rainfall and temperature. Building resilience against these changes is possible and required. While avoiding effects of water shortage through irrigation is possible but may not be feasible on very large areas and will require significant investments. We propose a number of key areas of research and interventions that can make Rwandan agriculture more resilient to climate change. These include adoption of climate smart and good farming management practices such as: improving soil fertility management for higher productivity; integrated water management, particularly to increase infiltration of excess water; improved system for the development of locally adapted high quality seeds; supporting increased integration of livestock and vegetable production; small scale mechanization; better data management to allow the development and use of decision support tools; building capacity of farmers, extension services, and research organizations; and creation of knowledge sharing and communication platforms to enhance collaboration and sustainability.

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Annexes

Annex 1. Detailed SWOT Analyses

I. Agenda

USAID Feed the Future Sustainable Intensification Innovation Lab - Kansas State University and CIAT - Kigali, Rwanda
Dates: 20 August and 21 August, 2015
Address: Umubano Hotel, Boulevard de l'ynygabdam, BP 874, Kigali, Rwanda
Primary Local Contact:
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Program Outline

Day One: Thursday 20 August		
9:00 – 9:10 a.m.	Welcome remarks and opening	CIAT and KSU
9:10 – 9:20 a.m.	Official opening	Chief Guest
9:20 – 9:30 a.m.	Introduction of participants	All participants
9:30 – 9:45 a.m.	Overview of SIIL	Dr. Vara Prasad, KSU
9:45 – 10:00 a.m.	Program overview and plan of action:	Dr. Gary Pierzynski and Dr. Jan Middendorf, KSU
10:00 – 10:30 a.m.	Discussion on "Climate Smart Agriculture (CSA)"	Dr. Jan Middendorf
10:30 – 10:45 a.m.	*Coffee/Tea Break*	
10:45 – 12:30 p.m.	SWOT analysis for CSA:	Dr. Jan Middendorf
12:30 – 1:30 p.m.	*Lunch*	
1:30 – 3:00 p.m.	SWOT analysis for CSA (continued)	Dr. Jan Middendorf
3:00 - 3:15 p.m.	*Coffee/Tea Break*	
3:15 – 4:15 p.m.	Mapping our way forward:	Dr. Jan Middendorf
4:15 to 5:00 pm	- Priorities and strategies (CSA and SI)	Moderated by: Dr. Jan Middendorf
Day Two: Friday 21 August		
9:00- 9:30 a.m.	Welcome back and overview of Day 1	Dr. Gary Pierzynski
9:30 -10:30 a.m.	Discussion on Sustainable Intensification (SI)	Dr. Jan Middendorf
10:30-10:45 a.m.	*Coffee / Tea Break*	
10:45-11:45a.m.	SWOT Analysis for SI:	Dr. Jan Middendorf
11:45-12:30 p.m.	- Identify opportunities for various components of SI; - Identify barriers for various components of SI.	Dr. Jan Middendorf
12:30-1:30 p.m.	*Lunch*	
1:30 – 3:00 p.m.	- Strategies to address and incorporate Gender - Strategies to address and incorporate Nutrition	Dr. Jan Middendorf
3.00 – 3.15 pm	*Coffee / Tea Break*	
3:15-4:15 p.m.	Needs assessments / capacity building / partnerships	Dr. Jan Middendorf
4:15-5:00 p.m.	Next steps, wrap up and closing remarks	Dr. Vara Prasad

II. List of Participants-

The Needs Assessment and Scoping Meeting with Key Stakeholders for Determining Opportunities for Climate Smart Agriculture and Sustainable Intensification in Rwanda: 20 and 21 August 2015

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III. Defining Climate Smart Agriculture

A. Climate Smart Agriculture – Definitions (Select Participants)

- Crops adapted to local climate
- Use climate information tools
- Crop diversification
- Low carbon emissions
- Make agriculture (farming systems) more resilient
- Use of local input (via recycling)
- Integrated agriculture systems (includes both biophysical and social aspects)
- Increasing farmer's capacity
- Maximize productivity using adaptation and mitigation strategies
- Production and utilization of varieties adaptable to climate change and climate variability
- Sustainable production provides opportunities to increase yields for smallholders
- Increase income by skilled agro-dealers (leading to increased efficiency of inputs)
- Increased yield or sustainability
- increase nutrition food (nutrition sensitive – agriculture)
- Water conservation
- Reducing food waste
- Restoration of soil fertility
- Responsibility of end users (in terms use of inputs)
- Adaptation of new crop varieties (stress tolerant)

B. Specific Definitions (All Participants – Complete List) – To me, To my organization and To Rwanda

1. Participant 1
   - Responding to climate scenarios and changes
   - Designing agriculture to achieve intended goals/targets even in changing climates
   - Focus on CSA helps to achieve organizational research outputs/outcomes with minimal deviation
   - Food, income and nutritional security is achieved due to minimized climatic variations
   - Creates a healthy environment for agriculture that sustain livelihoods

2. Participant 2
   - A crop closing its lifecycle in a particular season well
   - Clear about reason characteristics of a place (planting time, application of suitable crop management, harvesting)
   - Know how quantify the risk of crop failure in a region
   - Know the future climate (temperature and rainfall) analogue of a place

- E-online climate variables (temperature and rainfall), soil and crop management in a modeling environment to know the expected yield of a place

3. Participant 3
   - Be clear on the crop systems, suitable for compatible crops in a particular location
   - Climate smart agriculture means the way in which agriculture is done in climate friendly – that reduces greenhouse gas emissions, reducing erosion, flooding, water pollution and air pollution as well as avoiding excess water and chemicals. Agriculture done in this way is a wish of my organization and my country satisfies the need of its population in a climate change resilient way.

4. Participant 4
   - Agriculture practices with no negative effects to climate change (vice versa)
   - Sustainable agriculture
   - Climate that favors high opportunity and climate that produces low harmful gases (e.g. carbon dioxide

5. Participant 5
   - Climate smart agriculture means increasing agricultural production with environmental friendly which means without destroying environment.
   - It means that farmers have to do agricultural business and farming to increase production and productivity but both with protecting environment
   - For Rwanda climate smart agriculture is a critical issues that needs to be aware by different organizations that work for agriculture sector in order to increase production without deteriorating environment

6. Participant 6
   - It is an approach in agriculture where while doing agriculture practice I also do it in a way that it friendly to the climate system
   - My organization works in Eastern province in Soya production in way that farmers use highly adaptable seeds but also care about soil and water conservation
   - To Rwanda CSA means the right approach to feed the current and future populations

7. Participant 7
   - Climate smart agriculture means that climate which is favorable to the agriculture and some crops are preferred due to their adaptability to the climate
   - for MINALOC it means our different districts can adopt crops to be cultivated basing on the specificity of their soil and climate
   - For Rwanda, CSA can be very helpful in terms of food security if every region develops crops which will boost productivity. This will also improve trade among the population rather than diversifying crops in one regions. It will also enhance the land consolidation

