# Using the Climate Atlas as a tool to spur climate change adaptation in the Kenyan horticulture sector

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## Introduction

Climate change presents one of the greatest challenges to the productivity and sustainable growth of the horticulture sector in Kenya due to extreme events such as drought and flood as well as changes in temperature (Patrick et al., 2020). Horticultural crops are particularly sensitive to climate change because of their high water demand and strict temperature requirements. A decrease in rainfall results in drought and lack of water for irrigation, while an increase in rainfall may lead to flooding. Elevated temperatures may affect flowering and fruit set, among other negative effects. Pests and diseases may emerge that affect the yields.

For these reasons, the 3R Kenya project identified climate change as a major threat to the Kenyan horticulture sector, potentially severely impacting the sector's growth and ability to transform into a mature trade sector and move away from reliance on aid support (Matui et al., 2016).

Understanding the impacts of climate change for a given crop under specific conditions is key to supporting further development of the horticulture sector. Since devolution in 2010, county governments have identified the agrifood sector as a driver for county development (Coninx and Kilelu, 2020).

### *Key messages*

1. Counties should develop an evidence-based and context-specific policy approach to climate change as part of their County Integrated Development Plans.
2. The Kenya Climate Atlas should be managed by a local 'owener' for sustainability. The Centre of Excellence for Research and Innovation on Indigenous Bioresources and Climate Change Adaptation at JKUAT can take on this role.
3. The Kenya Climate Atlas developed for Kajiado and Kiambu counties should be refined and adapted for use by the counties in planning for resilient agriculture.
4. Climate projections and scenarios should be made fit for purpose to suit the end users.
5. Policymakers and the financial sector should be actively involved in planning for climate adaptation in the agricultural sector – both at national but particularly at county level.

This policy brief describes how climate change may affect the Kenyan horticulture sector and what can be done to tackle climate change impacts. The main questions considered were:

- What kind of climate change can be expected?
- How will this impact the horticulture sector?
- What is the potential for action?

This brief describes how data is used to answer these questions.

## Kenyan climate adaptation policy

Adaptation to climate change is a joint responsibility of the national and county governments. The national government has developed guiding strategies such as the National Climate Change Response Strategy and the National Climate Change Adaptation Plan.

The county governments are mainly in charge of implementing adaptation policy. Some sectoral programmes exist that are funded through county government budgets and support from development partners, such as the Agriculture Sector Development Support Programmes. The County Integrated Development Plans (CIDPs) provide the policy environment to build agricultural resilience; however, our review of a selected set of CIDPs (Coninx and Kilelu, 2020) revealed that climate change adaptation is often not part of counties' strategies. Existing plans are not based on local data, and information about climate change scenarios that could be used in planning is missing. Furthermore, agricultural extension workers and farmers struggle to access relevant and useful data about the anticipated climate change.

*The role of county governments in climate change adaptation*

The Kenya National Adaptation Plan 2015–2030 states that: "County Governments shall integrate and mainstream climate change actions, interventions and duties into County Integrated Development Plans." (GoK, 2016, p. 11)

## Climate data

The climate data supporting this policy brief comes from the Copernicus Climate Data Store (CDS), managed by Copernicus Climate Change Service (C3S), and the HypeWeb viewer made by the Swedish Meteorological and Hydrological Institute. The Copernicus CDS provides quality-controlled free and open data. The C3S is part of the EU's Copernicus Earth Observation Programme.

The CDS contains a wealth of information, but not in a simple and actionable format that is useful in the horticulture sector. Data has to be processed and visualized to make it fit for purpose.

Climate change is mostly determined by global greenhouse gas emissions. The Climate Atlas makes use of two commonly used standardized emission scenarios (Representative Concentration Pathways [RCPs]): the high emissions scenario RCP8.5, which assumes business as usual (little to zero mitigation of $CO_2$ emissions) and the moderate emissions reduction scenario RCP4.5. As a reference, RCP4.5 emissions are above those stipulated in the 2015 Paris Agreement. Global greenhouse gas emissions are currently following the RCP8.5 trajectory.

## The Climate Atlas

A proof of concept for the Climate Atlas (http://www.climate-atlas.ke) was initiated to support county policymakers to design adaptation policies. The proof of concept was developed and demonstrated for Kajiado and Kiambu counties (Figure 1).

