THE CLIMATES ANALOGUES TOOL

Training Manual

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1 Rationale

In the last couple of decades, climate conditions have changed rapidly and are continuing to change at an ever increasing rate (IPCC, 2007). These changes in climate baseline, variability and extreme events will have far-reaching consequences on agricultural production and pose additional challenges to food security for a growing world population (Lobell *et al.*, 2008; Roudier *et al.*, 2011). Future farming and food systems will face substantial and entirely different, changes in their environments.

Some region's production rates may benefit from more favorable climate conditions to (the smaller pool of "winners"), while other regions will face increased climate change-related biotic and abiotic stresses (the far great pool of "losers") (IPCC, 2007). Where conditions improve, the traditional farming systems will be challenged to exploit the additional production potential. Where conditions deteriorate, rapid adaptation will be vital, as centuries-old coping mechanisms used by farmers may suddenly become insufficient or obsolete for those specific areas (Jarvis *et al.*, 2011).

As climate "migrates" between regions, it will disproportionally affect resource-poor and marginalized farmers who have lower adaptive capacities but may nonetheless depend entirely on agriculture for their livelihoods (Hitz and Smith, 2004; Thornton *et al.*, 2011). It is important to note that 70% of the climatic schemes anticipated in the future are already present on earth. In order to prepare for future changes, farmers must improve their adaptive capacities which can be accomplished by referencing current climate situations.

Research can help in this effort by improving the understanding of farmers and scientist alike in regards to climatic projections and adaptation pathways. To this end, scientists need to work together with politicians in the development of national plans and policy decisions regarding climate change adaptation.

It is in that context that the analogue methodology and its broad application concept was jointly developed by the Walker Institute of the University of Reading (UK), the International Center for Tropical Agriculture (CIAT), and the Climate Impacts Group at the University of Leeds (UK), with the financial support and leadership of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

2 What is the Climate Analogues Tool?

The analogue tool allows researcher to identify, connect and map sites with statistically similar climates across space and time in order to answer the question: where in the world can I find a future (or present) climate comparable to the future (or present) climate of my location of interest?

The tool has the potential to be applied in agricultural policy and planning and provides a novel way to support climate change adaptation in the agricultural sector.

Spatial analogues identify areas whose current climate appears as a likely analogue to a future projected climate for another location and thus present promising areas for comparative research the evaluation and formulation of adaptation planning. The tool can also be applied to facilitate knowledge sharing among communities, providing the opportunity to transfer practices and technologies in order to improve their adaptive capacities. Additionally, the tool could provide the opportunity to study whether successful adaptation options in one location can be transferred to a future climatic analogue site.

Temporal analogues make use of past climates in order to create a representative time series for future climates. In other words, the tool allows us to identify historic events that might provide insight into the possible future consequences of climate change. In particular, historical data can help us identify how agricultural communities in the past have changed their behaviors and have successfully adapted or failed to do so. These case studies can be analyzed for lessons learned, thus building an understanding of the best ways to improve climate resilience and/or facilitate climate adaptation.

The Climate Analogue Tool allows you to analyze the selected data (identify the analogue sites) in *three temporal directions*, which generally correspond to three different questions (Figure 2.1):

- *Where can I find sites at present that would be climatically analogue to how my site is projected to be in the future?* (Future → Present or "backward" direction).
- *Where can I find sites in the future that will be climatically analogue to how my site is at present?* (Present → Future or "forward" direction).
- *Where can I find sites at present that are similar to my site? Or where can I find sites in a projected future that would look like my projected future site?* (Present →Present **or** Future→Future, i.e non-directional).

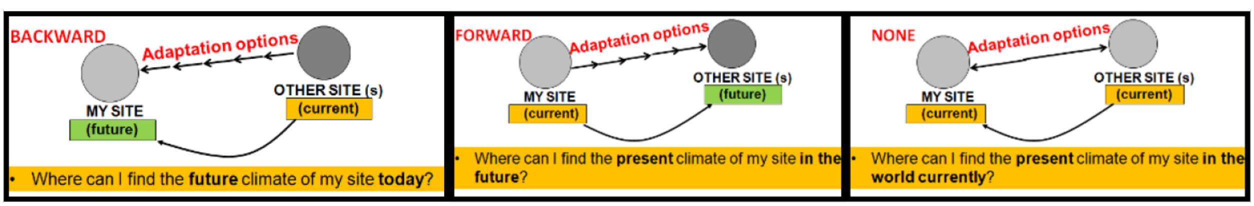

Figure 2.1 Different directions to run the climate analogue tool: Backward, forward, none.

Technical details

The analogues tool has been coded entirely as a library for the R environment for statistical computing (R Development Core Team, 2011), which is available at no cost at: http://www.r-project.org

To learn more about the methodology, you can visit our homepage: http://www.ccafs-analogues.org/

Also, an online interface has been developed in order to provide a user friendly and easily accessible platform to apply the Climate Analogues approach: http://analogues.ciat.cgiar.org/climate/.

This manual provides details on how to use this online tool.

3 Examples of applications that support agricultural adaptation planning

In this chapter, we will present two examples that illustrate how the analogues tool can be applied to support adaptation and planning processes in the context of climate change.

3.1 Germplasm exchange

Germplasm exchange within, across, and among countries or continents has been present throughout world history. However, in light of current and projected climatic changes, countries' needs for plant genetic resources are evolving along with their need for adaptive response in the face of future conditions and challenges.

Countries will increasingly come to depend on germplasm from foreign sources as climate changes require them to look further afield for adapted traits or species. In this context, the Climate Analogue tool can help identify where specific plant genetic resources will need to be present in response to the challenges related to climate change.

In the context of plant genetic resources interdependency, the climate analogue tool is able to:

- Help breeders to select future plant varieties and identify which species provide important traits useful for climate change adaptation
- Build scenarios with users regarding opportunities to increase future access to foreign plant genetic resources
- Identify what kinds of plant genetic resources are useful from other parts of the world to meet climate change adaptation needs
- Identify places where it is urgent to conserve plant genetic resources

Let us take a conceptual example of how climate analogues could help to plan and design a strategy for germplasm exchange among countries.

In the Kagera Basin of Uganda, farmers are mainly growing bananas (67% of all farmers), beans (59%) and maize (54%). If we assume that due to the expected changes in climate germplasm interdependency will increase among countries, it could be that some farmers across the globe would have the future conditions that are actually suitable for the germplasm currently grown in Kagera and thus would greatly benefit of having access to it. The Climate Analogue tool can help identify those geographic regions by answering the question made by the Ugandan farmers, "Which regions in the future may have our current climate and be potential beneficiaries of our knowledge and technologies?"

In Figure 3.1, the map displays analogue sites that will have future climates similar to the current climate of the Kagera Basin in Uganda. The analogue sites are mostly situated in Eastern Africa, northeast Brazil and the Andean region meaning that in the future, those regions may need some germplasms that are currently cropped in the Kagera Basin.

The climate analogue tool is only a starting input in this type of analysis. It would then be necessary to identify the constraints in those sites and analyze in more detail which germplasm from Kagera Basin could be transferred to those analogue sites. Once the feasibility of germplasm transfer is analyzed by studying field and social constraints, adaptation strategies can be planned for long-term challenges.