8. Participant 8
   - To me CSA is farming crops or raising animals which are locally adapted to local conditions (soil, humidity, temperature) for better yields
   - It is also practicing agriculture without disturbing or depleting natural resources for better future of the next generation
   - Selecting commodities which address climate constraints

9. Participant 9
   - To me CSA is the enabling environment so that I can practice agriculture i.e. growing crops and rearing animals that can yield high but without jeopardizing he environment
   - To my organization it simply means coming up with policies that can favor agriculture through cooperatives but strictly preserving the environment for high production and sustainability for future generations
   - To my country it simply refers to formulation of policies establishing organizations / institutions and research centers mainly to prefer environment that leads to good climate but at the same time the climate that favors agriculture. The farmers should be organized and trained on how to preserve the environment and practice agriculture

10. Participant 10
    - Climate smart agriculture is the principle of adopting agricultural technologies that encourage productivity of more food without harming the environment through release of GHG emissions
    - At personal level CSA means I have to conserve resources and reduce food waste in my daily living
    - For my organization CSA entails encouraging farmers to adopt conservation of production systems

11. Participant 11
    - For sustainable agriculture we have to mitigate climate change
    - If there is no stability of climate – there are losses of productivity

12. Participant 12
    - CSA is farming systems that allows farmers to produce food for household consumption / market with respect to the environment and restoration of soil fertility. Adaptive to agro-ecological zones
    - Improving farming systems to allow farmers to produce enough food product, manage the soil fertility, but mainly produce nutritious food that will sustain the health status of the whole family starting from small children

13. Participant 13
    - CSA means sustainable agriculture by using different farming techniques to boost the productivity and reduce poverty of small holder famers
    - For organization it means increasing agricultural productivity at smallholder farmers level and increases their income through skilled agro-dealers network who should avail the agricultural improved inputs, and those farmers should be linked to the output markets

14. Participant 14
    - This means that agriculture aiming at getting the maximum of the productivity from farmin gsytems in the face of climate change – it is built on three principles – Productivity; Adaptation to climate change; and Mitigation of GHG emissions from agriculture
    - RAB is a research organization in the field of agriculture should: find varieties adaptable to changing environment; develop adaptive and mitigation technologies adapatable in Rwandan context
    - for Rwanda it means mainstreaming policies for fostering CSA

15. Participant 15
    - To me: An integrated agriculture system that considers all productive factors from the biophysical (soil and climate) to socio-economic factors (value chains). It emphasizes the adaptation to climate variability and change
    - To Rwanda : A system that is based on good understanding of the Rwanda biophysical environment in terms of agro-ecological zones, different soil types and consider the farmers investing capacity. Agroforestry as a source of manure for water use productivity

16. Participant 16
    - Our program is focused on developing market-based pro poor solutions in low emissions and climate resilient agriculture. Through CSA program we build farmers capacity to adapt to the negative effects of climate change and increase agricultural productivity, reduce GHG emissions and build climate resistance farming systems

17. Participant 17
    - Low carbon emissions
    - Making crop production agriculture more resilient to climate change and climate variability
    - Increasing / improving sustainable use of land
    - Integrated approach / recycling / re-use

18. Participant 18
    - Where climate information is a basic tool used – where crops adapted to the local climate are used – where there is minimum carbon emission and other GHG are limited – minimum or no inorganic fertilizer are used – Minimum or nor use of inorganic (toxic) sprays to crops are used – Where water supply to crops is controlled
    - To my organization Metro Rwanda is required to contribute accurate climate information to agriculture
    - To Rwanda – assured of good yields and therefore food security is assured; carbon free atmosphere and safe food

19. Participant 19
    - Increase production (food security)
    - Protection of land to sustain yield
    - Availability of agricultural inputs / high yield varieties
    - Address climate change (rain shortages)

20. Participant 20
    - Agricultural practices, approaches and systems that sustainably increase production and helps small holder farmers to cope with shocks and vulnerabilities
    - One of our strategic objective is on resilience and livelihood – whose objective is to improve resilient livelihoods of smallholder farmers, agribusiness, and enterprises in target communities by 2020 – CSA is one of the R and L model to be used in technical approach

21. Participant 21
    - To me CSA means a favorable climate for all living especially for all crops and help farmers to increase their productivity through organic manure
    - To my organization CSA means good climate related to agriculture without any pollution from different chemical substances

22. Participant 22
    - For me: It is about home methods and techniques with strategies to be taken for improving our agriculture together with the climate change as shown in todays times
    - For my organization: Global communities is very interested in CSA because we work with smallholder farmers to develop improved agricultural techniques compared to the climate changes
    - Rwanda is facing a big climate change, to develop her agriculture we need to work with climate change

23. Participant 23
    - As agriculture which improves the traditional ways of farming by using technologies on climate change, and strengthen the agricultural information to sustainability taking into consideration the climate impact of all inputs use, avoiding fertilizer or other inputs which destroys environment
    - To my organization the target in agriculture and understanding is to avail quality planting materials to small farmers, teaching them how to produce OFSP in a good time/season; make sure they are getting vitamin A from the production; by teaching households with under 5 year children the best diet after that connecting them to the market

24. Participant 24
    - Climate smart agriculture means environmental management in agriculture, minimizing the disease caused by climate change in way to improve
    - Increase capacity building
    - Policies to enhance water conservation

IV. Clusters/Themes – Climate Smart Agriculture

A. Food and Nutrition

- Breeding for CSA
- Post-harvest management
- Promotion of locally available nutritious species
- Organization of producers and linkages with markets
- Development of value chain in food processing
- Inventory of highly nutritious locally available food
- Use of high yield varieties
- Use of fruit trees and vegetables as adaptation strategy
- Education and behavior change in food consumption
- Inventory of nutrient content in different food varieties (and crops)
- Role of private sector

1. Strengths (S)

- District plan for the elimination of malnutrition (S)
- Adapted crop varieties (S)
- Very adaptive farmers and culture (S)
- Maximize the yield (S)
- Healthy population and health insurance (S)
- Active population (S)
- Productivity from agriculture will be stable (S)

2. Weakness (W)

- High population (W)
- Lack of nutritious food (W)
- Not sufficient post-harvest activities (W)
- High population growth with high dependence on agriculture produces (W)
- Poor soil fertility and lack of access to water for smallholder farmers (W)
- Over population (W)
- Limited access to inputs (fertilizer and improved seed) (W)

3. Opportunities (O)

- Presence of subsidies (O)
- Introduction of fruit trees in dry seasons (O)
- More diversified food production (O)
- Multi-cropping opportunities (e.g. coffee and banana) (O)

4. Threats (T)

- Price fluctuations (T)
- Prices of agricultural products (T)
- Limited crop varieties (T)

- Preference of consumers that influence imports (T)

B. Environment (participant definitions directly below)

- Protection of natural resources and reforestation
- Control erosion
- Community based early warning systems
- Water management (in-situ)
- Planting trees on lands (with indigenous species) particularly in slopping lands (farmers managed natural regeneration)
- Integrated pest management)
- Construction of dams to control flooding
- Establish standards for environmental management
- Mainstreaming environmental management
- Rainwater harvesting

