

Digital Agriculture for Water Efficient Farming in Nohar and Sangaria

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Abstract

Agriculture in Nohar and Sangaria tehsils of Hanumangarh district is shaped by a semi-arid climate, irrigation infrastructure, diverse cropping choices and growing pressure to use water efficiently. This paper examines how digital agriculture and precision farming can support water productivity while sustaining farm output and income. It focuses on technologies that can assist with irrigation scheduling, field levelling, soil and crop monitoring, weather and pest advisories, remote sensing and shared machinery or service platforms. The analysis treats water productivity as a geographic and farm-management issue: access to water, field conditions, crop requirements, timing and the cost of technology influence outcomes. A literature-based review and proposed mixed-method design are used to frame a comparison of the two tehsils. The methodology combines farm surveys, interviews, administrative and agricultural statistics, and GIS analysis; water use should be directly measured where possible, with proxies clearly identified otherwise. Existing district-level sources establish the broader irrigated agricultural context but do not provide verified tehsil-level evidence of technology adoption or water savings. The paper therefore offers a testable research framework rather than reporting original impact results. It argues that digital tools can contribute to water-efficient farming when advice is locally calibrated, services are affordable and accessible, and programmes evaluate water use, yield, profitability and equity together.

Keywords: digital agriculture; water productivity; precision irrigation; GIS; Nohar; Sangaria; Hanumangarh; Rajasthan

Introduction

Water is a central factor in agricultural production across Rajasthan's irrigated north-western plains. Hanumangarh's farming system includes crops with distinct irrigation needs and economic roles, including wheat, mustard, gram, cotton and guar. Irrigation enables production beyond what seasonal rainfall alone can support, while the semi-arid setting makes efficient scheduling, conveyance and field application important. A geographical analysis must consider both the physical distribution of water and the social distribution of access to infrastructure, information, capital and services.

Digital agriculture offers practical tools for improving decisions around water. Soil-moisture sensors and weather information can help estimate when irrigation is needed; satellite imagery can flag crop stress; GIS can map crop and resource patterns; and mobile advisory services can communicate recommendations. Precision land levelling and improved irrigation systems can reduce uneven application when adapted to field size, soil and crop. These technologies should be viewed as complements to agronomic knowledge and local water institutions, rather than as independent solutions.

This paper shifts attention from general productivity gains to the relationship between technology, water use and geographic variation in Nohar and Sangaria. It asks: which digital and precision technologies are relevant to local crops and irrigation conditions; what factors enable or constrain their use; how can water productivity and farm profitability be assessed; and how do spatial differences within and between tehsils shape outcomes? The paper reviews relevant literature and proposes a field-based design. It does not claim measured water savings or yield impacts for the two tehsils.

Review of Literature

Research on digitalisation in agriculture describes possible improvements in efficiency, productivity and resilience through timely information, automation and better targeting of inputs. FAO's review of case studies in low- and middle-income countries finds that digital

and automation technologies can help address labour bottlenecks and improve efficiency, but access and suitability remain important constraints for smaller producers (McCampbell, 2022). These findings support an assessment of how farmers obtain services, not just whether a device or application exists locally.

Precision agriculture relies on sensing and spatial data to identify variation in crop, soil and water conditions. Remote sensing can provide repeated observations across large areas, while field sensors and soil tests provide more direct local measurements. Such data can improve irrigation timing or identify stressed areas when paired with reliable interpretation and agronomic advice. The literature on sensor-based agricultural monitoring emphasizes the role of decision-support systems and the need to connect measurements to appropriate farm actions (Journal of the Indian Society of Soil Science, 2022).

Digital tools may also improve the coordination of irrigation and farm services. Mobile phone systems can share forecasts, crop guidance, pest alerts and market information; platforms can connect farmers to equipment rental or advisory providers. The World Bank notes that digital tools' potential is conditioned by infrastructure and access, with connectivity gaps and limited resources affecting smallholder participation (World Bank, 2019). In the study area, water-related benefits would depend on whether digital recommendations are timely, credible, locally calibrated and feasible given the farmer's irrigation turn, pump capacity, energy cost and field layout.

Water productivity should be distinguished from water saving. Water productivity expresses output or value produced per unit of water consumed or applied, while water saving describes a reduction in water use. A technology may raise yields without lowering total water use, or reduce water applied while also reducing output. Therefore, research should report physical yield, net returns, irrigation volume or a transparent proxy, and relevant energy or labour costs together. Geography matters because soil, topography, canal access, groundwater conditions, crop choice and distance to services can all affect these relationships.