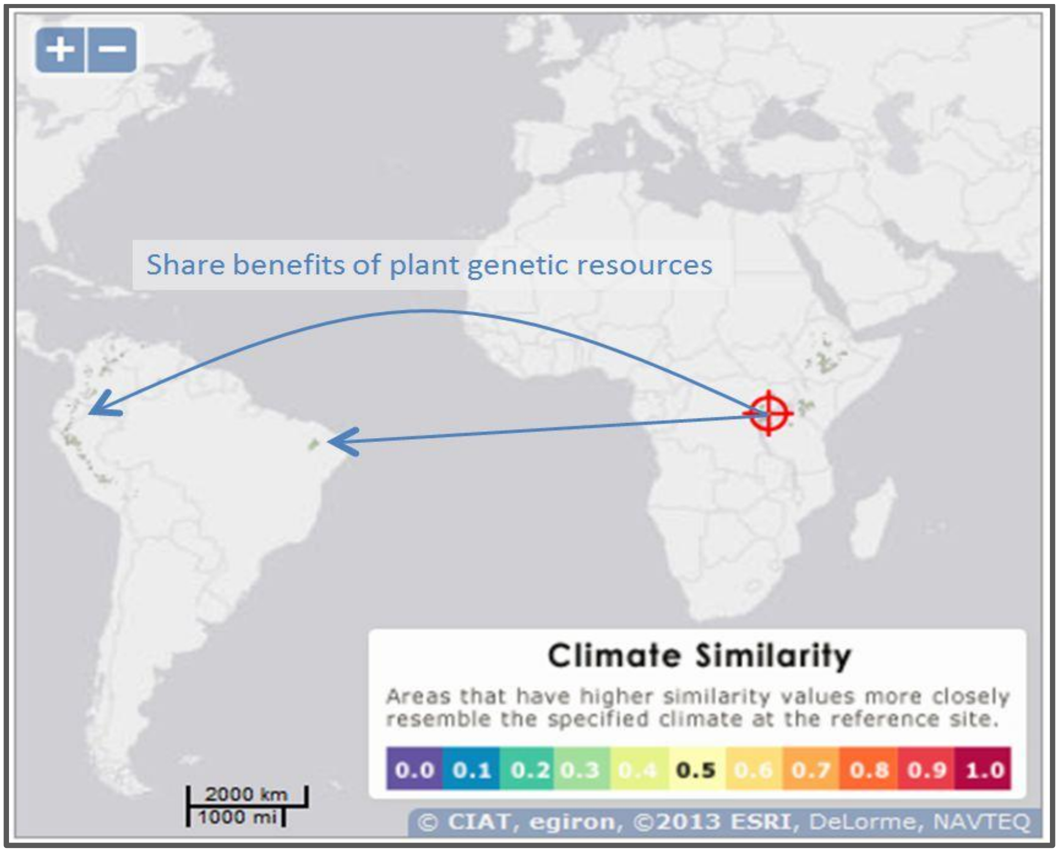

Figure 3.1 Climate Analogues help to identify sites where will be in 2030 the Uganda's current climate in order to design adaptation strategies to climate change in the context of germplasm exchange.

3.2 Farms of the Future

There is currently a lack of research regarding human cultural behavior and institutional facilitators/barriers to adaptive change (Thornton *et al.*, 2011). In the realm of politics and development, national plans and policy decisions regarding climate change adaptation are increasingly being made based on assessments that rely heavily on projections created by mechanistic, computational models (e.g. general circulation models, crop response models, and agricultural trade models). Despite advances in climate science in the past decade and the emergence of more complex, integrated models, substantial uncertainty remains (Challinor *et al.*, 2009; Challinor and Wheeler, 2008). By definition, models' predictions cannot be fully validated until the projected year actually arrives. As such, there are critical and inherent dangers in over-reliance on models to understand the future of agriculture (Challinor and Wheeler, 2008). Climate and crop models can provide projections of biophysical change, but they cannot adequately consider human behavior, particularly farmers' historically-proven, inherent capacity to respond to emerging threats. As such, computational models cannot tell us what kind of farming systems, supported by projected future conditions, might exist in a given location (Lobell and Burke, 2008).

Similarly, while substantial research funds and energies have been invested in creating more resilient crop varieties and helping farming communities adopt site-specific adaptive practices, not enough has been done to aggregate inventories of existing local adaptive knowledge or to facilitate inter-farmer exchange of knowledge between communities facing similar challenges.

The Farm of the Future project initiated by CCAFS is a way to put the analogue approach into practice by connecting farmers to their possible climate futures via 'farm visits'. This approach provides farmers the opportunity to "see" and envision in the analogue sites, how their site-specific agricultural future might look in terms of climate. Accordingly, farmers can facilitate the creation of a knowledge chain through which strategies and farming information can be passed down or shared. Specifically, on return to their villages this network of innovative farmers have the potential to be the vanguard of climate smart adaptation measures, allowing other farmers to interact and learn strategies to more effectively adapt to climate change.

This ongoing project, currently employed in East and West Africa and South Asia, also aims to identify social, cultural and gender specific barriers to behavioral change. Identification of these barriers will provide policy makers with key socio-cultural information to tailor local adaptation strategies. In addition the program also provides a foundation for scientists to ground mathematical projections with qualitative, real world assessments.

Project pilot in Tanzania

In May 2012, Tanzanian national partners and a team led by the University of Greenwich's Natural Resources Institute used maps generated by the Climate Analogues tool to pinpoint locations whose present climate is similar to the projected 2030 future climate of one of CCAFS research sites in Yamba village.

After analyzing climate analogues maps, agricultural practices, social aspects and other factors that influenced the choice of the analogue sites of Yamba, the research team drew-up the planned journey that would include visits to potential future climates of Yamba to learn what farmers are doing in those analogues sites. During the actual journey, a small group of Yamba's farmers learned about farming systems and practices that other farmers are currently doing in their likely future climate sites (Figure 3).

Participating farmers learned about soil and water conservation, tree and coffee nurseries, bee keeping and other practices that they could take back home and start to adapt in order to prepare for their future climate (Figure 4). During this journey, Yamba farmers were taking video of adaptations to share with their family and neighbors at home. Yamba farmers now have some tools in hand to start thinking about which risk management strategies they should apply to face the future climate of Yamba.

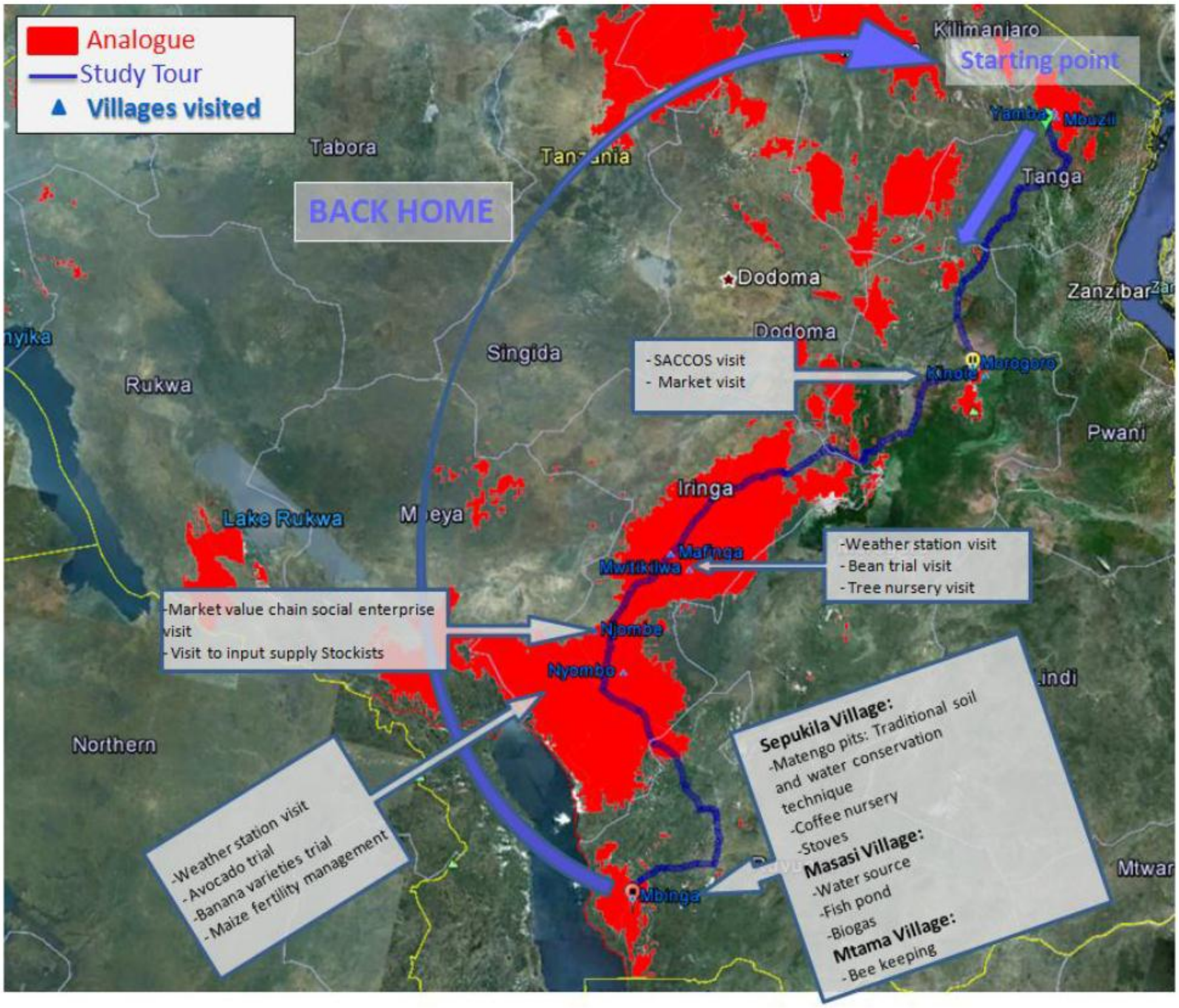

Figure 3 Yamba analogues map with the villages and activities carried out during the farm exchange.