1. Strengths (S)

- Existence of climate data (S)
- Meteorological agency (S)
- Four seasons and two agricultural seasons (S)
- Good environment (S)
- Small holder farmers are informed on climate changes and being adapted (S)
- Good climate conditions (weather) (S)
- Diversity of natural resources (S)
- Good agriculture climate (S)
- Three agricultural seasons (S)
- Low carbon foot print (S)
- Regularity of seasons (A and B) (S)

2. Weakness (W)

- High terrain (W)
- Soil erosion control (W)
- Soil erosion (W)

3. Opportunities (O)

- Ownership of people for agriculture and climate change development (O)
- Harvesting rain water (O)
- Water resources for irrigation (O)
- Diversity of climates and environment (O)
- Existence of 2-3 agricultural seasons (O)
- Dual rainfall pattern (O)
- No more modification of weather (O)
- The established NGOs that mainstream environmental protection (O)

- The concern by the global community (O)

4. Threats (T)

- Nuclear weapons/plants that deplete ozone layer (T)
- No control over the climate change trends that affect our agriculture systems (T)
- Extreme weather conditions (T)
- Diseases and Viruses (T)
- Erratic rainfall (T)
- Flooding destroys and grows in marshlands (T)
- Very little potential to irrigation (steep slopes and water in valleys) (T)
- Longer dry spells (T)
- Drought conditions (T)
- Flooding and erosion (T)
- Our countries topography (T)
- High slope of land which leads to soil erosion (T)
- Problem of water management (T)
- Complexity of the countries topography (hinders some agricultural practices e.g. irrigation (T)
- Crop failure due to diseases and disasters (T)
- Invasion of serious crop diseases (T)

C. Land Issues (participant definitions directly below)

- Land consolidation
- Off-farm jobs
- Marshland reclamation
- Systems approach for producing food
- Land use planning
- Development of land management information system
- Inter-cropping (farming systems)
- Creation of farmers' co-operatives
- Cost-Benefit analysis of land enterprise

1. Strengths (S)

- None (O)

2. Weakness (W)

- Small land (W)
- Land scarcity (W)
- Very small land per farm (W)
- Limited land holding systems for arable agriculture use (W)
- Limited land size (W)

- Scarcity of land plus topography leads to erosion (W)

3. **Opportunities (O)**
- None (O)

4. **Threats (T)**
- Land scarcity (T)
- Land shortage over high population growth (T)

D. Market Issues (participant definitions directly below)

- Infrastructure for post-harvest and transport
- Value chain market development
- Certification of organic (bio) product
- Storage and conservation of value chain produces
- Creation of regional markets
- Information of market/prices
- Promote collective marketing
- Cost benefit analyses of CSA
- Establishment of commodity markets
- Price fixation policies
- Carbon credits strategies

1. **Strengths (S)**
- Availability of output market (O)

2. **Weakness (W)**
- Status of feeder roads (W)

3. **Opportunities (O)**
- Regional integration for addressing market problems (O)
- Potential market for CSA products (O)
- High demand for organic and bio products (O)
- Existing regional export markets for agricultural practices (O)
- Economic regional – integration market (O)
- Presence of subsidies (O)
- Creation/establishment of value chains for smallholder farmers (O)
- Linkage of farmers to the market (O)

4. **Threats (T)**
- Farmer organizations can be barriers for agricultural practices to be successful (T)
- Comparative advantages in east African common market (T)
- Price of agricultural products in the market (T)

- Preference of consumers that influence imports (T)
- Price fluctuations (T)

E. Sustainable Soil Fertility (participant definitions directly below)

- Soil testing and analyses
- Integrated soil fertility management
- Soil management (liming of acidic soils with locally produced materials)
- Use agro-forestry
- Bush-fallowing; crop rotation; grafting; intercropping
- Climate resilient varieties
- Crop specific fertilizer use
- Soil erosion control

1. **Strengths (S)**

- None (S)

2. **Weakness (W)**

- Importation of fertilizer which can sometimes be dangerous (W)
- Poor soil fertility and lack of access to water for small holder farmers (W)
- Soil nutrient analysis are not updated (W)
- Lack of new resistant varieties to climate change (W)

3. **Opportunities (O)**

- Restoring soil fertility (e.g. cover crops in dry seasons) (O)
- Poor productive systems (acidic soils) – requires investment (O)

4. **Threats (T)**

- Intensive use of agrochemicals (pesticides) (T)
- Competition with climate unfriendly approaches (T)
- Lack of development of fertilizer industry (T)
- High levels of soil acidity in some places (T)
- High rate of chemical fertilizer use (T)
- Lack of inputs to implement CSA (T)
- Lack of appropriate agriculture inputs (fertilizers, pesticides) (T)
- Extinction of some varieties that were tolerant to pests and diseases due to SI (genetic erosion) (T)
- Poor productive systems (acidic soils) (T)

F. Data and Information (participant definitions directly below)

- User research on information needs on CSA
- Access to existing data for all users

- Application of ICT'
- Use of mobile phone for information
- Creation of knowledge and research centers
- Development of land management information systems

1. **Strengths (S)**

- e-communication systems (S)
- Rural infrastructure network (S)
- Existence of soil data (1:50k) (S)
- Data availability on climate (temperature, ranfall), soil, crops, crop management (S)
- Enough water available – good weather and climate data available – long term (S)

2. **Weakness (W)**

- Lack of information in different institutions (W)
- Weakness of prediction of events (W)
- Agriculture data not accessible to smallholder farmers (W)
- Lack of appropriate tools (W)
- Limited tools to be used in the collection and analysis of data (W)
- Climate related information still limited or unknown or abstract (W)
- Limited information sharing and reporting on climate change and projections (W)
- Little / ignorance of existing data (W)
- Success stories less documented and shared (W)
- Climate change – limited information or knowledge (W)
- Limited use of ICT for agriculture for smallholder farmers (W)

3. **Opportunities (O)**

- New technologies in data collection and analysis (O)
- Small country – accessibility of information is possible (O)

4. **Threats (T)**

- Limited appropriate ICT for CSA in Rwanda

G. Access to Funding (participant definitions directly below)

- Promotion of community finances
- Donor mapping on CSA activities
- New funding opportunities
- Payment for environmental services for smallholder farmers
- Increased agriculture guarantee / opportunities
- Creation of agriculture (crop) insurance

1. **Strengths (S)**

- None

2. **Weakness (W)**

- Limited access to crop insurance by smallholder farmers (W)
- Inadequate resources (W)
- Agriculture finance still weak (W)
- Insufficient access to finance for farmers (W)

3. **Opportunities (O)**

- Carbon market funding gate/streams (O)
- Existence of potential donors with commitment (O)
- International climate related financing (eg. Green Climate Fund – GFC) (O)
- Existence of guarantee funds (BDF in support to SMEs) (O)
- Available funding from banks and several other organizations (O)
- Climate smart agriculture funds (O)