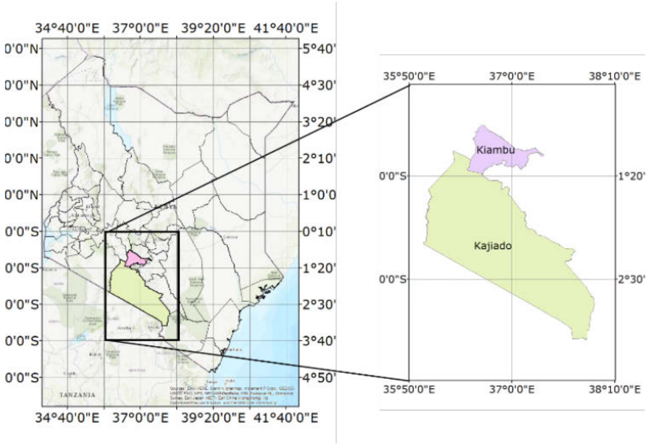


***Figure 1*** *Kajiado and Kiambu counties*

The Climate Atlas is a decision-support tool that contains maps and graphs about climate change for Kiambu and Kajiado. It provides a one-stop platform for visualizing existing information about climate change in the horticulture sector. The Climate Atlas is a service that brings complex climate data to users in an easy-to-grasp format.

The added value of the atlas lies in the fact that it is demand-driven. It translates complex data into a format that corresponds to the local situation. The information is crop-specific and seasonal, with the particular crop and seasonal characteristics having been determined with the target users: farmers, extension workers, meteorological staff and policymakers. It provides two types of information:

- storylines that engage and raise awareness among county agricultural officers, who then relay this information to farmers. The storylines set out the effects of climate change on key crops, with each storyline featuring a farmer from the region who grows one or more of these crops
- information for experts who, via the expert tool, have a great deal of flexibility to change the input variables that interactively change the maps and charts shown (Figure 2).

## Climate outlook

Climate change projections are uncertain and depend on many variables. There is uncertainty about two main areas: firstly, the emission of greenhouse gases, covered by different emission scenarios (see section “Climate data”). Lower emissions (RCP4.5) will result in smaller changes than higher emissions (RCP8.5). The second area of uncertainty is in how well models predict climate change resulting from these emissions. Therefore, to limit the uncertainty, climate change projections are always taken as the average of multiple models. In the first version of the atlas, 18 models were consulted. Later, five models were selected based on scientific literature about the area of interest.

These uncertainties mean that climate change projections are not weather forecasts, but rather potential future scenarios that can be used to encourage scenario thinking and inform strategic decisions about the trends emerging from the data. The confidence in the projected trend is judged by the number of models agreeing on the projection. In general, there is more agreement about climate change projections for temperature than about those for precipitation.

The projections on climate change indicate that Kenya will become warmer: by 2050, average temperatures are projected to be 2–3ºC higher than in the period 1981–2010, and temperature extremes will increase. All climate models point in that direction. Table 1 summarizes the projected changes in climate for several relevant climate parameters for the two counties.

Climate models also indicate that average precipitation will increase over the year. However, this is not necessarily a positive change. First of all, while rainfall in the long and short rains is highly variable from year to year, the cropping calendar is still tied to these rainfall seasons; changes in these will affect growing seasons. Secondly, a warming climate leads to more extreme events. The increase in annual precipitation might be concentrated in just a few torrential downpours, which may increase the risk of flooding. Other effects of climate change and agriculture, such as land degradation, may exacerbate climate hazards. The formation of hardpans on bare soils, for example, leads to poor infiltration and high run-off. This leads to drought and increased flood risk. It is important to keep this wider perspective in mind when working to climate-proof agriculture.

