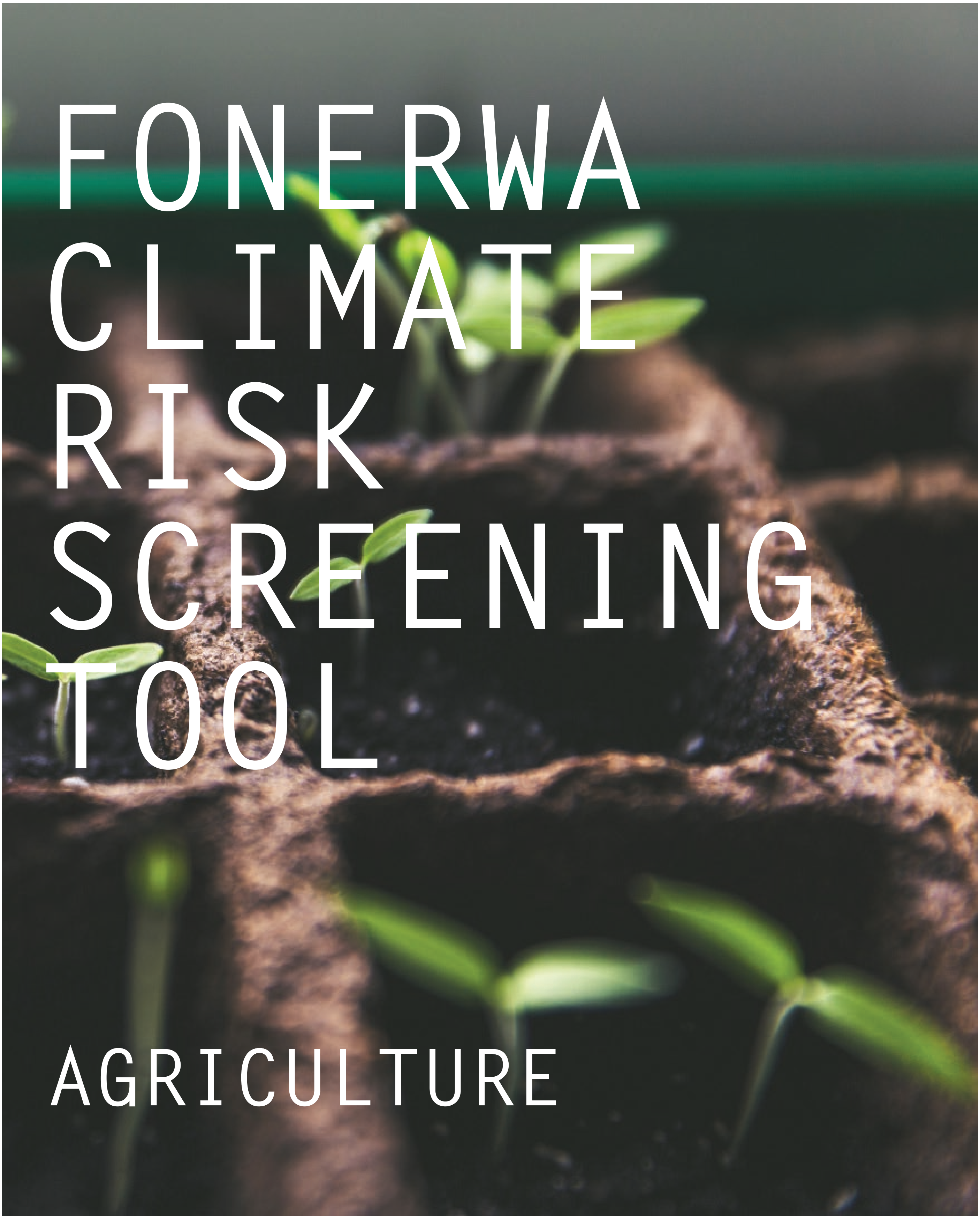

# FONERWA CLIMATE RISK SCREENING TOOL

## AGRICULTURE

FONERWA
For a Green & Resilient Rwanda

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# LIST OF ACRONYMS & ABBREVIATIONS

| | |
|---|---|
| $CACO_3$ | CALCIUM CARBONATE |
| $CO_2$ | CARBON DIOXIDE |
| CA | CONSERVATION AGRICULTURE |
| CBB | COFFEE BERRY BORER |
| CIAT | INTERNATIONAL CENTRE FOR TROPICAL AGRICULTURE |
| CLR | COFFEE LEAF RUST |
| ECe | ELECTRICAL CONDUCTIVITY OF SATURATED EXTRACT |
| GDP | GROSS DOMESTIC PRODUCT |
| FCFA | FUTURE CLIMATE FOR AFRICA |
| FONERWA | RWANDA'S FUND FOR THE ENVIRONMENT AND CLIMATE CHANGE |
| PD | PROJECT DOCUMENT |
| PD CLINIC | FONERWA AND PROJECT DEVELOPERS PROPOSAL DEVELOPMENT WORKSHOP |
| RAB | RWANDA AGRICULTURAL BOARD |
| UNFCCC | UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE |

# 1. INTRODUCTION

**Agriculture is one of the main economic activities for the people of Rwanda, contributing over 30% of the Gross Domestic Product (GDP), and provides employment to about 72% of the working population. Agricultural activities also ensure food security for all Rwandans. The Rwandan government is actively pursuing initiatives that will increase agricultural production such as the Crop Intensification Programme and Girinka Programme among others.**

Over the last few years these initiatives have significantly improved the livelihoods of Rwandans and resulted in agricultural production increases of 65% between 2010 and 2014. Even though agricultural production has generally increased in recent years, it is still at risk of being negatively affected by future climate change if relevant adaptation or mitigation activities are not appropriately adopted.

**The dependence of African agriculture on the climate, particularly for rain fed crops, increases the vulnerability of this sector to climate hazards. This is especially true for Rwanda, given that more than 90% of farms are rain fed and farmers depend on seasonal weather patterns.**

It is therefore critical that agriculture investments consider the impacts of current and future climate change. FONERWA is at the forefront of investing in agricultural projects and continues to address climate change issues through adaptation and mitigation projects. In order to ensure that investments have a long legacy and are appropriately aligned with Rwanda's green growth and climate resilience strategy, climate information needs to be integrated into project development and implementation.

Mainstreaming climate information in this way will take a step towards ensuring that FONERWA funded agriculture projects are cognisant of the impacts of climate change and take appropriate measures to account for these impacts. This will provide benefits to both the project, in providing value for money, and FONERWA, by ensuring that funding has impact while not being at risk of failure in the future as a result of climate change.

## 1.1. CLIMATE RISK SCREENING TOOL

This Climate Risk Screening Tool is primarily designed for FONERWA staff, expert reviewers and project developers to identify areas where climate risks and risk mitigation measures need to receive more attention within proposals. FONERWA staff and expert reviewers should use the tool during the project appraisal processes to flag for areas of potential climate risk. It provides reviewers with standardized feedback to project developers for consideration of climate risks.

Project developers in the agriculture sector should use the tool during the FONERWA design phase as an information resource and reference document to build the justification for their proposals as climate smart proposals, with improved value for money. In this regard, the tool provides examples of risks, impacts and solutions that can be interrogated and incorporated into the project design.

The tool also presents a clear and transparent account for project developers on how FONERWA reviewers will be screening their proposals for climate risks. More generally, the tool can provide the basis for understanding the logic behind climate impacts and risks, which could then be applied to other agriculture contexts (i.e. for crops not mentioned in the tool) and other sectors. The tool should not be used to outright reject proposals as climate only forms part of the overall project risk profile and justifications, with decisions around value for money (economy, efficiency, effectiveness), feasibility and others, weighing in on whether a project is funded or not.

**The information in this tool is not restricted to use within the FONERWA context. The information in this tool can be relevant for project preparation to other funds that use the crops, livestock or agriculture practices included in this tool and need to consider the same climate risks.**

However, this tool is not intended for use in daily decision making or more practical applications, e.g. farmers deciding on what crops to plant on their farm for the next season, as that type of decision requires more detailed information on local contexts that are not covered in this tool.

As such, it is important to note that the information presented in this tool is a guide to a range of potential climate impacts and therefore generalized for the whole of Rwanda. Therefore the tool assists in considering potential climate impacts, but is not a substitute for expert advice on particular decisions in specific contexts.

**This tool should be used for the following:**

- To gain a better understanding of how current or future climate can impact crops and livestock production.
- To identify key areas of climate risk within the design phase of a project.
- To highlight areas of missing climate information within relevant projects.
- To encourage discussion, with respect to current or future climate change amongst project developers and FONERWA.
- To avoid maladaptation or investment in non-viable areas, crops or practices.
- To ensure that projects are "*climate smart*" and therefore not at high risk of failure under future conditions caused by climate change.

## 1.2. Document Structure:

This document employs a color coding system to enable easy navigation for different users to relevant information.

The forthcoming sections cover a guidance for using the tool as FONERWA (reviewers) ***(Section 2, PURPLE)*** and for using the tool as project developers ***(Section 3, GREEN)***; Standardized questions and answers in the Risk Screening Checklist ***(Section 4, RED)***; Specific information on coffee, tea, banana, maize, beans, sorghum and livestock, including a summary infographic, detailed impact information, geographical crop suitability, a risk identifier table and references for each crop/livestock ***(Section 5, Orange)***; Appropriate Climate Smart Agriculture practices for each identified crop, per agro-ecological zone ***(Section 6, LIGHT BLUE)***; A worked example of how to use the tool to identify risk in a project ***(Section 7, BROWN***; an overview of how the information in this tool was created as well as how to handle the information ***(Section 8, DARK BLUE)***.

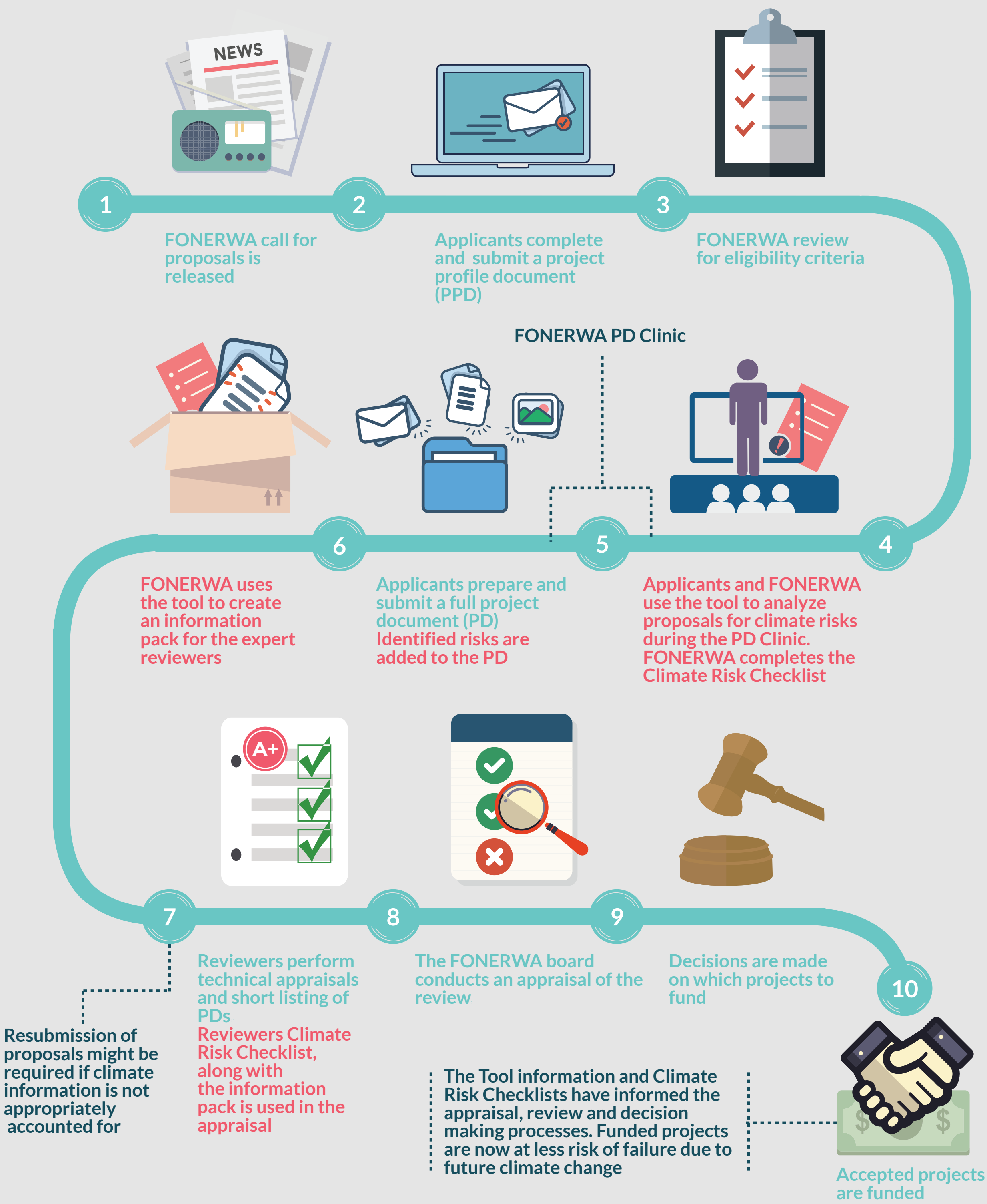
- **FONERWA reviewers** should refer to Sections **1**, **2** and **4** ( )
- **Project developers** should refer to Sections **1**, **3**, **5**, **6** and **7** ( ).
- **Project developers** who are interested in more detail on the information within the tool should refer to Section **8** ( ).
- To understand where the tool can be used by **projects developers** and **FONERWA reviewers**, please see the infographic on the next page ***"FONERWA Funding Process: 10 steps to funding, using the FONERWA Climate Risk Screening Tool"***.

The following infographic outlines where this tool fits in the FONERWA funding process, and how and where it is used to screen/improve prospective projects.

*Project developers will primarily use the tool during the Project Document (PD) development stages (4 and 5), while the FONERWA review team will use the tool throughout the PD development stages and the expert review process.*

# FONERWA PROJECT FUNDING PROCESS

10 Steps to funding, using the
FONERWA Climate Risk Screening Tool



# 2. GUIDANCE FOR REVIEWERS

## DURING THE PD CLINIC

### FOR THE MOST EFFECTIVE USE OF THIS TOOL, PLEASE WORK THROUGH RELEVANT SECTIONS OF THIS TOOL WITH THE PROJECT DEVELOPERS DURING THE PROJECT DOCUMENT CLINIC (PD CLINIC).

In order to screen prospective projects for climate risk, you will need to use the Climate Risk Checklist in Section **4** and refer project developers to the information in Sections **3**, **5** and **6**.

During the PD clinic, complete the checklist in Section **4**. This checklist is designed to provide some of the key questions that are important for projects that are likely to incur some level of climate risk. The questions from this checklist can be used to help direct project developers to build justifications for their decisions relating to climate.

**It is important to run through each question with the project developers and determine whether they have accounted for that question in their project.**

Throughout this process, you will be using the checklist from Section **4** to identify the potential areas of risk and missing information. For each relevant question, a standardized answer is provided and can be given to the project developers to help them understand why it is important.

It may be beneficial to have the infographics (from Sections **5** and **6**) for relevant crops and Climate Smart Agriculture (CSA) practices on hand. Project developers can be directed to additional information using these documents.

Questions 1 to 9 are key to providing essential information that can guide the success or failure of an activity (from the climate perspective) and therefore will need to be assessed and accounted for in any agriculture project.

Questions 10 to 15 may not be applicable to every agriculture project therefore it is critical to conduct this assessment with full cooperation of the project team in order to determine relevance.

**For each question in the checklist, one of three available responses should be noted in the box area:**

- **Adequately answered:** If you feel the project developers have adequate answers and have met the criteria (i.e. they can show the relevant information and justify their decisions/actions).
- **More information required:** If you feel that the project developers do not have sufficient information on a particular question, note that you are recommending that more information be provided. In these cases, it is expected that the project developers account for the missing information and expand on their justifications for climate sensitive decisions. This will need to be completed by the submission of the full PD document.
- **Not applicable:** In cases where you and the project developers agree that a particular question is not relevant, note this in the box space provided and the question can be skipped.

After completing the checklist in Section **4**, proceed to the relevant risk tables in Section **5** and work though each table with the project developers.

For the guidance on how to use the risk tables, please refer to Section **3**. Your completed checklist as well as the completed relevant summary tables will need to be collected and a copy given to the expert reviewer, accompanying the submission of the PD.

## DURING THE REVIEW

AS AN EXPERT REVIEWER, IT MAY BE BENEFICIAL TO FAMILIARIZE YOURSELF WITH THE QUESTIONS FROM THE CHECKLIST IN SECTION 5 BEFORE REVIEWING THE PD. TAKE NOTE OF THE CHECKLIST THAT WAS COMPLETED DURING THE PD CLINIC AS WELL AS THE COMPLETED RISK TABLES.

**It is important to identify areas where there was missing or inadequate information during the PD clinic and assess whether the project developer has addressed the issues.**

To understand how the checklist was completed, refer to ***"During the PD clinic"*** on the previous page. Along side your own assessment, complete the checklist in Section 4, identifying where there is missing information or weak justifications for climate sensitive decisions in the project.

- If the project developers have appropriately accounted for the missing or weak information as identified on the checklist during the PD clinic, and therefore met the agreed on criteria, then the climate risk for the project can be considered low.
- If the project developers have appropriately accounted for some of the missing or weak information (i.e. they have not addressed every recommendation from the PD clinic) and there is no justification for why they have not addressed the issues, then the climate risk for the project can be considered as medium.
  *At this stage you might recommend that the project developers resubmit their PD with the appropriate amendments.*
- If there are justifications for why the recommendations were ignored then the project may be considered to be low risk.
- If the project developers have not appropriately accounted for missing or weak information (as identified during the PD clinic) and there is no justification for why the recommendations were ignored then the project can be considered as high climate risk.

*At this stage it is difficult to reject a proposal based only on the climate risk, as there are other parts that make up a good project. However, a high-risk climate project that has not accounted for current or future climate change and that does not have appropriate adaptation/ mitigation plans may encounter issues over the duration of the project lifespan. For example, if a project proposes expanding maize production but has not accounted for the climate and its risks, there is a possibility that future production could decrease as a result of planting in areas that are not suitable for maize. Similarly proposing the development of additional irrigation infrastructure or practices in an area where it is likely to be wetter in the future may not be considered good value for money in the long term. Either way, the project should be sent back for a resubmission that appropriately accounts for current or future climate change.*

# 3. GUIDANCE FOR PROJECT DEVELOPERS

PLEASE READ THE FOLLOWING GUIDANCE TO ENSURE THAT YOU APPROPRIATELY USE THIS TOOL.

## 3.1. CLIMATE INFORMATION/DATA

In order to appropriately use this tool, it is critical that you have access to the best available climate information that is relevant to the type and scale of your project. There are many sources of climate information and data and it may be difficult to decide that one is better than another. Therefore it is suggested to make use of as many reliable sources as possible and compare the messages across the sources, and/or engage with Meteo Rwanda before you settle on a single source.

**For general information on Rwanda's current and future climate please read:**

- The Future Climate For Africa (FCFA) publication ***"Rwanda factsheet: Climate information for an uncertain future"***.

  *http://2016report.futureclimateafrica.org/reader/east-africa/rwanda-factsheet-climate-information-for-an-uncertain-future/*

  This factsheet will provide you with projections that are averaged for the entire country, and can be used as a reference point for comparison with smaller scale information that is better suited to your project. The factsheet also includes an overview of climate change impacts in Rwanda and how climate information is currently being used.

**For more detailed climate information, including site-specific data and climate maps (historical to present day), please visit:**

- Rwanda Meteorological Agency's Map Room. Information specific to agriculture can be found within the Map Room under ***"Climate and Agriculture"***. If you can't find the information or data from the Map Room, then communicate with Meteo Rwanda directly. *http://maproom.meteorwanda.gov.rw/maproom/*

The previous two sources of information provide important examples of the importance to understand that the scale of your project will define the scale of the climate information that you can use.

For example, it would not be appropriate and more accurate to use the average projections for Rwanda that can be found in the UNFCCC second National Communication as your source for a project covering the Gicumbi district or a community level project within Byumba city. This is mainly because the climate information presented in the second National Communication represents an area that is too large for a small-scale project in Byumba.

Therefore the local factors that influence the climate in the area won't be taken into consideration and the overall information or data may not be accurate or representative of your area.

**Inappropriately using climate projections in this manner can mean that your proposed solutions (adaptation or mitigation) may not account for the correct possible futures and therefore be at risk of failure.**

Future climate projections can often be confusing and difficult to interpret. As such, it may also be beneficial to have a basic understanding of uncertainty and how climate model projections are produced. This will help to ensure that you make the most informed decisions from the climate information at hand.

**As background reading to identifying climate risks for your project, we suggest that you read the FCFA publication on climate models and how they can be used in planning:**

***http://www.futureclimateafrica.org/resource/climate-models-what-they-show-us-and-how-they-can-be-used-in-planning/***

## 3.2. CLIMATE RISKS AND IMPACTS

**In order to identify potential climate risks for a given project, you will need to first read through the "*Detailed Impacts*" and "*Suitability Maps*" sections for the specific crop/livestock being considered in your project. This will provide you with an overview of the range of potential risks for a given crop/livestock as well as the currently suitable areas for crop growth.**

Even if the crop/livestock that is central to your project does not feature in the detailed impacts section, consider reading through the narratives to familiarize yourself with how climate can affect production and quality of yield. This will help you to identify similar information to inform your project.

Once you have familiarized yourself with the impacts and suitability maps, you should familiarize yourself with the worked example in Section **8**, in order to help you complete the risk table for crop/livestock in question.

The climate thresholds identified in the risk table are related to a specific impact on either yield, or quality, or both. If the risk table indicates that exceeding a threshold will impact on yield and/or quality, then more detailed information on the impact can be found in the detailed impacts sections (5.1.2 to 5.7.2) for the crop.

### Thresholds

**For all numerical thresholds in the risk table we have used a collection of logical operators (for instance, ">" for greater than) to help understand the nature of the threshold.**

The risk table contains the following logical operators:

- "**>**", Which means ***greater than the threshold***. Therefore exceeding the threshold would mean having a value greater than the threshold value.
- "**<**", Which means ***less than the threshold***. Therefore exceeding the threshold would mean having a value less than the threshold value.
- "**=**", Which means "***resulting in***". For instance "warmer = pests" means that warmer temperatures can result in more pests.

