Agricultural intensification and risk in water-constrained regions: a social-ecological systems analysis of horticulture cultivation in Maharashtra

Abstract

Half of India's population depends upon agriculture for its livelihood yet the farming sector is marked by low productivity and poor returns. Increasingly, agriculture also faces large variability due to factors such as climate change, degradation of natural resources and inefficient markets resulting in widespread farmer distress in the country. An important government strategy to raise productivity is the promotion of agricultural intensification through horticulture cultivation. Land under horticulture has nearly doubled in the past two decades and the total horticulture production has surpassed that of food grains. However, horticulture cultivation poses significant risk for the farmer as it is input intensive, requires assured access to water and is prone to high market variability. It is reported that though it raises productivity and farm incomes, horticulture cultivation also increases social inequality and leads to degradation of natural resources. Our objective is to analyze the social-ecological drivers and impacts of this intensification on farmers and communities, and to propose solutions that improve the social comprehension of risk and lead to resilient farming systems.

We follow an interdisciplinary approach, borrowing methods from anthropology, engineering, economics and systems thinking. We use Ostrom's social-ecological systems framework for characterizing our farming system and studying the coupled interaction between farmers and natural resources. Our focal social-ecological system (SES) is the water-constrained farm system overlaying shallow hard-rock aquifers of Maharashtra. Detailed ethnographic interviews and biophysical surveys were conducted in Sinnar block of Nashik district, Maharashtra, over two years: the drought year of 2015-16 and the good rainfall year of 2016-17. Narratives of 121 farmers in four villages were documented with respect to their investments and intensification trajectory.

Through the study of farm-level decisions, we find that intensification in water scarce regions is a response of individual farmers to remain economically viable in face of increasing uncertainties. Some of these are exogenous uncertainties such as the variability of monsoons, while others are endogenous, such as the risk in access to irrigation due to high stage of groundwater development

and the uncertainty created by competitive, and often informal, private investments to transfer and store water to secure irrigation.

We use systems thinking to understand the dynamics and feedback mechanisms through which risk propagates in the SES. We find that farm intensification and investments to assure water appear helpful in mitigating risk for individual farmers in the short run, but reinforce risk for the community as a whole in the long run by increasing stress on the limited common pool resource. This creates a vicious cycle in which other farmers are then induced to invest and intensify in order to stay viable, eroding the advantage of early movers and eventually reverting to high uncertainty for everyone with significantly higher cost of access. A large number of farmers are unable to intensify due to socio-economic constraints and many retreat from the "treadmill" after repeated failures. But limited non-farm livelihood opportunities preclude the option to exit.

This process is further catalyzed by government programs that are not only insufficient in stopping the vicious cycles at play, but instead are likely to accelerate them further by promoting intensification. Moreover, targeting of individual beneficiaries in state programs without consideration of broader impact weakens community action and feeds into the competitive behaviour. The poor outcomes are evidenced in the high rates of crop failures and farmer indebtedness, which contribute to the agrarian distress being witnessed in the state. An externality is high drinking water insecurity for the landless and asset-poor farmers who depend upon shallow dugwell-based public drinking water systems.

Through system dynamic modelling, we show that the ongoing intensification has a definite trajectory along which there are important resource thresholds at the community level. From the point of view of water, this threshold corresponds to quantities in the village water budget which vary dynamically every year depending upon the annual monsoon. The ability of a community to identify this annual threshold and to adjust its cropping pattern so as to sow less during bad years and intensify during good rainfall years is an important component of building resilience. Reduction in orchards, and a strategy of well-regulated seasonal intensification within the limits of available water resource will not only result in greater social-ecological resilience, but may also result in increasing net income due to reduction in uncertainty and wasteful infrastructure. We thus

suggest a convergence of the three dimensions of sustainability: ecological, economic and social sustainability, instead of a trade-off between them.

In order to achieve this, we need the scientific community to work closely with the state and farming communities to develop sound and practical tools that will enable scientifically-informed perception of risk, knowledge of resource thresholds and collective planning and regulation. A significant contribution of this work is the development of such a village water-budget based risk-assessment framework that evaluates the community's operating point with respect to its carrying capacity and guides community crop planning. The framework has been proposed to the Government of Maharashtra's Project on Climate Resilient Agriculture (PoCRA) currently being implemented in 15 districts of the state with the goal of enhancing climate resilience and profitability of smallholding farmers.