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▶ **AGRICULTURAL DIGITALIZATION AS AN
ACCELERATOR FOR TRANSFORMING FOOD
SYSTEMS: A PERSPECTIVE FROM THE AMERICAS**

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Inter-American Institute for Cooperation on Agriculture (IICA) 2021



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▶ AGRICULTURAL DIGITALIZATION AS AN ACCELERATOR FOR TRANSFORMING FOOD SYSTEMS: A PERSPECTIVE FROM THE AMERICAS

Agricultural digitalization can serve as the main trigger for the transformation of food systems, and therefore become a key process for achieving the Sustainable Development Goals. At the same time, however, the digitalization process may exclude certain people, which can increase inequalities. Incorporating digital technologies into agriculture is a necessary element for achieving the digital transformation of food systems; as such, it must be prioritized and planned for in a proactive manner by regional and local policy makers to reap its benefits and offset threats. Plans to drive the digitalization of agriculture should aim to generate incentives for and an environment that is conducive to the development and inclusive use of technologies, within a context of horizontal cooperation between different stakeholders.



1. THE NEED TO TRANSFORM FOOD SYSTEMS

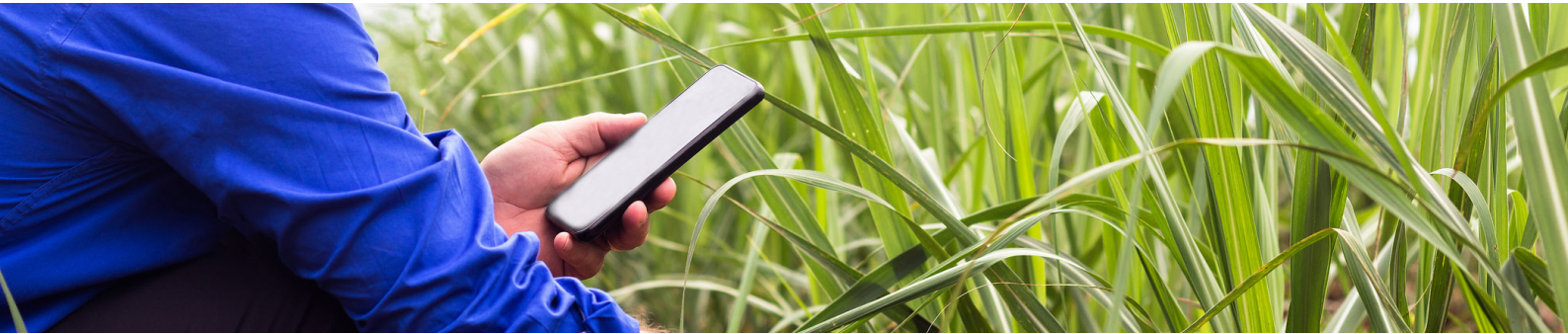
The Food Systems Summit (FSS) convened by the United Nations (UN) for 2021 responds to the concrete need to transform food systems. The need to transform food systems as a whole, from production to consumption, has been identified as a necessary condition to achieve sustainable development, and, in turn, the Sustainable Development Goals (SDGs). This transformation process must take place through reforms that are good for people and the planet; it must also aim to achieve good nutrition and health for all of the planet's inhabitants, preserve or regenerate ecosystems, as well as foster well-being and equity. The FSS proposes 5 Action Tracks (ATs) that seek to promote discussions and agreements on guidelines and goals to drive this transformation.

Recent and projected global changes, such as population and economic growth; growing inequalities; urban concentration; changes in land use, diets and work habits; greater environmental warnings and awareness, among others (Camill 2010) **demonstrate the need for the abovementioned transformation process**, while also **hinting at its potential characteristics**. Within this context, new food systems should be characterized by the production of safe food in large volumes using the best scientific-technological knowledge available (to balance production with conservation or regeneration), unrestricted access (with food being available in a timely manner and at an accessible cost) and the development of healthy and responsible consumption habits.

Transforming food systems will require reforms in all of its components (production, processing, distribution, marketing and consumption), taking into account interdependencies with health, ecological and energy systems. Given the key, **irreplaceable role played by agriculture in food systems** (and increasingly in energy systems), **the sector's transformation is a necessary and decisive factor for the transformation of food systems**. Although agricultural systems have recently undergone major transformations that have greatly improved food availability¹, they

(1) From 1960 to 2010, the global population grew 2.3 times while agricultural production tripled; as a result, the average availability of food for human consumption, excluding waste, increased from approximately 2,200 Kcal/inhabitant/day to about 3,000 Kcal/inhabitant/day (<http://www.fao.org/faostat/en/#data>).

must continue to evolve in the future to meet the growing demands of humanity without harming nature or health and while offering development opportunities. The most substantive reforms will likely result from the incorporation of knowledge and technologies, especially digital ones (according to an analysis by Lajoie-O'Malley et al. 2020, FAO, OECD and the World Bank mostly agree on this vision).