Figure 4 Yamba farmers learning about farming systems and agricultural practices from the farmers living in the potential future climate of Yamba.

4 THE CLIMATE ANALOGUE ONLINE INTERFACE

The Climate analogue tool online interface can be accessed at: http://analogues.ciat.cgiar.org/climate/. In this chapter we will show you how to use the Climate Analogues Tool by walking you through the following steps:

- 1 Selecting a reference site and search range
- 2 Selecting a direction and global climate models
- 3 Selecting climate variables and other analysis settings
- 4 Observing, interpreting and saving your results
- ? Additional information for using the online tool can be found using these help icons.

4.1 SELECT YOUR LOCATION

Variables required:

Reference site- the location for which you want to find analogue sites.
Search range- the geographical area within which you want to find analogue sites.

In order to run an analysis, you must first indicate the geographic location of the reference site. This can be done either by manually entering the latitude and longitude coordinates into the appropriate boxes or alternatively you may click on a location on the map to generate the coordinates. This process may be made quicker by using the drop down tab to zoom to the country within which the reference site will be located. The red target displayed on the map marks the reference site that will be used for the analysis (Figure 4.1).

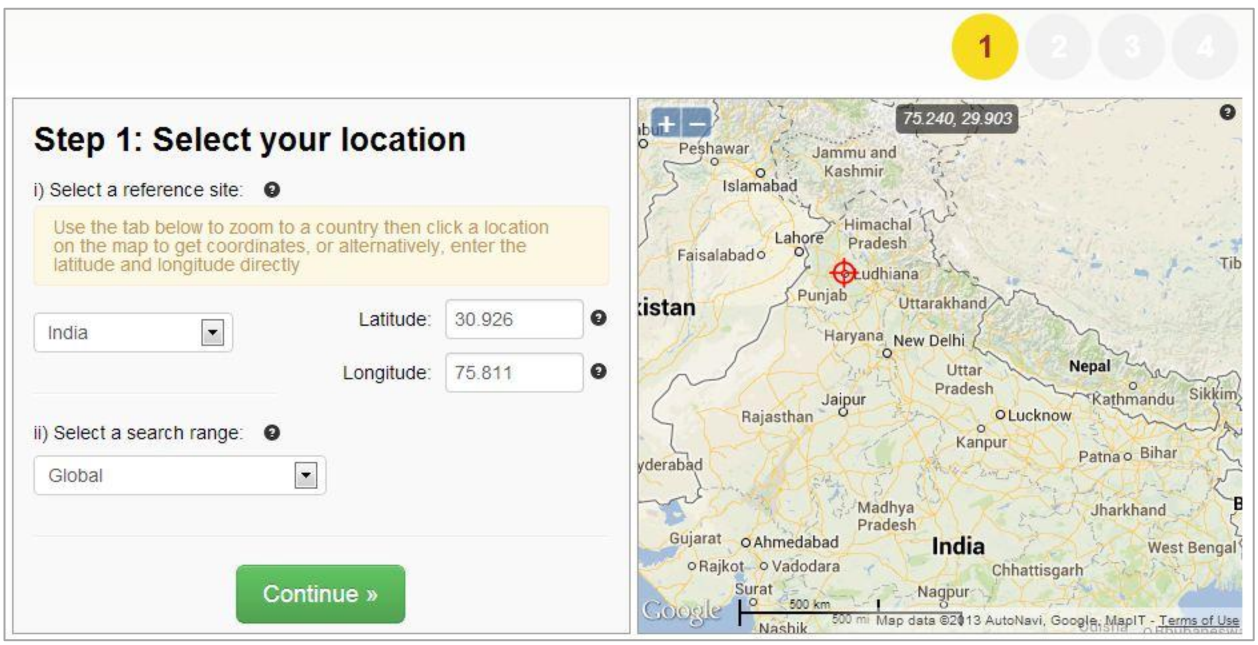

Figure 4.1 Selection of the reference site and search range.

You must then designate the search area within which you want to find analogue sites:

- If you select the "global" search range, the tool will look for climate analogues across all land areas in the world excluding Antarctica (i.e. -60 to 90 degrees latitude, 180 to -180 degrees longitude). If you are unsure where you expect to find analogue sites the global search range may be a good starting point from which you can narrow your search later.

- Alternatively, you may also select a specific country or continent in order to focus the climate analogues search, speed processing time and produce results with a higher resolution. *Note*: the reference site does not have to located within the search range, i.e. you have the ability to look for an analogue of Ludhiana, India in the country of Brazil or the entire continent of South America.

4.2 Select a Direction and Global Climate Models

Variables required:

Direction- The direction in time to run the calculation relative to the reference site.
Period- The time period over which average climatic conditions are calculated.
Scenario- The Special Report on Emissions Scenarios (SRES) scenario used to predict future climatic conditions.
Model- The global climate models (GCMs) used to predict future climatic conditions.
Resolution- The pixel size of input and output rasters.

In the second section "Select a direction and global climate models" you must define the temporal parameters for the analysis.

First, you define the *direction* in time in which run the analysis. The direction is very important because depending on which direction you choose the tool will produce different results with quite different interpretations.

Three options are available (Figure 4.2):

1. A backward analysis, in which the future climate of the reference site is compared with the present climate of all other locations in the search range,

2. A forward analysis, in which the present climate of the reference site is compared with the future climate of all other locations in the search range, or

3. A non-directional analysis (none), in which the present/future climate of the reference site is compared with the present/future climate of all other locations in the search range.