Where a threshold has been exceeded, a number is provided in the "*more information*" column. This number will lead you to more detailed information on the impact, which can be identified by finding its pair in the detailed impact section (5.1.2 to 5.7.2).

In order to complete the risk table, you will need to start by sourcing climate information for the project area. Suggestions for obtaining climate information are covered in Section **3.1.** Make sure to collect the same type of information as presented in the relevant risk table in the "*Climate Variable*" and "*Climate Threshold*" columns - e.g. for the climate variable "*Temperature*" you need to source several types of data, including mean monthly temperature data. This is so that you will have historical and future mean monthly temperature data for your project area if that is one of the climate thresholds in the risk table.

**Once you have your relevant historical and future climate information, complete the table for each threshold as follows:**

### Compare current climate information

**In this section of the risk table, match your project specific data with the climate data from the "*climate thresholds*" column.**

For instance, if the threshold is stating mean monthly temperature then you will need to calculate the mean monthly temperature from your own data and place that value in the ***"Current Climate"*** column on the same row as the threshold for mean monthly temperature.

This process must be completed for each climate threshold in the risk table.

## Current threshold

**In this section of the risk table, you must determine if the current climate data exceeds each identified threshold in the risk table by comparing the current climate information for your specific project area with the climate threshold values presented in the *"climate threshold"* column.**

This step is to determine whether the current climate of your project site is currently at risk of any negative climate impacts as identified in this tool.

If the climate (temperature, rainfall) for your project area exceeds the given climate threshold, then there is a current risk that the crop in question is negatively impacted by the climate already and may not be producing optimal yields/quality.

If the climate for your project area does not exceed the given climate threshold, then the crop is considered not to be at risk of that particular negative impact as identified in this tool.

- For each threshold that is **exceeded**, place a tick (✔) in the ***"yes"*** column under the ***"current threshold"*** heading.
- For each threshold that is **not exceeded**, place a tick (✔) in the ***"no"*** column under the ***"current threshold"*** heading.
- For each instance where there is a tick (✔) in the ***"yes"*** column, there is a potential negative impact for that crop and the negative impact can be identified as influencing the yield or quality or both (by the presence of a red block

Further reading on the nature of the impact can be found in the detailed impacts section by finding the pair of the number in the ***"more information"*** section of the risk table.

## Future climate

**In this section you need to account for future climate change, by determining whether the climate variable (e.g. mean monthly temperature, or total rainfall) will increase or decrease in the future.**

- To deal with conflicting information there is a ***maybe*** category. Since future climate projections should always be presented in a range, there is a possibility that one part of the range exceeds the threshold while the other does not. This is most common in rainfall where climate change could mean an increase or a decrease in rainfall.
- If there is consensus that a particular variable (temperature, rainfall) will increase (e.g. it will be warmer or wetter) then tick (✔) in the ***"yes"*** column under the ***"future climate"*** heading.
- If there is consensus that a particular variable (temperature, rainfall) will decrease (e.g. it will be cooler or drier) then tick (✔) in the ***"no"*** column under the "***future climate"*** heading.
- If there is no consensus that the particular variable might increase or decrease in the future (e.g. the future projections show a change in rainfall by -10% to +15%) then tick (✔) in the ***"maybe"*** column under the ***"future climate"*** heading.

## Future threshold

**In this section of the risk table, you must determine if the future climate data exceeds each identified threshold in the risk table by comparing the future climate information for your specific project area with the climate threshold values presented in the *"climate threshold"* column.**

This step is to determine whether future climate trends present risks to your project site.

If the future climate (temperature, rainfall) for your project area exceeds the given climate threshold, then there is a future risk that the crop in question is negatively impacted by the climate and may not produce optimal yields and/or quality in the future.

If the future climate for your project area does not exceed the given climate threshold, then the crop is considered not to be at risk of that particular negative impact in the future as identified in this tool.

It is also possible that for certain thresholds, future climate change can make an area more suitable for a particular crop, even if it is currently not suitable.

- For each threshold exceeded by the entire range of future projections (e.g. the future potential change in temperature does exceed the threshold), place a tick (✔) in the "*yes*" column under the "*future threshold*" heading.

- For each threshold where the range of future projections does not exceed the threshold in any way (e.g. the range in change in future rainfall projected does not exceed the threshold), place a tick (✔) in the "*no"* column under the "future threshold" heading.

- If there is no consensus of whether the range of future projections will exceed the threshold (i.e. the lower part of the future climate range does not exceed the threshold but the upper part does), then place a tick (✔) in the "*maybe*" column under the "*future threshold*" heading.

  *If this occurs, it is important to consider that the crop in question may or may not be at risk, depending on what the climate turns out to be in the future. It will then be necessary to plan your activities to perform well across the range of projections. For example, intensifying irrigation in areas that are currently prone to drought. Whether it is drier or wetter in the future, being able to cope with current droughts will mean that the project would be better able to cope with future droughts.*

- For each instance where there is a tick (✔) in the "*yes*" or "*maybe*" columns, there is a potential negative impact for that crop in the future and the negative impact can be identified as influencing the yield or quality or both (by the presence of a red block).

Further reading on the nature of the impact can be found in the detailed impacts section by finding the pair of the number in the "*more information*" section of the risk table.

## Descriptive thresholds

**For each crop there is a number of descriptive thresholds.**

Descriptive thresholds are not numerical (i.e. they don't provide specific numbers as thresholds) but give qualitative descriptions (e.g. "*warmer"* or "*drier*" or "*more frequent flooding*"). In these cases, you can use the qualitative description and future trend to determine if the threshold is relevant or not (e.g. if the future trend indicates warming then the "*warmer*" threshold is likely to be relevant and therefore impact the crop).

It is important to note that this type of "*threshold*" is generalized and its relevance may be determined by the way you present the climate data for your area, based on the variable or time scale. For instance, in the future, rainfall might be decreasing during the first rainy season but increasing over the entire year.

- If the future trend agrees with the threshold description (i.e. both suggest warming) then place a tick (✔) in the "*yes*" column under the *"future threshold*" heading.

- If the future trend does not agree with the threshold (i.e. one suggests wetter while the other suggests drier) then place a tick (✔) in the "*no*" column under the "*future threshold*" heading.

- If there is no obvious trend then place a tick (✔) in the "*maybe"* column under the "*future threshold*" heading.

- For each instance where there is a tick (✔) in the "*yes*" or "*maybe*" column, there is a potential negative impact for that crop and the negative impact can be identified as influencing the yield and/or quality (by the presence of a red block).

Further reading on the nature of the impact can be found in the detailed impacts section by finding the pair of the number in the "*more information*" section of the risk table.

## Impacts

**This section is used to identify which climate impacts are relevant and where to find more information within the *"detailed impacts"* section in this tool.**

- Where you have ticked "*yes*" or "*maybe*" for the "***future threshold"*** section, read across the table for the impact on yield, impact on quality and the reference for location of the detailed impacts.

- Red boxes in the '*impact on yield*" or "*impact on quality*" columns in the risk table indicate where the crop/livestock is negatively impacted by climate.
*The lack of a red box in this section indicates where the crop/livestock is not impacted or may only be negligibly impacted by climate.*

Once you have determined there to be a current or future climate impact (e.g. as a result of the current or future climate exceeding the threshold, identified as ticks in the ***"yes"*** or ***"maybe"*** columns, and therefore a red box in the impacts on yield and/or quality section), there is a number associate with the impact of exceeding that threshold in the ***"detailed information"*** column. ***The number within the "more information" box is a reference to more detailed information on the specific impact within the "detailed impacts" sections (5.1.2 to 5.7.2).***

**It is important to note the identified risk areas in the relevant sections of the FONERWA PD document and appropriately show how you are accounting for these risks in your project.** This is such that if you have identified a risk that future temperatures could negatively affect coffee production from increased incidence of antestia bug, note this in the FONERWA PD document and show how you will adapt to or mitigate against this risk.

Once you have identified what impacts are relevant for your project and therefore have identified potential risk areas, you can continue to the next section that covers the suitability of each crop across Rwanda.

## 3.3. CROP SUITABILITY

### REFER TO SECTION 8 FOR MORE INFORMATION ON THE UNDERLYING DATA IN THE SUITABILITY MAPS.

The crop suitability maps are intended to provide geographical perspective on the best potential area for growing specific crops.

As the maps do not cover the change in suitability from climate change, it is important to be aware of how this will affect your crop over time. For example, in many cases, the suitable areas for lowland crops like maize and sorghum will likely shrink with climate change so it is important to consider this when deciding on which crop to grow.

The suitability maps can therefore be used to justify your crop choice and site selection, in relation to the current climate. The maps can also be used to frame the justification for choosing particular adaptive practices.

**If a suitability map for a particular crop indicates an area as unsuitable, but appropriate practices/technologies are in place to counter the negative impacts, or local, more exact knowledge contradicts the suitability map, then the suitability map may be overruled.**

This means that the suitability map should not completely define whether a project is good or bad (climate wise), or a crop will or won't work in a specific area, as this also depends on a range of other factors like adaptation practices and farm management.

- If your project site falls in an area within a district that is not currently suitable, then you should consider another crop or another project site if appropriate adaptation/ mitigation practices and technologies are not possible, or other justification is not available for proceeding.

- If your project site falls in an area within a district where it is currently suitable, then you could continue with the crop of choice.

- For project areas larger than a district (provincial/ national) it will be important to consider how much of the area is not suitable and determine how the impact of the unsuitable areas will affect the overall success of the project.

***Note that the maps are for current suitability and will likely change in the future, resulting in some currently suitable areas becoming unsuitable, and currently unsuitable areas becoming suitable. Therefore the maps should only be used in relation to the current and historical climate and not with future climate change projections.***

After identifying the suitability of your crop for a given area, continue to Section **7** that covers a range of climate smart agriculture practices.

## 3.4. CLIMATE SMART AGRICULTURE

**After identifying the climate risks in your project, the Climate Smart Agriculture (CSA) section can help to identify potential climate smart practices that can be used to counter the negative effects of climate change.**

- The infographic in the beginning of Section 6 provides an overview of the key climate smart practices for each crop per agro-ecological zone.
- Sections **6.1** to **6.14** provide a detailed description of each practice as well as the impact of each practice in Rwanda.

**The practices identified for each crop across Rwanda in the CSA infographic are considered to be the most appropriate for a given crop, out of the entire range of practices identified in this tool.**

As such, it is important to consider how these practices will help to counter the negative impacts of current or future climate change.

For each crop you can make use of the information in Section **6** to justify the choice in agriculture practices in your project. Since the effectiveness of many practices is dependent on the local context and influencers (for instance, available technologies, finance, soil structure) it is important to identify which practices are best for your specific project and clearly state the justification for your decisions in relevant sections of the FONERWA PD document.

# 4. CLIMATE RISK CHECKLIST

## CURRENT CLIMATE INFORMATION

### QUESTION 1

**Is there any reference to the current or historical climate of the project area?**

*The current or historical climate information needs to be specific for the project site and activities. This includes specific information on temperature, rainfall and extreme events.*

**Standard Answer**

It is important to have a baseline climate for your study area, in order to help identify current and historical climate risks. Without this, it may be difficult to justify why your agricultural activity or crop/livestock is appropriate for your specific site.

**Please Circle One of the Following:**

| Adequately answered | More information required | Not applicable |
|---|---|---|

### QUESTION 1.1.

**If yes, is there consideration for temperature?**

*This includes current and historic temperatures (monthly and/or seasonal minimum, maximum and average) for a range of temperature thresholds.*

**Standard Answer**

Please account for the range of temperature variables that may be important for your activity or crop/livestock. Outside of the typical minimum, mean and maximum temperature, you may also need to account for unique thresholds like maximum temperature over 30°C or the number of days where the temperature is above a specific value. A seasonal scale is likely required for this.

**Please Circle One of the Following:**

| Adequately answered | More information required | Not applicable |
|---|---|---|

### QUESTION 1.2.

**If yes, is there consideration for rainfall?**

*This includes current and historic rainfall (annual/ monthly/seasonal amount and distribution) for a range of metrics.*

**Standard Answer**

Please account for the range of rainfall variables that may be important for your activity or crop/livestock. Outside of the typical minimum, mean and maximum rainfall, you may also need to account for unique metrics like rainfall above a specific threshold or accumulated rainfall over a period of time. A monthly and/or seasonal lens is likely required for this.

**Please Circle One of the Following:**

| Adequately answered | More information required | Not applicable |
|---|---|---|

### QUESTION 1.3.

**If yes, is there consideration for extreme events?**

*Extreme events would include heavy rainfall, drought, heat waves, frost, high winds and thunderstorms. Extreme rainfall events can lead to flooding and landslides in prone areas.*

**Standard Answer**

It is important to consider how extreme events and the attributed impact (i.e. flooding or drought) will affect your crop/livestock or activities. The threshold value for rainfall that leads to flooding and landslides should be unique to your area. Accounting for historical extreme events can give an indication of what you might have to deal with in the future. A monthly and/or seasonal lens is likely required for this.

**Please Circle One of the Following:**

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 2

### Is there a reference to the source of the climate data?

*All presented climate information should come from authentic scientifically credible sources and be referenced.*

**Standard Answer**

Climate information that does not come from a credible source may not be accurate and therefore you might be planning inappropriate activities/crops/livestock to adapt or mitigate. Similarly, if your baseline data is incorrect, it is difficult to justify site and activity choices for your project and compare with the future. Please consider discussing your data options with Meteo Rwanda.

**Please Circle One of the Following:**

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 3

### Have the historical trends been considered?

*Is there reference to whether the temperature or rainfall has been increasing, decreasing or is there no significant trend?*

**Standard Answer**

Understanding the historical trends is important as they can be used to support short-term practices either alongside or in absence of climate change information. You need to present the trends for as many climate variables as necessary for your project.

**Please Circle One of the Following:**

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 4

### Have the historical climate impact events been recorded?

*To provide learning (based on economic losses and/or how the impacts were managed) on how to best manage impacts in the face of a more severe event in future. For instance how a severe drought had led to significantly decreased maize yields and therefore affected the GDP/farmers' livelihoods.*

**Standard Answer**

It is important to show how the climate has affected crops/livestock or activities in the past so that you can justify the change (crop/livestock and/or activity) that is being proposed. In order to appropriately adapt to future climates, you need to know what has happened in the past.

**Please Circle One of the Following:**

| Adequately answered | More information required | Not applicable |
|---|---|---|

# FUTURE CLIMATE INFORMATION

## QUESTION 5

### Has future climate information been presented/considered?

*Is there any reference to climate projections for the mid-term (2050) or long-term future (2100)? The mid-term future climate is applicable for perennial crops like tea and coffee, while long-term climate is currently more applicable for bigger agriculture infrastructure projects or activities with a long lifespan.*

**Standard Answer**

It is important to understand how the climate will change in the future, especially with crops and practices that are fixed for a long lifespan. Without this, it may be difficult to show how your agricultural activity or crop/livestock is still appropriate for your specific site in the future. Appropriate climate change information can be difficult to find. You might need to engage with Meteo Rwanda or other climate centers for tailored information.

**Please Circle One of the Following:**

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 5.1.

### Are projections of future temperatures presented?

*Including future temperatures (monthly or seasonal minimum, maximum and average) for a range of metrics.*

### Standard Answer

It is important to account for the range of future temperature variables that may be relevant for your activity or crop/livestock. Outside of the typical minimum, mean and maximum temperature, you may also need to account for unique metrics like maximum temperature over 30°C or the number of days where the temperature is above a specific value. A seasonal lens is likely required for this.

The range of future model projections should be presented, as well as consideration for uncertainty. The future projections should be compared with the current climate information to show whether there is a significant difference that poses future risk or opportunity, as well as how appropriate the crops/livestock or practices will be in the future. It is important to show the future trend (i.e. whether it is likely to be warmer/wetter/drier in the future).

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 5.2.

### Are projections of future rainfall presented?

*This includes future rainfall (annual/monthly/seasonal amount and distribution) for a range of metrics.*

### Standard Answer

It is important to account for the range of future rainfall variables that may be relevant for your activity or crop/livestock.

Outside of the typical minimum, mean and maximum rainfall, you may also need to account for unique metrics like rainfall above a specific threshold or accumulated rainfall over a period of time. A seasonal lens is likely required for this.

The range of future model projections should be presented, as well as consideration for uncertainty. The future projections should be compared with the current climate information to show whether there is a significant difference that poses future risk or opportunity, as well as how appropriate the crops/livestock or practices will be in the future. It is important to show the future trend (i.e. whether it is likely to be warmer/wetter/drier in the future).

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 5.3

### Are projections of future extreme events presented?

*Future extreme events would include heavy rainfall, drought, frost, high winds and thunderstorms. This would cover the 90+ percentile ranges in the data. Extreme rainfall events can lead to flooding and landslides in prone areas.*

### Standard Answer

It is important to consider how future extreme events and the attributed impact (i.e. flooding or drought) will affect your crop/livestock or activities. The range of future model projections should be presented, as well as consideration for uncertainty. The future projections should be compared with the current climate information to show whether there is or isn't future risk, as well as how appropriate the crops/livestock or practices will be in the future. A seasonal lens is likely required for this. It is important to show the future tremnd (i.e. whether it is likely to be warmer/wetter/drier in the future).

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 6

### Is there a reference to the source of the future climate information?

*All presented future climate information should come from authentic scientific sources and be referenced.*

### Standard Answer

Climate information that does not come from a credible source may not be accurate and therefore you might be planning inappropriate activities/crops/livestock to adapt or mitigate to. Similarly, if future climate information is incorrect or misinterpreted, then you could be planning for an unrealistic future, which can have serious consequences on the success and legacy of your project.

The future climate information also needs to be appropriate for the scale of your project, such that you are not using the projections for the entire country to explain what could happen in your district.

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 7

### Has uncertainty been accounted for?

*Uncertainty is a complicated and broad topic, however it is necessary to account for the range of possibilities in the future. In this regard, it is important to consider the following:*

- *Uncertainty in the range of the future projections (i.e. some models will be suggesting a wetter future while others a drier future).*
- *Uncertainty in the global efforts to manage greenhouse gas concentrations (i.e. the 4 Representative Concentration Pathways; RCP2.6, RCP4.5, RCP6.0 and RCP8.5).*

### Standard Answer

Please clearly show the full range of climate change projections from a wide range of climate models (i.e. it is not appropriate to use the projections from only one or two models), a strong justification would need to be presented otherwise. Please justify your choice of Representative Concentration Pathway; in most cases, at least two should be used. Please indicate how the aforementioned uncertainty affects the crop and/or activities.

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 8

### Is there reference to how project activities and site selection is guided by the current climate or future climate change?

*The decision to choose one practice/crop over another is often based on a number of variables including economics, profit, market access or cultural preferences.*

*However it can also be determined by the current or future climate. Showing how a decision for site/activity/crop/ livestock is supported by the climate information is key here. E.g. irrigation and water harvesting/retention activities could be more appropriate in areas that are getting drier instead of those that are getting wetter.*

### Standard Answer

Temperature and rainfall will influence which areas are appropriate for specific crops and specific activities. Future climate change will change an area's risk to climate factors such as drought, high temperatures and rainfall, but also influence environmental factors such as flooding, erosion and landslides, disease and pest outbreaks. Therefore you should account for how the current and future climate is conducive to your crop/livestock, activity and site. Please refer to Sections 6 and 7 of the Climate Risk Screening Tool. Please highlight your identified risks in relevant sections of the PD Template.

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 9

### Does the proposed adaptation practice account for current climate risks?

*You need to demonstrate how each adaptation practice is beneficial/useful at present. This will show that the practice will have impact in the short term (now). Implementing something that is not appropriate for the future but is for the current climate will need to be strongly justified. Please refer to Section 7 of the Climate Risk Screening Tool for reference information. Please highlight your identified risks in relevant sections of the PD Template.*

### Standard Answer

You need to demonstrate how each adaptation practice is beneficial/useful at present. This will show that the practice will have impact in the short term (now). Implementing something that is not appropriate for the future but is for the current climate will need to be strongly justified. Please refer to Section 7 of the Climate Risk Screening Tool for reference information. Please highlight your identified risks in relevant sections of the PD Template.

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 10

### Does the proposed adaptation practice account for future climate risks?

*Any agricultural adaptation practice that will be used over a period of years will need to consider the effects of future climate change. For example, if the recommendation is to create water retention ponds to account for current drought/ low rainfall, if the future climate is expected to be much drier and more droughts, small-scale retention ponds may not be effective. In this case a more large-scale irrigation scheme might be necessary.*

### Standard Answer

You need to demonstrate how each adaptation practice will be beneficial/useful in the future. This should also cover the benefit of your practice in a range of climate scenarios. This will show that the practices will have impact and legacy in the long term. Please refer to Section 7 of the Climate Risk Screening Tool for reference information. Please highlight your identified risks in relevant sections of the PD Template.

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 11

### Is the linkage between the projected climate and crop performance (productivity and quality) well explained?

*An understanding of how the projected climate will affect the productivity (either directly or indirectly) should be well articulated (with reference to Climate Risk Screening Tool where possible).*

### Standard Answer

Please make use of Section 6 of the Climate Risk Screening Tool for relevant crops, as a starting point for showing relevant impact for your specific context. Please highlight your identified risks in relevant sections of the PD Template. If your crop is not presented in the tool, then please identify your climate impacts in a similar way.

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

# CLIMATE RISK AREAS (CROPS)

## QUESTION 12

### Will the proposed crops be grown in current and future suitable areas?

*If the project site falls in an area (see Sections 6.1.3 to 6.5.3) where the current conditions are unsuitable for that crop and will still be unsuitable in the future, then that crop is at risk of failing. It may then be high risk to keep using that crop unless appropriate adaptation measures are in place.*

### Standard Answer

You will need to strongly justify why a crop is being proposed for cultivation in an unsuitable area as well as show that the area will still be or may become suitable in the future (along the crop's life cycle).

### Please Circle One of the Following:

| Adequately answered | More information required | Not applicable |
|---|---|---|

## QUESTION 13

### Does the future temperature or rainfall for this crop exceed any threshold presented in the Climate Risk Screening Tool?

*If the future climate exceeds the threshold for a particular crop, then that crop is at risk of failing or having lower yields/ quality. This is especially significant if there is no appropriate adaptation practice in place.*

**Standard Answer**

If the future climate exceeds the threshold for a particular crop, then that crop is at risk of failing or having lower yields/quality. This is especially significant if there is no appropriate adaptation practice in place.

