

Modelling drought impacts on coffee production in Viet Nam: A system dynamics approach

Y. Pham , **K. Reardon-Smith**  and **S. Mushtaq**

Centre for Applied Climate Sciences, University of Southern Queensland, Australia,

Email: YenHoang.Pham@usq.edu.au

Abstract: Viet Nam is the world's largest producer of Robusta coffee, accounting for more than 40% of global Robusta output. Coffee production contributes to about 10% of agricultural export turnover in the country and supports the livelihoods of approximately half a million smallholder farmers. However, coffee cultivation faces numerous challenges, particularly drought and water shortages driven by changing climate conditions and unsustainable agricultural practices.

Using a system dynamics approach, our study aims to assess the major impacts of drought affecting sustainable coffee production in Dak Lak Province, a key coffee growing region responsible for more than 30% of Viet Nam's coffee output. A dynamic hypothesis (causal loop diagram) was formulated based on literature review and qualitative data from interviews with 60 coffee farmers and experts to capture the interrelationships and feedbacks among factors relating to drought impacts on coffee production.

Mapping these relationships to produce the causal loop diagram indicates that the consequences of drought on coffee cultivation are an outcome of complex interactions between the climate system and human systems, specifically population growth, deforestation and agricultural development. Key factors driving drought impacts on coffee production are declining rainfall in the dry season, increasing coffee expansion and over-irrigation, which interact with other factors, such as rising temperature and evapotranspiration, through reinforcing and balancing feedback loops. The impact of drought on coffee yield and coffee quality mainly depends on drought severity and supplemental ground and surface water availability.

Our analysis highlights several systems archetypes, including '*tragedy of the commons*' and '*limits to growth*', associated with overuse of regional common resources, triggered by uncontrollable agricultural expansion and water exploitation, particularly of groundwater for irrigation. The unintentional outcomes of a number of management decisions or policies (indicated through the '*fixes that fails*' systems archetype)—such as the planned migration program which has led to population growth and deforestation, contributing to declining water availability—are also analysed. The monoculture cropping system of Robusta coffee also has undesirable consequences, including increasing vulnerability of the coffee system to changing climate and market risks such as price volatility.

A suite of management strategies is proposed including awareness raising and promotion of technologies and policy measures on efficient water use for irrigation, sustainable planning for coffee development, livelihood diversification, agroforestry either through intercropping or shading, and forest protection, reforestation and afforestation.

An initial simulation model based on these results is in progress for robust quantification of drought impacts and for the design and testing of various policy interventions for sustainable coffee production.

Keywords: *Causal loop diagrams, system dynamics, drought impact assessment, adaptation*