Developing an Agricultural Land and Policy Simulator to Promote Climate-Smart Policy

Safae ELMISAOUI
Souhail MAAZIOUI
Saad BENJELLOUN
Abdelkrim LACHGAR

Université Mohammed VI Polytechnique

saad.benjelloun@um6p.ma

Charles JONES
Travis FRANCK

Climate Interactive

cajones@climateinteractive.org

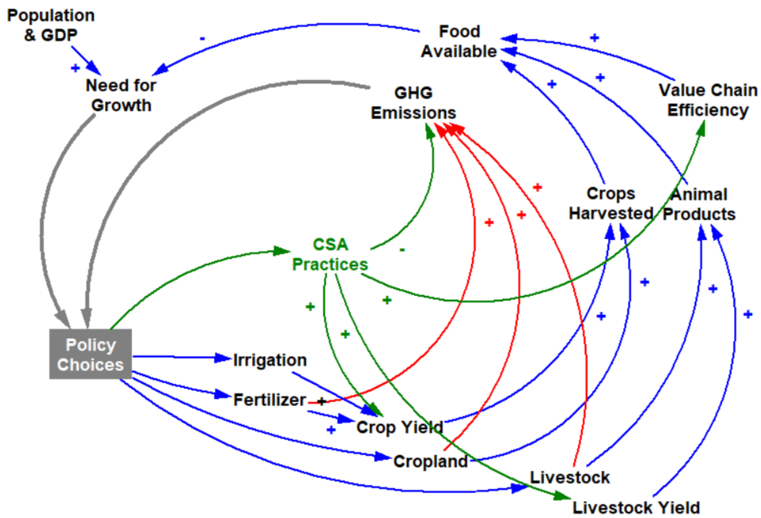
Feeding 1.5 billion people by 2030, and 2 billion by 2050, while mitigating and adapting to climate change, is a daunting challenge that countries in Africa are attempting to address. In this paper we report in a project between Mohammed VI Polytechnic University (UM6P) and Climate Interactive (CI). Our tool, the Agriculture and Land Policy Simulator (ALPS) helps policy-makers and stakeholders make climate-smart decisions in their agriculture strategies.

ALPS models the intersections among land, agriculture, and climate. We base our work on the Climate Smart Agriculture (CSA) concept, the three pillars of which are: food security, resilience to climate changes, and mitigation of emissions. Using System Dynamics, a multidisciplinary team of agronomists, agricultural economists, and system dynamics developed the causal relationships. We refined system structure and formulations based on discussion with experts, existing research, and analysis of strategic policy documents. The model parameters are set to fit historical data from a variety of sources.

In this paper we present the Moroccan case of ALPS, incorporating significant improvements over prior work and fitted to the Morocco policy context. The Green Morocco Plan (known by the French acronym PMV) is specifically used for simulation and modeling exercise. The simulator allows the user to test assumptions and scenarios through varying levels on different policy components. ALPS has previously been used to simulate the Ethiopian context, and future development will improve both these cases and will be extended to cover several African countries.

The causal loop below summarizes all interactions between the model variables that interlink agriculture sectors. Food Demand increases with population and living standards. The user makes choices to ensure Food Available – Production and Imports less Losses and Exports – can meet demand. Land use can change between five categories – Cropland, Pasture, Forest, Grassland, and Dessert. The availability and need for irrigation depends on rainfall and infrastructure. These physical limits enforce the constraints the agriculture system faces.

Action to meet food demand also create undesirable consequences. Countries have goals such as reducing greenhouse gas emissions and deforestation. ALPS includes direct emissions from crop and livestock farming, as well as emissions from land-use changes and the stocks of carbon sequestered in soil and biomass. These help the user see the impact on other goals when meeting food needs.