4. **Threats (T)**

- Low involvement of farmers' insurance and insurance companies in agriculture sector (T)
- Budget limitation (money inflation) (T)

H. Policy (participant definitions directly below)

- Generate and analyze existing CSA specific policy
- Make policies known to stakeholders
- Need to harmonize different policies to avoid duplication
- Evidence base policy advocacy implementation
- Private Public Partnerships

1. **Strengths (S)**

- Strong government policy to preserve the environment through regulated agriculture (S)
- Rwanda has a program of priority crop adapted to local areas based on climate (N,S,E) (crop intensification programs (S)
- Enabling environment (policies, political will, structure0 (S)
- Policies supporting sustainable land use in Rwanda (e.g. terracing, contour farming systems) (S)
- Government policy of protecting environment by encouraging reforestation (S)
- Strong policies and strategies (S)
- Government commitment (S)
- Political will (S)
- Great and high political will towards green growth economy development (S)

- Agricultural government policy (S)
- Political favors to protect environment (S)
- Government policies (S)
- High political support for green growth and CRS available (S)

2. **Weakness (W)**

- None

3. **Opportunities (O)**

- Existence of the policies of strategic on agriculture (O)
- Ratification to different international conventions on climate change (O)
- Existence of decentralization in agriculture (O)
- Cautious harmonization of policies and practices in CSA (O)
- Government support and policies (O)
- Existence of conducive policies (O)
- High enforcement of policies (O)

4. **Threats (T)**

- Changing policies and heads of institutions (T)
- Policy maker side – others systems not known by local agents (T)

I. Technology Innovations (participant definitions directly below)

- Agriculture mechanization
- Processing facilities
- Identification of CSA technollgies in Rwanda
- Behavior change technologies
- Improving networking

1. **Strengths (S)**

- None (S)

2. **Weakness (W)**

- CSA difficult to mechanize (W)

3. **Opportunities (O)**

- Positively perceived on innovations / transformation (O)

4. **Threats (T)**

- Awareness of technologies for smallholder farmers (T)

J. Supporting Institutions/ Stakeholders (participant definitions directly below)

- Stakeholder platforms for CSA
- Database of CSA stakeholders
- Mechanism for coordination among institutions
- MoU between institutions to share knowledge and research findings to avoid duplication

1. Strengths (S)

- Presence of strong institutions (REMA, MINAGRI, Meteorology, CG Centers – CIAT, IITA (S)
- Good institutions (S)
- Organizations with mandate and skills are available (S)
- Like minded complementing organizations (S)
- Local government structure at the village, sector and district level (S)
- Established research centers (S)
- Existence of institutions in charge of agriculture and environment regulations (S)
- Organized farmers in cooperatives (S)

2. Weakness (W)

- No research institutions (W)
- Parallel programs that are no CSA (e.g. mono-cropping) (W)
- Inadequate coordination among the organizations (W)

3. Opportunities (O)

- New international research organizations and institutions of education and sciences coming up (O)
- Collaboration between international institutions, stakeholders levels of decision making (O)
- Presence of international research centers with results from elsewhere (O)
- Different stakeholders in agriculture sector (O)
- Effective management of existing structure (O)
- Potential partnerships in the agriculture sectors (O)
- Existence of the technicians in the local level of administration (O)

4. Threats (T)

- Lack of commitment of collaboration with other institions (governments) in the region (T)

K. Capacity Building

1. Strengths (S)

- Women are more involved in agricultural practices (proactive and skills) (S)
- Existence of skilled labor (S)

2. Weakness (W)

- Limited CSA skills and knowledge among farmers (W)
- Difficulties with farmers using new technologies (W)
- Unskilled farmers (W)
- Farmer's knowledge on practices (W)
- Education level (understand agricultural technologies) (W)
- Less adaptive technologies (W)
- Un-empowered people (W)
- Limited knowledge on off-farm activities (W)
- Poor adoption of new technologies due to unskilled farmers (W)
- Local capacity on CSA is still low (W)
- Levels of literacy of small holder farmers (W)

3. Opportunities (O)

- Efficacy of training delivery of CSA practices (O)
- Coordination can be improved (O)

4. Threats (T)

- Resistance of farmers to new technologies (T)
- Farmers reluctant to use climate friendly approaches due to low productivity (T)

V. Sustainable Intensification – Definitions

A. Definitions from Selected Participants

- Produce as much as preserve natural resource base
- Sustainable government policies
- Process of implementation / innovation policies in various sectors
- Shaping existing knowledge for longer-term
- Longer term program that are sustainable and limits environmental hazards
- increasing yield per unit area to ensure food security but protecting environment
- Obtaining optimum yield without damaging environment
- Way of increasing food production from same land and decreasing environmental issues (response from growing food demand and due to short supplies of resources (water, energy etc..) leading to sustainable livelihoods
- Putting policy to improve and control disaster including gender issues
- Emphases on climate adaptation focused on information delivery
- Sustainable scale up of interventions
- Farmers must have ownership and willingness to participate actively
- CA should be maintained and sustained in an insensitive manner
- Intensification (meaning more inputs) is in contraction with limited resources

B. Definitions from all Participants

1. Participant 1
   - Produce much on a small land while keeping the environment healthy
   - Increase food production from existing farmland while minimizing pressure on the environment
   - It’s a response to the challenge of increasing demand for food from a growing global population in a world where land, water, energy, and other inputs are in short supply

2. Participant 2
   - To maintain and build on what has been done the see the way it can be improved in terms of infrastructures, M&E (regular)
   - For my organization: The sustainability means a lot of things for our beneficiaries (farmers). We tried to implement Ints techniques / agriculture by training farmers from Int levels because sustainability begins by ownership of beneficiaries. Their participation must be demonstrated

3. Participant 3
   - Describes practices and approaches used to scale up CSA through smallholder or community led extension

4. Participant 4
    - Refers to farming systems adapted to climate change and focused to improve risk management
    - Diversified systems to flow informations to the farmers (innovations)

5. Participant 5
    - It is a process of increasing the agriculture productivity with a maximum level of restoration and regeneration of natural resources including soil structure so that future generations do not suffer from current overexploitation of those resources

6. Participant 6
    - Increasing food production from existing farmland while minimizing pressure on the environment
    - It responds to the challenges of growing demand for food from a growing population in a country where land, water, energy and other resources are in short supply.

7. Participant 7
    - To increase production per unit area with minimum pressure on the environment
    - To maximize the production per unit area without compromising the benefit of future generations

8. Participant 8
    - Is a way of enhancing agriculture intensification, optimizing agricultural productivity while ensuring it is done in a way that is friendly to climate system
    - Sustainable intensification is required to feed ever increasing population without compromising our environment

9. Participant 9
    - Intensification is about increasing production and productivity. It can be done through increasing the area under cultivation, and/or improving the technology package such as use of improved varieties, use of fertilizers (organic + mineral) chemicals, and other inputs
    - Is about increasing / improving productivity without depleting the natural resources (water, forest, etc) or polluting the environment (e.g. groundwater by fertilizers and chemicals), considering the livelihoods of local population.

