Climate Corridor Analysis – an introductory manual

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This introductory manual gives background and basic concepts of climate corridor analysis, together with some examples. Further references and do-it-yourself instructions are given in the Additional resources section.

Introducing climate corridors

Speaking geographically, many of the world regions where Swiss NGOs work will suffer from negative impacts of climate change on crop productivity (see Figure 1). The need for assessing the impacts of climate change is therefore obvious, also within projects which address a wider range of climate-related issues such as water resource management, migration and conflicts. Especially rural livelihood

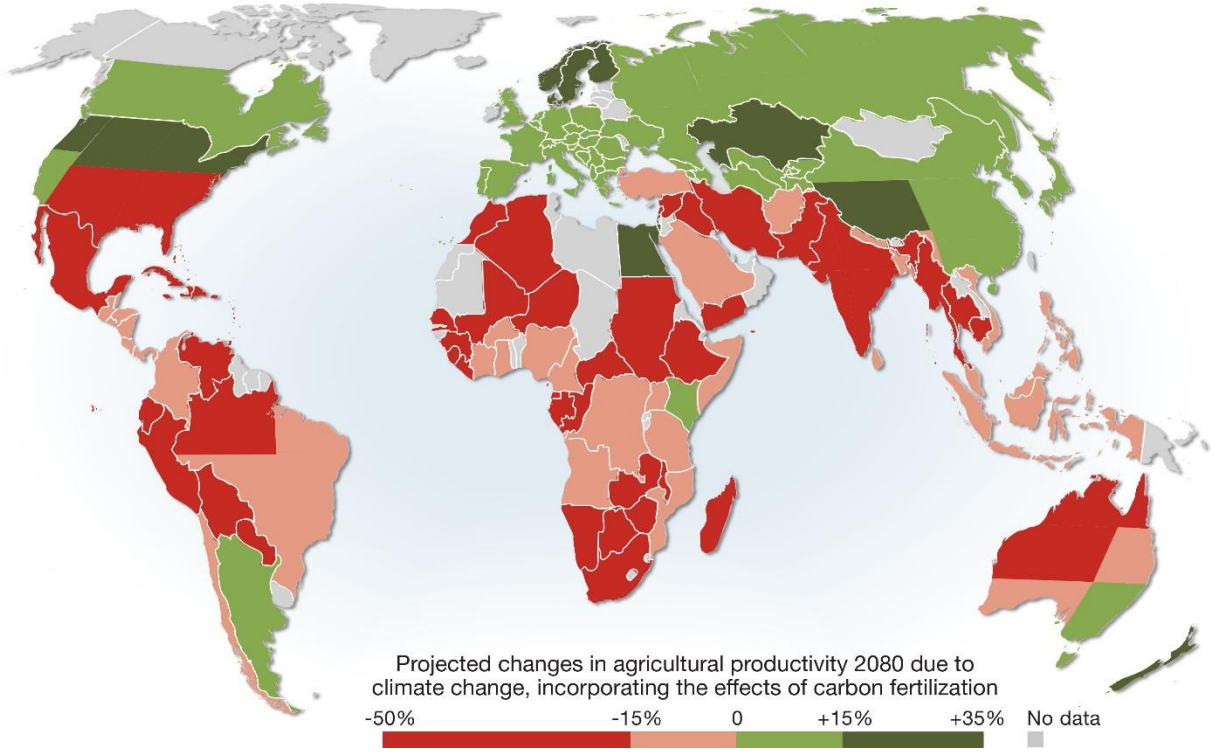

Figure 1: Projections on the climate in the future provide some guidance for us, but what do we know about societies' responses? This map presents a rough idea of changes in agricultural output from increased temperatures, precipitation differences and also from carbon fertilization for plants. Projecting climate is one thing, but agriculture adds multiple more dimensions of complexity – extreme events, crop rotations, crop selection, breeds, irrigation, erosion, soils and much more. Source: www.grida.no/resources/6829 (accessed December 2017).

improvement can face serious limitations from climate change. Unfortunately, addressing the dimension of climate change in development projects is challenging.