A significant improvement in this version of ALPS is the addition of water. Annual rainfall scenarios can be selected with or without year-to-year variability and different long-term trends, based on extant climate projections. Choices about irrigation and storage infrastructure affect the availability and efficiency of water use, and in turn crop yield. Because water is a local resource, ALPS is disaggregated into six zones varying by rainfall, resources, and crop mix. Water need was calculated based on evapo-transpiration, weighted by the area planted for five representative crops in each of the climatic zones.

A co-flow structure tracks the total amount of carbon in biomass and soil for each land use category. ALPS calculates the emissions and transfer of carbon in the course of land use changes as well as the sequestration or degradation of carbon over time within each land use. The structure allows testing the impact of de- and afforestation, and such practices as soil management and agroforestry.

ALPS is calibrated to historical data from the Ministries of Agriculture and of Environment in Morocco, and the Food and Agriculture Organization and other United Nations sources, as well as other data. Scenarios for future drivers in the system can be selected, including population, per person income, and rainfall.

The ALPS tool serves as an interactive version of a country's strategic plans, such as the Green Morocco Plan. Users are able to see how elements of the plan complement or interact with each other based on stated predictions of their impact. We show some examples, including emissions mitigation measures and the non-linear interactions of water infrastructure investments. The model adds realistic time delays and physical constraints to published plans, giving policy-makers and stakeholders a means of making smarter decisions.

References

[1] *Sectorial results of the inventory- GHG emissions from the agriculture sector, 4C Morocco*

[2] https://www.finances.gov.ma/en/Pages/Strat%C3%A9gies/Strat%C3%A9gie-de-d%C3%A9veloppement-agricole--le-Plan-Maroc-Vert.aspx

[3] M Mohammed Jellali Direction *Général de l'Hydraulique Rabat, Maroc: Développement des ressources en eau au Maroc.*

[4] http://www.our-africa.org/morocco/climate-agriculture

[5] https://www.finances.gov.ma/en/Pages/Strat%C3%A9gies/Strat%C3%A9gie-de-d%C3%A9veloppement-agricole--le-Plan-Maroc-Vert.aspx

[6] Mohammed Badraoui, INRA. *The Green Morocco Plan: An Innovative Strategy of Agricultural Development Environment and development AL-BIA WAL-TANMIA (Journal) Nov 2014*.

[7] Jones Charles, Saad Benjelloun: *Policy Decisions and Climate-Smart Agriculture in Africa*. Paper presented at the 35th International Conference of the System Dynamics Society, Cambridge, Massachusetts.

[8] Ying Qiu, Xianliang Shi, Chunhua Shi: *A system Dynamic Model for Simulating the Logistics Demand Dynamics of Metropolitans: A Case Study of Beijing, China.*

[9] H. Bouloiz, E. Garbolino, M. Tkiouat, and F. Guarnieri: *A system dynamic model for behavioral analysis of safety conditions in a chemical storage unit.*

[10] Ministry Delegate of the Minister of Energy, Mines, Water and Environment, in charge of Environment: Moroccan Clime Change Policy, March 2014.

[11] Agency for Agricultural Development. *Investors guide in the agricultural sector in Morocco*.

[12] FAO 2010. "Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. Rome: FAO.

[13] United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision, DVD Edition.

[14] Guardian 2011. GDP projections from PwC: how China, India and Brazil will overtake the West by 2050 (Data Blog entry) https://www.theguardian.com/news/datablog/2011/jan/07/gdp-projections-china-us-uk-brazil. Accessed Jan 2017.

[15] G. Huffman, D. Bolvin, D. Braithwaite, K. Hsu, R. Joyce, P. Xie, *Tropical Rainfall Measuring Mission Project (TRMM)*

[16] Gomes et al 2009. World Bank - Morocco study on the impact of climate change on the agricultural sector: Impact of climate change on agricultural yields in Morocco. WB/Morocco/FAO.

[17] FAO 2012. *Crop Yield Response to Water*. FAO Drainage and Irrigation Paper 66. Rome.

[18] FAOSTAT 2018. Food and Agriculture Data (online database) http://www.fao.org/faostat/en/#data. Accessed Jan 2018.