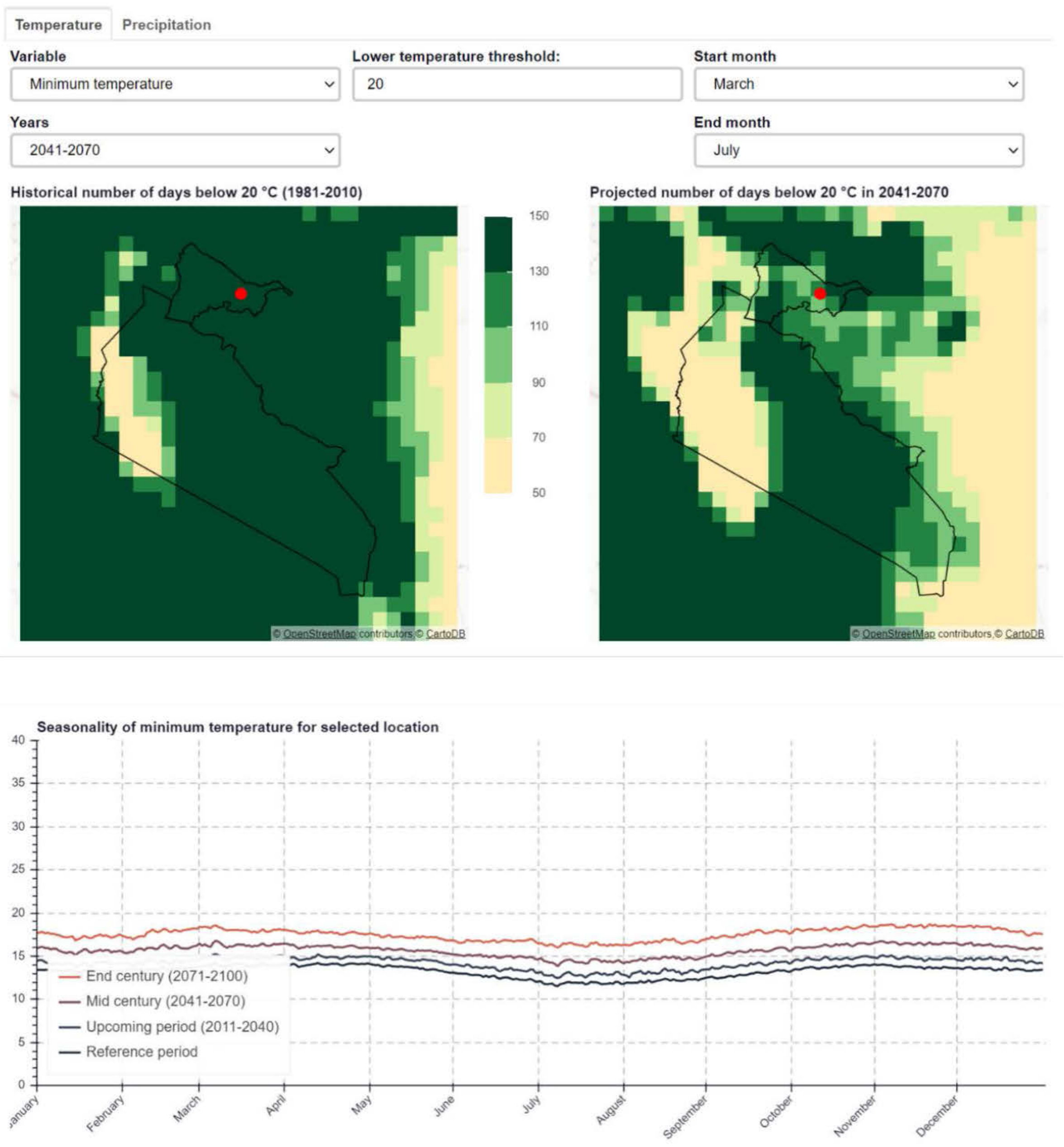


***Figure 2*** *Screenshot from the expert tool in the Climate Atlas. Users can inspect the number of days above or below custom temperature thresholds during a custom growing season. Clicking on the map updates the graph to provide a seasonal perspective*

The effect of climate change on the long and short rains, which are the determining factors for the cropping calendar at this point, is still unclear. The first analyses indicate that the short rain season might become slightly wetter and move to later in the year, while the long rains might start and end earlier and bring less rain. However, further research should take into account the climate phenomena that govern the rainfall patterns in Kenya, most notably the intertropical convergence zone and the sea surface temperatures in the Indian Ocean.