Reasons include the need to tackle targets such as health, poverty, violent conflicts and environmental degradation with higher priority, although many of these targets are often exacerbated by climate change. In practice equally important are resources limitations that do not allow for performing sophisticated analyses of local impacts of climate change.

Instead of performing such sophisticated analyses, the climate corridor approach puts the focus on the specific climate conditions that many human activities require. A typical example is crop cultivation, which needs temperature and precipitation being within crop specific ranges. These ranges, termed here for short as "climate corridors", are compared with present-day climate conditions and future climate projections to assess the activities' viability under climate change.

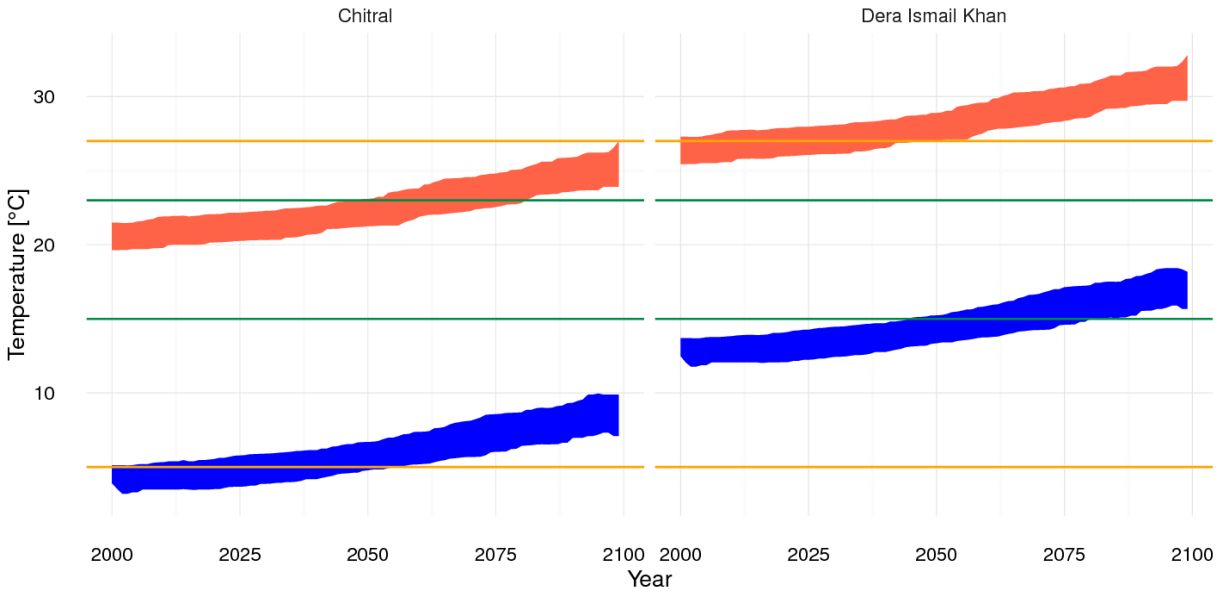

Figure 2: Temperature corridors for wheat cultivation from FAO's Ecocrop database (horizontal green lines: optimal corridor, orange lines: absolute corridor). Current and future projected temperatures of the coldest (blue bands) and warmest (red bands) months during the growing season, displayed for two districts in Pakistan according to a scenario of strong climate change. See Orlowsky et al. (2017) for details.

For example, Figure 2 shows temperature ranges for producing a standard wheat variety (green and orange lines) together with projections of the coldest and warmest months of the growing season in two districts of Pakistan. The coldest months in mountainous Chitral are barely within the absolute corridor during the first half of the 21st century, and only in the second half both coldest and warmest months are within the absolute corridor. The critical conditions today and for the coming decades are consistent with the fact that today wheat in Chitral (above 1500m a.s.l.) does not reach maturity and is produced for fodder mainly. Improving conditions after about 2050 give an example of an opportunity arising from climate change.