10. Participant 10
    - Increasing productivity in a way that this productivity will not be there just once or in a limited time
    - This means that Rwanda needs to increase productivity that will last and there will no longer be lack of basic crops be it seasonal or perennial ones

11. Participant 11
    - Climate smart agriculture which is durable to all

12. Participant 12
    - The different ways of methodology and techniques used to increase productivity on small scale land size in order to reach to the sustainable likelihoods through sustainable income and food security

13. Participant 13
    - The strategy and approaches for expanding agriculture within the consideration of how those strategies will be stay without funder/donor support

14. Participant 14
    - Since we have been dealing with CSA it simply means maintained CSA in an intensive manner bearing in mind that Rwanda is a small country. The CSA should be done to the extent that the components/factors are not depleted to deprive the posterity of their right to keep on with CSA in future

15. Participant 15
    - The modification / changes in the Government policies or activities aiming at creating a positive outcome
    - The process of implementing policies, innovations, and decisions / practices in different sectors such as agriculture, education, climate, environment aiming at coming up with good results but without jeopardizing the existing structures
    - The process of shaping and reshaping the existing structures in the country that can last for a long time

16. Participant 16
    - Producing as much we can as we preserve the natural base
    - Developing cropping technologies which are environmentally friendly (RAB)
    - Developing policies regulating the SI (nation)

17. Participant 17
    - The capacity of obtaining the optimal yield without compromising the natural resource for current and future generations.
    - In Rwanda, this implies actions like erosion control, manuring, liming, and adapted crop varieties. This would imply irrigation where possible. It would also imply the control of pesticides

18. Participant 18
    - Increasing productivity (yield per unit area) to ensure food security without harming or destroying the environment
    - For my organization: Farmers have to use appropriate way to increase productivity also by protecting environment (increase of productivity to ensure food is available in quality and quantity)

- For the country: Due to the shortage of land it is a critical concept aiming at helping farmers increase yield per unit area to ensure food security without destroying environment

19. Participant 19
    - Putting in pace programs that can be run for the long term but also produces consistent results at a consistent pace. It should also minimize any environmental effects while ensuring that food is adequately available while preserving water, land and other resources.

VI. Sustainable Intensification Clusters / Themes

A. Human Resources

1. Strengths (S)
- Expertise in intensification programs (S)
- Human capacity engaged in CSA (S)
- Willingness of population for change (S)
- Active population ready to learn (S)
- Farmers’ willingness (S)
- Active agricultural manpower (S)
- Willingness of stakeholders (S)
- Strong stakeholder partners (S)

2. Weakness (W)
- Low level of public private partnerships engagement in agriculture (W)
- Lack of appropriate knowledge for intensification (W)
- Population pressure (W)
- Inadequate coordination among institutions (W)
- High percentage of population involved in agriculture (W)

3. Opportunities (O)
- ICT inclusion (O)
- Active population for labor (O)

4. Threats (T)
- High growing population (T)
- Lack of clear communication (media etc..) (T)

B. Climate and Environment

1. Strengths (S)

- None (S)

2. Weakness (W)

- Low level of climate data information usage (W)

3. Opportunities (O)

- Existence of two rainy seasons (O)
- Favorable seasons (O)

4. Threats (T)

- Climate change (T)
- Drought and flooding (T)
- Climate change and climate variability (T)
- Erratic rainfall (T)
- Pests and diseases (T)

C. Finance

1. Strengths (S)

2. Weakness (W)

- Limited funds (W)
- Limited financial resources (W)

3. Opportunities (O)

- Existence of private sector that can provide inputs for SI (O)
- Potential donors that can support SI projects (O)
- Advocate for additional resources from existing donor agencies (O)
- Existence of many stakeholders to contribute to intensification effort (O)
- Willingness of donors to provide agricultural grants (PSDAG and USAID) (O)
- Value addition on agricultural produces (O)

4. Threats (T)

- Inadequate sustainable funding to smallholder farmers (T)
- No guarantee funds (T)
- No off-farm jobs (T)

D. Soil Survey and Soil Fertility Management

1. **Strengths (S)**
- Soil maps available (exists) for Rwanda (S)
- Water resources (rainfall, lakes, rivers) (S)
- Good land for intensification (S)
- Existence of marsh lands (S)

2. **Weakness (W)**
- Widespread soil acidity (W)
- Topography (W)

3. **Opportunities (O)**
- Maximization of crop production per area of land (O)
- Minimize the over-exploitation of natural resources (land, water, energy and other inputs) (O)

4. **Threats (T)**
- Acidic soil (T)
- Unfavorable topography (steep slopes and water in valleys) (T)
- Land scarcity (T)
- Land scarcity and land size and topography (T)

E. Policy

1. **Strengths (S)**
- Mechanization policy available (S)
- Supportive government policy (S)
- Favorable government policies and politics (S)
- Existing agriculture infrastructure (irrigation – post harvest etc..) (S)
- Enabling political environment (S)

2. **Weakness (W)**
- Inadequate manpower to implement policy on sustainable intensification (W)
- Government of Rwanda to support improved inputs (seeds, fertilizer etc.)

3. **Opportunities (O)**
- Government involvement in subsidies (O)
- Existence of land consolidation policy (O)
- Existence of policy on agricultural and food security (O)
- Creation of fare trade (O)

- Membership to regional economic blocs (O)

4. Threats (T)

- Monetary inflation (T)
- Regional competition (T)
- Changing leadership (T)
- Commodity price fluctuation (T)
- Competitive markets with high cost of production for local commodities (T)

F. Capacity Building

1. Strengths (S)

- Existence of community base etenstion system (Twigire Muhinzi) (S)
- Farmer’s knowledge of soils (S)

2. Weakness (W)

- Lack of appropriate tools private tools for intensification (W)
- Limited technicians (W)
- Limited capacity of extension services (W)
- Monoculture (W)
- Limited skills (W)
- Low capacity in resource an extension services (W)
- Lack of modern technologies (W)
- Limited skilled work force (W)
- Reliance of local farming methods (W)

3. Opportunities (O)

- Diversification of extension services (O)
- Availability of technologies from research that can be used (O)

4. Threats (T)

- None (T)

VII. Strategic Focused / Themes Topics (CSA)

A. Integrated Soil Fertility Management
B. Integrated Water Management
C. Adoption of CSA Interventions
D. Capacity Building in Rwanda
E. Promoting Partnerships in Rwanda

* Considered Gender, Technology, Communication and Youth (wherever appropriate)

Strategic focus topics:

A. <u>Integrated soil fertility management (including mitigation strategies)</u>

Group 1

- Crops adapted to local climate; with a focus to improve soil fertility (legumes)
- Crop rotation
- Use of agroforestry trees (hedge rows)
- Promote innovation in generating large quantities of organic manures (crop residues, compost, green manures)
- Efficient use of fertilizers / application methods respected, crop specific recommendation methods
- Intercropping