**Please Circle One of the Following:**

| | | |
|---|---|---|
| Adequately answered | More information required | Not applicable |

## QUESTION 14

**If the climate exceeds the threshold for a given crop (see Climate Risk Screening Tool), has an adaptation practice been recommended?**

*If no adaptation practice is being implemented to account for the sub-optimal climate conditions, the crop is at risk of failure or having lower yields/quality.*

**Standard Answer**

You need to clearly show how an adaptation/mitigation practice will prevent the negative impact of climate change on your selected crop(s), and therefore show how the exceeded threshold can be managed. This needs to be shown for current and future thresholds if both are exceeded.

**Please Circle One of the Following:**

| | | |
|---|---|---|
| Adequately answered | More information required | Not applicable |

# ADDITIONAL QUESTIONS

## QUESTION 15

**If irrigation is being considered in the project: Has the impact of climate on irrigation been explored?**

*In areas that are expected to become warmer in the future, some farmers may choose to plant new fields in areas of higher altitude where it is cooler and will be more suitable for certain crops in the future. For irrigation pumps, this will mean pumping water further up the hill, which typically requires a larger motor or a new system. Therefore it is important to consider how climate change will influence newly planted areas and thus what pump is needed to accommodate the new areas.*

**Standard Answer**

It is important to consider how climate change will influence newly planted areas, and thus the type of pump systems that are needed to accommodate the new areas. This could introduce additional costs and if not done correctly, can mean that the irrigation system may not be completely useful for its original intention.

**Please Circle One of the Following:**

| | | |
|---|---|---|
| Adequately answered | More information required | Not applicable |

# 5. CROP & LIVESTOCK SPECIFIC INFORMATION

**This section contains detailed climate impact and crop suitability information for coffee, tea, banana, maize, beans, sorghum and livestock. The information in this section can be used as a resource base for understanding and identifying climate risks in relevant crops and livestock.**

# 5.1. COFFEE

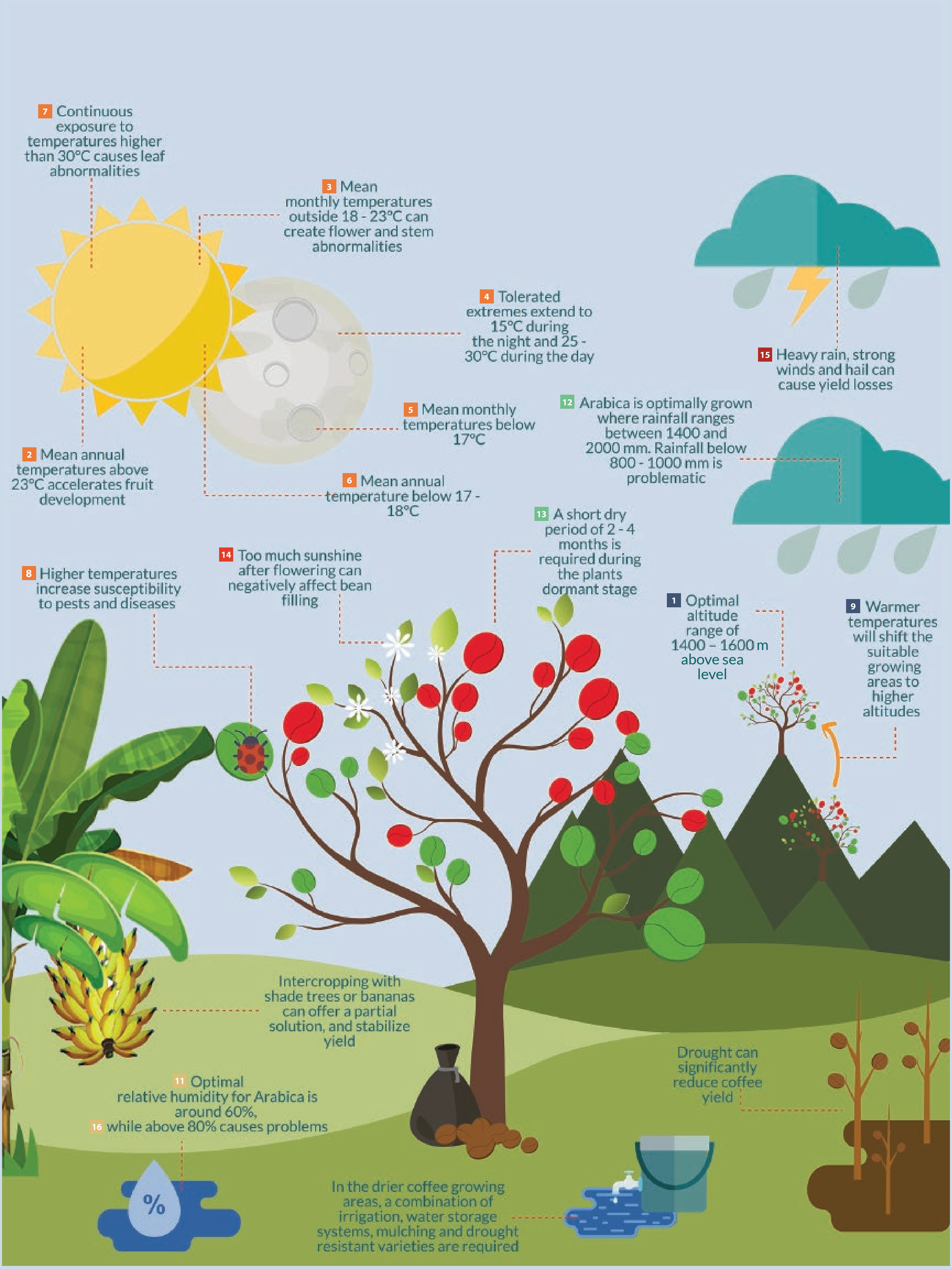
**Lead Author:** Julio Araujo

**Contributing Authors:** , Nkulumo Zinyengere, Zablone Owiti

**Disclaimer:**

This information should only be used as a reference for identifying and justifying areas of risk, and not to be absolute for all contexts. Since the suitability map does not factor in soil properties, it is important to note that the map is indicative of a crop's suitability to the climate, and not the climate and environment. Since a crop could be well suited to the climate but not the soil or vice versa, it is more indicative of potential suitability and is only accurate over an area if the soil is similarly suitable. For more information, please refer to ANNEX 2.

## 5.1.1. INFOGRAPHIC



# 5.1.2. DETAILED IMPACTS

**1 Rising temperatures and lower rainfall can negatively impact coffee-growing areas. Warmer temperatures will shift the suitable growing areas to higher altitudes. 2 While high temperature boosts yield significantly, it degrades bean quality due to accelerated development and ripening of fruits, resulting in losses for smallholder farmers.**

3 Similarly, high temperatures lead to abnormalities in stems and flowers, abortion of leaves on the plants, and lower yield and quality of the bean.. 4 High temperatures during the day or night can cause heat stress on coffee trees. This negatively impacts the coffee trees' ability to produce food, resulting in a drop in yields. 5 6 Low temperatures, also affect coffee, such that it can cause cellular damage, longer germination period and depressed growth, leading to lower yields and reduced bean quality. Using shade netting to protect the crop from high temperatures can be effective, but may only be financially accessible to the larger-scale farms. Intercropping with shade trees or bananas can offer a partial solution, and stabilise yield. Whereas this allows coffee cultivation at relatively lower altitudes, the temperatures can still be too high, pushing farmers to shift their planting to higher altitudes.

**7 Exposure to a high number of consecutive hot days leads to more abnormalities such as yellowing of the leaves and growth of tumours at the base of the stem, and subsequently a drop in yield and berry quality. Coffee grown at lower altitudes or that are not shaded, where the temperatures are typically higher, are more susceptible to this.**

Higher temperatures increase susceptibility to pests and diseases in the coffee growing areas. 8 Coffee leaf rust (CLR) and coffee berry borer (CBB) prefer warmer temperatures and almost always lead to a yield and/or bean quality loss whenever they attack. 9 The incidence of these pests and diseases is higher at lower altitudes where it is typically warmer. Shading or shifting coffee planting to higher altitudes where it is cooler mitigates the impact of CLR and CBB.

10 Higher temperatures and lower rainfall can result in greater occurrence of dry conditions that cause weakening and wilting, especially of young plants. Weakening and wilting of coffee trees causes yield fluctuations and often results in a yield loss, as well as death of young plants. 11 Dry conditions can sometimes lead to lower humidity that causes the plants to lose more moisture and can lower the yield. 12 Low rainfall is not good for coffee growth, even if it is well distributed.

It typically leads to a drop in yield and can cause complications for scheduling cultivation practices and harvesting. Irrigating from water sources along steep slopes require strong pumps and quality systems that are usually expensive. In the drier coffee growing areas, a combination

| CLIMATE THRESHOLD COLOUR LEGEND |
|---|
| Temperature |
| Humidity |
| Rainfall |
| Extreme Events |
| Altitude |
| Drought |
| Solar Radiation |

1 Arabica coffee typically grows between 1200 - 1950 m, optimal altitude range of 1400 - 1600 m in 2011. Potential shift to 1600 - 1800 m by 2050
2 Mean annual temperatures above 23°C
3 Mean monthly temperatures outside 18 - 23°C
4 Tolerated extremes extend to 15°C during the night and 25 - 30°C during the day
5 Mean monthly temperatures below 17°C
6 Mean annual temperature below 17 - 18°C
7 Continuous exposure to temperatures higher than 30°C
8 Warmer = pests
9 Lower altitude

of irrigation, water storage systems, mulching and drought resistant varieties are required.

**However, hot and dry conditions can also be beneficial. Higher night temperatures reduce the occurrence of frost and its associated damage; reducing incidences of burned beans, and bud and flower deaths. Similarly, depressed growth, damage to plant cells and a longer germination period, which typically reduce yield, are increasingly less common in warmer conditions.**

13 The distribution of rainfall for coffee growth is critical. High rainfall throughout the year is often responsible for scattered harvests and lower yields. As such, a short dry period between rains is important, especially during the plants dormant period.

However, when rains are not well distributed throughout the season, flowering can happen continuously. This requires farmers to harvest coffee throughout the year and not at distinct periods. 14 Too much sunshine after flowering affects bean filling negatively and leads to low quality and quantity yield.

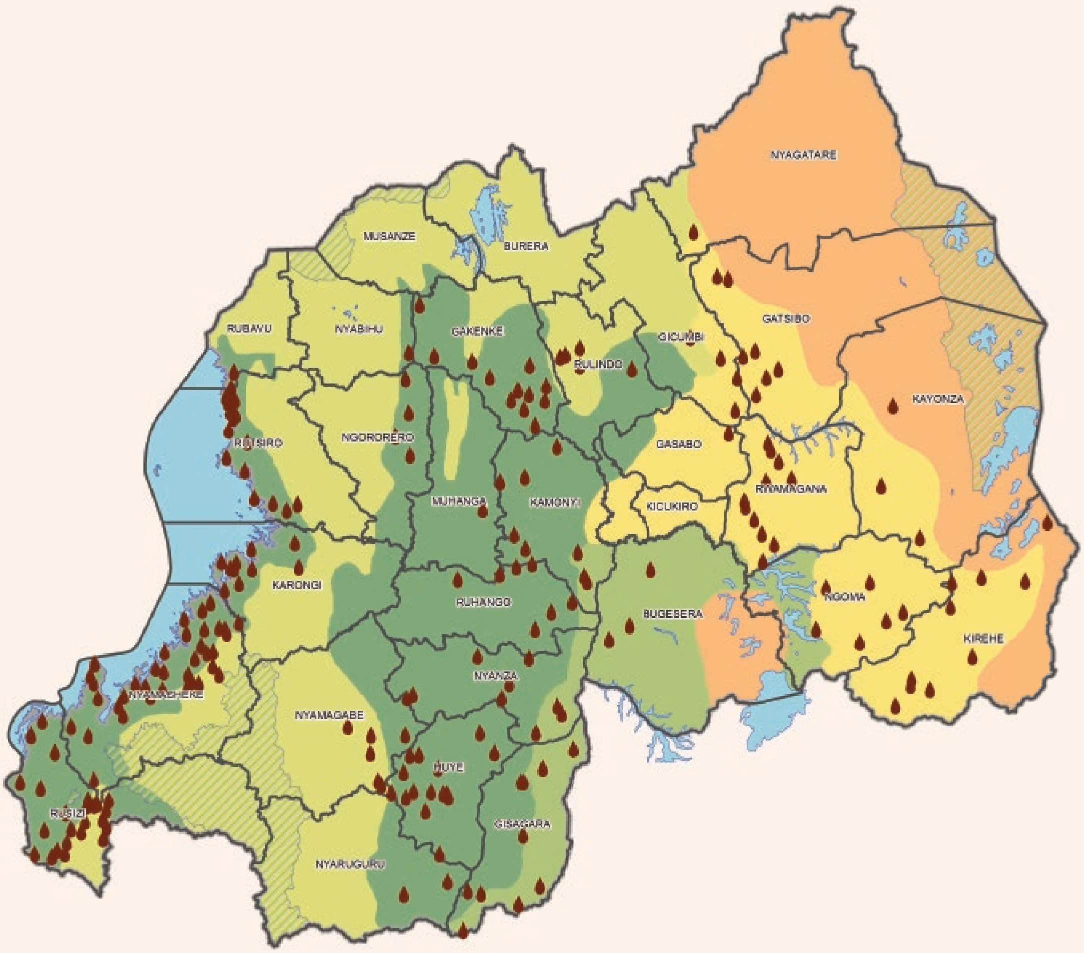
15 Heavy rain, strong winds and hails all result in physical damage to the coffee tree. The physical damage as well as increased shedding of developing flowers and fruits can result in a lower yield. Windbreaks and tree shelter can help to minimise the damage. 16 While high levels of humidity will reduce water loss by the plants, too high humidity will often lead to a lower quality crop.

10 Warmer & drier
11 Optimal relative humidity for Arabica is around 60%
12 Arabica is optimally grown where rainfall ranges between 1400 and 2000 mm
Rainfall below 800 - 1000 mm is problematic
13 A period of little to no rainfall lasting 2 - 4 months
14 High sunshine
15 Heavy rain, strong wind & hail
16 Relative humidity above 85%

# 5.1.3. CROP SUITABILITY

## CLIMATE SUITABILITY FOR ARABICA COFFEE

Rwandan coffee tends to perform well in the middle altitude areas that have an ample supply of rain. Areas that are known to provide optimal conditions for coffee cultivation include the central to western areas such as the Impara and in the Central Plateau agro-ecological zones. Towards the east where the rainfall is lower, often results in a reduction to suitability, therefore areas like the Eastern Savanna and Central Bugesera are moderately to marginally suitable.




**CLIMATE SUITABILITY**

- High
- High to moderate. Limitation: Rainfall
- Moderate to marginal. Limitation: Altitude
- Moderate to marginal. Limitation: Rainfall
- Marginal to unsuitable. Limitation: Rainfall

**LEGEND**

- Coffee Washing Stations
- Lakes
- National Parks
- Districts
- Boundary of Rwanda

# 5.1.4. RISK TABLE

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the key climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| | | TEMPERATURE | >23°C (mean annual) | | | | | | | | | | ■ | 2 |
| | | | >18 - 23°C (mean monthly) | | | | | | | | | ■ | ■ | 3 |
| | | | >15°C (daily minimum) | | | | | | | | | ■ | | 4 |
| | | | 25 - 30°C (daily maximum) | | | | | | | | | ■ | | 4 |
| | | | >3 days with temps higher than 30°C | | | | | | | | | ■ | ■ | 7 |
| | | | <17°C (mean monthly) | | | | | | | | | ■ | ■ | 5 |
| | | | <17°C (mean annual) | | | | | | | | | ■ | ■ | 6 |
| | | | Warmer = pests | | | | | | | | | ■ | ■ | 8 and 9 |
| | | RAINFALL | >1400 mm | | | | | | | | | ■ | | 12 |
| | | | Dry Period (2 - 4 months) | | | | | | | | | ■ | | 13 |
| | | ALTITUDE | <1400 - 1600 mm | | | | | | | | | ■ | ■ | 1 |
| | | | Lower altitude | | | | | | | | | ■ | ■ | 9 |
| | | DROUGHT | Warmer & drier | | | | | | | | | ■ | | 10 |
| | | EXTREME EVENTS | Heavy rain, strong wind & hail | | | | | | | | | ■ | | 15 |
| | | HUMIDIDTY | <60% | | | | | | | | | ■ | | 11 |
| | | | >85% | | | | | | | | | | ■ | 16 |
| | | SOLAR RADIATION | High sunshine | | | | | | | | | ■ | ■ | 14 |

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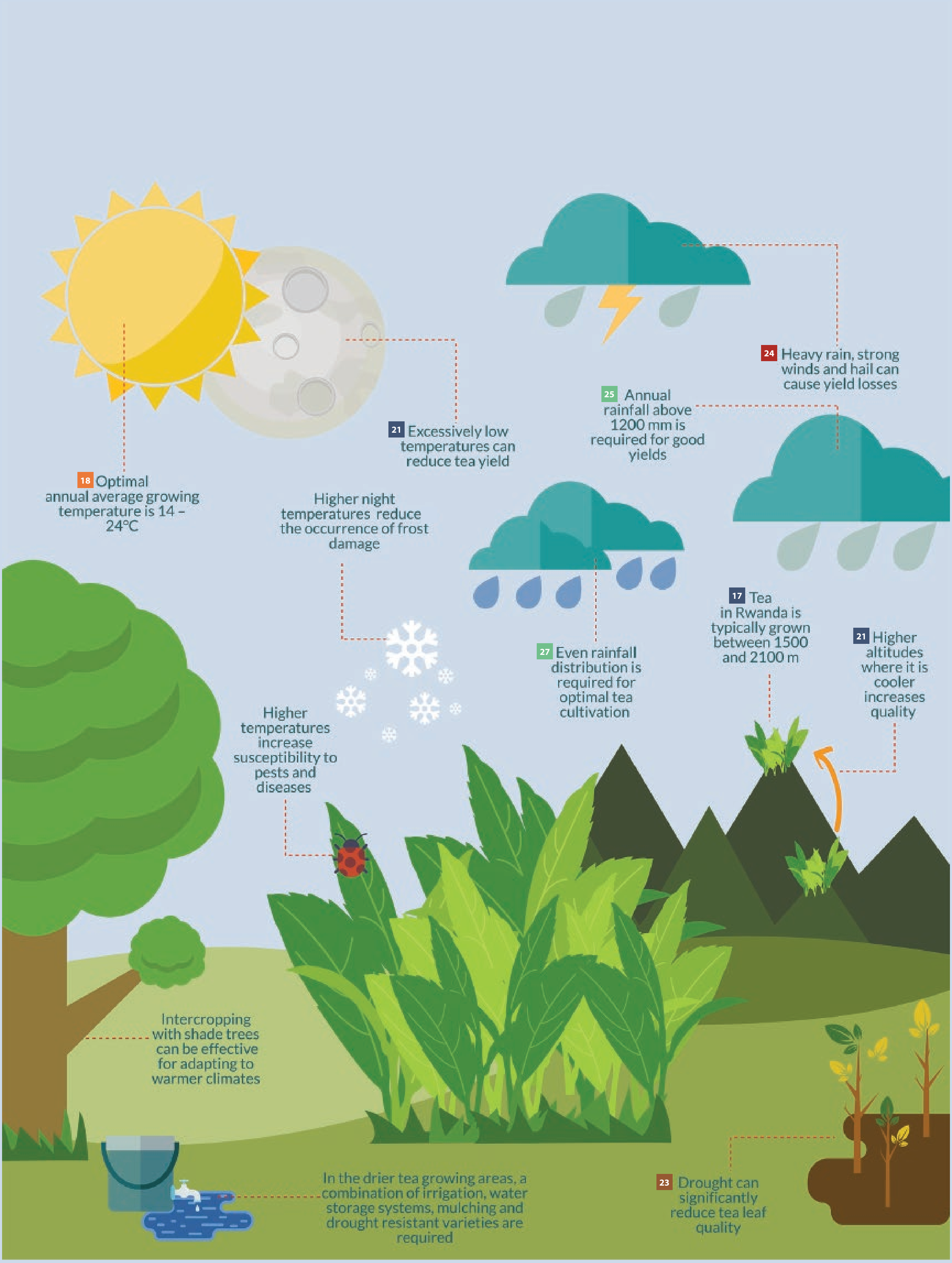
**Lead Author:** Julio Araujo

**Contributing Author:** Zablone Owiti

**Disclaimer:**

This information should only be used as a reference for identifying and justifying areas of risk and not to be absolute for all contexts. Since the suitability map does not factor in soil properties, it is important to note that the map is indicative of a crop's suitability to the climate, and not the climate and environment. Since a crop could be well suited to the climate but not the soil or vice versa, it is more indicative of potential suitability and is only accurate over an area if the soil is similarly suitable. For more information, please refer to ANNEX 2.

# 5.2.1. INFOGRAPHIC



# 5.2.2. DETAILED IMPACTS

**High temperatures and low rainfall are known to negatively affect tea production in Rwanda. 17 Since tea is sensitive to changes in temperature, warmer temperatures will shift the suitable growing areas to higher altitudes. 18 Tea is grown within a specific temperature range, outside of which the quality and yield are affected.**

High temperatures are known to reduce the available space for growing tea, especially as potential growing areas at higher altitudes are limited. 19 High temperatures also cause sun damage to the tea leaves, which result in a loss of quality. There is a relationship between temperature, altitude, tea quality (flavor and grade) and tea yields. 20 At lower altitudes, the temperature is warmer, which causes the leaf tips to grow faster, resulting in a higher yield but a lower quality.

21 Similarly the opposite occurs at higher altitudes. This means that tea grown in warm (low altitude) areas tend to fetch a lower price at the international markets than tea grown in cooler (higher altitude) areas. Higher temperatures in the future will mean that high quality tea will not be grown where it currently is today, and new planting will need to be at higher elevations where the increase in temperature is less.

22 High temperatures also tend to result in drying of the soils and increased chances of erosion, both of which result in yield losses. 23 Low rainfall, either by itself or in conjunction with high temperatures, can result in reduced water content of the tea crop, which results in a lower quality leaf. Potential ways of adapting to higher temperatures and lower rainfall is by using shade trees, new tea clones, conservation farming and mulching.

**Higher night temperatures can also be beneficial as it reduces the occurrence of frost and its associated damage. Higher temperatures in the future will therefore reduce the risk of frost, therefore allowing tea to be grown in previously frost prone areas.**

Extreme weather events such as hail, storms, floods and landslides can significantly affect tea production. 24 Extreme events tend to physically damage the tea plants, causing a drop in both yield and quality.