In Dera Ismail Khan in the low-lying Indus plains, on the other hand, conditions are acceptable today, but less so starting from about 2025 when the warmest month is projected to leave the absolute corridor. This suggests that without adaptation, wheat cultivation will become difficult to sustain during the second half of the 21st century, giving an example of a threat from climate change.

Figure 2 stems from an analysis within the Livelihoods Programme Hindukush in Pakistan, led by HELVETAS Swiss Intercooperation, which contributes to improving livelihood strategies of rural

households and reducing their vulnerabilities to disasters and climate change in North-Western Pakistan. Capacity building enabled local partners to perform these analyses independently, which led to their integration into the official Local Adaptation Plan of Action of Chitral district.

The wider context

Current scientific approaches to these questions often involve complex modelling systems that in theory are able to simulate the relevant processes with detail. However, these models require a similar level of detail in input, e.g. information on cropping choices, crop calendars, local weather and climate, management of irrigation and fertilizers, to name just a few. In practice, this information is mostly not available at the local level. As an alternative to the complicated process of setting up such a modelling system for a site of intervention, several internet platforms publish ready to use output from established modelling systems (see for example the Global AgroEcological Zones, hosted by FAO). However, information there is limited to few standard crops.

Climate corridor analysis provides a flexible and versatile alternative that accommodates different levels of complexity, adapted to the availability of local information. Climate corridor analysis is no rocket science, and, compared to other state of the art scientific approaches, may appear as oversimplifying important aspects. Nevertheless, results from this analysis have shown a remarkable robustness, recommending the approach for a first-order evaluation of climate change impacts.

Involvement of local partners and field staff when applying the approach is essential, for example to get the climate corridors of the considered crops right and for validating the climate projections with local realities. This involvement additionally creates ownership and awareness of constraints arising from future climate change.

Moving towards evidence-based design and management of development projects is a trend that many NGOs follow for a while now. While learning along the way is enormous, large potentials for better exploit of available or easy to generate information prevail. Several conceptual investigations with climate corridor analysis encourage the pursuit of this avenue. Besides providing an indication on if and when a specific measure becomes impossible (or viable), the experiences from the discussions around local climate corridors and climate conditions of today and the future proved of immense value for a deeper understanding of the overall context.

Applying climate corridor analysis

Basically, climate corridor analyses combines three ingredients:

1. The climate corridors themselves, for example suitable ranges of temperature and precipitation (in Figure 2, these are the horizontal lines)
2. Average local climate conditions of today – for many applications, monthly averages will be enough (in Figure 2, this corresponds to the starting temperatures of warmest and coldest months)
3. Future projections of climate (in Figure 2, projected temperature changes are added to the starting temperatures to give future temperatures)

All these ingredients are available from public data sources (see Table 1). It is however strongly advised to cross-check and complement them with local knowledge and data, not only for increased accuracy but for the significant co-benefit of involving local people into the discussion.

Table 1: Ingredients of Climate Corridor Analysis

	Pulic data source	Local knowledge
Climate corridors	Climate corridors for a large number of default varieties are available at the ecocrop portal maintained by FAO (www.ecocrop.fao.org)	Sometimes studies by local research institutions on local crop varieties allow for variety-specific climate corridors.
Today's climate	Average monthly temperatures and precipitation amounts are available for the entire globe from various datasets, for example at http://sdwebx.worldbank.org/climateportal/	Sometimes weather stations exist nearby or can be installed during the project. Their data provide an essential advantage for correctly quantifying today's climate conditions
Future climate	Various data portals make climate projections of the current global and regional climate models available. Particularly user-friendly: the "climate explorer" at www.climexp.knmi.nl	Sometimes further information can be found in national or sub-national studies on climate change. These however often focus on specific climate models and thus do not capture the full range of uncertainty.