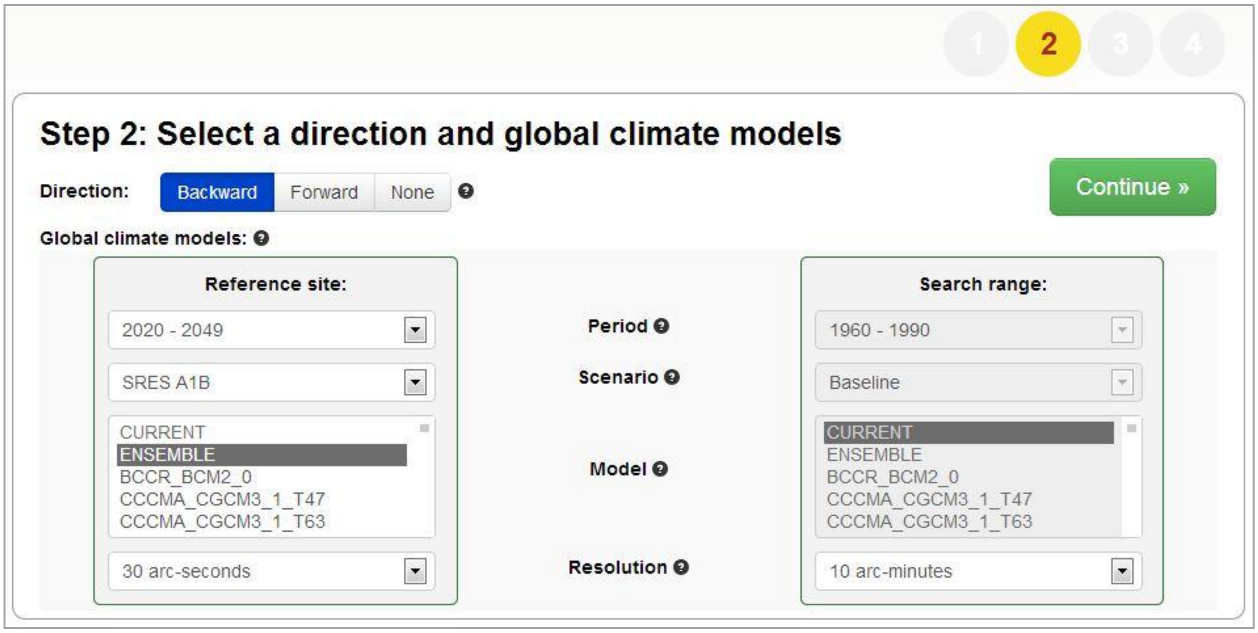

Figure 4.2 Selection of the direction

The baseline climate is calculated over the period 1960-1990 which is a commonly used reference period for future climate studies. Currently future climate forecasts are limited to the 2020-2049 time period (i.e the climate of the 2030s decade), however more options that forecast further into the future are to be added to the online tool. If you are performing a backwards or forwards analysis there are three emission scenarios to choose from: A1B, A2 and B1. Each emission scenario describes future projected greenhouse gas emissions when global development proceeds with varying emphasis in areas of social and economic development, i.e. between globalisation vs regionalisation, and between an economic vs environmental focus. For example, emissions scenario A1B is an intermediate scenario which describes a future world of very rapid economic growth, low population growth and rapid introduction of new and more efficient technologies. As the future projected greenhouse gas emissions under each scenario vary they thus produce different projected future climatic conditions.

You then need to select the global climate models (GCMs) that will be used in the analysis. It is possible to choose between the individual GCMs for each emission scenario or an ensemble which uses the average of all available GCMs. Results will vary slightly with each GCM. Generally, to decrease the uncertainties of GCMs, the ensemble option is preferred. However, in order to observe GCMs uncertainties, you can run each GCM separately and compare the results.

When applicable you may also select the *resolution* of the sites. Resolution refers to the pixel size of the input and, subsequently, output rasters. By selecting pixels of a smaller size (e.g. 30 arc seconds versus 10 arc minutes) the resolution of the results map will be increased but this comes at the cost of an increase in processing time. Thirty arc-seconds is approximately 1 km when measured at the equator while 10 arc-minutes is approximately 19 km.

4.3 Select climate variables and define other analysis settings

Variables required:

Climate variables- Input climate data used to calculate climatic similarity.
Weights- Allow the adjustment of the contribution of each variable to the final similarity measure.
Rotation- Data may be rotated using a Fourier transform to compensate for effects of seasonality.
Temporal scale- The months of the year (growing season) that you want to focus the search on.
Threshold- The minimum level of similarity that will be displayed on the results page.

You are able to select between two types of variables: climatic, which refers to monthly precipitation and mean temperature, and/or bioclimatic, which includes 19 variables that describe in detail the seasonality, extremes, and climate averages of sites. A maximum combination of three variables may be selected simultaneously for each analysis (Figure 4.3).

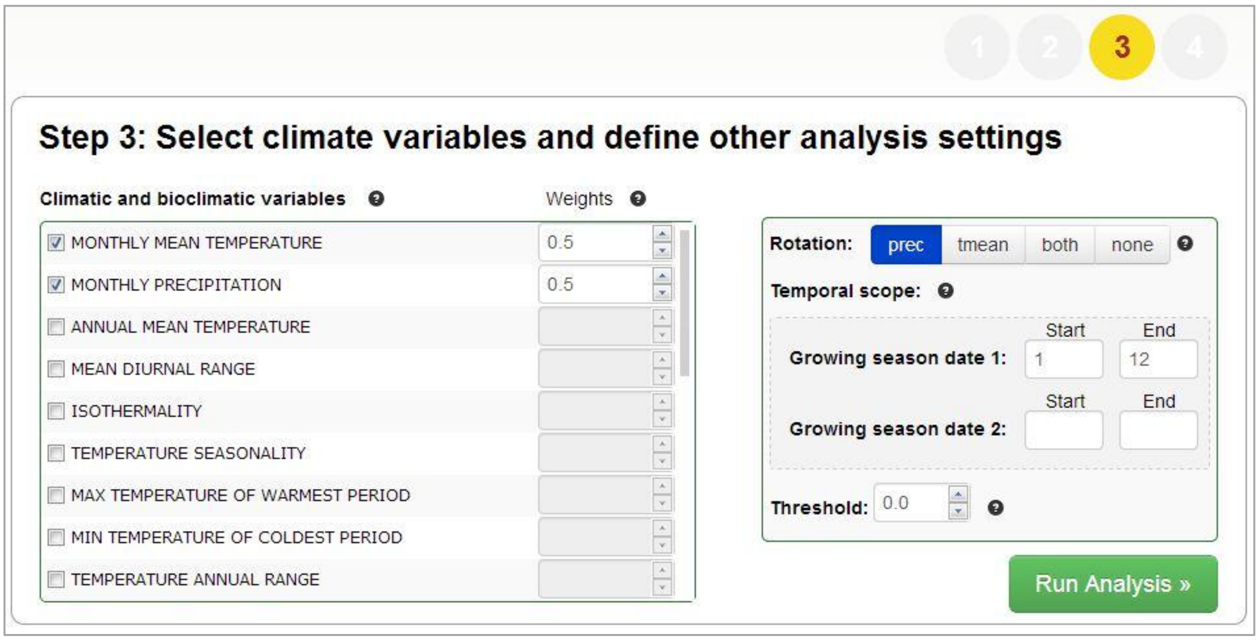

Figure 4.3 Types of climate variables, rotation, growing seasons and thresholds.

There is also the option to *weight* the variables according to the importance we want to give them in the analysis. If you do not have insight into the importance of each variable in the search area, we suggest you first use equal weights of “0.5” for both temperature and precipitation in order to first observe these preliminary results. If one variable is known to be more influential you may modify the weights for temperature and precipitation.

The *rotation* allows you to compensate for the fact that rainfall events and temperature seasonality do not occur at the same period of the year in the northern and the southern hemispheres (as well as other less distinct, but equally important, regional variations). By selecting a rotation the tool will shift (rotate) the climatic data variables for all locations in the search range to align the underlying trends in the data and eliminate the effects of seasonality. Users are free to experiment with the rotations, however we recommend rotating by precipitation in tropical and subtropical locations where there is little seasonal temperature variation but the timing of the raining season may have large agronomic implications, and by temperature at higher latitudes where large seasonal variations in temperature may be observed, i.e. summer versus winter temperatures.

Then, a *temporal scope* can be specified to focus the calculation on a specific period during the year. If there is interest in a specific crop, we recommend defining this period in terms of the crop's growing season. Up to two time periods may be specified and only the months falling within these time periods will be considered when calculating the climatic similarity of the sites. E.g. in Figure 4, the specific temporal scope is chosen from February to June. If you are interested in analyzing the entire year, and do not want to specify a growing season, leave the temporal scope set at 1 to 12 i.e. January to December.

Finally, a *threshold* value can be defined to restrict or filter the results of the analysis to only the most similar sites. i.e. selecting a threshold of 0.5 will result in only those sites with a similarity measure greater than 0.5 being displayed on the map.

4.4 RUN THE ANALYSIS

Once all parameters are set, click on the *Run Analysis* button to begin the calculation. The calculation starts by loading the reference site data during 'training', continues by loading the weights, and then calculates the dissimilarity values between the reference site and all other sites within the search range. Depending on the climatic variables chosen, number of GCMs, the resolution chosen and size of the search range chosen results may take between 1 and 15+ minutes.

4.5 RESULTS

The results are displayed on a basemap in discrete colours from low to high climate similarity with the reference site represented by the target symbol. If a threshold value was chosen only those sites whose CCAFS similarity statistic exceeds that value will be shown. You may zoom to investigate a specific area of interest, view results on a larger map and also print a summary report of your results. These results of a backwards analysis of Ludhiana, in the Punjab region of India identify potential analogue sites in Mexico as well as the Sahel region of Africa that warrant further investigation (Figure 4.4). As the direction of this analysis was backwards the high similarity sites in this instance refer to areas that currently possess a climate that is similar to the future project climate of the reference site (Ludhiana, India).