***Table 1*** *Summary of climate outlook, impacts and possible adaptation measures for Kiambu and Kajiado by 2050 under RCP8.5 (high emissions scenario)*

| Condition | Kiambu | Kajiado | Confidence | Impact | Potential adaptation measure |
|---|---|---|---|---|---|
| **Drought probability** | | | | | |
| Aridity (actual) | Decrease | Decrease | Many models | • Reduced production, leading to higher prices<br>• Increase in pests<br>• Scarcity of water for irrigation<br>• Increase in theft because of scarcity and high prices | • Use water-efficient irrigation methods<br>• Mulching<br>• Water harvesting in the wet season |
| Average rainfall | Increase | Increase | Many models | • Increase in yield of vegetables leading to low prices and market saturation | • Integrated pest management<br>• Value addition<br>• Staggered planting (better production planning)<br>• Storage facilities |
| | | | | • Increase in diseases | • Greenhouses<br>• Forecasting/warning systems |
| | | | | • Problems with infrastructure, e.g. roads affected by rain | • Soil conservation measures<br>• Water harvesting<br>• Prioritizing road investment |
| | | | | • Increase in post-harvest losses | • Value addition<br>• Storage facilities<br>• Timely and proper harvesting |
| Rainfall Nov–May | Increase | Increase | Many models | | |
| Soil moisture Nov–May | Increase | Increase | Many models | | |
| Soil moisture and rainfall during the dry period Jun - Sep | Decrease | Decrease | Many models | | |
| **Flood probability** | | | | | |
| Discharge | Increases in April–May | Increases in April–May | Many models | | |
| Run-off | Increases in April–May | Increases in April–May | Many models | • Soil erosion<br>• Leaching of nutrients<br>• Contamination of water bodies | • Soil conservation measures |
| **emperature** | | | | | |
| Temperature > 30°C | Slight increase | Increase | Many models | • Temperature too high for some horticulture crops<br>• Low labour productivity (active working time)<br>• High fruit abortion<br>• Increase in pests<br>• Reduced water use efficiency<br>• Increase in post-harvest losses<br>• Plant development is faster, leading to reduced yield | • Grow different crops<br>• Grow adapted varieties<br>• Shade house/netting<br>• Two crops in one season |

## Impact and perspective for action

Adaptation to climate change in the Kenyan horticulture sector is still in its early stages. The impacts are still largely unknown, and there is little overview of what can or should be done. Once the effects of climate change on the sector begin to take shape, stakeholders and policymakers can decide on what goals they set. Climate change could be a trigger for *transformational adaptation*, where the sector seizes the opportunity to change the fabric of the sector completely. This could include landscape restoration; adaptation of cropping calendars; and new value chains, crops and commodities. Alternatively, the goal could be to limit impacts as much as possible without changing much: the “standstill principle”. Measures could include shade nets for high temperature mitigation and water storage to prevent water shortage.

The first step in working towards such decision-making is to include a range of stakeholders. For this purpose, climate information should be easy to understand and interpret and should support a discussion about potential implications: what are the main characteristics of the sector and how are they touched by climate change?

Information to support a discussion on horticulture and climate change should take into account two points: the rain seasons determine horticultural growing seasons, because they define when water is available; and heat stress is an increasing problem but has received little attention to date. Figure 3 shows the average maximum temperatures per month for the historical climate and the 2050 climate (RCP8.5); and gives the growing seasons and temperature thresholds that apply to two crops, bean and tomato, that are grown in Kajiado County. Similar figures for precipitation, minimum temperature, run-off and other variables have been used in workshops with county extension and meteorological staff and the 3R team.

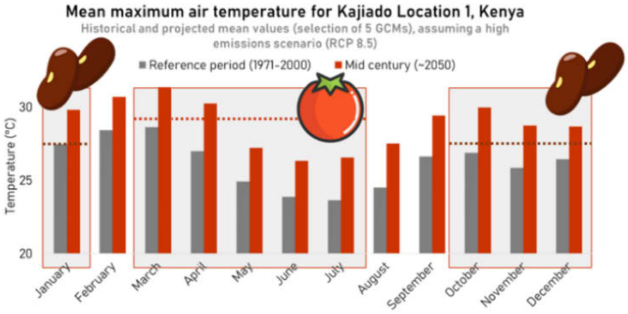


***Figure 3*** *Change in monthly maximum temperatures for a location in the northern part of Kajiado County. The dotted line indicates the temperature threshold for the crops*

These projections have proven very useful to support discussions about the magnitude of climate change impact on the sector. The current growing seasons for tomatoes and beans in Kajiado will very likely be too hot just a few decades from now. Tomatoes could be grown May–September instead of March–July or during the short rains October–January, but the June–September period is very dry, and the short rains are insufficient to grow tomatoes without irrigation.