Climate corridor analysis, being developed to work under data and resource scarce situations, does not require any major investment in data or software. Climate data of present-day conditions and future projections are publicly available from several web resources, and the simplest form of climate corridor analysis can be done within Excel (see also Additional Resources at the end of this document). However, for a proper application, it does require some background in climatology and its relation to the activity of interest (which will in many cases be related to agriculture or forestry). Local observations e.g. from weather stations add of course to the accuracy of the analysis, but they are generally not a must-have.

Extending climate corridor analysis: An example from Tajikistan

CARITAS Switzerland coordinates a project in Tajikistan to counteract the overuse of forests in recent decades (resulting from declined supply of heating material and coal after the end of the Soviet Union) and support the Forestry Agency in planning and implementing forest rehabilitation. In order to assess the potential role of walnut trees, a species of economic and cultural value to the region, within the national reforestation strategy, the project needed to assess climate change impacts on these trees, in particular to know the elevation ranges in which walnut trees will be able to grow in future.

Tajikistan is characterized by considerable topographic variations, which induce strong climatic gradients. While temperature decreases with increasing elevation, the opposite holds for precipitation (see the read and blue curves, respectively, in Figure 3, left). This means that there is a lower elevation, above which precipitation is enough to sustain walnut trees, and an upper elevation, below which temperatures are high enough to sustain production during the coldest month of the growing season (April to October).

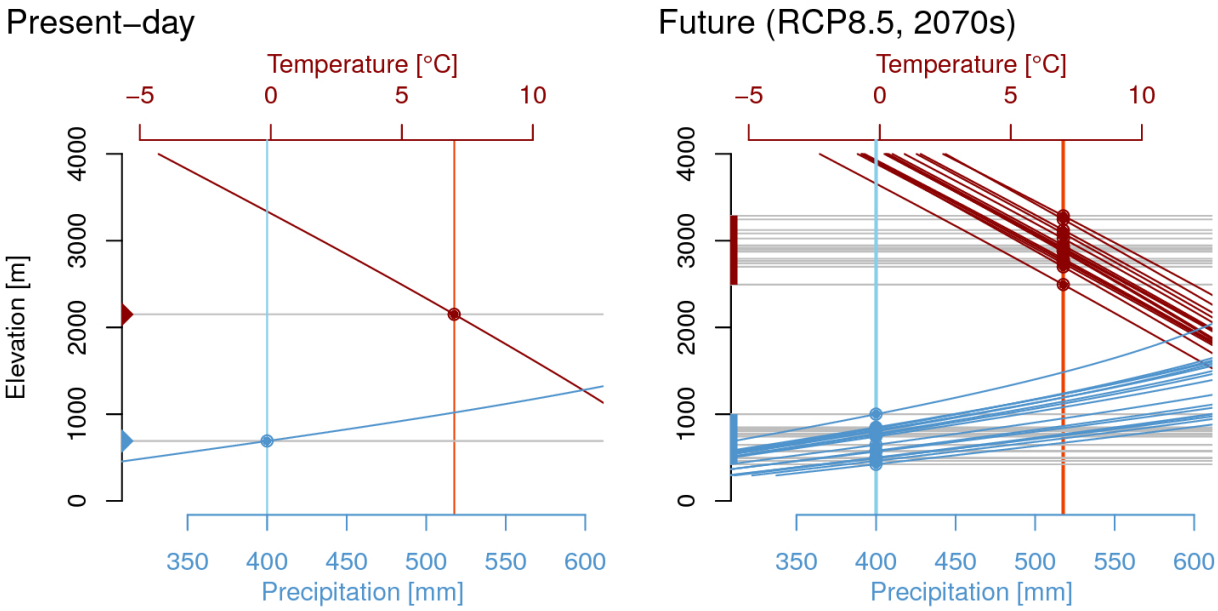

Figure 3: Left: Temperature and precipitation relations to elevation (red and blue curves, respectively). Vertical lines show minimum required temperature of the coldest month and minimum annual precipitation. Their intersection with the temperature and precipitation curves mark the suitable elevation range for growing walnut trees in Western Tajikistan Right: the same for 17 GCM projections of the 2061-2080 conditions.