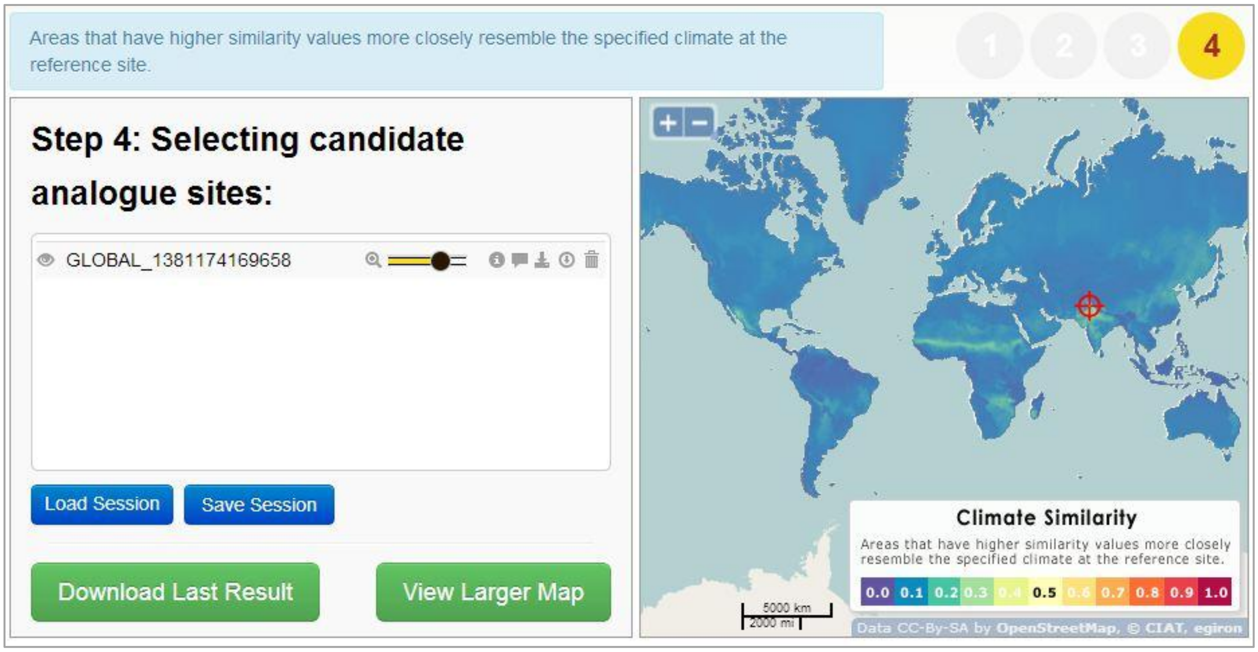

Figure 4.4 CCAFS climate similarity results projected onto a map in the online tool.

There are a number of options available on the results page to assist in visualizing the results and identifying candidate analogue sites:

	Turn on/off layer. Makes layers visible/invisible in the map window.
	Zoom to layer. Zooms to the search area specified for this run.
	Adjust the opacity of this layer. Allows for the results of more than one analogues run to be viewed simultaneously.
	View the parameters used to obtain this result. Displays relevant information for reference site and search range specifications as well as climate variables used.
	Code to use in R. Displays the equivalent R code that could be used to replicate these results locally if supplied with the correct input data.
	Save these parameters. Saved parameters may be reloaded at Step 1. removing the need to renter the parameters
	Download the results in GeoTIFF format for further analysis or display in other platforms.
	Remove this result. Deletes map layer and all unsaved run information.

Upon finishing the first analysis, the user can make additional runs by returning to the *Step 1. Select your location* window or alternatively *Step 2* or *Step 3*. To save time the parameters used during the previous run remain loaded, so only the variables you wish to change need to be modified. The results of all subsequent runs will appear concurrently with the first on the results page, *Step 4. Selecting candidate analogue sites*.

5 CLIMATE ANALOGUES EXERCISES

Now that you have learned how to use the climate analogue tool with the online platform, it is time to practice doing some exercises. Below, you will find two types of exercises: conceptual exercises and exercises with the online platform.

The conceptual exercises do not need the online platform. Those exercises will help you to understand the climate analogue concept and identify situations where you can apply the climate analogue tool.

The exercises with the online platform are designed to help you understand and use with the different parameters that you will choose for the analysis.

5.1 CONCEPTUAL EXERCISES

The conceptual exercises were made to help you clearly understand the climate analogue concept and the three directions that you can use with the tool. Also, those exercises will give you an idea of climate analogue applications in the context of agricultural adaptation strategies.

5.1.1 TRANSITION SYSTEMS ACROSS AFRICA

A critical adaptation strategy for vulnerable areas in Sub-Saharan Africa is the complete switch from a crop-based system to a livestock system, or to a cropping system with more robust crops such as cassava. This transition occurs when the number of growing season days (i.e. days with adequate water and no temperature-stress) drops to a level that is not sufficient to reliably grow crops. Transition from one system to the other might be considered a “tipping” point in these agricultural systems. By analyzing the likelihood of a failed season, these tipping points and the location of transition systems can be determined.

An analysis by Jones and Thornton (2009) has shown that in East Africa there are a number of areas likely to suffer from increasing drought conditions and in which the likelihood of an unsuccessful cropping season is so high that it would be much better to shift to livestock systems (red areas in Fig. 5.1). If these predictions are realized, this means that adaptation strategies for crop producers in these areas need to be implemented for adaptation to future conditions (see Fig. 5.2 for an example of such transition).

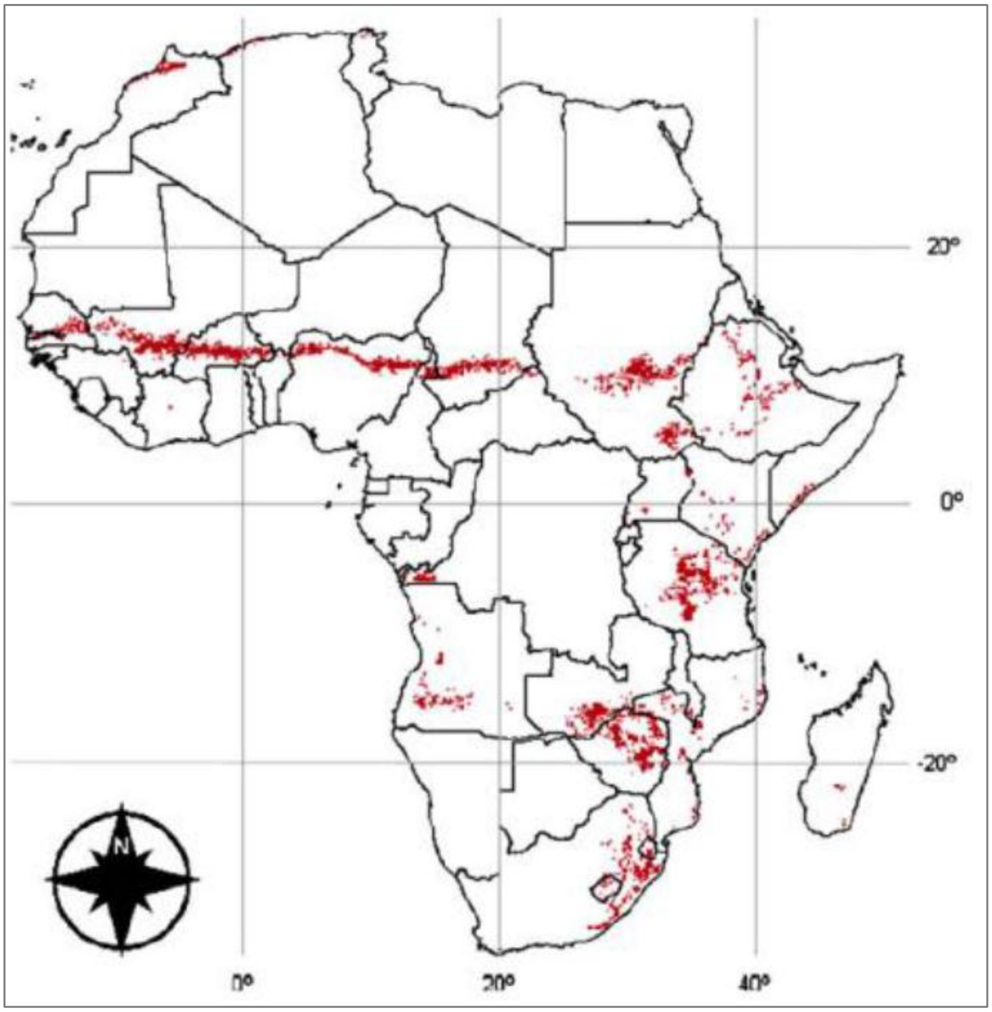

Figure 5.1 Transition zones of Africa by 2050. Areas in which the number of reliable growing season days falls from above to below 90 days between the present-day and the 2050 climates (Jones and Thornton, 2009).

