Digital Irrigated Agriculture

Subjects: Microeconomics and Decision Sciences | Agricultural Sciences & Agronomy

Submitted by: Francesco Cavazza

Definition

Entry on a new approach to decision modelling for ICT adoption in irrigated agriculture.

1. Introduction

Information and Communication Technology (ICT) is defined by the World Bank as "(…) any device, tool, or application that permits the exchange or collection of data through interaction or transmission" [1]. As in everyday life we have seen the proliferation of ICTs contributing to support many decisions, also agriculture is taking part to this digitalization process. In this sector, ICTs mainly include Decision Support Systems (DSS), tools based on Artificial Intelligence (AI), Internet of Things (IoT), Climate Services, Geographic Information Systems (GIS) and many other digital tools which offer Decision Makers (DMs) a wide variety of support [2].

Because of the great potential of ICTs, some authors call this phenomena the Digital Agriculture Revolution (DAR), and they believe it can help to solve some challenges the sector is facing [3]. This expression highlights just how important the stage of agricultural development we are living in according to scholars. While the DAR can be expected to be comparable in magnitude with the "green revolution" [1][3], the innovation paradigm brought by the DAR is different. During the green revolution technologies were aimed at altering the agroecosystem through fertilizers, pesticides and genetics. The DAR is altering the decision environment through information provision. Accordingly, all digital technologies in agriculture have one common element, which is in the use and generation of data. With it, the new platforms generate information aimed at supporting decisions by lowering uncertainty. Decision processes can now move from precautionary and inefficient choices forced by uncertainty, to decisions based on sound information. In this context, irrigation and water management are one of the key sectors where ICT-information would have the most important applications with the highest benefits [2][4]. Many ICT have been developed in irrigation and water management [4][5][6]. This sector is more susceptible to uncertainties than others and ICT have a great potential to lower uncertainty and help facing the challenges posed by conflicting uses, water scarcity and extreme weather events [6][7][8][9].

2. Digital Water Journey

In the industrial and utility sectors, the adoption of ICT to support decisions on water use and allocation is rapidly growing in what is identified by the International Water Association as the *digital water journey* [10]. In irrigated agriculture, the digital water journey is more difficult due to the intrinsic characteristics of the sector. Here, dynamics for ICT implementation are extremely complex and lack of infrastructures, lack of supporting technologies, financial restrictions and knowledge gaps often pose significant barriers to ICT diffusion [7][11]. More trivially, in some occasions Water Authorities (WAs) and farmers might decide to not implement an ICT because the information conveyed by the ICT is not mature enough or not suitable for the purpose for which it is used [12]. For example, the low accuracy of available devices makes many platforms useless to aid farmers' irrigation decisions [8]. The low accuracy of the information provided through existing ICT devices is also documented at the level of WAs for the allocation of water resources through open-air canals [7]. Even when the information conveyed through ICT is mature enough to generate appreciable benefits, behavioral barriers can hinder the digitalization process [13]. As a result, the digital transition for irrigation management cannot be self-accomplished by the sector. Constraints to digitalization will not only slow ICT implementation, but they also risk compromising the progress of ICT innovations in agriculture, leaving the sector with obsolete tools and not effective to face issues of water scarcity and conflicting uses [10]. These conditions highlight the need to understand decision processes and to design policies to favor ICT development and uptake for water management in agriculture [14][15].

In the applied economics literature, there are several studies addressing the topic of ICT implementation in agriculture and water management [4][5][16]. The most important works in applied economics estimate the benefits of ICT implementation by defining the circumstances in which information has a value for a DM [17]. Although scholars agree

on the theoretical settings in which ICT-information is valuable, empirical applications show discordances and ICT-benefits are still unclear. Further, there are gaps in the modelling of decision on ICT implementation to account for the uncertainty settings which affect DM's behavior and might impede ICT uptake. Accordingly, there are different sources of uncertainty around the decision for ICT implementation. These can be caused by the following issues: (i) the ICT provides imperfect information (information is not 100% reliable) and (ii) the DM does not know ICT's reliability (the ICT is new to the DM). However, uncertainty is often modeled not distinguishing between its different sources and issues generated by a lack of knowledge on ICT reliability are overlooked. This does not allow to understand how perceptions on ICT reliability affect the farmer's or Water Authority's (WA) behavior and, in turn, the decision on ICT implementation.