Group 2

- Clear understanding of biophysical environmental (soil and climate) and link the soil map of Rwanda (1:50,000) with the soil fertility management process
- Techniques to improve/increase the quality of locally produced manure
- Building on farmers knowledge (improve) of soils and soil fertility management
- Recycling nutrients through crop residue management and mulching
- Reinforce the role of research in SFM

Group 3

- Soil content test and analysis
- Inventory of nutrient use and opportunities for ISFM
- Erosion control methods reinforced

Group 4

- Tillage techniques (conservation agriculture)

- Encourage soil liming to reduce acidity

Group 5

- Enhance linkage between agro-dealers and smallholder farmers (i.e. train agrodealers as ToT)
- Cost benefit analysis of ISFM options

Moderator

- Adapt and calibrate soil fertility models

B. <u>Integrated Water Management</u>

Group 1

Water resources available in Rwanda

- Rain water (Runoff)
  - Rainwater harvesting
    - Ponds / Dams construction as priority by local administration (performance contracts)
    - Water tanks affordable by smallholder farmers
    - Create village committees for water management (gender balanced)
    - Use of suitable roofing materials
  - Terracing and hillside irrigation
    - Use labor intensive public work (HIMO)
    - Train smallholder farmers on terracing and hillside irrigation countrywide
- Ground water
  - Country-wide survey and mapping
  - Test water quality and categorize uses
  - Drill wells
  - Introduce fees for water management and ownership
- Surface water
  - Mapping and test quality
  - Protect watersheds (agro-) forestry
  - Raised bed and furrow system (infiltration, irrigation etc..)
- Policies and laws for water use and management

Group 2

- Protecting wetland ecosystems (water sources)
- Enhance efficiency in irrigation (hillside, wetland)

Group 3

- Enhance soil water retention capacity through increasing the soil organic matter content
- Recycle water for domestic use for agricultural uses

Group 4

- Promote policy of efficient water use
- Available irrigation materials affordable by farmers
- Increase technical skills of technicians on water management

Moderator

- Promote policy of efficient water use
- Subsidies, grants, for rainwater retention projects

C. Adoption of CSA interventions

Group 1

- Meeting between the GoR and stakeholders to strategize CSA in the local context
- Awareness campaigns (workshops, seminars, …)
- Sharing responsibilities among institutions / stakeholders
- Implementation plan (general = for all local government stakeholders) but specific to institution and leading to one common goal.
- Setting MOUs between the government institutions and the stakeholders in regard to implementation
- Institutional Monitoring and evaluation plan to assess the implementation of CSA strategies
- Feedback collection process to determine the status of CSA implementation
- Adjust if needed
- Implementation plan stages:
    - Situational analysis: agro-climatic conditions, topography, local beliefs
    - Comparisons with existing CSA practices in order to avoid / minimize duplication
    - Capacity building of implementers and decision makers

Group 2

- Conduct specific research on regional micro-climate
- Publish specific climatic zones in Rwanda
- Enact policies and regulation for adoption of CSA

Group 3

- Incorporate CSA in curricula of agriculture and environmental teaching schools

Group 4

- Inventory and assessment of CSA technologies adapted to micro-environments of Rwanda
- Develop approaches for CSA technology transfer
- Develop tools to assess CSA technology adoption level
- Develop a strategy to provide incentives to CSA technology adopters

Group 5

- Inclusion of women and youth in CSA approaches

Moderator

- Subsidies: small scale irrigation; energy generation – small holder farmers

D. Capacity building

Group 1

- Formal education
    - Include CSA courses/components in curricula adapted at primary, secondary and higher education
    - Specialization in CSA at MS, PhD and post-doctorate
- Farmers and other end-users
    - Training of trainers on CSA
    - Awareness creation
    - Expose farmers to CSA technologies
- Creation of a national center in charge of delivering short trainings in CSA overseeing the implementation CSA strategies countrywide
- Building the capacity of research center staff in mobilizing funds for CSA (including proposal writing)

Group 2

- Monitoring the outcomes of the trainings
- Linkage between International Research organizations with National Institutes
- Availability of extension messages on CSA in Kinyarwanda (posters, media, manuals, social networks)
- Study tours of farmers, staff, to CSA initiatives
- Plan refresher trainings
- Use learn by doing approach to farmers

Group 3

- Introduce age-appropriate CSA in primary and secondary education as CSA is a specialized branch of Agriculture. Rather teach it at Bsc, Msc, Phd level
- Develop CSA manuals for use by extension workers
- Creating a research & training center or site specifically dedicated to CSA, it has to be a decentralized system with presence in each District
- Establish demonstration farmers across the country where CSA technology will be demonstrated and where farmers can learn from (through Farmer Field Schools).

Group 4

- Establish CSA platform for knowledge sharing
- Highlight the need to factor climate change and its variability in all planning and decision making processes at all levels for sustainable CSA

Group 5

- Identify gaps related to CSA in Rwanda

E. Promoting partnerships in Rwanda

Group 1

- Put in place partnership policy in CSA
- Mapping stakeholders involved in CSA
- Stakeholders orientation (e.g. region, intervention, value chain)
- Clear value chain management (linking …)
- Promoting farmers organizations through cooperatives
- Farmers easy accessibility to finance (microfinance institutions)
- Strengthen skill and knowledge to all actors (farmer’s training)
- Partnership enhancement through technology, ensuring gender balance, youth and vulnerable groups

Group 2

- Enhancing public-private partnerships in CSA
- Creating ownership of the CSA by International institutions. For example: Agroforestry center to commit to train farmers and provide agro-forestry seedlings
- MOU within partnerships
- Creating a conductive environment to attract new partners (e.g. easy registration of a company) (task for GoR)

Group 3

- Introduce preventive measures to avoid possibility of any corruption (laws, regulation)

Group 4

- Partnerships/stakeholders are with:
  - Farmers (individuals)
  - Farmer’s organizations (cooperatives)
  - Local and international NGOs
  - Private sectors
  - Public institutions

Group 5

- Dissemination of existing policy and regulations about partnerships (leading ministries)
- Proper identification of relevant partners

Moderator

- Government has policy to share knowledge
- Farmers move around and share knowledge

VIII. Success Stories

Group 1

Project name: Crop acidification in acidic soils of Rwanda through the use of lime and other ISFM inputs

Where: Nyaruguru and Nyamagabe districts

Why:

- The acidity was the most limiting factor
- The project provided quality seed (Irish potato, climbing bean, maize and wheat) with livestock and hedgerows (agroforestry) on contour lines.
- Effective use of bench terraces;
- 20,000 farmers benefited from the project;
- This created high productivity and household food security
- High demand for lime and seeds

Partnerships: AGRA, RAB (implementer), farmer cooperatives

Group 2

Project name: SASHA (Sweetpotato action for food security and health in Africa) Rwanda. This project aimed to assist farmers in improving productivity of orange flesh sweetpotato rich in Vitamin A and adding value by processes products such as Mandaz (doughnuts)

Where: Turwanyubukene farmer groups, Gakenke Sector, Gakenke District

Why: Currently selling planting materials, supply roots for Urwibutso enterprise. They have now increased in their income to pay health insurance, school fees, buying basic planting materials themselves. And woman can contribute to household expenses. Land is properly used now with recommended manure erosion control also applied.