Figure 5.2 Illustration of both types of systems. **LEFT**: A cropping system with a relatively high likelihood of drought (photo Michael Budde, U.S. Geological Survey); **RIGHT**: A livestock system in Turkana (Kenya) (photo British Red Cross). If predictions of Jones and Thornton (2009) are realized, the left system would need to be transformed into the right one for those areas marked in red on Figure 5.1.

Please discuss the following points within your group:

a) Imagine that you own a farm in one of the areas marked red in the map above that is projected to transform to livestock production in the future. How could you use the Climate Analogues tool to identify areas that currently experience you future predicted climatic conditions? Can these be determined with certainty? Why or why not?

b) Key adaptation strategies that could help the systems in red in the long-run can be explored and (possibly) transferred from the identified sites. Could the efficiency in resource use (e.g. water, fertilizer) be increased in these systems and avoid changing farmers livelihoods (i.e. from cropping to livestock production)?

c) List any strategy that would aid these systems in adapting to climate change in the long-term, and discuss with your working group.

5.1.2 Kenyan tea

Tea is probably the most important cash crop in Kenya, where it makes a significant contribution to the economy. In 2007, the country produced 369 thousand tons of tea (of which ~95% was exported). This represents about 26% of the total export earnings, and about 4% of the GDP for the country. Currently the tea growing areas in Kenya are in the following districts: Bomet, Embu, Kakamega, Kericho, Kiambu, Kirinyaga, Kisii, Meru, Murang'a, Nakuru, Nandi, Nithi, Nyamira, Nyeri, Trans-Nzoia and Vihiga (Fig. 5.3).

Analyses from CIAT have depicted the highest-suitability areas for tea production (these are shown in Fig. 5.3, in green). However, future projected climatic conditions show that precipitation is likely to increase, as well as is temperature (Fig. 5.4). These changes might bring challenges or opportunities to tea growers of Kenya.

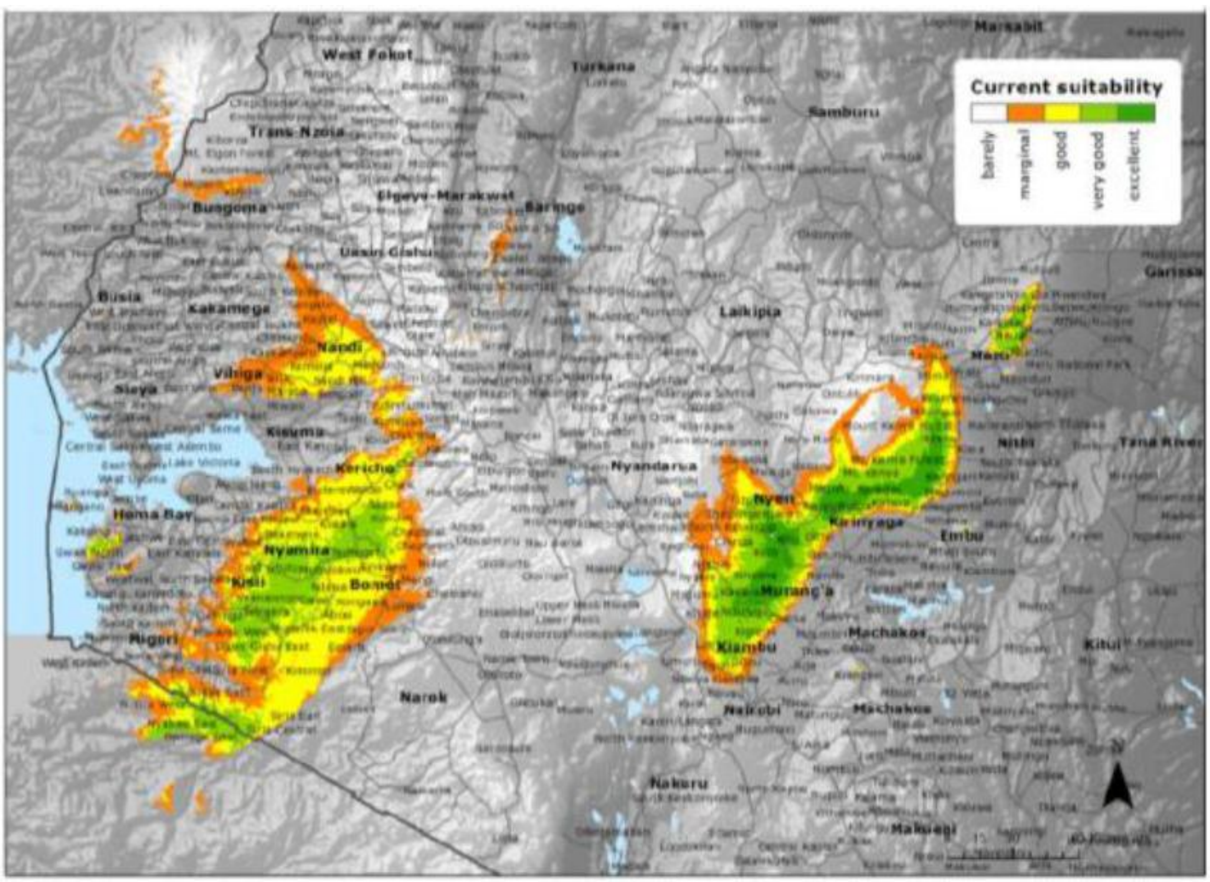

Figure 5.3 Current climatic suitability for tea production in Kenya (CIAT, 2011)

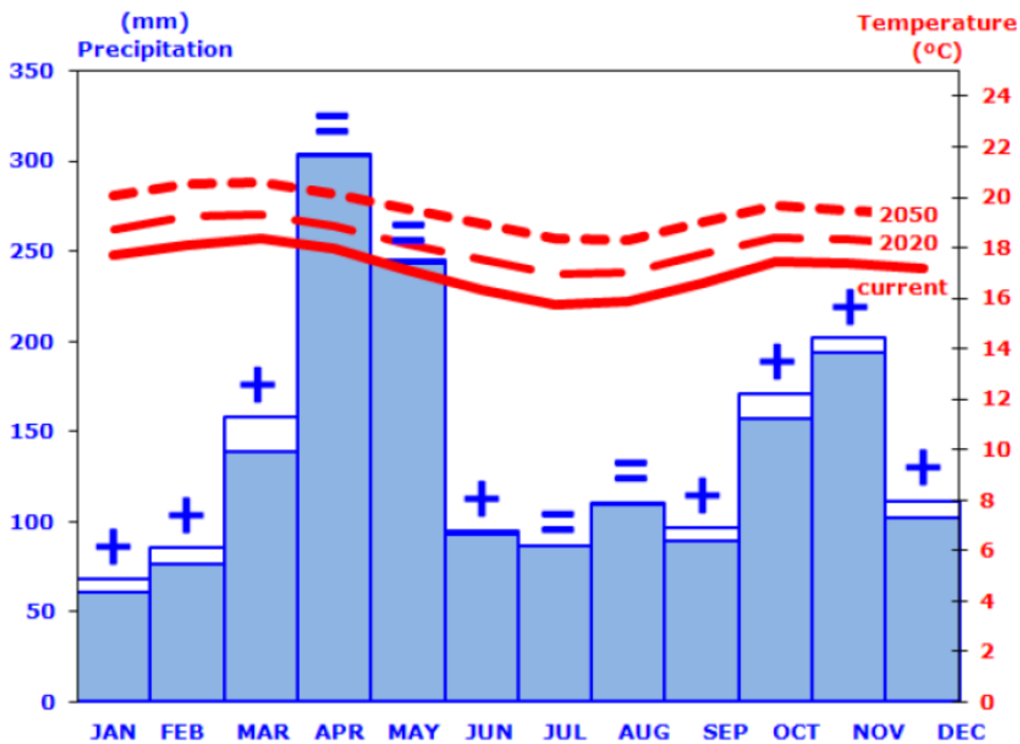

Figure 5.2 Monthly changes by 2020 and 2050 in the tea producing areas of Kenya (CIAT, 2011)

With the above information:

Describe how you would use the analogues tool to explore the likely impacts and adaptation pathways for the tea sector of Kenya. This must be based on what are the expected responses of the crop to predicted changes in climates.