High levels of rainfall can reduce soil fertility, removing the critical nutrients needed by tea plants and causing extra costs to the farmers through additional fertilization. Making use of composting, mulching and/or conservation farming can help to minimize the negative effects of reduced soil fertility. Similarly cover crops can be used to reduce the damage caused by extreme weather events.

Tea also requires a certain rainfall level distributed evenly throughout the year. 25 High season variability can lead to problems especially if the annual rainfall is not high enough. 26 New tree plants are generally planted during the "short rains", but if it is too dry, then planting has to be delayed, and this has an impact on the seedlings. For mature plants, the expected period of rainfall during the short rains is associated with fertilizer application.

27 If there is either no rain, or that which falls is too much or too heavy, then fertilizer cannot be applied. This affects both quality and quantity (i.e. the leaves are not tender enough).

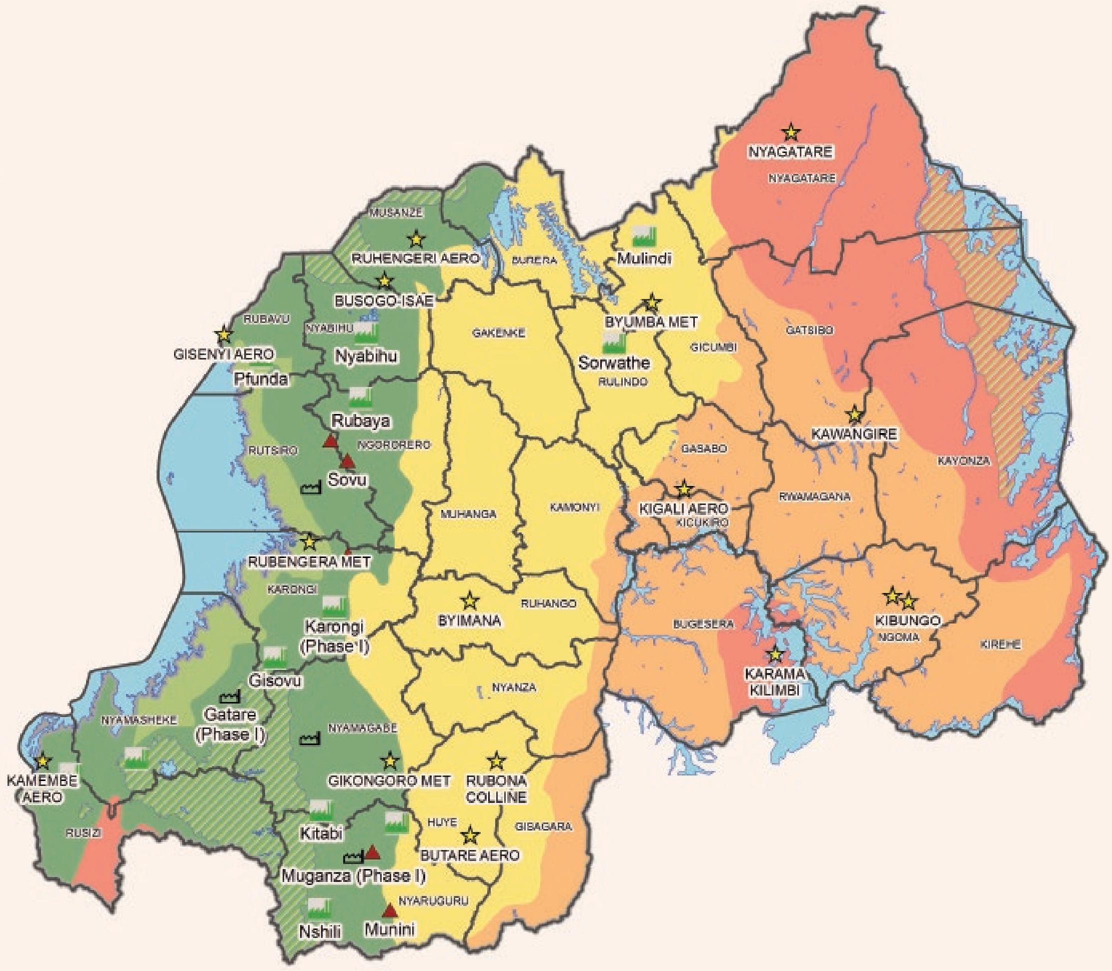
| CLIMATE THRESHOLD COLOUR LEGEND |
|---|
| Temperature |
| Rainfall |
| Extreme Events |
| Altitude |
| Drought |

17 Tea in Rwanda is typically grown between 1500 and 2100 m
18 Optimal annual average growing temperature is 14 - 24°C
19 Warmer 1
20 Lower altitude
21 Higher altitude
22 Warmer 2
23 Warmer & drier
24 Hail & heavy rain
25 Annual rainfall above 1200 mm
26 Rainfall period from the end of September to end of December
27 High variable rainfall

# 5.2.3. CROP SUITABILITY

## CLIMATE SUITABILITY FOR TEA

Tea can be considered as a crop that requires high rainfall with relatively cool temperatures. As such the wetter areas of Rwanda like Impara, the Congo-Nile Watershed Divide, the Birunga and the Kivu Lake Borders tend to provide optimal conditions for tea cultivation. Conversely, the lower drier areas such as Mayaga, Bugesera, Eastern Plateau and Eastern Savanna are considered to be marginal to unsuitable.




**LEGEND**

**CLIMATE SUITABILITY**

- High
- High to moderate. Limitation: Rainfall
- Moderate to marginal. Limitation: Altitude
- Moderate to marginal. Limitation: Rainfall
- Marginal to unsuitable. Limitation: Rainfall
- Unsuitable. Limitation: Rainfall

- Under Construction
- Factory
- Metro Stations
- Identified Site
- Lakes
- National Parks
- Districts
- Boundary of Rwanda

# 5.2.4. RISK TABLE

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the key climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| | | TEMPERATURE | <14°C (annual average) | | | | | | | | | | | 18 and 20 |
| | | | >24 °C (annual average) | | | | | | | | | | | 18 and 21 |
| | | | Warmer 1 | | | | | | | | | | | 19 |
| | | | Warmer 2 | | | | | | | | | | | 22 |
| | | RAINFALL | Rainfall period from the end of September to end of December | | | | | | | | | | | 26 |
| | | | High variable rainfall | | | | | | | | | | | 27 |
| | | ALTITUDE | <1500 - 2100 m | | | | | | | | | | | 17 |
| | | | Lower | | | | | | | | | | | 20 |
| | | | Higher | | | | | | | | | | | 21 |
| | | DROUGHT | Warmer & drier | | | | | | | | | | | 23 |
| | | EXTREME EVENTS | Hail & heavy rain | | | | | | | | | | | 24 |

# 5.2.5. REFERENCES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# 5.3. BANANA

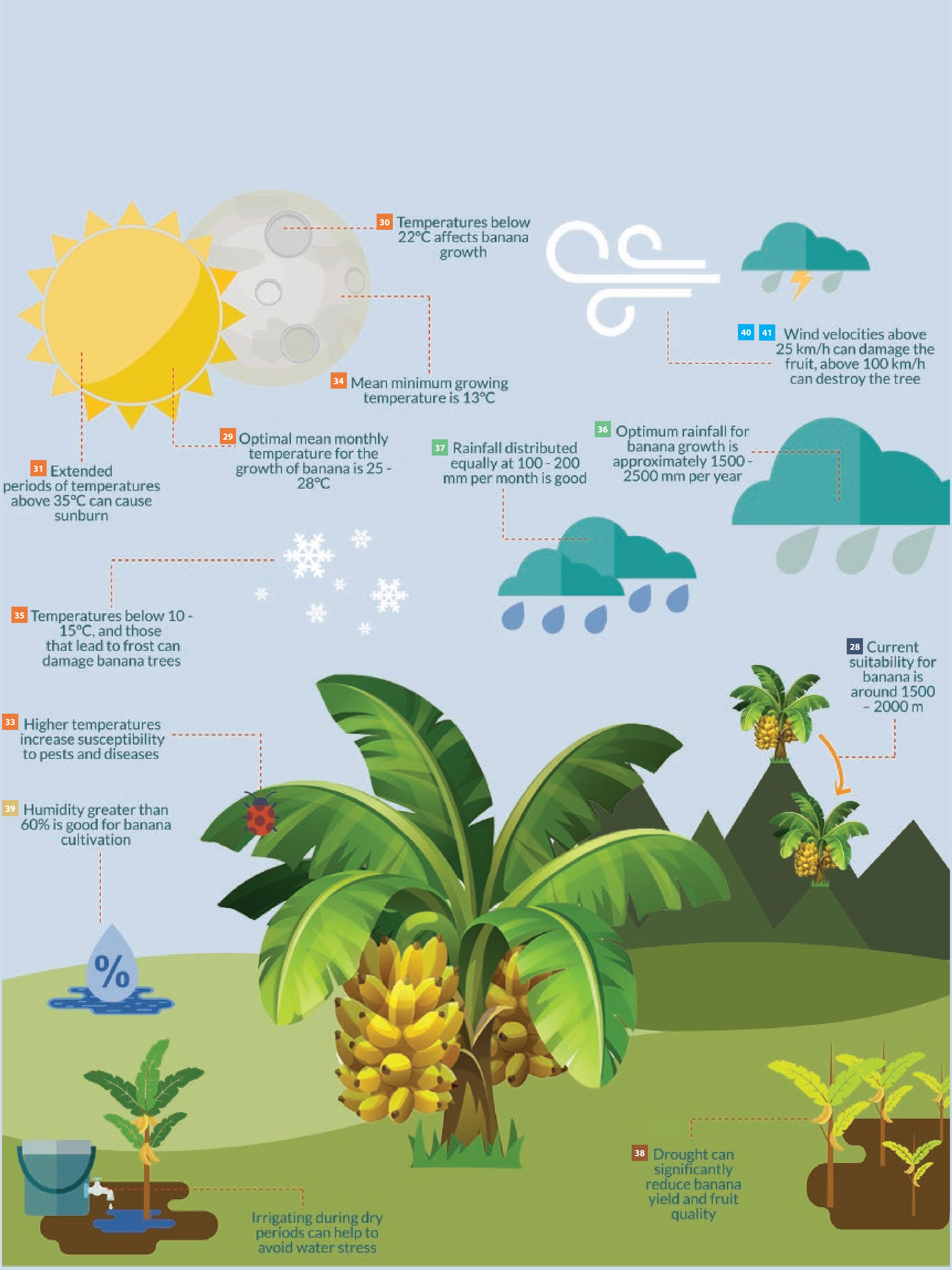
**Lead Author:** Julio Araujo

**Contributing Author:** Nkulumo Zinyengere

**Disclaimer:**

This information should only be used as a reference for identifying and justifying areas of risk and not to be absolute for all contexts. Since the suitability map does not factor in soil properties, it is important to note that the map is indicative of a crop's suitability to the climate, and not the climate and environment. Since a crop could be well suited to the climate but not the soil or vice versa, it is more indicative of potential suitability and is only accurate over an area if the soil is similarly suitable. For more information, please refer to ANNEX 2.

# 5.3.1. INFOGRAPHIC



# 5.3.2. DETAILED IMPACTS

**28 Banana mostly grows in the low-lying areas of Rwanda, where it is typically warmer. 29 30 Relatively high temperatures are usually good for bananas, while relatively cool temperatures often result in reduced growth. 31 High temperatures, especially when occurring over an extended period of time, often result in sunburn on the exposed fruit and cause a drop in the quality and quantity of yield.**

32 High temperatures also increase the risk of abandoning banana cultivation as a result of the impact on other crops. Consequently, banana is often cultivated as a secondary crop to the likes of coffee. Since high temperatures are beneficial to banana but not to coffee, extreme temperatures in the future could cause some farmers to abandon banana if they abandon coffee. 33 Higher temperatures will also result in the proliferation of pests and diseases, such as black leaf streak and banana bunch top virus, both of which reduce the quality and quantity of the yield.

**Growing banana at higher altitudes and lower temperatures can have serious implications for fruit development. 34 35 Low temperatures delay maturity and leaf emission (lengthening the period of bunch maturity) and lead to malformation of bunches, affecting the size and shape of the bunch and therefore yield. Low temperatures also increase the risk of frost, which damages the plant tissue and distorts flowering and the fullness of banana bunches.**

36 37 Good rainfall distributed evenly throughout the year is optimal to banana growth, however cultivating in an area with a well pronounced dry season is also tolerated. 38 Since banana prefers a good amount of rainfall, drought often leads to a reduction in yield and fruit quality. A slowed rate of leaf emergence, smaller bunch sizes (if this occurs during or after flowering), and increased length of the vegetative period (retarded growth) are all common under drought conditions. 39 In addition, banana trees prefer being planted in areas with relatively high humidity. Using or increasing irrigation during drought periods can help to avoid water stress and minimize the negative effects.

40 Strong winds affect the production of banana and often result in a yield loss. This is especially significant when pests and diseases (nematode *Radopholus similis*) weaken the roots. Strong winds can break and/or uproot the banana "trunk" as well as tear the leaves. 41 Excessively high winds are known to completely destroy the tree. Planting suitable trees as wind breaks can minimize the damage caused by strong winds.

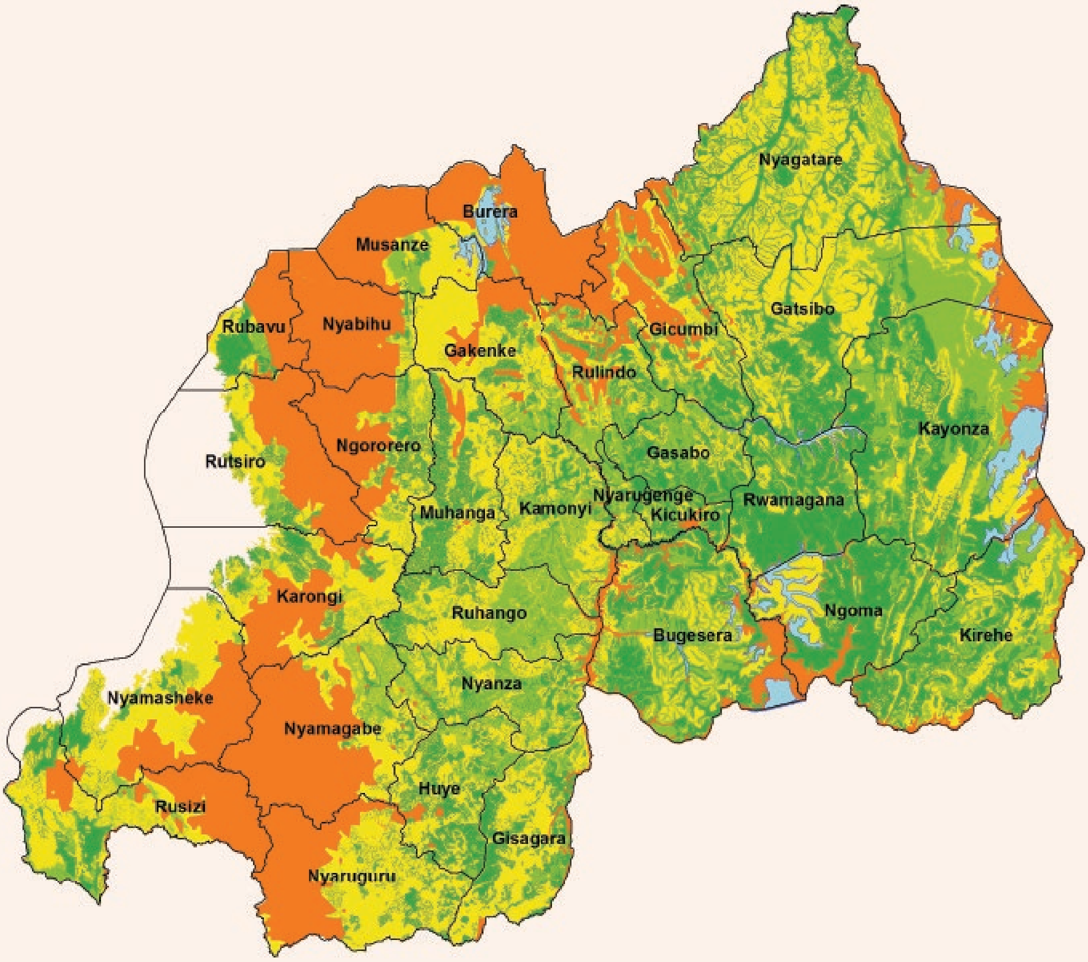
| CLIMATE THRESHOLD COLOUR LEGEND |
| --- |
| Temperature |
| Humidity |
| Rainfall |
| Altitude |
| Drought |
| Wind |

28 Current suitability for banana is around 1500 - 2000 m
29 The optimal mean monthly temperature for the growth of banana is 25 - 28°C
30 Temperatures below 22°C
31 Extended periods of temperatures above 35°C
32 Warmer 1
33 Warmer 2
34 Mean minimum growing temperature is 13°C
35 Temperatures below 10 - 15°C
36 Optimum rainfall for banana growth is approximately 1500 - 2500 mm per year
37 Rainfall distributed equally at 100 - 200 mm per month is good
38 Warmer & drier
39 Greater than 60%
40 Wind velocities above 25 km/h
41 Wind speeds above 100 km/h

# 5.3.3. CROP SUITABILITY

## CLIMATE SUITABILITY FOR BANANA

Banana tends to perform well in the warm and sub-humid agro-climatic zones of the Imbo and the Mayaga and the Peripheral Bugesera. Similarly, good growing conditions can be found along the Kivu Lake border. Conversely the cooler areas such as the highlands tend to be accompanied by unsuitable conditions for banana cultivation. Some areas to the East where the rainfall is too low, reduces suitability for banana, such as the Eastern Savanna.



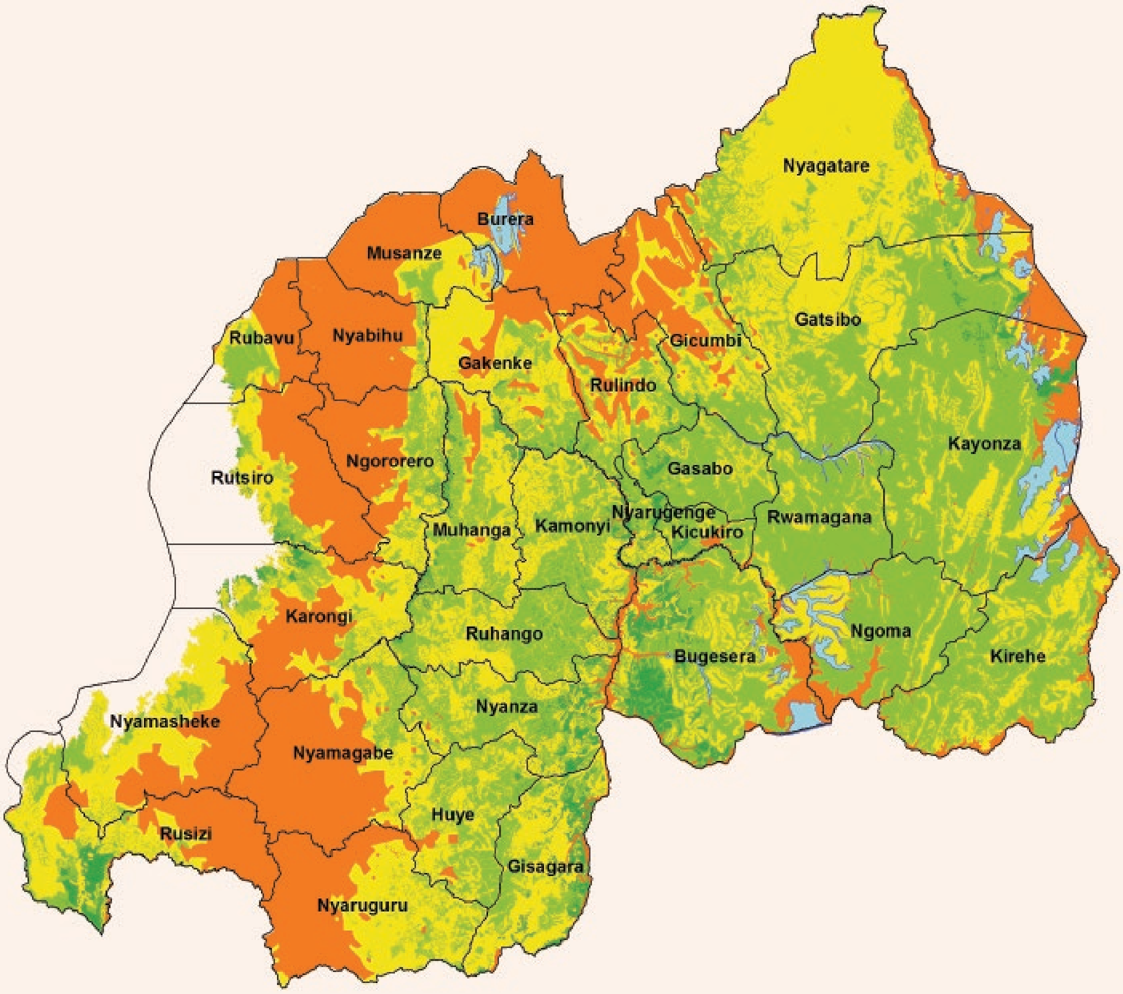

## SUITABILITY CLASSES OF BANANA IN SEASON A (SEPTEMBER TO JANUARY)

**CLIMATE SUITABILITY**

- High Suitability
- Moderate Suitability
- Marginal Suitability
- Currently Not Suitable
- Permanently Not Suitable

**LEGEND**

- Lakes
- National Parks
- Districts
- Boundary of Rwanda




# SUITABILITY CLASSES OF BANANA IN SEASON B (FEBRUARY TO JUNE)

## CLIMATE SUITABILITY

- High Suitability
- Moderate Suitability
- Marginal Suitability
- Currently Not Suitable
- Permanently Not Suitable

## LEGEND

- Lakes
- National Parks
- Districts
- Boundary of Rwanda

# 5.3.4. RISK TABLE

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the key climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| | | TEMPERATURE | <25 - 28°C (mean monthly) | | | | | | | | | | | 29 |
| | | | <22°C (mean monthly) | | | | | | | | | | | 30 |
| | | | >35°C (mean monthly) | | | | | | | | | | | 31 |
| | | | <10 - 15°C ( mean monthly) | | | | | | | | | | | 35 |
| | | | >13°C (mean monthly) | | | | | | | | | | | 34 |
| | | | Warmer 1 | | | | | | | | | | | 32 |
| | | | Warmer 2 | | | | | | | | | | | 33 |
| | | RAINFALL | <1500 - 2500 mm (annual total) | | | | | | | | | | | 28 |
| | | | <100 - 200 mm per month | | | | | | | | | | | 37 |
| | | ALTITUDE | >1500 - 2000 m | | | | | | | | | | | 36 |
| | | DROUGHT | Warmer & drier | | | | | | | | | | | 38 |
| | | HUMIDIDTY | >60% | | | | | | | | | | | 39 |
| | | WIND | >25 km/h | | | | | | | | | | | 40 |
| | | | >100 km/h | | | | | | | | | | | 41 |