Methodology

Study design: The proposed research uses a comparative mixed-method design in Nohar and Sangaria tehsils. Farms are nested within villages, allowing analysis at plot, village and tehsil scales. Village selection should represent differences in irrigation access, crop composition, farm size, market distance and connectivity. A pilot study should inform the final sample size and survey instrument; no primary data have been collected for this paper.

Primary data: A structured farm survey should record plot area, crop sequence, irrigation source and timing, irrigation duration or volume where measurable, technology ownership or service access, seed and input use, machinery services, yield, output price, costs, labour, credit and advisory access. Farmer interviews should explore how water decisions are made, what information is trusted, barriers to adopting efficient practices and experiences with canal or groundwater scheduling. Interviews with extension staff, irrigation officials, custom-hiring providers, cooperatives and local market actors can document the institutions and services that shape adoption.

Secondary and spatial data: Relevant sources include the Census of India District Census Handbook for settlement and administrative context, Rajasthan agricultural statistics, district crop and irrigation reports, meteorological data, soil information and available irrigation infrastructure maps. GIS analysis can examine the location of sampled villages, roads, service points, markets and irrigation features. Satellite imagery may support seasonal crop and vegetation monitoring, but estimates must be validated with field observations and should not be presented as measured yield or water consumption without calibration. Administrative boundaries and source years should be harmonised before comparison.

Indicators: Water productivity should be measured as crop output or value divided by irrigation water applied or consumptive water use, depending on what the data allow. Direct water

measurement is preferable. If direct measurement is not feasible, irrigation duration, pumping hours or farmer-reported frequency may be used only as clearly labelled proxies. Other indicators should include yield per hectare, gross margin per hectare, energy cost, labour days, input intensity, irrigation reliability and perceived production risk. Results should be disaggregated by crop, farm size, irrigation source and technology access.

Analysis: Descriptive statistics and maps can identify spatial patterns and differences across groups. Regression models may test associations between technology use and water productivity while accounting for crop, farm size, soil, irrigation source, weather, credit and market access. Since farmers who adopt technology may differ systematically from non-adopters, cross-sectional associations should not be described as causal effects. Stronger impact claims require longitudinal data, a phased intervention or another defensible comparison design. Qualitative interviews can explain why technologies succeed or fail under local conditions.

Research Gap

The evidence available for Hanumangarh describes the broader agricultural setting and crop economy, while general studies discuss the potential of digital tools and precision farming. However, this literature does not establish water use, technology adoption or the distribution of benefits separately for Nohar and Sangaria. It also does not explain whether observed efficiency gains, if any, vary across villages according to irrigation access, soil and farm service availability.

A second gap concerns the way outcomes are measured. Adoption counts or yield alone cannot show whether a technology reduces water use, raises water productivity, improves farm profit or shifts costs to energy and equipment. Technology may be accessible to larger farms yet unavailable to smaller farms except through shared service providers. A comparative geographic study linking farm-level water and economic measures with village accessibility and irrigation conditions can address these gaps and provide a basis for locally targeted policy.

Importance of the Study

The study can help farmers and extension agencies identify which water-related technologies are practical for particular crops and irrigation settings. It can show where training, field demonstrations, soil and moisture monitoring, equipment rental or shared digital advisory services may improve access. Mapping service gaps can support targeted planning and reduce the risk that programmes mainly reach farms already well served by infrastructure and capital. For water and agricultural planners, evaluating water productivity alongside yield and net returns provides a more complete basis for investment. The study can help distinguish technologies that merely increase application from those that improve timing, reduce avoidable losses or support more resilient production. For researchers, the comparison of Nohar and Sangaria offers a way to investigate how geographic variation within one district shapes technology use and outcomes, with a replicable approach that can be extended to other irrigated tehsils.

Conclusion

Digital agriculture and precision farming can support more water-efficient agriculture in Nohar and Sangaria through better irrigation timing, field and crop monitoring, spatially informed advice and access to shared equipment or services. Their value depends on local crop and water conditions, trustworthy and actionable information, connectivity, affordability, extension support and the organisation of irrigation. Technology is therefore best evaluated as part of a wider farm and service system.

The sources reviewed justify investigating these tools but do not establish tehsil-level effects. A field-based comparative study should measure or transparently proxy water applied, and assess yield, farm returns, labour and energy costs together. GIS and interviews can reveal how geographic access shapes both adoption and outcomes, while a suitable evaluation design can

distinguish association from causal impact. This evidence would help direct technology investment toward sustainable and broadly shared productivity gains.

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