The economic literature on decision making under uncertainty to seek for the theoretical basis for better modelling ICT uptake decisions in irrigated agriculture. Between theories, we found the one of ambiguity developed by Ellsberg (1961) to be suited to help modelling the uncertainty settings affecting ICT uptake for irrigation management. In particular, we represent ambiguity as the share of uncertainty generated by not knowing ICT's reliability and risk as the error in ICT-information. This distinction will yield a deeper understanding of decision processes when the reliability of ICT is not known. Further, it allows to model the process of familiarity which occurs as the DM gains experience on the ICT. As familiarity can be a powerful tool to ease ICT-uptake we will also consider policy implications to favor the achievement of the digital irrigated agriculture

The novelty of this research is in the application of economic literature's theories to provide the basis needed to model the uncertainty settings around ICT adoption for irrigation management. In most of applied studies on ICT adoption in agriculture risk is modeled in the decision process to be the only element which shapes uncertainty. Contrarily to these studies, we introduce the concept of ambiguity explaining the share of uncertainty rising when the reliability of a new ICT is unknown.

References

1. World Bank. ICT in Agriculture (Updated Edition): Connecting Smallholders to Knowledge, Networks and Institutions; 2017, (Updated Edition). Available online: https://openknowledge.worldbank.org/bitstream/handle/10986/27526/9781464810022.pdf?sequence=2&isAllowed=y (accessed on 22 October 2020).
2. Baseca, C.C.; Sendra, S.; Lloret, J.; Tomas, J. A smart decision system for digital farming. Agronomy 2019, 9, 216.
3. Rotz, S.; Duncan, E.; Small, M.; Botschner, J.; Dara, R.; Mosby, I.; Reed, M.; Fraser, E.D.G. The politics of digital agricultural technologies: A preliminary review. Sociol. Rural. 2019, 59, 203–229.
4. Jeuland, M.; Hansen, K.; Doherty, H.; Eastman, L.B.; Tchamkina, M. The economic impacts of water information systems: A systematic review. Water Resour. Econ. 2019, 26, 100128.
5. Masseroni, D.; Arbat, G.; De Lima, I.P. Editorial—Managing and planning water resources for irrigation: Smart-irrigation systems for providing sustainable agriculture and maintaining ecosystem services. Water 2020, 12, 263.
6. Clara Eli-Chukwu, N. Applications of Artificial Intelligence in Agriculture: A Review. 2019. Available online: www.etasr.com (accessed on 26 August 2020).
7. Cavazza, F.; Galioto, F.; Raggi, M.; Viaggi, D. The role of ICT in improving sequential decisions for water management in agriculture. Water 2018, 10, 1141.
8. Galioto, F.; Raggi, M.; Viaggi, D. Assessing the Potential Economic Viability of Precision Irrigation: A Theoretical Analysis and Pilot Empirical Evaluation. Water 2017, 9, 990.
9. O'Mahony, B.; Dalrymple, J.; Levin, E.; Greenland, S. The role of information communications technology in sustainable water management practice. Int. J. Sustain. Agric. Manag. Inform. 2016, 2, 79.
10. Ceo, W.S.; Foundry, W.; Webb, R. Digital Water Industry Leaders Chart the Transformation Journey. 2019. Available online: https://iwa-network.org/wp-content/uploads/2019/06/IWA_2019_Digital_Water_Report.pdf (accessed on 9 July 2019).
11. Molina-Maturano, J.; Speelman, S.; De Steur, H. Constraint-based innovations in agriculture and sustainable development: A scoping review. J. Clean. Prod. 2020, 246, 119001.
12. Galioto, F.; Chatzinikolaou, P.; Raggi, M.; Viaggi, D. The value of information for the management of water resources in agriculture: Assessing the economic viability of new methods to schedule irrigation. Agric. Water Manag. 2020, 227, 105848.
13. Kirchhoff, C.J.; Lemos, M.C.; Engle, N.L. What influences climate information use in water management? The role of boundary organizations and governance regimes in Brazil and the U.S. Environ. Sci. Policy 2013, 26, 6–18.
14. Irrigants d'Europe Water Framework Directive Position Paper. 2018; pp. 1–9. Available online: https://www.irrigantsdeurope.eu/files/documents/IE%20-%20WFD%20%20position%20paper%20.pdf (accessed on 21 October 2020).
15. Giupponi, C. Decision support for mainstreaming climate change adaptation in water resources management. Water Resour. Manag.

2014, 28, 4795–4808.
16. Meza, F.J.; Hansen, J.W.; Osgood, D. Economic value of seasonal climate forecasts for agriculture: Review of ex-ante assessments and recommendations for future research. J. Appl. Meteorol. Clim. 2008, 47, 1269–1286.
17. Keisler, J.M.; Collier, Z.A.; Chu, E.; Sinatra, N.; Linkov, I. Value of information analysis: The state of application. Environ. Syst. Decis. 2014, 34, 3–23.

Keywords

digital irrigated agriculture;ambiguity