Partnerships: CIP, RAB, IMBARAGA, YWCA

Group 3

Project name: Increasing soil fertility benefits of climbing bean to smallholder bean production systems (Crop intensification program)

Where: Remera sector, Musanze District.

In 2012 the crop intensification program (CIP) has cultivated 150 ha of land to grow climbing beans in Remera. The trial was repeated for 6 seasons.

These beans were fertilized by different chemicals and they produced 3 tonnes per ha. This yield is three fold higher than the production of bush beans using the same inputs.

This high production provides to the smallholder farmer an opportunity to feed his family and sell the surplus to the market.

By supplying this commodity to the markets famers were able to generate income to meet other family needs while meeting the demand for climbing beans in their communities.

Partnerships: AGRA, RAB, local government, Farm cooperatives, CIP

Group 4

Project name: Bucket drip irrigation technology

Where: Nyamagabe, Huye and Nyaruguru Districts (southern province)

Why:

- High rate of malnutrition (stunting > 50%)
- Land shortage
- Drought
- High pressure on marshlands
- Low household income

How:

- Modeling
  - 6 model farmers
  - Local fabricators / sustainability purpose
  - Investment costs: $78 per kit
  - Land size (space): 15 x 5 m

Impacts/success:

- Yield increased
- Malnutrition rate decreased / reduced
- Household income increased up to 97%
- Now 106 smallholder farmers adopting the technology
- Payback: within one season
- Three seasons of production

Partnerships: World Vision Rwanda, Vision Finance Co., Local government, others

Group 5

Project name: IFDC fertilizer program

Location: Musanze District (all sectors)

Activities: fertilizer use monitoring, training on appropriate fertilizer use.

Success:

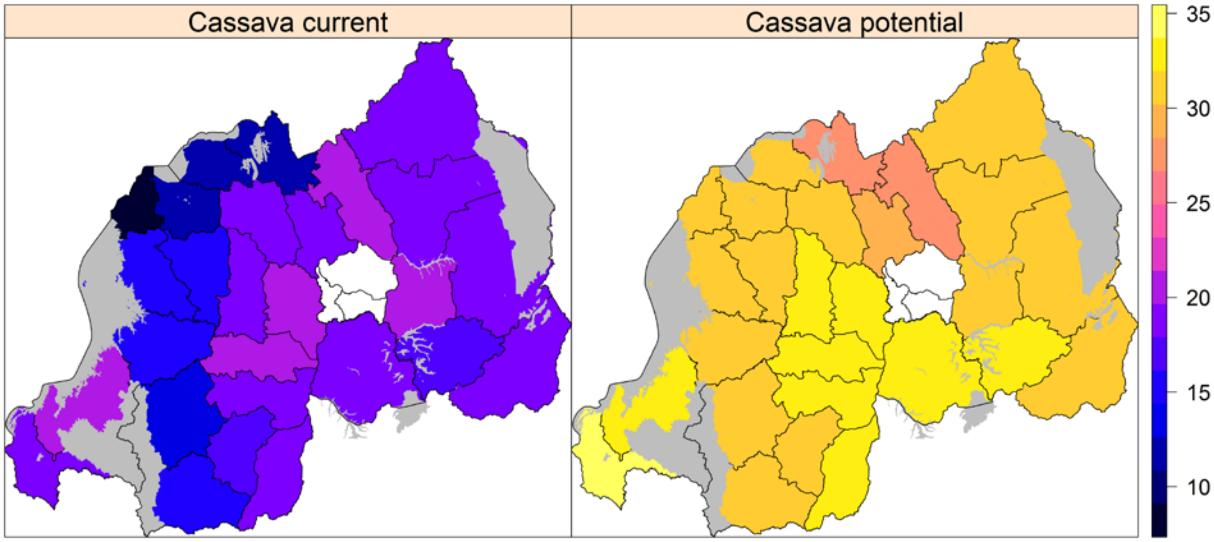
- Increased productivity / food security
- All agro dealers trained
- Increased knowledge of farmers

Challenges:

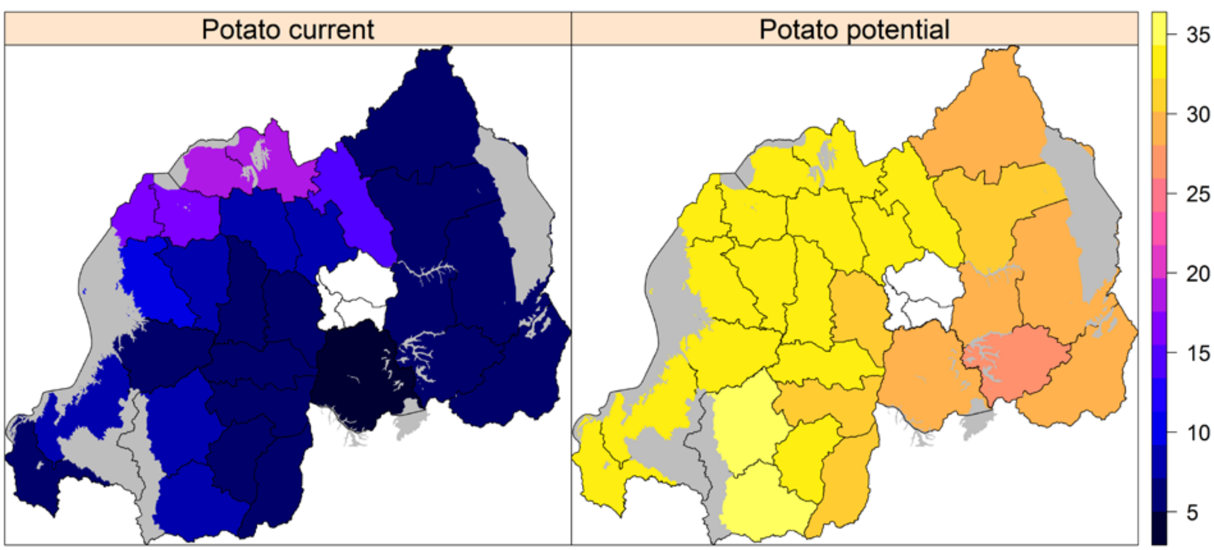
- Price fluctuations
- Climate

Partnerships: IFDC, IMBARAGA, RAB, DERN, local government, farmer cooperatives

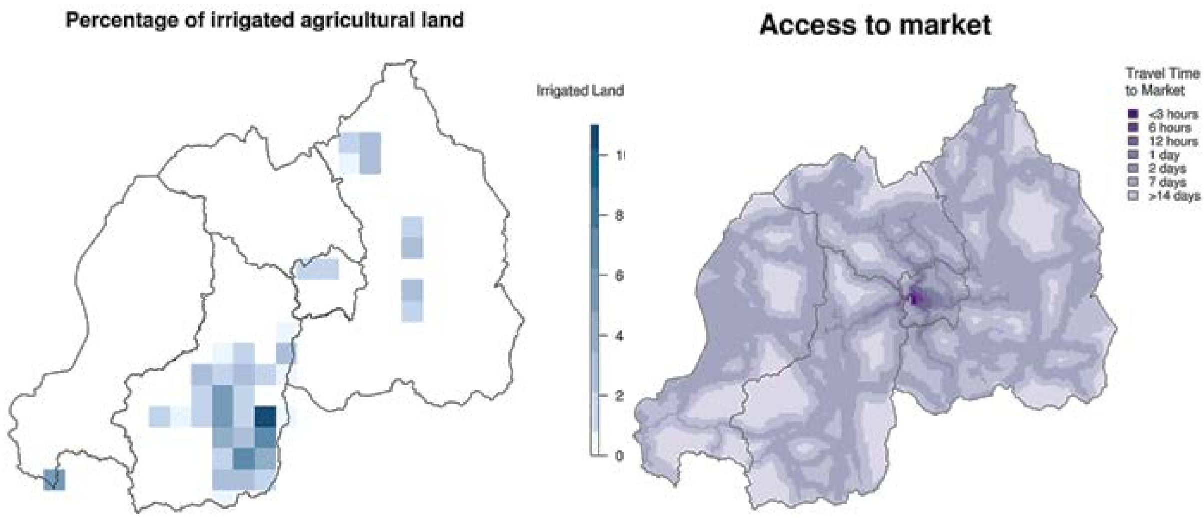
Annex 2. Additional figures supporting the report.



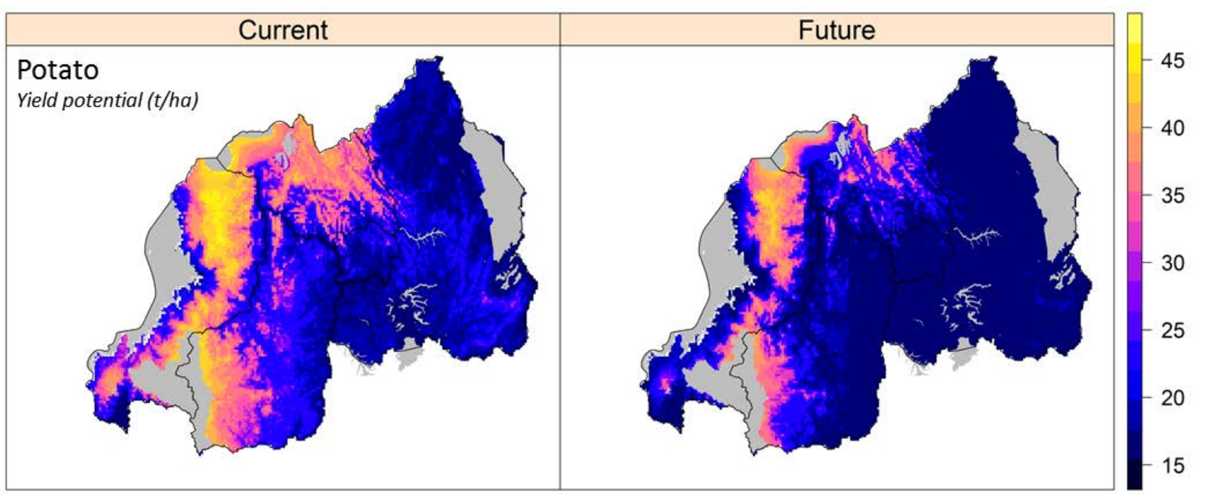
Current yield and potential yield (1000 kg/ha) for rainfed cassava in Rwanda



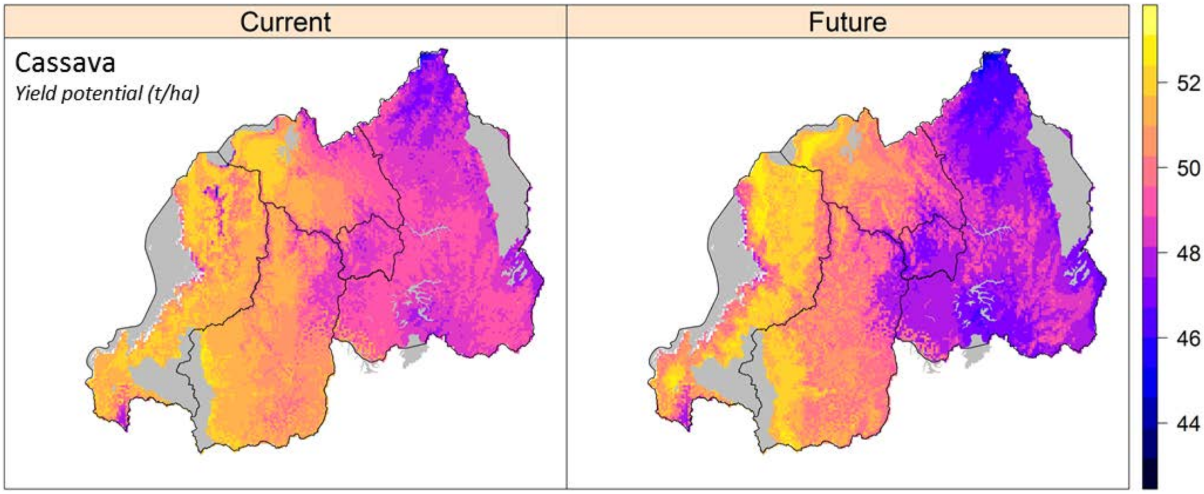
Current yield and potential yield (1000 kg/ha) for rainfed potato in Rwanda



Percentage of irrigated land and access to market (time in hours) in Rwanda



Changes in yield potential of potato with 2℃ increase in temperature compared to current yield potential.



Changes in yield potential of cassava with 2℃ increase in temperature compared to current yield potential.

Annex 3. Draft framework of various domains and scales for sustainable intensification indicators.

Domains	Field/Plot	Farm	House Hold	Zone of influence
Productivity				
- Crop Yield				
- Yield variability				
- Livestock yield				
Economic				
- Gross Margin				
- Gross margin variability				
- Total factor productivity				
Environment				
- Soil quality				
- Veg cover				
- Water prod				
- Nutrient prod				
- GHG emissions				
- Nutrient balance				
- Biodiversity				
- Soil organic matter				
- Soil conservation				
Social				
- Gender equity				
- Education/training				
- Social connectedness				
- Underserved (land tenure and security)				
Human Condition				
- Nutrition				
- Food security				
- Labor				