2. DIGITAL TRANSFORMATION: THE MAIN OPPORTUNITY FOR TRANSFORMING FOOD SYSTEMS

Digitally transforming food systems is likely our best bet for meeting the challenge of more sustainable agricultural and food systems (Basso and Antle 2020). Digital transformation, by definition, involves redesigning a value chain's strategy based on demand (a "consumer-driven" approach) and incorporating digital technologies. The incorporation of digital technologies into food systems would trigger improvements in production, processing, distribution, marketing and consumption processes, resulting in more educated, connected and accurate decisions and operations. Although there is still uncertainty regarding the potential consequences of introducing digital technologies (e.g., Lajoie-O'Malley et al. 2020, Klerkx and Rose 2020), there is no doubt that their potential benefits could facilitate the emergence of new, healthier, more sustainable and more equitable food models (e.g., see series of changes described in Project Breakthrough, 2019, United Nations).

At present, the growing availability of digital technologies offers the potential to digitally transform food systems (GSMA 2020, among others) and generate unprecedented proximity and feedback between their components (such as through the online marketing of agricultural products). The incorporation of digital technologies² into food systems would allow for increasing their productivity and stability; improving efficiency in the use of natural and external resources; accelerating learning cycles; supporting decision making; facilitating traceability and certification; boosting interaction among stakeholders themselves and in value chains; as well as improving living and working conditions in rural areas, among other things. Most of the benefits afforded by digital transformation would contribute directly to the 5 FSS ATs (see Table 1). Likewise, digital agriculture has the potential to **contribute to the fulfillment of at least nine SDGs**, namely SDGs 2, 6, 8, 9, 11, 12, 14, 15 and 17 (United Nations, Project Breakthrough, 2019).



In addition to the aforementioned technical benefits, incorporating digital technologies into food systems could also yield significant social benefits. The adoption of digital technologies **offers real possibilities for equalizing development opportunities**, by supporting and integrating disadvantaged stakeholders based on their location, gender, scale, etc. (e.g., digital advisory services or participation in **digital markets; see a very interesting example in Fabregas et al. 2019**). **Likewise**, digital technologies could play a key role in reconnecting youth to rural areas. The digital transformation process offers development opportunities for youth and renders rural areas more attractive, thereby facilitating youth engagement, which is necessary to accelerate the transformation process (FAO 2019; IICA-IDB-Microsoft Corporation 2021). Nevertheless, and as will be discussed below, all of these benefits may become real threats if access to and capacities for utilizing technologies are limited and unequal (OECD 2019).

2. Incorporation of sensors (remote and ground), communication networks, data science and artificial intelligence (including “machine learning” and “deep learning”), applications or platforms, smart machinery (equipped with sensors and actuators), robots, etc., into decision-making and operational processes

TABLE 1. BENEFITS AFFORDED BY THE DIGITAL TRANSFORMATION OF FOOD SYSTEMS AND THEIR DIRECT CONTRIBUTIONS TO THE ACTION TRACKS (GRAY CELLS)

The information included in the table is not exhaustive; it simply highlights the main benefits (which are not necessarily completely independent of each other) and contributions, but there may be others not included in the table; examples are provided to illustrate in what ways.

ACTION TRACKS (a summary of each is provided)	AT1: Ensure access to safe and nutritious food for all	AT2: Shift to sustainable consumption patterns	AT3: Boost nature-positive production	AT4: Advance equitable livelihoods	AT5: Build resilience to vulnerabilities, shocks and stress
BENEFITS OF DIGITAL TRANSFORMATION	(Increase the availability of nutritious foods, make them more affordable and reduce inequalities in food access)	(Strengthen local value chains, reduce waste, facilitate the transition to more nutritious diets that require fewer resources)	(Optimize the use of environmental resources in production, processing and distribution; governance that readjusts incentives to reduce losses)	(Promote full, productive employment and decent work for stakeholders of the food value chain)	(Ensure the continued functionality of sustainable food systems; guarantee preparation for and resistance to instability)
SUPPORTING DECISION MAKING (from production to consumption)	Apps providing digital extension services	Apps to guide the design of customized healthy diets	Simulation models to support the adoption of good agronomic practices	Open-access information systems to monitor markets	Information systems that issue alerts regarding extreme weather or climatic conditions
INCREASING PRODUCTION AND STABILITY	Machinery to adjust the application of inputs to spatial soil properties		Sensors to monitor soil nutrients and define optimal fertilization rates		Platforms that recommend climate-smart agronomic decisions
INCREASING EFFICIENCY (from production to consumption)		Algorithms to predict stock reposition in markets and restaurants	Systems for time and space precision irrigation		