Base your analyses on: (i) challenges that can arise from stresses to the crop; and (ii) opportunities from crop migration (i.e. the possibility of growing tea in new areas).

5.2 EXERCISES WITH THE ONLINE INTERFACE

The exercises with the online interface were made to manipulate the different parameters of the tool. You will learn about direction of the analysis, seasonal variation, temporal scope, climatic variables, weight of the climatic variables and model uncertainties. Below, you will find the description of all exercises. Farmer stories were accessed on CCAFS' Adaptation and Mitigation Knowledge Network: http://amkn.org/

5.2.1 Adapting to changing climatic conditions in Mali.

Tidiane Diarra discussing agricultural adaptation to changing climatic conditions in his fields at Bouwèrè, Mali. (Video may be accessed at: https://www.youtube.com/watch?v=PCIB2z4b8wI&feature=player_embedded)

Bouwèrè is a village in Mali that has successfully adapted agricultural practices to reduce the negative effects of changes that have been observed in local climate conditions. Tidiane Diarra is a successful local farmer who produces millet, sorghum, sesame and cowpea. Over the years Tidiane has observed changes in rainfall patterns during the cropping season that increased the possibility of crop failure for late-maturing varieties and explains how he has modified his production practices in response to this:

> *"In the past it rained early, now it only rains now and then. This is why we switched to fast growing crops."*

Empowered with the provision of seasonal climate forecasts and the use of early-maturing varieties Bouwèrè farmers can make informed decisions on the timing of production practices and have improved their resilience of in the face of climate change. Further, the installation of a weather station in the village by PRECAD (Projet de Renforcement des Capacités pour une Agriculture Durable) has improved climate observations taken in the village and provided a firm foundation for monitoring and quantifying future climate change.

a) Although seasonal forecasts provide invaluable knowledge for short term planning in terms of crop selection and timing of production practices describe the additional benefits Bouwèrè farmers could achieve by using the Analogues approach to look further into the future and identify analogue sites.

b) Perform a backward analysis on Bouwèrè (latitude: 13.660, longitude: -6.240) over the rainy season (May to October) to identify areas within Mali that currently experience climatic conditions similar to the future predicted climate of Bouwèrè. Note: using a threshold of 0.5 will highlight the most similar sites.

c) How could this analysis be further refined? What other variables have important effects on crop growth (or product marketing) and should be considered before making a final decision on analogue sites to investigate?

5.2.2 TECHNOLOGY TRANSFER FOR HANOI, VIETNAM.

The exchange of agricultural knowledge and germplasm is not only important for long-term adaptation strategies, but is also invaluable for short-term planning and offers opportunities for collaborative progress. With this in mind the Climate Analogues online tool also allows you to identify locations that currently possess similar climates, which may be fruitful areas for the exchange of knowledge and resources.

a) Perform an analysis to identify other areas around the world that currently have a climate similar to the current climate of Hanoi, Vietnam (latitude: 14.102, longitude: -15.539).

b) Discuss the similarity map and if the identified analogue sites are realistic in terms of climate similarity to Hanoi (Hanoi experiences a warm, wet summer and a relatively cool, dry winter).

c) Discuss the different crops and technologies used at the identified analogue sites and there appropriateness for adoption at Hanoi. What factors other than climate drive the production of crops in the different areas around the world?

5.2.3 Understanding future climate uncertainties at Panama City.

Global climate models are mathematical representations of the climate in which complex physical and chemical interactions occurring in the atmosphere and ocean are simplified to allow us to predict future conditions. This simplification means that the models are not perfect and differences in grid size, time steps and parametisation between global climate models (GCMs) may result in differences in future projected climatic conditions. Although use of the ensemble option on the online tool may reduce some of the individual model uncertainty, it is important to understand and appreciate the underlying uncertainties produce by individual models.

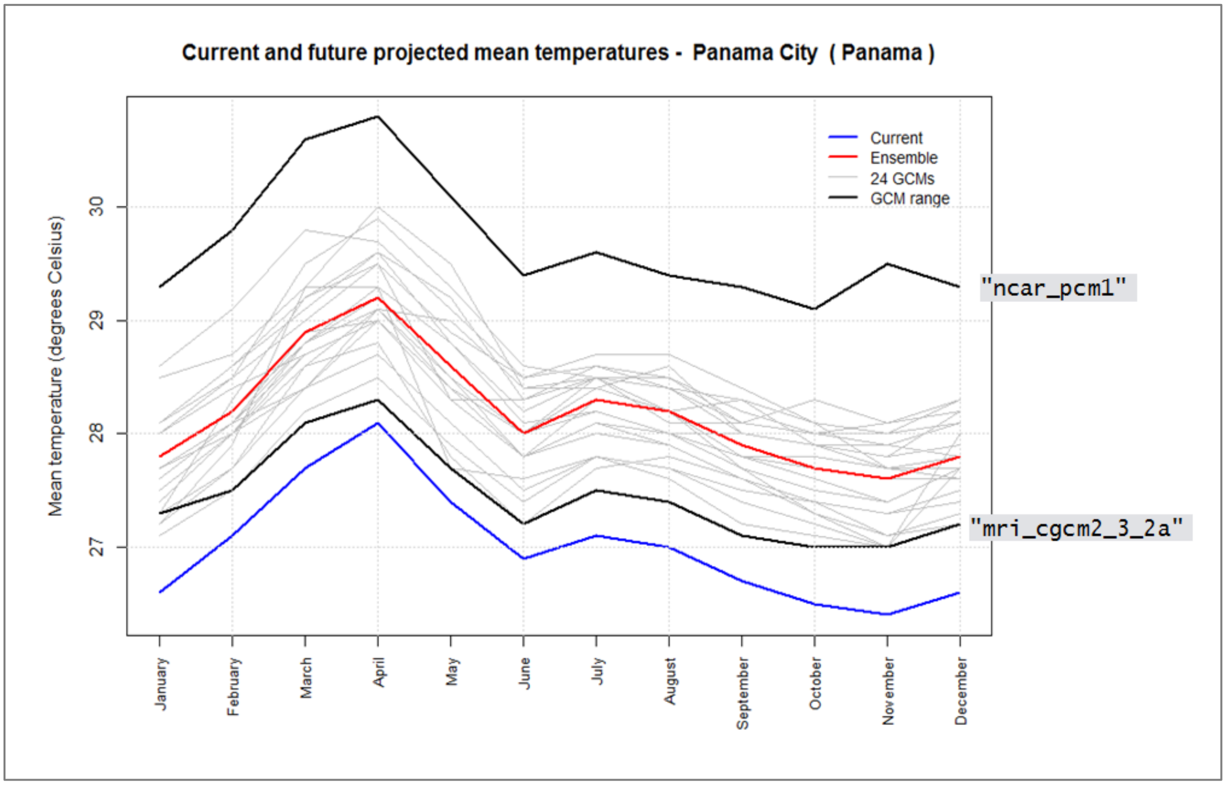

Figure 5.5 Monthly mean temperatures at Panama City, Panama, depicting current temperatures (blue line), the average projected future temperature for all global climate models (GCMs) (red line), as well as the projected temperatures for individual GCMs (grey lines, the GCMs producing the highest and lowest temperatures highlighted in black).

a) Perform three backward analyses at Panama City to investigate the similarity maps produce by comparing the mean temperature using "ncar_pcm1" (higher range temperature), "mri_cgcm2_3_2a" (lower range temperature) and the ensemble for emissions scenario A1B.

b) Discuss differences in the produced similarity maps and the importance of not relying on a single GCM for your prediction. Why does "ncar_pcm1" show a smaller area with similar temperatures compared to "mri_cgcm2_3_2a"?

c) Emissions scenarios add another level of uncertainty to future climate projection as different levels of greenhouse gases emitted under the various scenarios have the potential to directly impact future climatic conditions. Produce two additional backwards analyses for Panama City using the ensemble and emissions scenarios A2 and B1. Compare this to the previous map produced for emissions scenario A1B and discuss differences. *Note:* emissions scenario A2 describes a future world with a greater emphasis on regionally focused economic development, while B1 describes a future world with a greater emphasis on global development with a focus on environmental sustainability.

d) Which produces more uncertainty to the 2030s decade GCMs or emissions scenarios?