# 5.3.5. REFERENCES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# 5.4. MAIZE

**Lead Author:** Julio Araujo

**Contributing Author:** Nkulumo Zinyengere

**Disclaimer:**

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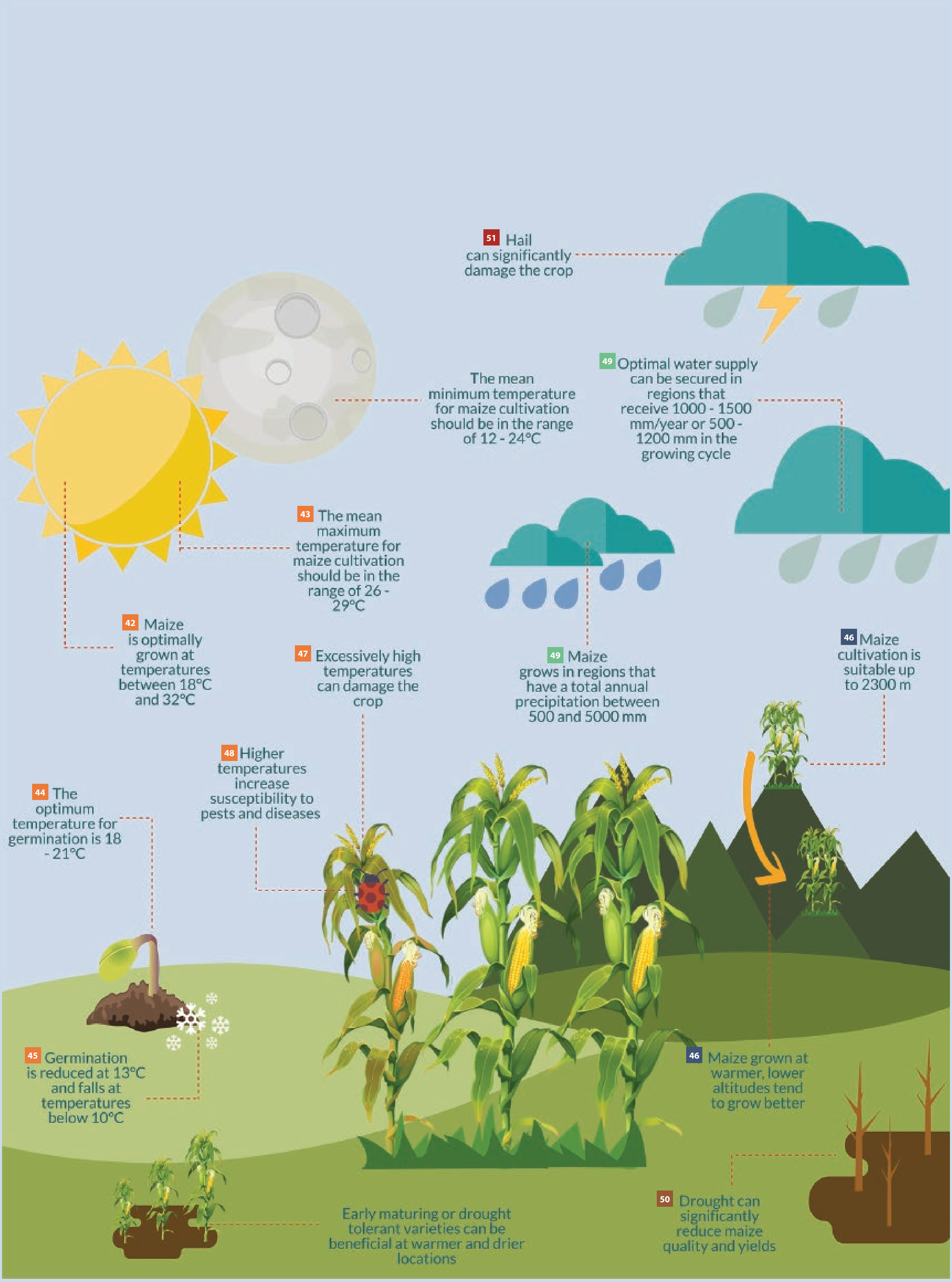
## 5.4.1. INFOGRAPHIC



# 5.4.2. DETAILED IMPACTS

**Maize is impressively tolerant to a wide range of environmental conditions and can grow in most areas of Rwanda. 42 Warm temperatures tend to be beneficial to growth and promote good yields. 43 Changes in daytime and/or night time temperatures can affect the quality and quantity of yield.**

44 45 Cool temperatures or growing maize at high altitude affects the ability of the plant to grow from a seed, therefore affecting its growth and eventual quality and quantity of yield. 46 As such, maize grown at low altitude tends to perform better in Rwanda. 47 Depending on the type of maize being grown, excessively high temperatures can damage the internal processes in the plant, resulting in a yield drop.

**48 High temperatures can also lead to an increased occurrence of existing pests and diseases, as well as the potential for new pests to become present. Pests and diseases almost always lead to a drop in quality and yield, and are often expensive to treat. Additional pesticides (if accessible) are costly and can significantly increase the financial stress and burden on farmers.**

49 Maize can grow in areas with a wide rainfall range, as long as the rainfall is distributed correctly during its growth. Maize tends to perform better in the central plateau area of Rwanda, where the rainfall is typically higher.

50 As such, drought and typically low rainfall areas tend to have low yields and struggle with the production of quality maize. Using early maturing varieties, practicing conservation agriculture (CA) and drought tolerant varieties can help to reduce the negative effects associated with drought. In certain cases, switching from maize to more drought and heat tolerant crops such as sorghum and millet might be preferable.

51 Extreme events such as hail can significantly damage the crop and result in a loss of yield.

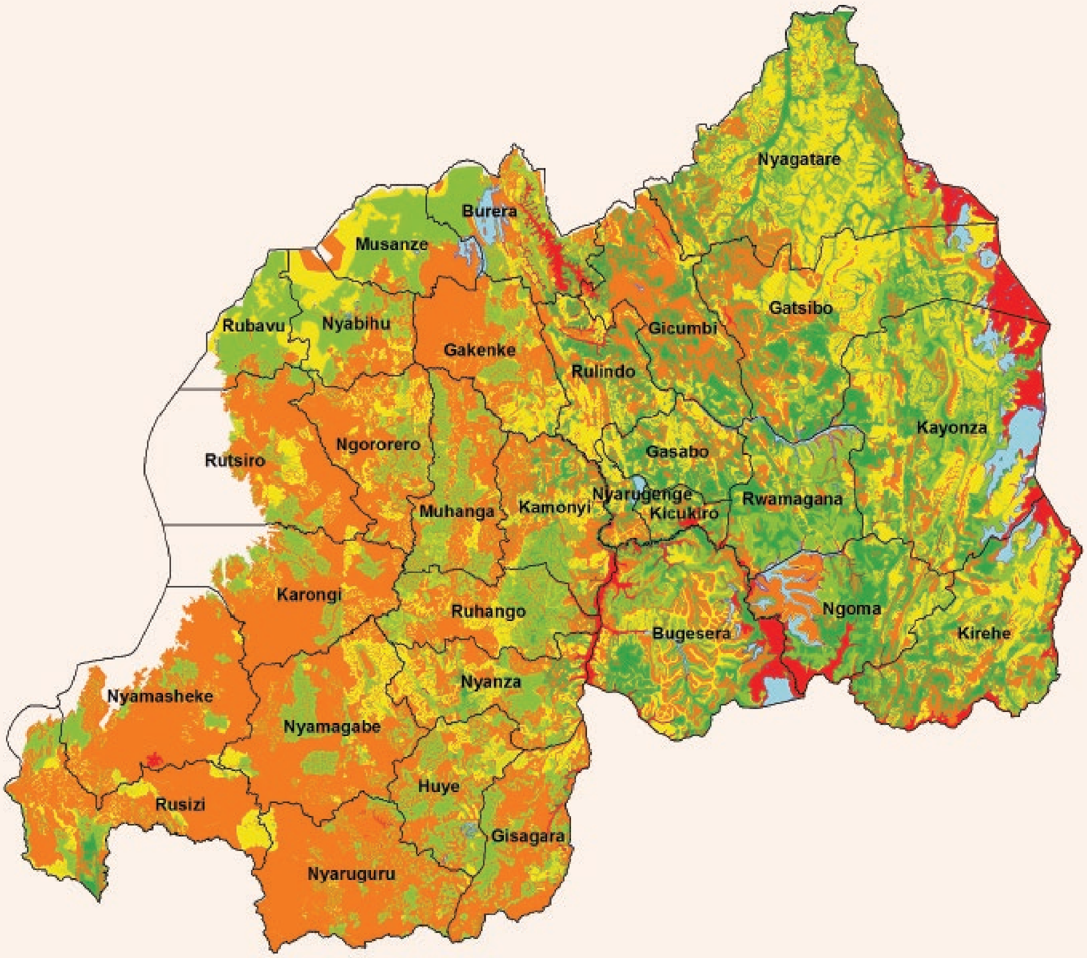
| CLIMATE THRESHOLD COLOUR LEGEND |
|---|
| Temperature |
| Rainfall |
| Extreme Events |
| Altitude |
| Drought |

42 Maize grows in the temperature range of 14 - 40°C, however it is optimally grown at temperatures between 18°C and 32°C.
43 The mean minimum temperature should be in the range of 12 - 24°C, while the mean maximum temperature should be in the range of 26 - 29°C.
44 The optimum temperature for germination is 18 - 21°C
45 Germination is reduced at 13°C and falls at temperatures below 10°C
46 Maize cultivation is suitable up to 2300 m
47 Excessively warmer
48 Warmer
49 Maize grows in regions that have a total annual precipitation between 500 and 5000 mm, however an optimal water supply can be secured in regions that receive 1000 - 1500 mm/year or 500 - 1200 mm in the growing cycle.
50 Warmer & drier
51 Hail

# 5.4.3. CROP SUITABILITY

## CLIMATE SUITABILITY FOR MAIZE

Maize tends to be more suitable in the low lying areas of the Birunga, Eastern Savanna, Imbo and the wetter parts of the Eastern Plateau. As such, maize suitability tends to be higher in the eastern parts of Rwanda, provided that there is enough rainfall, and marginally suitable to not suitable in the central and South Western areas.



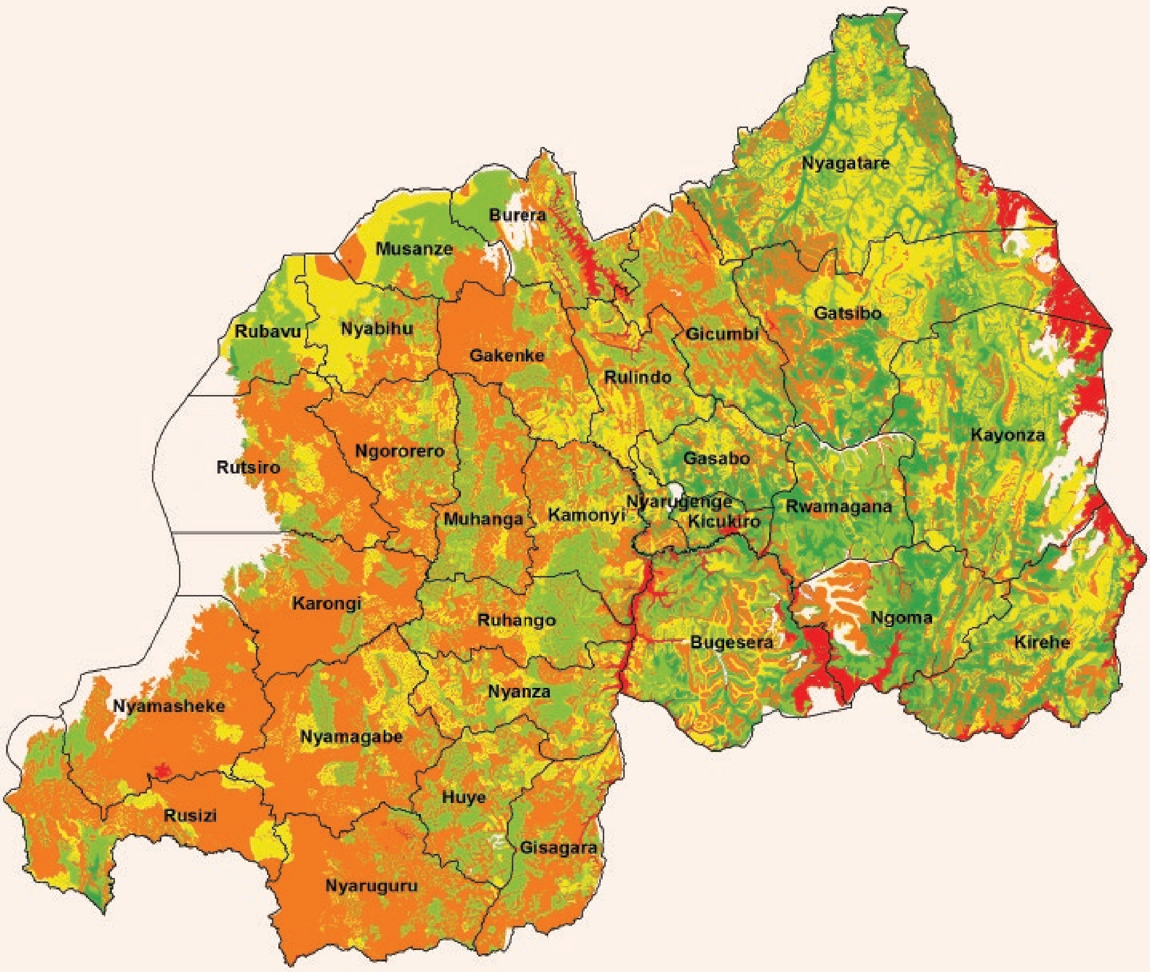

## SUITABILITY CLASSES OF MAIZE IN SEASON A (SEPTEMBER TO JANUARY)

**CLIMATE SUITABILITY**

- High Suitability
- Moderate Suitability
- Marginal Suitability
- Currently Not Suitable
- Permanently Not Suitable

**LEGEND**

- Lakes
- National Parks
- Districts
- Boundary of Rwanda




## SUITABILITY CLASSES OF MAIZE IN SEASON B (FEBRUARY TO JUNE)

### CLIMATE SUITABILITY

- High Suitability
- Moderate Suitability
- Marginal Suitability
- Currently Not Suitable
- Permanently Not Suitable

### LEGEND

- Lakes
- National Parks
- Districts
- Boundary of Rwanda

# 5.4.4. RISK TABLE

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | DETAILED IMPACTS |
| | | TEMPERATURE | <18°C (mean annual) | | | | | | | | | | | 42 |
| | | | >32°C (mean monthly) | | | | | | | | | | | 42 |
| | | | <12 - 24°C (mean minimum monthly) | | | | | | | | | | | 43 |
| | | | >26 - 29°C (mean maximum monthly) | | | | | | | | | | | 43 |
| | | | <18 - 21°C (mean monthly) | | | | | | | | | | | 44 |
| | | | <10 - 13°C | | | | | | | | | | | 45 |
| | | | Excessively warmer | | | | | | | | | | | 47 |
| | | | Warmer | | | | | | | | | | | 48 |
| | | RAINFALL | <1000 - 1500 mm/year | | | | | | | | | | | 49 |
| | | DROUGHT | Warmer & drier | | | | | | | | | | | 46 |
| | | ALTITUDE | <2300 m | | | | | | | | | | | 50 |
| | | EXTREME EVENTS | Hail | | | | | | | | | | | 51 |

# 5.4.5. REFERENCES

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# 5.5. BEANS

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**Contributing Authors:** Zablone Owiti, Nkulumo Zinyengere

**Disclaimer:**

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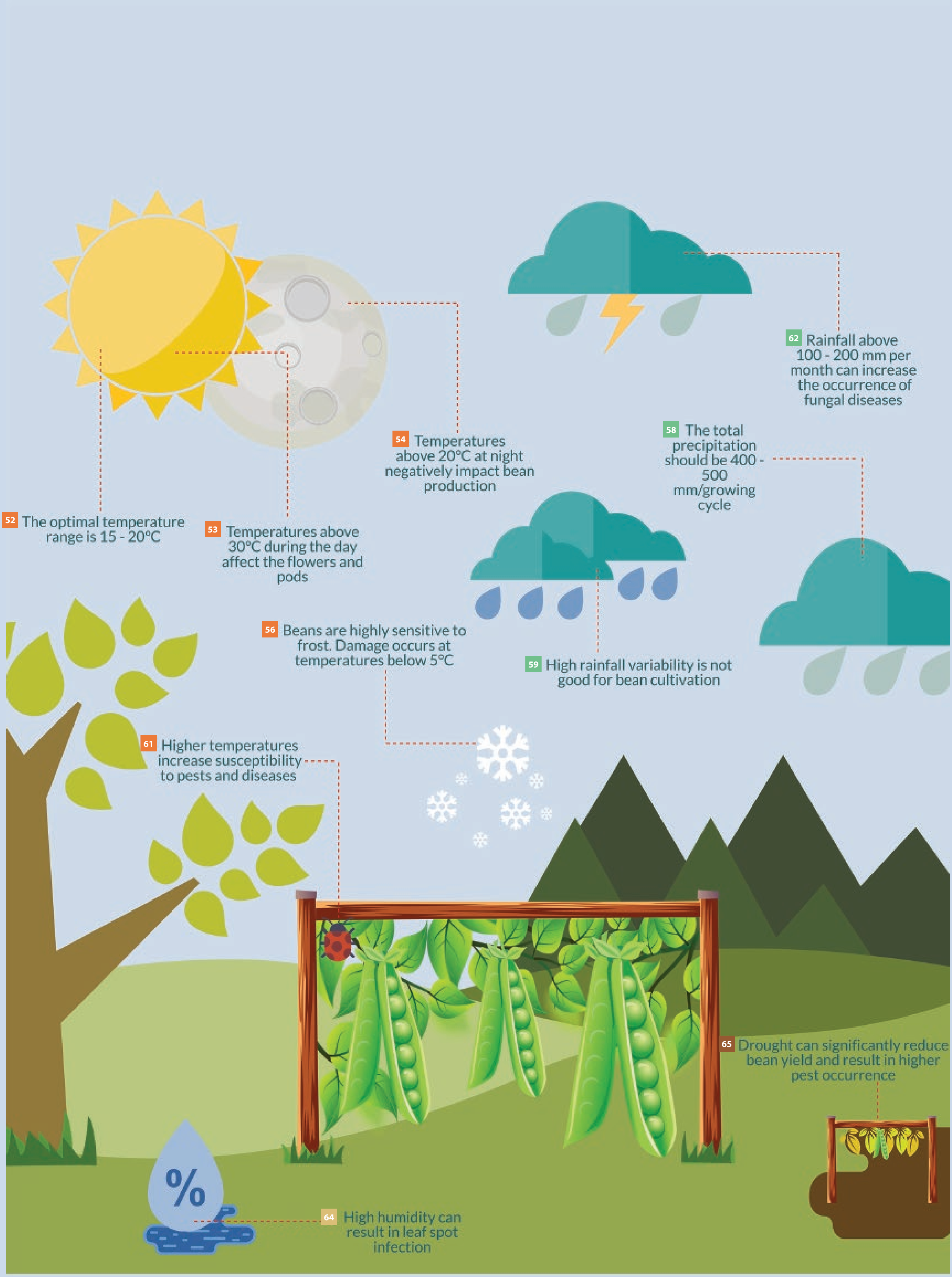
# 5.5.1. INFOGRAPHIC



# 5.5.2. DETAILED IMPACTS

**52 Beans are highly sensitive to temperature, as too high or too low temperatures will affect the overall quality and quantity of yield. 53 High daytime temperatures are known to cause flower and pod deaths and reduce the seed size, reducing both the quality and quantity of yield. This is more destructive during the early stages of plant flowering.**

54 Similarly, high temperatures at night affect the ability of the plant to reproduce, therefore reducing the yield and quality of beans. 55 Higher air temperatures lead to higher soil temperatures, especially in the rooting zone, resulting in poor root formation and a subsequent yield reduction. Adapting to high temperatures has been somewhat effective by providing shade cover and planting varieties that are genetically adapted to high temperatures. Shifting the planting dates to periods where it is cooler can have some benefits, as long as the conditions are still suitable throughout the crop's growth and the cropping season is long enough.

**56 57 Bean crops are highly sensitive to frost, which damages the flowers and beans at low temperatures. Frost almost always results in a drop in the quantity and quality of yield, and in severe cases can kill the plant. Higher temperatures in the future will reduce the occurrence of frost and thus reduce the risk of yield loss.**

58 Beans require a specific rainfall amount and distribution in order to produce a good harvest. Too much or tool little rainfall can significantly affect bean production. 59 High rainfall, especially in areas where there is poor drainage, can cause flower drop as well as a host of diseases. As such, moisture stress should be avoided during the flowering and setting periods. 60 Conversely, prolonged dry conditions constrain bean production and often result in a complete loss of yield. High rainfall variability between years can often be problematic for bean growing. Alternating years of heavy rainfall and drought can make choosing appropriate genetic varieties of bean difficult, especially if the required growing season is significantly different.

61 Pests and diseases can harm bean production, especially if there is excessive rainfall or high temperatures. High temperatures increase the occurrence of angular leaf spot, anthracnose and blight. Proliferation of these pests and diseases almost always lead to a drop in yield and quality of beans. 62 Similarly, excessive rainfall can lead to water logging if the soils do not drain well. 63 Stagnant water can cause fungal diseases, Panama or Fusarium wilt, to attack the crop and lower the yield and quality of beans. 64 High humidity is also known to increase the incidence of leaf spot infection. Pests and diseases also affect beans during severe drought periods. 65 Diseases caused by *Fusarium oxysporum* and *Macrophomina phaseoli* can be more severe on drought-stressed crops.

