Water scarcity and farmers' adjustments in South India: The Nagarjuna Sagar irrigation project

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Abstract: *In many river basins, upstream water development and interannual variations in rainfall can cause episodic and chronic shortages in water supplies downstream. Farmers of the Nagarjuna Sagar irrigation project, located in the Andhra Pradesh part of the Lower Krishna Basin (South India), faced several consecutive years of low water availability due to low inflows in the reservoir supplying the irrigated area. Farmers adapted to this drought in many different ways: coping strategies are context specific. This paper calls for the recognition of local level adjustments and adaptability to design and implement efficient and equitable water allocation procedures that would, in turn, mitigate the effects of water supply shocks on rural livelihoods in large surface irrigation projects of developing countries.*

Keywords: *water availability, adjustments, resilience, allocation rules, spatial pattern*

The Nagarjuna Sagar Project is a large multi purpose project located in the South Indian State of Andhra Pradesh. The Nagarjuna Sagar dam, on the downstream reaches of the Krishna River, was built between 1955 and 1974 and irrigation canals were designed to supply 415,000 and 485,000 hectares on the left and right bank of the river, respectively. This large irrigation project has become central for both sustaining local livelihoods and ensuring the State self-sufficiency in food and non-food crops. Crops as varied as water consuming paddy and sugarcane; field crops such as maize, sorghum, millets; and cash crops requiring supplementary irrigation such as cotton and chillies, are grown. Inflows into the reservoir have been continuously decreasing due to water development upstream in the Krishna Basin. Upstream water use is not adjusted to reflect interannual variations in rainfall: total water availability and supply shocks to downstream irrigated areas are likely to become more frequent and more acute, dramatically affecting local livelihoods (Gaur et al., in press).

This paper highlights the adaptive capacity of irrigated farming systems during a period of low water availability (2001-2005). Primary data were collected during farmers' interviews in six villages with irrigation, located along the canal network on the left bank of the Krishna River. 65 farmers where interviewed in three villages of the head-end (*Halia*) and 48 in three villages of the tail end (*Konijerla*). The surveys aimed at identifying short-term adaptive strategies driven by sudden changes in water availability and focused on cropping pattern changes. Secondary data on canal discharge were then used to identify the relationship between water availability and cropping pattern. Figure 1 summarizes the results for two levels of water availability during the rainy season (*Kharif*), in each of the two regions.

In each chart, black shades indicate the proportion of farmers adopting a given cropping pattern. The y-axis represents the proportion of farmers with a given cropping pattern. The x-axis represents the share of the area of each landholding that is cultivated with paddy. The z-axis represents the share of the area of each landholding that remains fallow. At the bottom right corner, farmers cultivate paddy on their whole farm; at the top left corner the entire farm is fallowed. Other black shades indicate farmers who have a mixed cropping pattern. Figure 1 illustrates that crop diversification strategies are context specific. In the head-end region (*Halia*; top panel) where farmers are generally used to high water availability, farming systems are highly resilient: two-thirds of the farmers cultivate paddy on their whole farm whether water availability is maximum or only 70% of the maximum. For such levels of water availability, 10 to 20% of the farmers completely fallow their land; the others engage in paddy cultivation on part of their farms. This resilience of farming systems has historical and structural roots: paddy cultivation has always been promoted in the head-end region of the project and paddy fields are real terraces with seepages from upper levels draining to lower levels: cultivating dry crops is thus risky because fields could get flooded.

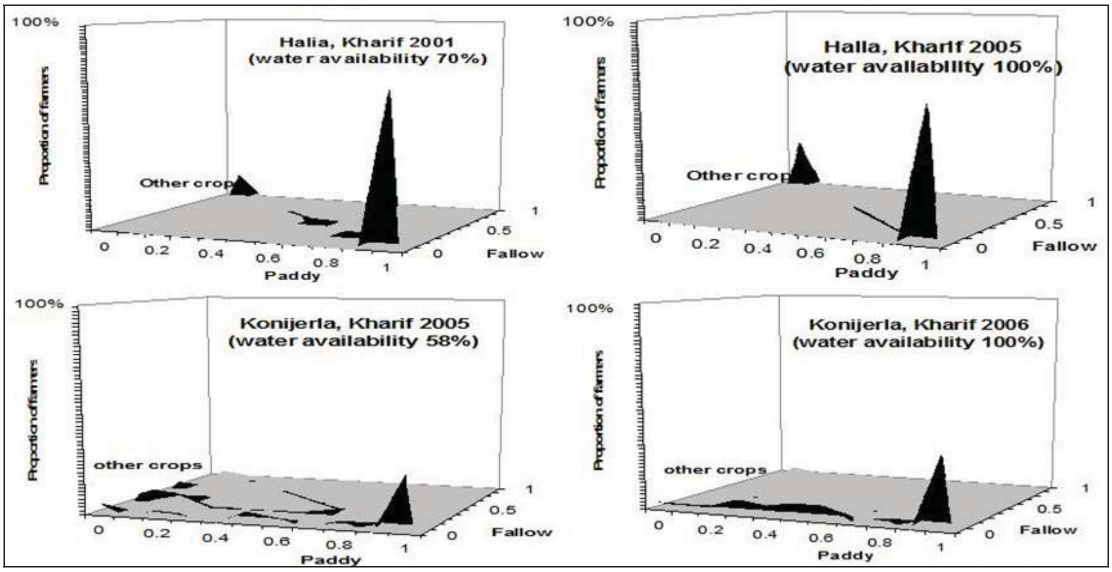

Figure 1. Crop diversification and cropping pattern changes in relation to variable water availability in two regions (Head-end, Halia and Tail-end, Konijerla) of the Nagarjuna Sagar left bank irrigation project.

In the tail-end region (*Konijerla,* bottom panel), water availability and reliability have always been low and farmers are used to face adverse conditions for cultivation. Irrigation practices and adaptive strategies are more diverse than in the head-end region. First, figure 1 highlights that cropping pattern is more diverse in the tail than in the head-end region with 60% of the farmers surveyed reporting that they cultivate two crops or more. This reveals strategies of risk mitigation and is possible because of the rugged topography (with paddy lands and rainfed uplands), the local water allocation rules (with some fields are entitled to intensive irrigation and other are entitled to supplementary irrigation), and the unconsolidated character of local landholdings (farmers generally cultivate several non-contiguous plots; this is not the case in the head-end region). Second, when water availability decreases farmers adopt very diverse strategies in accordance with their objectives and the physical, social and economic characteristics of their production system. Black shades are spread over the whole plan: strategies are heterogeneous. Paddy remains the main crop but the proportion of land devoted to a particular crop is highly variable from one farmer to another. In both regions and for lower levels of water availability (not shown), most farmers engage in rainfed cultivation and keep part of their land fallow. Other adaptive strategies include: (i) groundwater abstraction; (ii) livestock sale; (iii) out-migration; (iv) tampering with the irrigation system.

In large irrigation projects, managerial setup and water allocation rules in the main canal system are decisive in shaping water availability and farmers' practices. Studying farmers' adjustments to changing water availability highlighted that head-end farming systems were little affected when water availability decreased by up to 30%. Recognizing local level adjustments and flexibility when designing water allocation rules at the project level would allow (i) more efficient and more equitable water and (ii) mitigating the effects of water supply shocks on rural livelihoods by re-allocating water further down the irrigation system. A formal modification of water allocation procedures is not an easy task and would require further investigating the social, economic and environmental costs and benefits of uncoordinated local level strategies.

Reference

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