CLIMATE CHANGE, LAND USE, AND CONFLICT IN NORTHERN AFRICA

P. Michael Link, Jasmin S. A. Link, Jürgen Scheffran

Forschungsgruppe Klimawandel und Sicherheit (CLISEC), Institut für Geographie, Centrum für Erdsystemforschung und Nachhaltigkeit, Universität Hamburg

michael.link@zmaw.de
jasmin.link@zmaw.de
juergen.scheffran@zmaw.de

Introduction

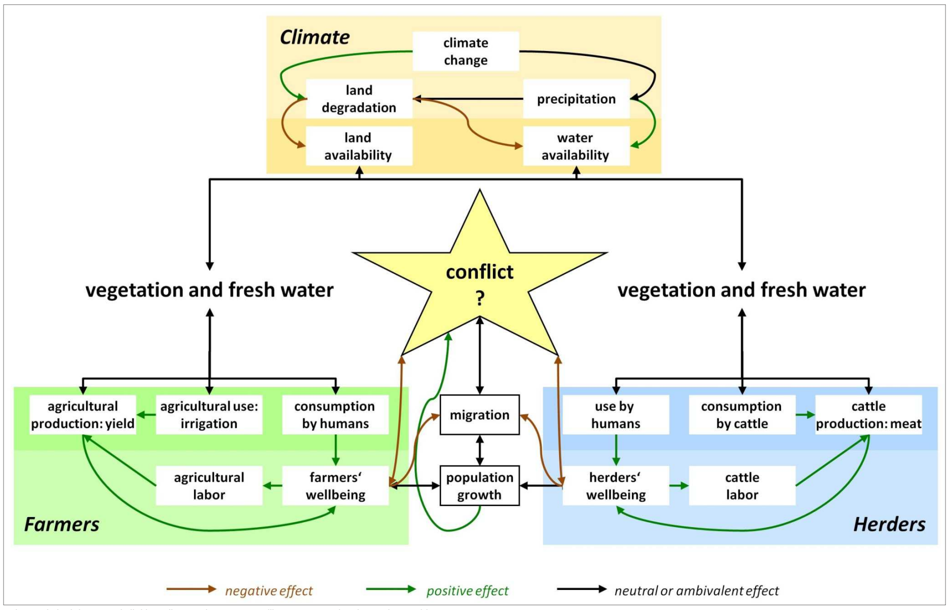
There is a complex relationship between environmental conditions and their change due to anthropogenic activities and the possible implications for societal stability. Increased stress on resources that are vital for human wellbeing can trigger conflicts or they can actually lead to increased cooperation for the common good. Climate change affects the availability of water and land, which are both essential for the production of agricultural goods. However, there are additional pressures on land and water due to a constantly growing population in Northern Africa as well as economic development, both of which increase the overall demand for resources.

Based on model simulations with an ocean-atmosphere general circulation model, the possible links between environmental conditions, the production of agricultural goods, the availability of water, and the conflictive or cooperative interactions between humans in Northern Africa are explored.

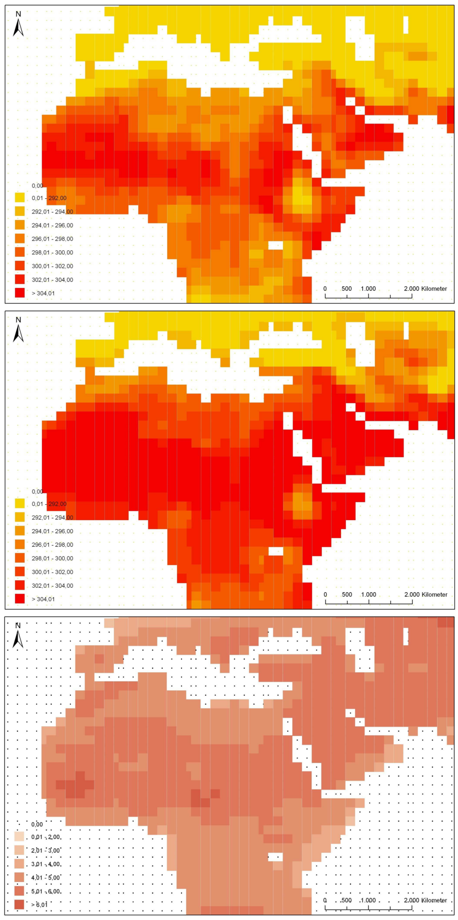
Climate model simulations

Several variables of the earth system are of fundamental importance for the ability to produce agricultural goods in Northern Africa. Among these are temperature, precipitation, and soil moisture. Simulations of an RCP 8.5 scenario using ECHAM6 show a distinct warming trend, which affects all areas of Northern Africa more or less similarly. However, the picture is less clear for precipitation and soil moisture.