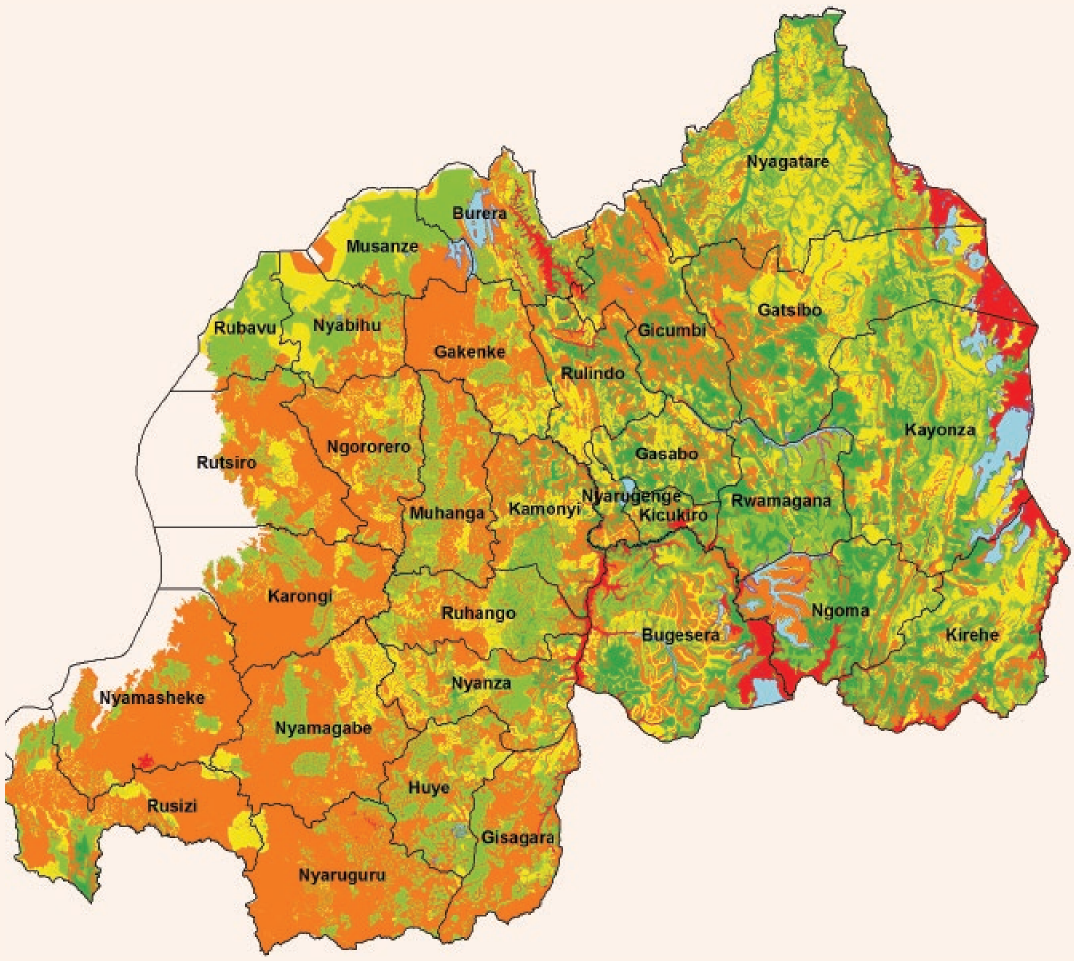
| CLIMATE THRESHOLD COLOUR LEGEND |
|---|
| Temperature |
| Humidity |
| Rainfall |
| Drought |

52 The optimum temperature range is 15 - 20°C
53 Temperatures above 30°C
54 Temperatures above 20°C
55 Top 20 cm of soil
56 Damage occurs at 5°C
57 Temperatures below 0°C
58 The total precipitation should be 400 - 500 mm/growing cycle
59 High rainfall
60 Dry conditions
61 Warmer
62 100 - 200 mm per month
63 Wetter
64 High humidity
65 Drought

# 5.5.3. CROP SUITABILITY

## CLIMATE SUITABILITY FOR BEANS

The suitability of beans in Rwanda tends to be high across most of the country, with exception to some of the hot and dry areas of the Eastern Savanna and the cold, high altitude areas of the Birunga and Congo-Nile Watershed Divide.



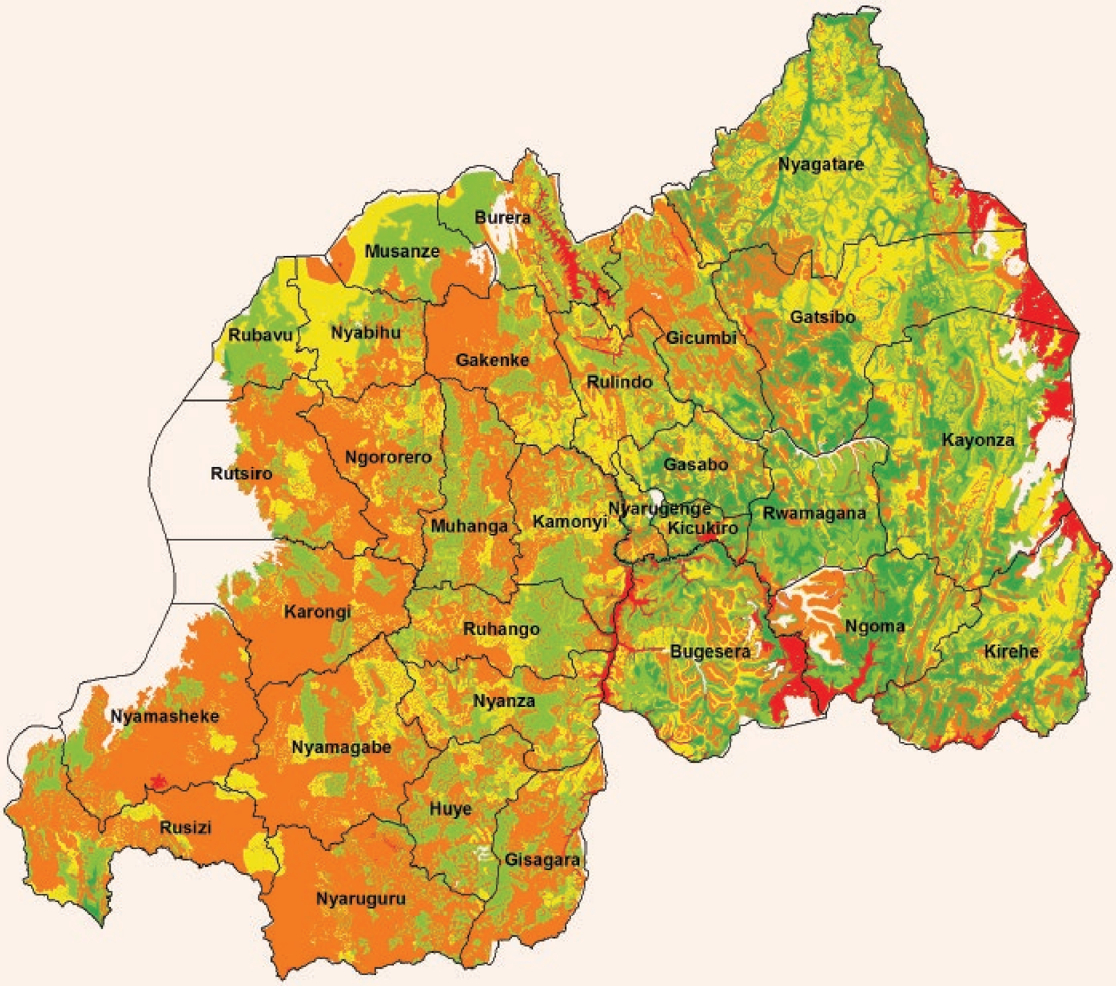

## SUITABILITY CLASSES OF BEANS IN SEASON A (SEPTEMBER TO JANUARY)

**CLIMATE SUITABILITY**

- High Suitability
- Moderate Suitability
- Marginal Suitability
- Currently Not Suitable
- Permanently Not Suitable

**LEGEND**

- Lakes
- National Parks
- Districts
- Boundary of Rwanda




## SUITABILITY CLASSES OF BEANS IN SEASON B (FEBRUARY TO JUNE)

### CLIMATE SUITABILITY

- High Suitability
- Moderate Suitability
- Marginal Suitability
- Currently Not Suitable
- Permanently Not Suitable

### LEGEND

- Lakes
- National Parks
- Districts
- Boundary of Rwanda

# 5.5.4. RISK TABLE

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | DETAILED IMPACTS |
| | | TEMPERATURE | >20°C (mean monthly) | | | | | | | | | | | 52 |
| | | | <15°C (mean monthly) | | | | | | | | | | | 52 |
| | | | >30°C (daily maximum) | | | | | | | | | | | 53 |
| | | | >20°C (daily minimum) | | | | | | | | | | | 54 |
| | | | <5°C (minimum daily) | | | | | | | | | | | 56 |
| | | | <0°C (minimum daily) | | | | | | | | | | | 57 |
| | | | Warmer | | | | | | | | | | | 61 |
| | | RAINFALL | <400 mm/growing cycle | | | | | | | | | | | 58 |
| | | | >500 mm/growing cycle | | | | | | | | | | | 58 |
| | | | >100 -200 mm per month | | | | | | | | | | | 62 |
| | | | High rainfall | | | | | | | | | | | 59 |
| | | | Wetter | | | | | | | | | | | 63 |
| | | | Dry conditions | | | | | | | | | | | 60 |
| | | DROUGHT | Warmer & drier | | | | | | | | | | | 65 |
| | | HUMIDITY | High humidity | | | | | | | | | | | 64 |

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# 5.6. SORGHUM

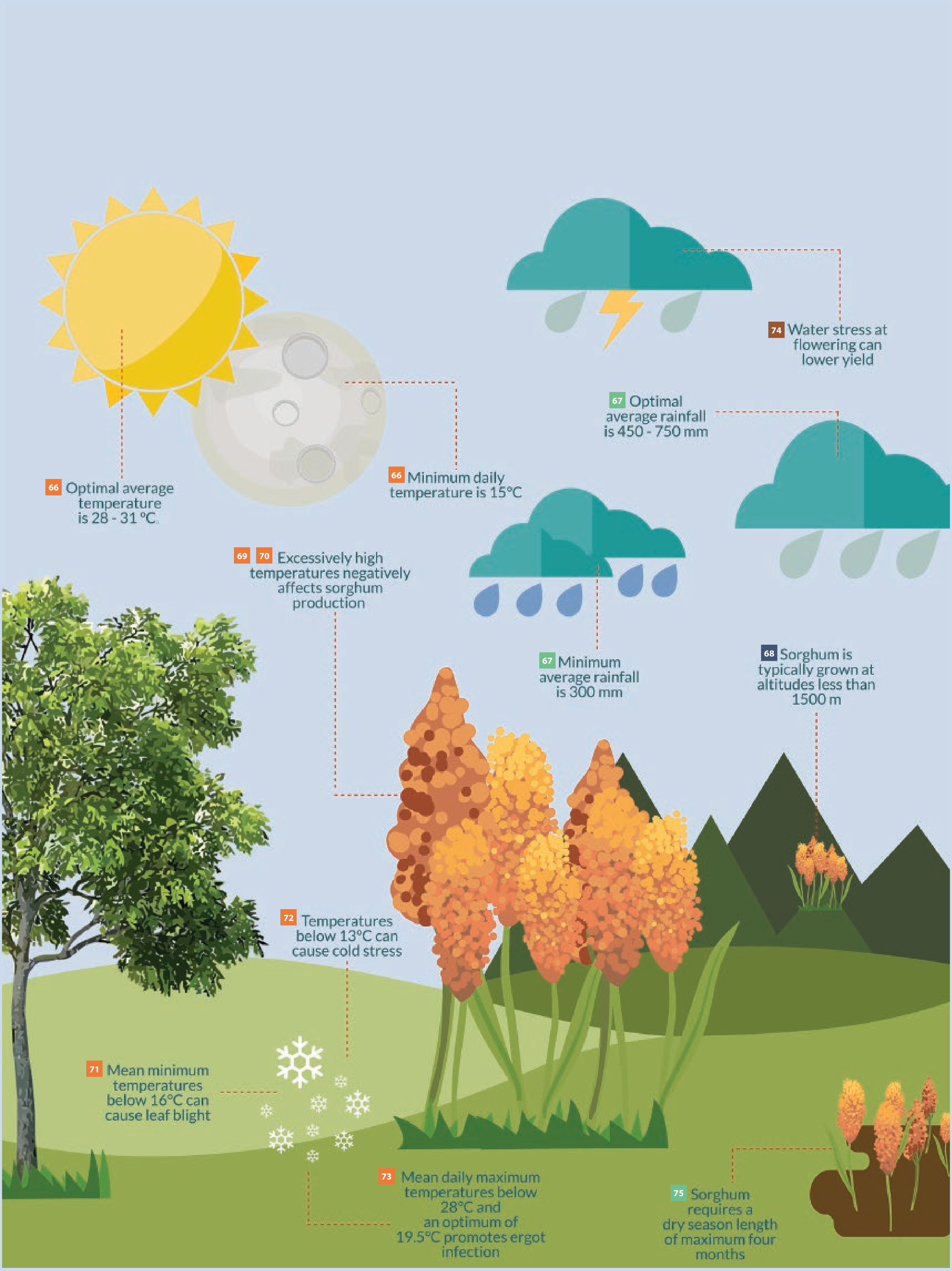
**Lead Author:** Julio Araujo

**Contributing Authors:** Zablone Owiti, Nkulumo Zinyengere

**Disclaimer:**

This information should only be used as a reference for identifying and justifying areas of risk and not to be absolute for all contexts. Since the suitability map does not factor in soil properties, it is important to note that the map is indicative of a crop's suitability to the climate, and not the climate and environment. Since a crop could be well suited to the climate but not the soil or vice versa, it is more indicative of potential suitability and is only accurate over an area if the soil is similarly suitable. For more information, please refer to ANNEX 2.

# 5.6.1. INFOGRAPHIC



# 5.6.2. DETAILED IMPACTS

**66 67 Sorghum is one of the more drought resistant crops in Rwanda, with a high tolerance to temperature and rainfall. Excessively low rainfall can often result in water stress and lead to reduction is yield and quality. 68 Given sorghum's tolerance to warm temperatures, it is commonly grown in the middle to low altitude areas of Rwanda.**

69 Although sorghum prefers warm temperatures, too high temperatures can decrease the quality and quantity of yield. 70 An increased rate of seed growth, reduced panicle (the loose cluster of flowers at the top of the crop) length and diameter, and inadequate growth at flowering stage just some of the effects of high temperature stress on the crop.

Sorghum is affected by a number of pests and diseases such as leaf blight, loose smut and ergot. 71 Sorghum that is affected by leaf blight tends to occur in areas of lower temperatures and can significantly reduce yield and quality. 72 Cold stress 3 to 4 weeks prior to flowering reduces pollen viability which, in turn, predisposes sorghum to ergot infection by reducing self-pollination ability, which can cause a reduction in yield. 73 Moderate temperatures during anthesis (pollination processes), promote ergot infection and disease development.

**74 Although sorghum is somewhat drought resistant, water stress at the flowering stage reduces seed numbers significantly and final biomass, leading to a low yield. 75 Sorghum prefers areas with a pronounced dry season. While maize is the crop of the rainy west, sorghum clearly is yielding best in central and eastern Rwanda where it is typically drier and warmer.**

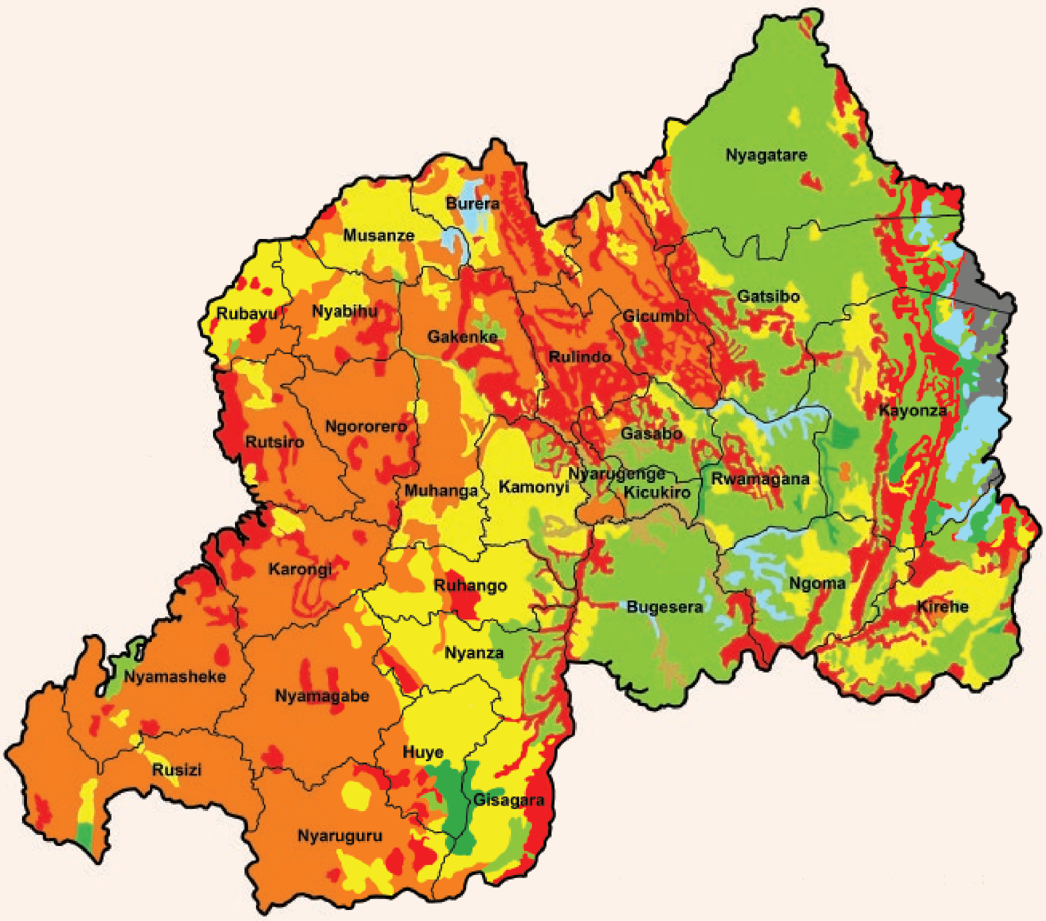
| CLIMATE THRESHOLD COLOUR LEGEND |
|---|
| Temperature |
| Rainfall |
| Altitude |
| Drought |

66 Optimal average temperature is 28 - 31°C. Minimum daily temperature is 15°C.
67 Optimal average rainfall 450 - 750 mm. Min average rainfall is 300 mm.
68 Less than 1500 m
69 Excessively Warm 1
70 Excessively Warm 2
71 Mean minimum temperatures below 16°C
72 Temperatures below 13°C
73 Mean daily maximum temperatures below 28°C and an optimum of 19.5°C
74 Warmer & drier
75 Dry season length of maximally 4 months

# 5.6.3. CROP SUITABILITY

## CLIMATE SUITABILITY FOR SORGHUM

Since sorghum tends to perform better in warmer climates and can handle dry conditions, the middle altitude regions are suitable, while the dry eastern lowlands are very suitable to moderately suitable for sorghum cultivation. As such, the low temperatures recorded in the high altitude regions of Rwanda tend to be a limiting factor to sorghum suitability. Agro-ecological zones such as the Impara, Kivu Lake Borders, Congo-Nile Watershed Divide, Central Plateau and Buberuka Highlands all tend to be unsuitable for sorghum cultivation.




**CLIMATE SUITABILITY**

- High Suitability
- High to Moderate Suitability
- Moderate Suitability
- Marginal Suitability
- Marginal to Actually Unsuitable
- Actually Unsuitable
- Unsuitable

**LEGEND**

- Lakes
- Marsh
- Districts
- Boundary of Rwanda

# 5.6.4. RISK TABLE

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the key climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| | | TEMPERATURE | 28 - 31°C (optimal average) | | | | | | | | | | | 66 |
| | | TEMPERATURE | <16°C (mean minimum) | | | | | | | | | | | 71 |
| | | TEMPERATURE | 15°C (minimum daily) | | | | | | | | | | | 66 |
| | | TEMPERATURE | <13°C (daily minimum) | | | | | | | | | | | 72 |
| | | TEMPERATURE | <28°C (daily maximum) | | | | | | | | | | | 73 |
| | | TEMPERATURE | 19.5°C (daily maximum) | | | | | | | | | | | 73 |
| | | TEMPERATURE | Excessively Warm 1 | | | | | | | | | | | 69 |
| | | TEMPERATURE | Excessively Warm 2 | | | | | | | | | | | 70 |
| | | RAINFALL | <450 - 750 mm (annual average) | | | | | | | | | | | 67 |
| | | RAINFALL | <300 mm (minimal average) | | | | | | | | | | | 67 |
| | | RAINFALL | Dry season (4 months) | | | | | | | | | | | 75 |
| | | ALTITUDE | <1500 m | | | | | | | | | | | 68 |
| | | DROUGHT | Warmer & drier | | | | | | | | | | | 74 |

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# 5.7. LIVESTOCK

**Lead Author:** Julio Araujo

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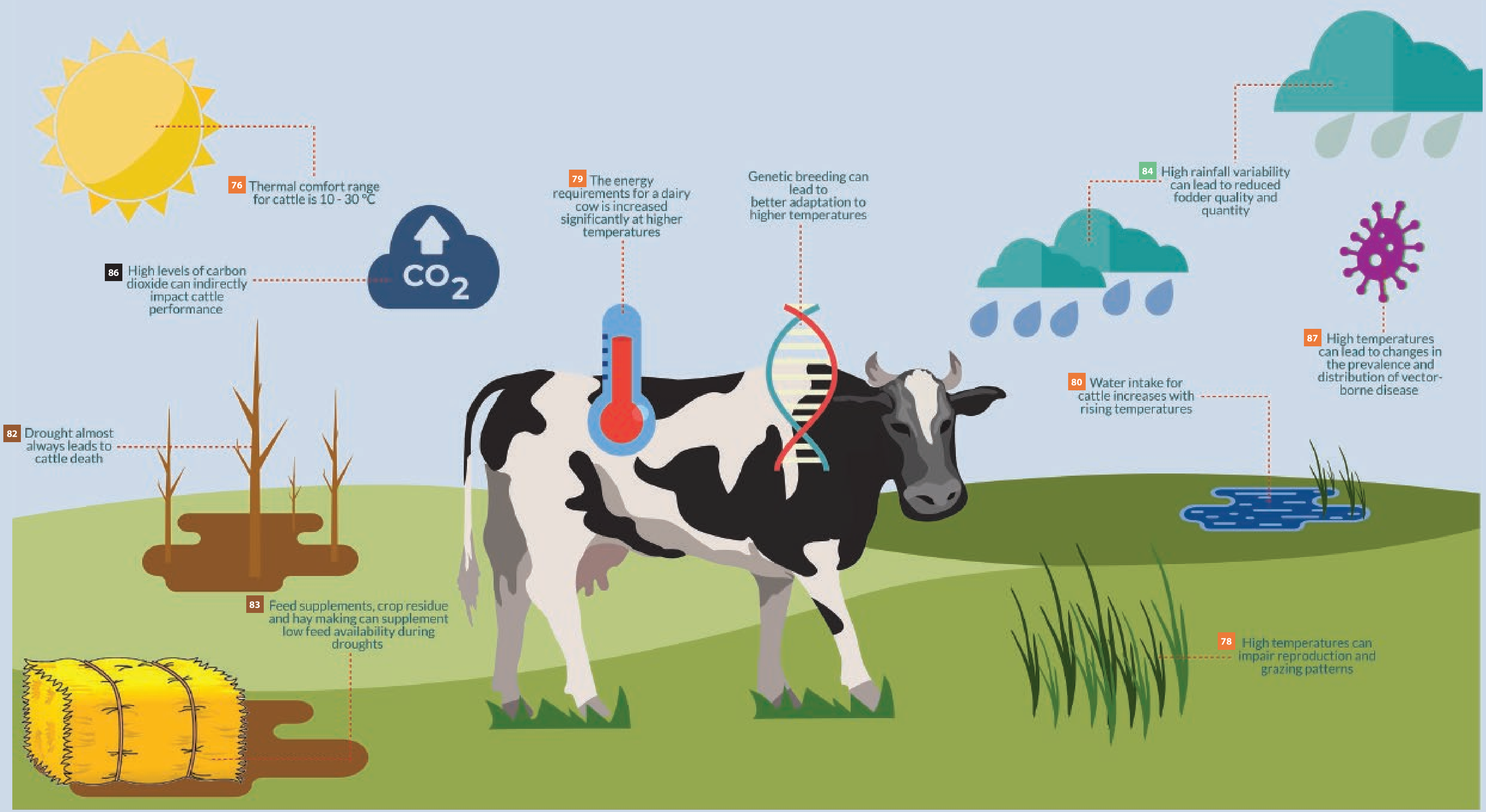
**Disclaimer:**

This information should only be used as a reference for identifying and justifying areas of risk, and not to be absolute for all contexts. For more information, please refer to ANNEX 2.