Looking at the curves of Figure 3, under present day conditions, walnut trees can grow between approximately 800 and 2200 m a.s.l., which agrees well with their actual occurrence. Looking into the future, note that there are now 17 curves relating elevation with precipitation and temperature, respectively. These come from 17 individual future climate projections from different climate models. Together, these curves highlight that recipitation does not change much, and hence the lower elevation bound remains similar. However, increasing temperatures make the upper elevation rise, extending the suitable range into higher elevations. This is a case of an opportunity arising from climate change.

Discussion and Conclusion

Climate corridors as applied to the walnut tree analysis in Tajikistan and wheat in Pakistan provide a simple means to assess the general suitability of a crop or tree, both in space and time (where and when do changing conditions make cultivation of a certain crop feasible or impossible). Such analysis gives a first check of the activity's sustainability. However, it is important to keep in mind that other factors can be of equal or even greater importance. Soil, ability to manage efficiently, including the application of fertilizers in the case of agriculture, and social acceptance will affect the long-term feasibility as well, to name just a few.

While the analysis in this paper all derive from crop cultivation and forestry, and climate corridor analysis is likely to have its most applications in these areas, other types of activities also lend themselves to this approach. Consider for example pest management – potentially harmful bugs have just like crops preferred climatic ranges, and changing climate conditions change the extent of their habitats, often into higher elevations. Generally speaking, climate corridor analysis applies to any activity or measure which requires a certain window of climate conditions.

Another important point to consider is the uncertainty inherent to future climate projections. This uncertainty stems on the one hand from the fact that we do not know future anthropogenic influences on the climate, mostly through greenhouse gas emissions and land use change. To address this uncertainty, different scenarios of how these influences may vary in the coming decades have been developed, and

climate models translate these future story lines into a response of the climate system. These models are highly sophisticated computer programs, more or less independently developed by several research groups around the world. Differences between these models in the description of some physical processes add another source of uncertainty, which comes on top of a third category of uncertainty from the complexity of the climate system itself and its partly chaotic behavior.

All these sources can be accounted for in climate corridor analysis – e.g., the uncertainty from the differences in climate models is reflected the width of the temperature bands in Figure 2 or the range from the many lines for the future relationships between temperature, precipitation and elevation in Figure 3. Both figures reflect changes of a scenario of strong climate change. Reproducing them for scenarios of weaker climate change allows for quantifying the effect of another path of global development on the specific local activity. The simplicity including this uncertainty is an important asset, since many impact studies rely only on selected future projections and thereby risk to be overconfident on a specific climatic future. The two examples presented here also nicely show that the existing uncertainty does not prevent practice-relevant conclusions.

Additional resources

The webpage of the Swiss NGO DRR platform hosts a number of additional resources

- A scientific publication on climate corridors: Orlowsky, Boris, Pierluigi Calanca, Irshad Ali, Jawad Ali, Agustin Elguera Hilares, Christian Huggel, Inamullah Khan, et al. 2017. "Climate Corridors for Strategic Adaptation Planning." International Journal of Climate Change Strategies and Management 9 (6):811–28. https://doi.org/10.1108/IJCCSM-12-2016-0183.
- Crop Weather and Climate Vulnerability Profiles, including climate corridors of important crop and additional climatic requirements. Published by CONCERN worldwide (see here for more information).
- The Local Adaptation Plan of Action for Chitral District in Pakistan, which features climate corridor analyses for local staple crops.
- A step-by-step guide and an Excel workbook to perform simple climate corridor analyses (similar to the one in Figure 2), including instructions for downloading the required data.
- Several presentations on related case studies.