According to the latest IPCC AR5 report, estimates of possible precipitation changes in Northern Africa vary, except for the region adjacent to the Mediterranean Sea where a clear signal of reduced precipitation emerges. Other areas, e.g. the Ethiopian highlands, can possibly even benefit from increased precipitation. In the RCP 8.5 scenario soil moisture generally decreases in Northern Africa even though there are a few local deviations from this trend. Considering the developments of these key variables, it is likely that agricultural production is adversely affected by environmental change in this century.



The analytical framework linking climate change to conflict or cooperation in Northern Africa



Top: Land temperature, average in the 2010s
Middle: Land temperature, average in the 2090s
Bottom: Change in land temperature from the 2010s to the 2090s

Impacts on agricultural yields

Agricultural yields are dependent on a number of environmental variables. For each crop these variables have to be in particular ranges in order to allow for optimal plant development. Assuming the optimal conditions for a given crop are known, it is possible to determine how yields are affected by changes in envionmental conditions as they are brought about e.g. by climate change.

Let *Y* be the yield of a crop that depends on the climate variables (x_1, …, x_i, … x_n) in a given area and during a given time span. Let us then assume that there is one global maximum $\bar{Y}$ as a function of the n variables ($\bar{x}_1$, …, $\bar{x}_i$, … $\bar{x}_n$) so that for every change in the combination of variables only a yield lower than $\bar{Y}$ would be obtained. Additionally, assume that the graph of the yield function *Y* is some kind of a bell curve, somewhat like an n-dimensional parabola. Then the function *Y* (x_1, …, x_i, … x_n) can be described with coefficients determined by the set of environmental conditions ($\bar{x}_1$, …, $\bar{x}_i$, … $\bar{x}_n$) as the equations in the next column indicate.

$$Y(x_1, \ldots, x_i, \ldots, x_n) = \beta_0 + \beta_1 x_1 + \beta_2 {x_1}^2 + \ldots + \beta_{2i-1} x_i + \beta_{2i} {x_i}^2 + \ldots + \beta_{2n-1} x_n + \beta_{2n} {x_n}^2$$

$$\xRightarrow{\text{partial derivative}} \forall i = 1, \ldots, n: \frac{\partial Y}{\partial x_i} = \beta_{2i-1} + \beta_{2i} x_i$$

$$\text{for } Y = \bar{Y}: \frac{\partial Y}{\partial x_i} = 0, \forall i = 1, \ldots, n \Leftrightarrow \bar{x}_i = -\frac{\beta_{2i-1}}{2\beta_{2i}}$$

$$\Rightarrow \bar{Y} = Y(\bar{x}_1, \ldots, \bar{x}_i, \ldots, \bar{x}_n) = \beta_0 - \sum_{i=1}^{n} \beta_{2i} {\bar{x}_i}^2 \quad \text{with} \quad \beta_{2i} < 0 \; \forall i = 1, \ldots, n$$

If this equation can be obtained by a regression using agricultural data and the additional coefficients generated by the equation for $\bar{x}_i$, the general yield function *Y* (x_1, …, x_i, … x_n) can be computed in the following way:

$$Y(x_1, \ldots, x_i, \ldots, x_n) = \bar{Y} + \sum_{i=1}^{n} \beta_{2i-1} x_i + \beta_{2i} \left({x_i}^2 + {\bar{x}_i}^2 \right)$$

This links agricultural production to environmental conditions. Now a further connection to water availability in Northern Africa is possible.

Water availability in the Nile River Basin

Water availability is a key issue in Northern Africa that has a considerable conflict potential, particularly in the Nile River Basin. The overall amount of water is limited and riparians have to share the available water. A model has been set up to simulate the possible investment paths of the countries to meet their water needs. These can be either cooperative or conflictive. Agricultural production fundamentally affects water consumption in the region. Due to population growth and economic development the overall water demand is constantly growing and countries need to invest to increase their supply or to reduce consumption by improving water use efficiency.

Among the key riparians of the Nile, Egypt is most likely to turn to conflictive means to secure their water share. However, extensive attempts are made to reach a cooperative agreement on the Nile water allocation.