# 5.7.1. INFOGRAPHIC



# 5.7.2. DETAILED IMPACTS

**High temperatures affect both beef and dairy cattle. 76 77 High temperatures outside of the comfort zone for cattle can cause a reduction in feed intake, thereby increasing mortality. 78 Similarly high temperatures are known to impair reproduction and grazing patterns, leading to a reduction in milk production. Increased energy deficits from high temperatures may decrease fertility, fitness and longevity.**

79 The energy requirements of a dairy cow weighing 635 kg and yielding 36 kg of milk per day is increased by 22% at 32°C compared to the energy requirement at 16°C. Water intake for cattle tends to increase with rising temperatures. 80 For example, *Bos taurus* water intake increases from about 3 kg/kg dry matter intake at 10°C ambient temperature, to 8 kg at 30°C, and to about 14 kg at 35°C.

81 While high temperatures can lead to a reduction in milk yield and unhealthy cattle, there are methods available to adapt in the future. Changing the livestock breed and species to more stress tolerant can help to adapt to high temperatures.

This genetic based adaptation can result in breeding cattle with better thermoregulatory control, however it is unlikely this will coincide with high production potential. Increased cooling, water management, crop residue management and grazing management, can also help cattle adapt to higher temperatures.

82 High temperatures, especially in conjunction with low rainfall can lead to drought conditions. The occurrence of drought has almost always led to cattle death, especially if prolonged. 83 84 Drought conditions as well as high rainfall variability can lead to reduced fodder quality and quantity, either resulting in additional costs for farmers or reduced productivity.

This is especially of concern for some of the "improved breeds" in Rwanda that consume more feed and specific nutrient concentrations in order to achieve their higher yield potential. 85 While lack of both water and plant growth adversely impact livestock health and productivity, feed availability in particular tends to decrease during the dry season and drought events due in part to greater competition for land and water resources between planted forages and crops.

This can cause additional stress on cattle performance if additional feed is not produced during the rainy season. Similarly, making use of feed supplements, crop residue and haymaking can supplement the lower feed quantities during drought periods.

86 High levels of carbon dioxide can indirectly impact cattle performance as a reduction in the nitrogen concentration of plants during the summer grazing months can be large enough to bring about considerable decreases in animal performance as a result of reduced forage digestibility. 87 Heightened instances of diseases can often be associated with higher temperatures. High maximum temperatures can lead to changes in the prevalence and distribution of livestock vector-borne disease (e.g east coast fever, Rift Valley fever, trypanosomiasis). 88 Acute events such as flooding, landslide, and storm events cause significant livestock losses in affected areas.

| CLIMATE THRESHOLD COLOUR LEGEND |
|---|
| Temperature |
| Rainfall |
| Extreme Events |
| Drought |
| Carbon Dioxide |

76 Thermal comfort range is 10 - 30°C
77 For each degree increase, livestock reduce feed intake by 3 - 5%, livestock cannot dissipate enough heat from the digestive processes, hence they reduce intake to try to maintain a constant body temperature.
78 Warmer 1
79 Warmer 2
80 Warmer 3
81 Warmer 4
82 Warmer & Drier 1
83 Warmer & Drier 2
84 High rain variability
85 Warmer & Drier 3
86 Increased carbon dioxide ($CO_2$)
87 Warmer 5
88 Heavy rainfall

# 5.7.3. RISK TABLE

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the key climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| | | TEMPERATURE | <10°C (daily) | | | | | | | | | | | 76 |
| | | | <30°C (daily) | | | | | | | | | | | 76 |
| | | | per 1°C increase | | | | | | | | | | | 77 |
| | | | Warmer 1 | | | | | | | | | | | 78 |
| | | | Warmer 2 | | | | | | | | | | | 79 |
| | | | Warmer 3 | | | | | | | | | | | 80 |
| | | | Warmer 4 | | | | | | | | | | | 81 |
| | | | Warmer 5 | | | | | | | | | | | 87 |
| | | RAINFALL | High rain variability | | | | | | | | | | | 84 |
| | | DROUGHT | Warmer & drier 1 | | | | | | | | | | | 82 |
| | | | Warmer & drier 2 | | | | | | | | | | | 83 |
| | | | Warmer & drier 3 | | | | | | | | | | | 85 |
| | | EXTREME EVENTS | Heavy rainfall | | | | | | | | | | | 88 |
| | | CARBON DIOXIDE | Increased $CO_2$ | | | | | | | | | | | 86 |

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# 6. CLIMATE SMART AGRICULTURE

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**Contributing Authors:** Desire Kagabo, Michel Kabirigi

This section on climate smart agriculture can help to identify potential climate smart practices that can be used to counter the negative effects of climate change. The infographic in the beginning of this section provides an overview of the key climate smart practices for each crop per agro-ecological zone.

Disclaimer:
The information in this section is generalized for key crops and practices in each agro-ecological zone. It is therefore important to note that the most appropriate climate smart practice may differ slightly for your project, as small-scale local contexts are not taken into consideration. Similarly, not all climate smart practices are represented in this section as it represents the key practices.

## 6.1. PEST AND DISEASE RESISTANT VARIETIES

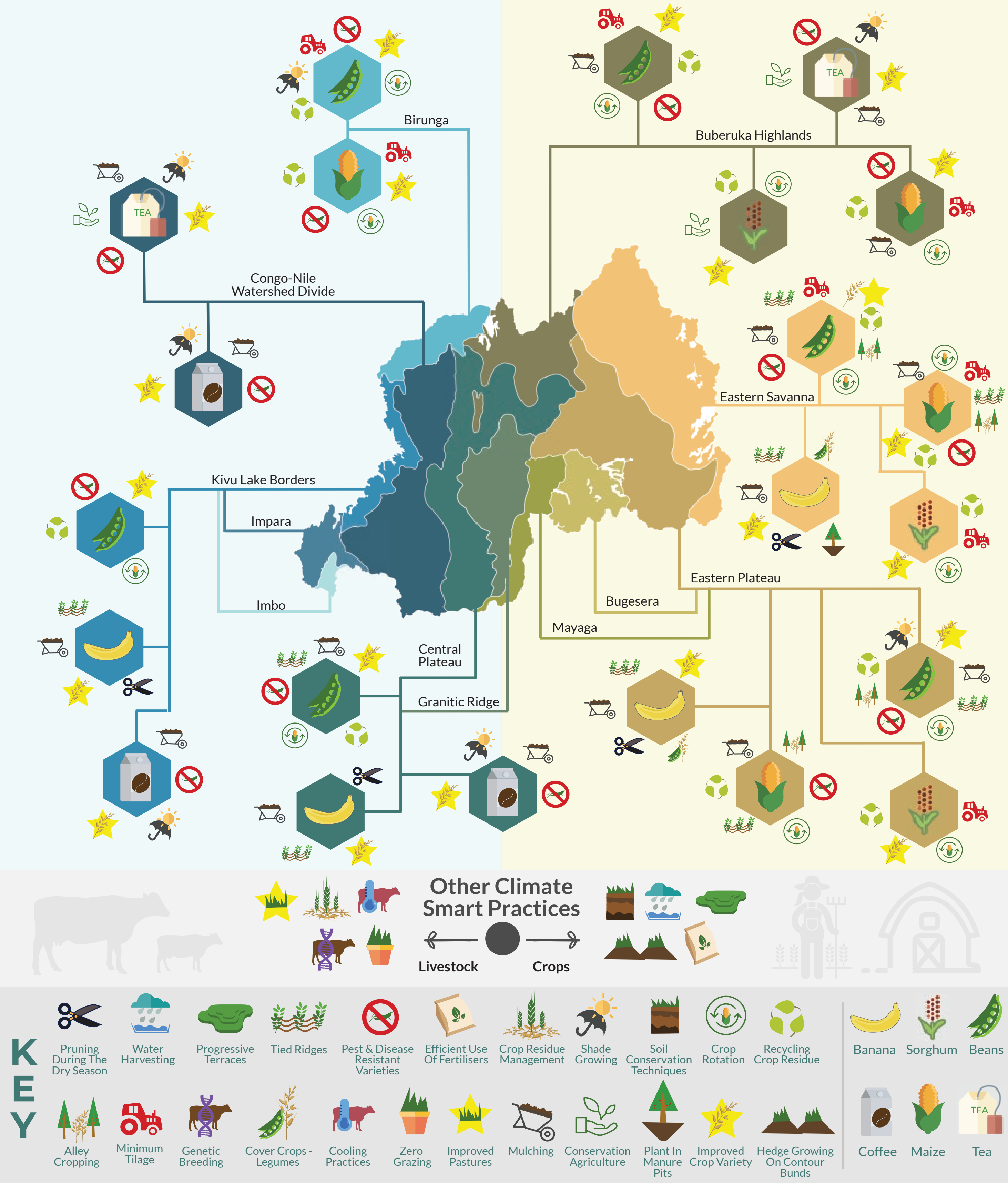
**Pests and diseases almost always lead to losses in quality and production. Some of the common pests and diseases in Rwanda include bean flies, the antestia bug, cassava mosaic virus, coffee leaf rust, and banana bacterial wilt.**

These are widespread in Rwanda, causing yield losses ranging from a third up to 100% in infected plants. In the livestock sector, disease outbreaks in 2008 caused a 13% loss in milk production in comparison with the previous year's production, and cost an estimated US$10 million in lost income for farmers and US$163,000 in the value of destroyed, slaughtered, or dead cattle.

Due to poor access to preventative inputs, food crop producers are often more vulnerable to pests and disease outbreaks compared to export crop producers. Using resistant varieties can significantly reduce the incidence of specific pests and diseases and therefore reduce the negative impact on agriculture production.

**For coffee, pests can reduce quality and yields, leading to lower income for farmers. With higher temperatures, the occurrence of many pests and diseases grows, further increasing the demand for resistant crop varieties.**

# KEY CLIMATE SMART PRACTICES FOR SIX MAJOR CROPS IN RWANDA'S AGRO-ECOLOGICAL ZONE



## 6.2. SHADE-GROWN CROPS

**Shade grown crops can be beneficial, through directly lowering the temperature of the canopy and soils, which favors physiological processes in the plants, and indirectly reduces pest and disease growth and occurrence as a result of the cooler conditions.**

The negative effects of high temperatures already impact some crops in Rwanda and this is likely to get worse with global warming. Intercropping coffee and banana in Rwanda has provided some success in reducing the canopy temperatures, which can increase crop productivity and quality.

By introducing fruit and/or woody trees (as a diversification strategy), it can contribute to increased resilience to climate change. Intercropping with fruit and/or woody trees may provide additional sources of income for farmers, while also positively impacting the main crops (coffee in the case of banana intercropping) yield.

**Shading coffee trees can help to maintain a controlled temperature for coffee growth and enhance ecosystem services. Intercropping and other shading practices are just some of the options for addressing current or future high temperatures.**

Another form of intercropping that is used in Rwanda is called alley cropping. This involves planting rows of trees at wide spacings with a companion crop grown in the "alleyways" between the rows. Alley cropping can diversify farm income, improve crop production and provide protection and conservation benefits to crops.

Common examples of alley cropping plantings include maize, beans or hay planted in between rows of *Sesbania sesban* (L.) Merrill trees. Both beans and maize have been shown to increase yields as a result of alley cropping legumes with food crops in the highland region of Rwanda.

## 6.3. EFFICIENT USE OF FERTILIZERS

**Areas where the soils are subject to erosion or loss of organic matter often have to deal with low crop productivity, especially if no appropriate adaptive management is in place.**

This is especially evident in the south west of the country, where research stations have reported soil losses of 35 to 246 tons/ha/year. Appropriate fertilizer application can be beneficial to plants in a number of ways.

Proper plant nutrition can help build resilience in crops as some micronutrients can help with water stress (e.g. zinc and calcium), while phosphoric fertilizers can promote strong root development.

Similarly, adequate timing, amount, and placement of fertilizers can reduce the negative effects of excessive fertilization, reduce soil salinity and nutrient leaching, and reduce production costs. Therefore if used properly, fertilizers can be highly beneficial to achieving stable or higher yields, especially in areas that currently experience low rainfall that can cause water stress in crops. However, access to fertilizers can be costly and is often not possible for small scale or subsistence farmers in Rwanda.

Applying nutrients according to plant needs, placed correctly to maximize uptake at an amount to optimize growth, and using the most appropriate source will reduce fertilizer losses and toxicity, as well as reducing injuries to plants caused by fertilizer ions like ammonium.

## 6.4. SOIL CONSERVATION TECHNIQUES

**Soil structure conservation can be beneficial to many crops as it reduces erosion and enhances in-situ moisture conservation. In Rwanda, where land conversion to cropland is increasing soil erosion, conservation techniques can be beneficial.**

The mean soil erosion rate over cropland, which occupied 56% of the national land area in 2016, was estimated at 421 tons/ha/year and was responsible for about 95% of the national soil loss, appropriate conservation practices could significantly drop this number.

Similarly, soil conservation can improve land productivity and fertilizer use efficiency. The effectiveness and choice of technique is often site and context specific, factoring in the climate and environmental conditions, crop type and soil type.

Soil conservation and management practices often include reduced tillage, the incorporation of crop residues, gypsum and manure application, crop rotation and cover crops to increase soil organic matter, soil water holding capacity and infiltration.

The use of green manure as a soil conservation technique can be effective in increasing soil drainage and water retention capabilities of the soil, leading to improved soil structure and texture both by rooting systems and by decayed organic materials.

## 6.5. CROP ROTATION

**Crop rotation is the practice of growing a series of dissimilar or different types of crops in the same area in sequenced seasons. This reduces the risk of a specific soil nutrient that is needed by a specific crop being depleted over time.**

The benefits of crop rotation include maintenance of soil structure and organic matter, a reduction in soil erosion often associated with continuous plantings of row crops and a reduction in plant disease caused by soil-borne pathogens. Crop rotation also contributes to a smarter use of nutrients and can reduce the requirement for nitrogen fertilizers when nitrogen-fixing plants are used (e.g. leguminous species).

In forage legume/grass mixtures, nitrogen is also transferred from legume to grass, increasing pasture production. The higher protein content of legumes is also beneficial to livestock production, especially when combined with feed.

**An appropriate and diverse crop rotation can reduce the need for applying nitrogenous fertilizers, thereby lowering the input cost for that crop. Similarly this can lead to enhanced productivity and when coupled with lower input costs can increase the profitability of the harvest.**

Maize in rotation with legume crops such as beans and soybean in Rwanda was reported to increase maize yield by 20% to 30% when compared to sole, continuous grown maize. This is a result of the benefit of biological nitrogen fixed by legume crops. Soybean provide higher results than beans when rotated with maize.

## 6.6. RECYCLING OF CROP RESIDUES

**Field residue is material from the crop after the harvest and often includes leaves, stems and seed pods.**

**Using crop residue as a form of soil protection can help with moisture conservation and keep the soil cool. Similarly, crop residue application can reduce weed growth, water erosion and restore soil carbon through decomposition.**

All of these benefits will contribute to enhancing the productivity of the crop. A reduction in farm organic waste through residue recycling can also have financial benefits. For integrated crop livestock systems, mixing crop residues into the feed will increase fodder quantity, providing a cheaper feed source.

## 6.7. ZERO GRAZING

**Zero grazing is commonly practiced as feeding cattle with cut grass that is brought to them, as apposed to being put to pasture.**

Preventing cattle from feeding through grazing pastures can be beneficial, especially for dairy cattle as it reduces heat stress through shading. Less heat stress almost always results in increased milk and meat production.

Zero grazing can also be beneficial through reduced requirement for grazing lands, especially in areas of Rwanda where there is competition between livestock, crops and humans for land access. Zero grazing can prevent land degradation caused by over-grazing as well as cattle movement along terraces.

## 6.8. IMPROVED PASTURES

**Growing appropriate grasses for fodder, that are more tolerant to drought conditions can be beneficial in the typically drier east of Rwanda.**

Growing the deep rooted Brachiaria grasses instead of the more common vegetation can result in more stable fodder yield during a drought. This can address part of the fodder deficit that would typically be present during a drought.

**Having access to fodder during these events can benefit the livestock through appropriate nutrition and other practices like zero grazing.**

## 6.9. MULCHING

**Mulch is a layer of material (usually organic, e.g. bark chips) that is applied to the soil surface.**

Mulching can be beneficial to crops in a number of ways, such that it can prevent rainwater from eroding the top soil, shade the plant roots, keep the top soil cool, help maintain water retention in the soil and improve soil fertility through decomposition by soil micro organisms.

Mulch also increases soil stability through increased resistance to soil detachment as a result of humic acid accumulation from organic matter mineralization. All of these benefits can help prevent yield loss during periods where there is either drought or heavy rainfall.

There has been success with mulching applications across Rwanda, especially when using banana mulch. Areas where banana and coffee are intercropped have benefitted from banana mulch, in an attempt to address the impacts of climate variability (drought and erosion).

Use of external mulch in coffee plots is often expensive and labour intensive, thus not feasible in the context of many smallholders. Integrating coffee and banana in the same field decreases the amount of labour required to transfer mulch from one field to another, and from other external sources.

## 6.10. TIED RIDGES

**Tied ridges are small soil "ties" (mounds) that connect two ridges together, creating small retention areas in between ridges.**

Tied ridges can be used to reduce soil erosion in areas with steep slopes, which can be beneficial during the rainy seasons in Rwanda. Since tied ridges can slow down the flow of water, it can also help to increase water retention in the soil, which can be beneficial for many plants through greater water availability, especially during the dry season.

The benefits of tied ridges are often context dependent and therefore some areas in Rwanda have experienced yield increases while others have experienced little change. A case study in Cyili, in the northern province in Rwanda highlighted an increase of maize yield by 25% with this technique, compared to traditional ways.

## 6.11. CONSERVATION AGRICULTURE

**Conservation agriculture (CA) is a widely used approach that can be effective in increasing agricultural productivity and profits, while maintaining and enhancing the natural environment. CA is characterized by four practices:**

1. Continuous minimum tillage.
2. Permanent organic soil cover.
3. Crop rotation.
4. Agro-forestry practices.

Through the four practices, CA can be used to build soil organic matter, reduce soil degradation, and conserve soil moisture. CA can be considered as a potential climate change adaptation strategy as improved soil quality and improved nutrient cycling can improve crop resilience.

In Rwanda recycling crop residues can be recommended on hillsides, and reduced tillage recommended in wetlands. CA has shown potential benefit for both high rainfall areas and low rainfall areas.

## 6.12. IMPROVED CROP VARIETY

**Making use of improved crop varieties can be beneficial in addressing the negative impacts of climate variability and change.**

This can often include varieties emergent from breeding schemes that are more resilient to drought, mature earlier or are higher yielding. These improved crop varieties can be resilient to climate change and use nutrients, water and external inputs more efficiently.

The extent to which Rwanda's bean farmers have benefitted from yield increases varies, however on average, the yield gain over local varieties from improved varieties is approximately 53%. This has translated to a household gain of approximately 42 kg of yield per agricultural season, increasing household revenue by US$50.

## 6.13. HEDGEROWS ON CONTOUR BUNDS

**This is typically the practice of growing vegetation on the edge of the farming area that tracks the contour of the slope, therefore remaining at the same elevation for each plot.**

Planting vegetation on contour bunds can be a successful way of reducing water runoff, controlling soil erosion and optimizing water capture and infiltration. This type of practice can lead to improved productivity and soil fertility, however this is dependent on crop type and other environmental and climate contexts.

This can be especially effective on steeper slopes, where excess water can be safely diverted downhill. The additional benefits can include sticks for beans, additional fodder, and fuel wood at farm level.

## 6.14. TERRACING

**A number of terracing options are available, including progressive, radical and bench terracing.**

Progressive terracing is typically where the terrace size progressively increases further down the slope. Progressive terracing can be used to reduce runoff and soil erosion on the slope and to improve soil quality and soil moisture retention for crops.