Climate adaptation and climate-smart agriculture usually focus on drought. However, heat is also a critical factor. The combined impact of drought and heat pose a serious threat to rain-fed agriculture in the lower areas of Kiambu and Kajiado, and this is probably true for other lowland areas in Kenya as well. A switch to irrigation systems, water retention and storage or infiltration would:

1. Reduce flood risk
2. Reduce drought risk
3. Allow crops to be grown outside of the traditional growing seasons through irrigation and water management techniques

4. Provide greener and more humid landscapes, which can reduce the temperature increases to some extent
5. Reduce heat on farms, by providing shade and creating macropores in the soil, e.g. agroforestry

Such measures and combinations of measures should be explored further to assess their feasibility, efficacy and economic viability.

## Recommendations

The key to adaptation is to make complex climate information accessible in a relevant, simple and actionable way. Although there are still uncertainties about the impacts of climate change on horticulture, the information facilitates a discussion on the future development of the sector. To this effect, we recommend:

1. **Counties should develop an evidence-based and context-specific policy approach to climate change as part of their CIDPs.**
   There should be county integrated adaptation plans based on empirical evidence (farmer realities), which create systematic linkages between county-based ongoing climate-resilience efforts and national/global opportunities (technological and financial).

2. **The Kenya Climate Atlas should be managed by a local 'owner' for sustainability**
   - The Centre of Excellence for Research and Innovation on Indigenous Bioresources and Climate Change Adaptation at JKUAT can take on this role
   - The Kenya Climate Atlas can then be made available for use by counties in planning for resilient horticulture.

   This may be achieved through:
   - Capacity-building of Kenyan stakeholders so they will be able to take over further development of the Kenya Climate Atlas
   - Training the counties to use the atlas for planning and climate-proofing their CIDPs
   - Building a network/platform of stakeholders who work together to provide information to counties, policymakers and others about climate change
   - Building a solid knowledge base, as very little is known about vital aspects such as the effects of climate change on the long and short rains.

3. **Make climate projections and scenarios fit for purpose for end users.**
   Too much uncertainty, scenarios and jargon confuse stakeholders and impede further action. Focus on what is known: temperatures will go up, rainfall will be more extreme and rainfall patterns in terms of rain seasons will become less unpredictable, so prepare to be ready for multiple climate hazards.

4. **Include policymakers and the financial sector in planning for climate adaptation.**
   Policymakers need to address the issue of climate change and ensure that farmers have access to finance and benefit from other support programmes so they can apply adaptation measures.

## References

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**3R Kenya Project**
The 3R Kenya (Resilient, Robust, Reliable — From Aid to Trade) project is a learning initiative supported under the Agriculture and Food and Nutrition Security (FNS) programme of the Embassy of the Kingdom of the Netherlands. 3R Kenya seeks to assess evidence and lessons from FNS and other related programmes that support competitive, market-led models in spurring agricultural development. It focuses on the aquaculture, dairy and horticulture sectors. 3R Kenya is executed at a time when Dutch government's bilateral relations in Kenya are transitioning from a focus on Aid to a focus on Trade to enhance the development of agrifood sectors. Through evidence generation and stakeholder dialogue, 3R seeks to contribute to an understanding of effective conditions for sustainable inclusive trade for transforming resilient, robust and reliable agrifood sectors.

**Resilient**: dynamic and adaptive capacities that enable agents and systems to adequately respond to changing circumstances

**Robust**: systematic interactions between agents that enable them to adjust to uncertainties within the boundaries of their initial configuration

**Reliable**: the ability of a system or component to perform its functions under changing conditions for a specified period of time, to create opportunities for (inter)national trade.

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