5.2.4 Luigi's mother-in-law farm germplasm exchange

A "backward" comparison of the climate of researcher Luigi Guarino's mother-in-law's farm in the Limuru highlands (Longitude=36.700, Latitude= –1.080) has been carried out. The analysis showed areas located within Kenya as well as in Ethiopia that currently have climatic conditions similar to the future projected conditions at Luigi's mother-in-law's farm (Fig. 5.6). Germplasm exchange from these identified locations could help adaptation by provided plants that are already well adapted to these distinct climatic conditions. So, based on a map of dissimilarity, Luigi said to his "Grandma":

> *"Well you need to look ahead, here's a map of places which right now look like your place will look like in 2030. You need beans from a bit further north in Kenya, as well as some bits of Ethiopia."*

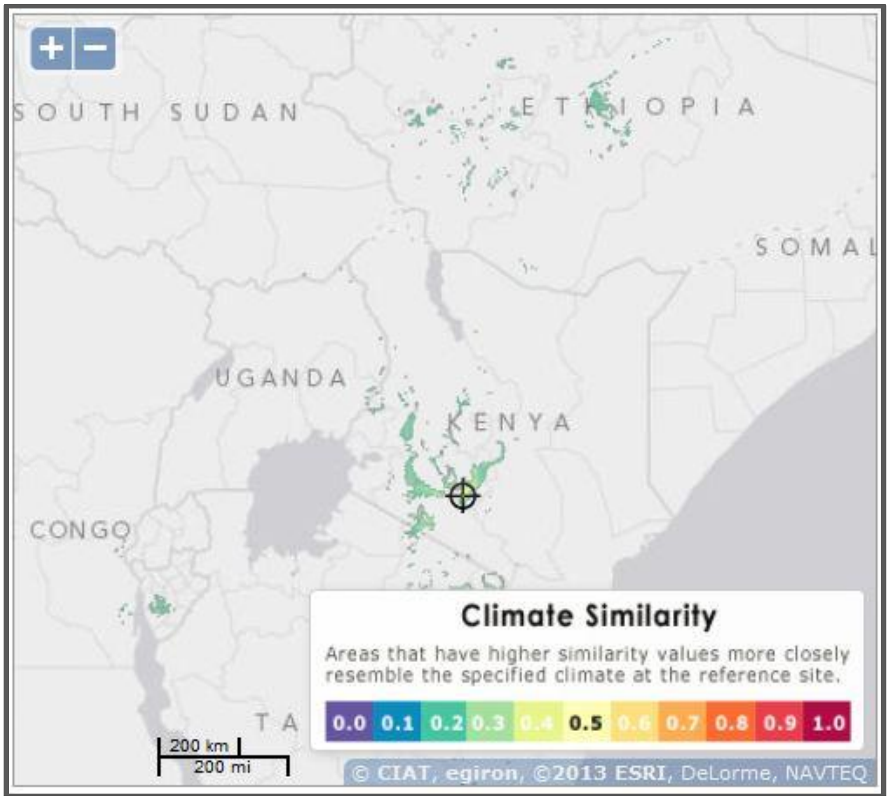

Figure 5.6 Map of dissimilarity between the future climates of Luigi's mother-in-law farm (marked with the black target, in Kenya) and all other climates in East Africa.

a) Perform an analysis in order to find other areas in Africa that could currently benefit from germplasm exchange with our target farm in Limuru (36.700, –1.080).

b) Find other the locations within Africa that in the future could benefit from the germplasm that Luigi's "Grandma" is currently growing.

c) Analyse the results to answer the following questions:

- Is Luigi's "Grandma" likely to become more or less internationally "dependent" in regards to germplasm exchange? Why? (*hint: compare the now-to-now analyses, with the backward analyses*)

- Discuss from where to where genetic resources could flow for both analyses and how could this be achieved for the region.

- What would be the possible implications of such exchange for the East African region?

- How confident would you be in the predictions you have just made? Why? Would you recommend the Kenyan breeding programs and genebanks to look for genetic resources elsewhere in Africa based on these predictions?

5.2.5 Dry season vegetable garden in Lawra, Ghana.

Although the rainy season provides sufficient water to grow crops such as groundnuts, maize, sorghum and millet, farmers in Lawra, Ghana struggle through the dry season as no crops can be grown unless they are watered with irrigation. This problem has become worse in recent years as the rainy season has been starting later and finishing earlier meaning less water is recharging irrigation sources. Naakpi, a local farmer, tells how he has found it increasingly difficult to water his vegetables through the dry season even though he has had a borehole sunk on his property and also invested in a pump to bring water from a nearby river in which he built a dam. Although Naakpi's vegetable garden is lush and green at the moment he believes that the small amount of irrigation water he has left will not be sufficient for the plants to mature and they will dry up and die before they are ready to harvest.

Naakpi in his currently lush vegetable garden in Lawra, Ghana. (You can read more of Naakpi's story here: http://ccafs.cgiar.org/fr/blog/defending-vegetable-farm-against-drought#.Uk0G9CgjHBw)

a) Perform a forward analysis of Lawra, Ghana (latitude: 10.637, longitude: -2.859) to identify areas within Ghana that are predicted to have a similar climate to Lawra in the future.
It is these locations that will benefit most from hearing Naakpi's story and how he utilises the rainy season to grow his staple crops but struggles through the dry season. By identifying the practices and crop varieties have performed well in Lawra's current climate and also understanding the difficulties the climate has placed on agricultural production, farmers at the identified sites will be better prepared for the limitations that the climate may place on them in the future and may more effectively adapt to overcome them.

b) Discuss strategies that could be used in Lawra now, and the identified analogue sites in the future, to improve the adaption of agriculture to water limitations through the dry-season and reduce the risk of total crop failure.

6 The Climate Analogues Team

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The Climate Analogues tool is under continual development and will be continuously improving. Please don't hesitate to contact us if you have any questions or comments about the tool.

7 Glossary

Backward direction: Identify where we can find the future climate of my site. The future climate of the reference site is compared with the present climate of all other locations in the world (or region of interest)

Forward direction: Identify where the present climate of my site can be found in the future. The present climate of the reference site is compared with the future climate of all other locations.

GCMs: The **G**lobal **C**limate **M**odels. Several research institutes developed a total of 24 GCMs.

None direction: Identify sites with climate similarity at the same time scale. The present or future climate of the reference site is compared with the present or future climate of all other locations.

Reference site: Site selected to start the climate analogue analysis

Rotation: Takes into account the fact that rainfall events and temperature seasonality do not occur during the same period of the year in the northern and the southern hemispheres.

Similarity measure: The CCAFS similarity measure calculates the climatic distance between sites, this value is then use to consider whether one site is an analogue of another.

SRES: Special Report on Emissions Scenarios. The IPCC developed six families of climatic scenarios. For the moment, the one used in the analogue online platform is the scenario A1B which is an intermediate scenario. This scenario refers to a future world of very rapid economic growth, low population growth and rapid introduction of new and more efficient technology. In this world, people pursue personal wealth rather than environmental quality. In later versions, you will have the choice between 3 different emission scenarios from the IPCC report: A1B, A2 and B1.

Temporal scope: Specify the period of time you want to study with the analogue tool. Normally, when running the analogues, we focus a specific crop growing season.

8 Climate Analogues Resources

- The CCAFS climate analogues homepage: http://www.ccafs-analogues.org/

- The climate analogues online platform: http://analogues.ciat.cgiar.org/climate/

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