**These terraces can be effective in slowing down the flow of water during heavy rainfall that can often lead to soil erosion.**

In many areas, terracing can increase yields through reduced soil erosion and increased soil quality. Some assessments indicate that adopting terraces can reduce the mean cropland erosion rate and the national soil loss by 79% and 75% respectively.

Since many areas of Rwanda have steep slopes, especially in the mountainous north-west, appropriately constructing terraces can help to provide permanent agriculture in areas that would otherwise have been too steep. This means that terracing has the potential to play a significant role in conserving Rwanda's rich soils.

Bench terraces are a series of level or virtually level strips running across the slope at vertical intervals, supported by steep banks. This type of terrace can be used to reduce run-off and minimize soil erosion. It can also be used to conserve soil moisture, and fertility and to facilitate modern cropping operations i.e. mechanization, irrigation and transportation on sloping land.

**Bench terraces and slow forming terraces can reduce soil loss by 43% and 57% when compared with plots without soil conservation practices. This results in the increase of yield from 20% to 100% as a result of safeguarded nutrients.**

Radical terraces involve creating reverse-slope bench terraces, which have properly shaped banks stabilized with grass or trees on embankments to avoid collapse. Radical terraces increase cultivable area (i.e at a slope of 15% the cultivable land is increased by 5% when terraces are established while on slopes of 60%, the cultivable land is increased by 21%).

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# 7. ANNEX 1: WORKED EXAMPLE

## PROJECT DESCRIPTION

**Your project is a small-scale community coffee farm aimed at providing income opportunities and skills development for youths in the area. A nearby coffee plantation has agreed to support the project and use the additional harvest to supplement yield gaps as a result of recent droughts.**

Your project is situated just outside Ruhango town in the Ruhango district. Following meetings with the supporting coffee plantation manager, you are advised to prioritize growing coffee on the higher altitude sections outside Ruhango and ensure that your crop varieties are resilient to local pests and diseases.

**Given the droughts in the recent past, community leaders have recommended investigating options for accessing irrigation.**

You have realized from past farming projects that weather and climate risks can have a serious impact on your success, so you get a copy of the FONERWA Climate Risk Screening Tool to get a better understanding of what the potential risks are, and to ensure that your project is climate smart.

After reading through the tool, you realize that using accurate and geographically relevant climate information is critical in a project like this, so you look for more information online.

**Looking online, you find it difficult to locate any useful climate information for your area so you set up a meeting with Meteo Rwanda. After discussing the project, they have provided data from a nearby weather station.**

You notice the threshold values in the tool and have edited the data to match the thresholds for: type of climate variable (for instance, temperature, rainfall and humidity), the time scale of the threshold (for example, annual, monthly and daily) and the way the threshold is handled (mean, maximum and minimum values).

***Following this, you are left with the following climate data for your area:***

| CURRENT/HISTORICAL CLIMATE DATA: | |
|---|---|
| TEMPERATURE | 21°C mean annual |
| | 19.5°C mean monthly |
| | 17°C daily minimum |
| | 28°C daily maximum |
| | 4 times a month where the temperature is above 30°C for 3 days |
| HUMIDITY | Average humidity is 70% |
| RAINFALL | Rainfall is 2500 mm per year |
| EXTREME EVENTS | There are periodic events of heavy rain in the area |
| ALTITUDE | The project is situated at 1500 m above sea level |

| FUTURE CLIMATE DATA: | | |
|---|---|---|
| TEMPERATURE | 23 - 25°C mean annual | 2 - 4°C higher mean annual temperature |
| | 20.5 - 21.5°C mean monthly | 1-2°C higher mean monthly temperature |
| | 18 - 19°C daily minimum | 1 - 2°C higher night-time temperature |
| | 30 - 31.5°C daily maximum | 2 - 3.5°C higher daytime temperature |
| | 5 - 6 times a month where the temperature is above 30°C for 3 days | 1 - 2 more instances a month where the temperature is above 30°C for 3 days |
| HUMIDITY | Average humidity is 63 - 58% | 10 - 17% decrease in average humidity |
| RAINFALL | Rainfall is 2375 - 2875 mm per year | - 5% to +15% rainfall per year |
| EXTREME EVENTS | There are periodic events of heavy rain in the area | Extreme rainfall is expected to become more frequent and more intense |
| ALTITUDE | The project is situated at 1500 m above sea level | The project is situated at 1500 m above sea level |

*Reading through the detailed impacts section of the tool makes you aware of the range of potential risks to coffee production, so you decide to use the risk table to understand which risks are relevant for your project.*

## Example 1

The first threshold in the table for coffee is ***">23°C (mean annual)"***, which means that the threshold is exceeded if your climate data (current or future) is greater than 23°C. Since our current climate data is 21°C, and 21°C is less than 23°C, the current climate does not exceed the threshold so a tick (✓) is placed under ***"no"*** in the ***"current threshold"*** section of the table. **See blue rings below.**

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the key climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| 21°C | 23 - 25°C | | >23°C (mean annual) | | ✓ | ✓ | | | | | ✓ | | | 2 |

For the next step under ***"future climate"*** we identify if there is a trend for the climate variable (for instance the data shows warming or cooling into the future). The future climate projections show that the temperature will be 2 - 4°C higher than the current climate, so we are expecting an increasing trend. Since we expect an increase in temperature, we place a tick (✓) under ***"yes"*** in the ***"future climate"*** section. **See green rings below.**

| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| 21°C | 23 - 25°C | | >23°C (mean annual) | | ✓ | ✓ | | | | | ✓ | | | 2 |

Moving to the future threshold section, does our future climate exceed the threshold value? The future climate range is 23 - 25°C that means the lowest number is equal to the threshold (eg. both 23°C) and the highest number is greater than the threshold of 23°C. This means that the threshold may be exceeded if the future is actually 25°C but may not be exceeded if the future is 23°C. As such we place a tick (✓) under ***"maybe"*** in the ***"future threshold"*** section. **See yellow rings below.**

| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| 21°C | 23 - 25°C | | >23°C (mean annual) | | ✓ | ✓ | | | | | ✓ | | | 2 |

If there is a tick (✓) under ***"yes"*** or ***"maybe"*** in the current threshold section then the ***"impact on yield"*** or ***"impact on quality"*** becomes relevant for the current climate and is identified by a red box. Since we place a tick (✓) under ***"no"***, we then assume that there is currently no risk under this threshold and move on to the future threshold section.

| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| 21°C | 23 - 25°C | | >23°C (mean annual) | | ✓ | ✓ | | | | | ✓ | | | 2 |

If there is a tick (✓) under ***"yes"*** or ***"maybe"*** in the future threshold section then the ***"impact on yield"*** or ***"impact on quality"*** becomes relevant for the current climate and is identified by a red box. For more information on that specific impact, we refer to the number in the ***"more information"*** box (number 2 in this case) and find the reference to ***"number 2"*** in the detailed impacts section of the tool for coffee (5.1.2).

This means that there is currently a climate risk relating to temperature that negatively impacts the quality of coffee through the following **(see red rings below)**:
Extracted from point 2 in the detailed impacts section for coffee

*"While high temperature boosts yield significantly, it degrades bean quality due to accelerated development and ripening of fruits, resulting in losses for smallholder farmers."*

## Example 2

The third threshold in the table for coffee is ***">18 - 23°C (mean monthly)"***, which means that the threshold is exceeded if your climate data (current or future) is greater than the range of 18 - 23°C. Since our current climate data is 19.5°C and this is in the middle of the 18 - 23°C range, the current climate does not exceed the threshold so a tick (✓) is placed under ***"no"*** in the ***"current threshold"*** section of the table. **See blue rings below.**

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the key climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| 21°C | 23 - 25°C | | >23°C (mean annual) | | ✓ | ✓ | | | | | ✓ | | | 2 |
| 19.5°C | 20.5 - 21.5°C | | >18 - 23°C (mean monthly) | | ✓ | ✓ | | | | ✓ | | | | 3 |

For the next step under ***"future climate"*** we identify if there is a trend for the climate variable (for instance the data shows warming or cooling into the future). The future climate projections show that the temperature will be 1 - 2°C higher than the current climate so we are expecting an increasing trend. Since we expect an increase in temperature we place a tick (✓) under ***"yes"*** in the ***"future climate"*** section. **See green rings below.**

| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| 21°C | 23 - 25°C | | >23°C (mean annual) | | ✓ | ✓ | | | | | ✓ | | | 2 |
| 19.5°C | 20.5 - 21.5°C | | >18 - 23°C (mean monthly) | | ✓ | ✓ | | | | ✓ | | | | 3 |

Moving to the future threshold section, does our future climate exceed the threshold value? The future climate range is 20.5 - 21.5°C, which means the lowest number (20.5°C) and highest number (21.5°C) are within the threshold (eg. between 18 - 23°C). This means that the threshold is not exceeded, therefore we place a tick (✓) under ***"no"*** in the ***"future threshold"*** section. **See yellow rings below.**

| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21°C | 23 - 25°C | | >23°C (mean annual) | | ✓ | ✓ | | | | | ✓ | | | 2 |
| 19.5°C | 20.5 - 21.5°C | | >18 - 23°C (mean monthly) | | ✓ | ✓ | | | | ✓ | | | | 3 |

If there is a tick (✓) under ***"yes"*** or ***"maybe"*** in the current threshold section then the ***"impact on yield"*** or ***"impact on quality"*** becomes relevant for the current climate and is identified by a red box. Since we place a tick (✓) under ***"no"***, for both the current and future threshold sections, we then assume that there is currently no risk and will likely be no risk in the future under this threshold.

## Example 3

The fifth threshold in the risk table is ***">3 days with temps higher than 30°C"***, which means that the threshold is exceeded if your climate data (current or future) is greater than 3 days with temperatures higher than 30°C. Since our current climate data is 4 days and 4 is greater than the threshold of 3, the current climate does exceed the threshold so a tick (✓) is placed under ***"yes"*** in the ***"current threshold"*** section of the table. **See blue rings below.**

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the key climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| 21°C | 23 - 25°C | TEMPERATURE | >23°C (mean annual) | | ✓ | ✓ | | | | | ✓ | | | 2 |
| 19.5°C | 20.5 - 21.5°C | | >18 - 23°C (mean monthly) | | ✓ | ✓ | | | | ✓ | | | | 3 |
| 17°C | 18 - 19°C | | >15°C (daily minimum) | | ✓ | ✓ | | | | ✓ | | | | 4 |
| 28°C | 30 - 31. 5°C | | 25 - 30°C (daily maximum) | | ✓ | ✓ | | | | | ✓ | | | 4 |
| 4 days | 5 - 6 days | | >3 days with temps higher than 30°C | ✓ | | ✓ | | | ✓ | | | | | 7 |

For the next step under ***"future climate"*** we identify if there is a trend for the climate variable (for instance the data shows warming or cooling into the future). The future climate projections show that there will be 1 to 2 more instances a month where the temperature is above 30°C for 3 days, so we are expecting an increasing trend. Since we expect an increase in the number of days, we place a tick (✓) under ***"yes"*** in the ***"future climate"*** section. **See green rings below.**

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 days | 5 - 6 days | | >3 days with temps higher than 30°C | ✓ | | ✓ | | | ✓ | | | | | 7 |

Moving to the future threshold section, does our future climate exceed the threshold value? The future climate range is 5 to 6 days, which means the lowest number (5) and the highest number (6) are greater than the threshold of 3 days. This means that the threshold will be exceeded if the future is actually 5 to 6 more days. As such we place a tick (✓) under ***"yes"*** in the ***"future threshold"*** section. **See yellow rings below.**

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 days | 5 - 6 days | | >3 days with temps higher than 30°C | ✓ | | ✓ | | | ✓ | | | | | 7 |

If there is a tick (✓) under ***"yes"*** or ***"maybe"*** in the current or future threshold sections then the ***"impact on yield"*** or ***"impact on quality"*** becomes relevant for the current climate or future climate and is identified by a red box. Since we place a tick (✓) under ***"yes"*** for the ***"current threshold"*** and ***"future threshold"*** sections, we notice that there is a risk of negative impact on both yield and quality (as identified by the red boxes) and more information on the impact can be found by referring to number 7 in the detailed impacts section for coffee (5.1.2). **See red rings below.**

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 days | 5 - 6 days | | >3 days with temps higher than 30°C | ✓ | | ✓ | | | ✓ | | | | | 7 |

This means that there is currently and will be a risk in the future relating to temperature that negatively impacts the quality and yield.
Extracted from point 7 in the detailed impacts section for coffee.

*"Exposure to a high number of consecutive hot days leads to more abnormalities such as yellowing of the leaves and growth of tumors at the base of the stem, and subsequently a drop in yield and berry quality."*

## Example 4

The eighth threshold in the risk table is ***"warmer = pests"*** which means that in typically warmer conditions there is usually pest and disease presence for coffee. For the qualitative thresholds like this, you can identify relevant risks by using the trend identified in the ***"future climate"*** section of the table.

Since the temperature has been shown to increase in the future you can place a tick (✓) under "yes" in the future climate section. **See green rings below.**

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21°C | 23 - 25°C | | <17°C (mean annual) | | ✓ | ✓ | | | | ✓ | | | | 6 |
| | | | Warmer = pests | | | ✓ | | | | | | | | 8 and 9 |
| 2500 mm | 2375 - 2875 mm | RAINFALL | <1400 mm | | ✓ | | | ✓ | | ✓ | | | | 12 |

For this type of threshold, ticking a ***"yes"*** in the future climate section means that the impact is relevant and is then highlighted by the presence of a red block. From the information under points 8 and 9 in the detailed impacts section for coffee (5.1.2), this risk means that:

*"Warmer temperatures increase susceptibility to pests and diseases in the coffee growing areas. Coffee leaf rust (CLR) and coffee berry borer (CBB) prefer warmer temperatures and almost always lead to a yield and/or bean quality loss whenever they attack. The incidence of these pests and diseases is higher at lower altitudes where it is typically warmer."*

For other qualitative thresholds, for instance, ***"high sunshine"***, "***heavy rain"*** and ***"drought"***, if there has been any occurrence in the past, then the impact becomes relevant for the current climate and the future climate. This is because it is likely that these events of the past will continue to occur in the future. For example, the current project has incurred periodic droughts and therefore will likely incur droughts in the future. This means that for current and future, the impact identified by the presence of a red box is relevant and can be explained by point 10 in the detailed impacts section for coffee (5.1.2). **See red rings below.**

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1500 mm | 1500 mm | ALTITUDE | <1400 - 1600 m | | ✓ | | | | | ✓ | | | | 1 |
| | | | Lower altitude | | | | | | | | | | | 9 |
| | | DROUGHT | Warmer & drier | ✓ | | | | | | | | | | 10 |
| | | EXTREME EVENTS | Heavy rain, strong wind & hail | ✓ | | | | | | | | | | 15 |

From number point number 10 in the coffee detailed impacts section we have the following explanation for the impact:

*"Higher temperatures and lower rainfall can result in greater occurrence of dry conditions that cause weakening and wilting, especially of young plants. Weakening and wilting of coffee trees causes yield fluctuations and often results in a yield loss, as well as death of young plants."*

# FOR THIS PROJECT, A COMPLETED RISK TABLE WOULD LOOK LIKE THE FOLLOWING:

| COMPARE CLIMATE INFORMATION | | | | CURRENT THRESHOLD | | FUTURE CLIMATE | | | FUTURE THRESHOLD | | | IMPACTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Add in the same type of data for current and future climate for each threshold | | | | Compare the current climate against the threshold values | | Check for the trend | | | Check if future thresholds exceed the key climate thresholds | | | Potentially significant impacts are in red. For more information on the impact refer to the reference number in the detailed impacts sections | | |
| | | | | Does the current climate data exceed the threshold? | | Is the value expected to increase? | | | Is the threshold exceeded by the future climate data? | | | | | |
| CURRENT CLIMATE | FUTURE CLIMATE | CLIMATE VARIABLE | CLIMATE THRESHOLD | YES | NO | YES | NO | MAYBE | YES | NO | MAYBE | IMPACT ON YIELD | IMPACT ON QUALITY | MORE INFORMATION |
| 21°C | 23 - 25°C | TEMPERATURE | >23°C (mean annual) | | ✓ | ✓ | | | | | ✓ | | ■ | 2 |
| 19.5°C | 20.5 - 21.5°C | TEMPERATURE | >18 - 23°C (mean monthly) | | ✓ | ✓ | | | | ✓ | | ■ | ■ | 3 |
| 17°C | 18 -19°C | TEMPERATURE | >15°C (daily minimum) | | ✓ | ✓ | | | | ✓ | | ■ | | 4 |
| 28°C | 30 - 31. 5°C | TEMPERATURE | 25 - 30°C (daily maximum) | | ✓ | ✓ | | | | | ✓ | ■ | | 4 |
| 4 days | 5 - 6 days | TEMPERATURE | >3 days with temps higher than 30°C | ✓ | | ✓ | | | ✓ | | | ■ | ■ | 7 |
| 19.5°C | 20.5 - 21.5°C | TEMPERATURE | <17°C (mean monthly) | | ✓ | ✓ | | | | ✓ | | ■ | ■ | 5 |
| 21°C | 23 - 25°C | TEMPERATURE | <17°C (mean annual) | | ✓ | ✓ | | | | ✓ | | ■ | ■ | 6 |
| | | TEMPERATURE | Warmer = pests | | | ✓ | | | | | | ■ | ■ | 8 and 9 |
| 2500 mm | 2375 - 2875 mm | RAINFALL | <1400 mm | | ✓ | | | ✓ | | ✓ | | ■ | | 12 |
| | | RAINFALL | Dry period (2 - 4 months) | | | | | | | | | ■ | | 13 |
| 1500 mm | 1500 mm | ALTITUDE | <1400 - 1600 m | | ✓ | | | | | ✓ | | ■ | ■ | 1 |
| | | ALTITUDE | Lower altitude | | | | | | | | | ■ | ■ | 9 |
| | | DROUGHT | Warmer & drier | ✓ | | | | | | | | ■ | | 10 |
| | | EXTREME EVENTS | Heavy rain, strong wind & hail | ✓ | | | | | | | | ■ | | 15 |
| 70% | 58 - 63% | HUMIDIDTY | <60% | | ✓ | | ✓ | | | | ✓ | ■ | | 11 |
| 70% | 58 - 63% | HUMIDIDTY | >85% | | ✓ | | ✓ | | | ✓ | | | ■ | 16 |
| | | SOLAR RADIATION | High sunshine | | | | | | | | | ■ | ■ | 14 |

# 8. ANNEX 2: INFORMATION HANDLING

## 8.1. DATA & INFORMATION

**Country specific crop characteristics and impacts are often hard to find in a single location, which has meant that this tool makes use of a broad literature review, as well as expert opinion from researchers within the Rwanda Agriculture Board (RAB) and International Center for Tropical Agriculture (CIAT).**

The in-depth literature review drew on both peer reviewed publications and institutional reports. As a result of the desk-based review that uses a wide literature base, it is important to recognize that the presented crop characteristics are generalized and therefore the actual values may change depending on local context, such as climate and environment influences and farm management.

For each crop and livestock there are a combination of numerical thresholds and descriptive thresholds. This has been done for impacts where no obvious numerical threshold was available in the literature.

**As a result, the thresholds presented in this tool are indicative rather than absolute, and should be used to infer potential risks and not to determine exact responses to climate stressors.**

How crops behave under certain climate conditions is extremely complicated given the diversity of crop varieties, the management of the crop, the environmental influences and other factors feeding into the local contexts. Since the information presented in this tool is generic for each crop, but as specific to Rwanda as possible, the metrics, thresholds and impacts may differ slightly for each case.

It may be that one variety of maize might be more drought tolerant and therefore have a slightly different threshold to what is presented here. This is not a reason to ignore the identified impacts in this tool, as it is important to highlight that a risk exists and then analyze the extent of the risk depending on more specific data.

## 8.2. SUITABILITY MAPS:

*Suitability Map 5.3.3. to 5.5.3.*

**The soils and climatic conditions of the districts situated within different provinces of Rwanda have been evaluated for their suitability for different crops namely - maize, beans and banana.**

**The parameters considered for evaluation are: climate, topography, soil wetness, and the soil's physical and chemical parameters (including soil texture, coarse fragments, $CaCO_3$, gypsum, apparent Cation Exchange Capacity, base saturation, pH, organic carbon content, the Electrical Conductivity of saturated Extract (ECe) and Exchangeable Sodium Percentage.**

In addition, wetness as indicated by flooding and drainage conditions have been considered for evaluation of the soil and site conditions.

*5.3.3.*

*Banana in Season A*

*Banana in Season B*

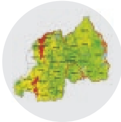
*5.4.3.*

*Maize in Season A*

*Maize in Season B*

5.5.3.

*Beans in Season A*



*Beans in Season B*

**The soil information has been taken from the soil map available from the Rwandan Agriculture Board (RAB). The crop suitability requirements and land physical and chemical properties were matched with each soil-mapping unit.**

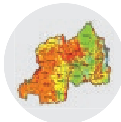
The determination of land suitability classes, namely - highly suitable (S1), moderately suitable (S2), marginally suitable (S3), currently not suitable (N1) and permanently not suitable (N2) have been determined by taking the least favorable of the individual factor ratings as limiting[89].

*Suitability Map 5.6.3*

**The land suitability classification incorporates crop-specific requirements to determine the suitability of the land for the cultivation of several crops.**

Land, at this level, is not only determined by the topographic and edaphic (soil) properties at a scale 1:250,000 but also by monthly climatic data recorded in several meteorological stations[90].

5.6.3.



*Sorghum*

*Suitability Map 5.1.3 to 5.2.3*

**These maps do not factor in soil properties. It is important to note that the maps are indicative of a crop's suitability to the climate and not the climate and environment.**

Since a crop could be well suited to the climate but not the soil or vice versa, it is more indicative of potential suitability and is only accurate over an area if the soil is similarly suitable.

Since the maps do not factor soil properties, it is important to understand that the high to low suitability assumes that the soil is also suitable for any given area, and therefore should be treated as a rough guide only.

5.1.3.

*Arabica Coffee*

5.2.3.

*Tea*

89. Sumadhura Geomatica (Rwanda) Ltd. 2015. **Final Report on Production of Land Use Consolidation and Crop Suitability for the Crop Intensification Programme.** Contract 1.11/949/014/JJMM/H.Q.

90. Verdoodt, A., Van Ranst, E. 2003. **A Large-Scale Land Suitability Classification for Rwanda.** Belgium: Ghent University. ISBN 90-76769-89-3. Available at: http://www.labsoilscience.ugent.be/docs/pdf/LE_Rwanda_book1.pdf

NOTES

# NOTES

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