MINIMIZING IMPACTS/ NEGATIVE EXTERNALITIES			Weeding robots to reduce the use of herbicides		
FACILITATING TRACE ABILITY AND CERTIFICATION	Blockchain-based platforms to trace product paths	Information systems map to trace production practices, stocks, expiration dates	Systems to monitor and control working conditions		
FACILITATING EXCHANGES AND COOPERATION (facilitating integration into/ throughout value chains)	Platforms to provide technical advice and facilitate knowledge sharing	Platforms to coordinate local markets	Platforms to coordinate product distribution	Platforms to coordinate selling or buying pools; e-commerce platforms for marketing regional products	Platforms to facilitate crowd-covering of risks
IMPROVING MONITORING AND PREDICTION	Digital networks alerting to the need for pest controls	Algorithms to monitor and predict consumption and production trends	Sensors to map production and characterize soil aptitude		Sensor networks and models to predict pests
IMPROVING WORKING AND LIVING CONDITIONS IN RURAL AREAS			Systems for remote management of herd feeding	"Milking robots" for dairy farms; virtual learning systems	

Other socioeconomic systems have already undergone or are undergoing digital transformation processes (e.g., finance, entertainment, passenger and cargo transportation, etc.), demonstrating the benefits afforded by digital technologies, as well as potential threats, which are inherent to any transformation process. Digital transformation will inevitably trigger the reconfiguration of stakeholders' roles, the nature of their relationships and their organizational schemes, among other things, which may eventually generate exclusion and conflicts. There are several examples of how the impossibility or inability to adopt digital technologies has increased gaps and excluded people in the sectors previously mentioned. Consequently, **the potential negative results of a digital transformation process must be addressed to guarantee a positive outcome.**

Although imminent, the digital transformation of food systems is, for the most part, still in its early stages. Several studies describe agriculture (in its broadest sense, as a key component of food systems) as one of the least digitalized sectors (one such example is the "Digitalization Index" prepared by McKinsey Global

Institute; Banco Mundial, FAO 2019) or one that takes only partial advantage of available technologies³. Literature on this topic describes multiple barriers that could account for the slow digitalization of agricultural chains. On the one hand, factors specific to the activity, such as the territorial and physical anchorage of rural activities, as well as the multitude and diversity of stakeholders involved, may be to blame. On the other hand, factors that often characterize other activities, such as the lack of technological infrastructure, limitations in the availability of and access to technologies (e.g., due to unaffordable prices), insufficient skills and capabilities of stakeholders, potential conflicts of interest and the absence of incentives, may also play a role in this regard.

Because the digital transformation of food systems is only just beginning, it is not too late to promote positive interventions, which should be swift and timely, given the current status of limiting factors. For instance, a recent study shows that only 37% of rural inhabitants in Latin America and the Caribbean (LAC) have access to significant connectivity (IICA-IDB-Microsoft Corporation 2020). Furthermore, a subsequent study for LAC shows that a very low percentage of people (less than 20%) in rural communities have basic digital skills and knowledge (IICA-IDB-Microsoft Corporation 2021). Likewise, there are very few examples in LAC of state policies that are geared towards facilitating and fostering the digital transformation of agriculture and food systems. Then, failure to undertake active actions to tackle the limiting factors, the inexorable introduction of digital technologies **will lead to deepen current gaps**, triggering severe social conflicts. The mobility restrictions derived from the COVID-19 pandemic revealed all these deficiencies and their strong discriminant effects.



3. Some examples: <http://www.ainfo.inia.uy/digital/bitstream/item/13951/1/Rev-INIA-59-Diciembre-2019-p-41-a-45.pdf>
<https://www.embrapa.br/busca-de-publicacoes/-/publicacao/1127064/agricultura-digital-no-brasil-tendencias-desafios-e-oportunidades-resultados-de-pesquisa-online>



3. WHY AND HOW TO DRIVE THE DIGITAL TRANSFORMATION OF FOOD SYSTEMS

3.1 Why is it necessary to stimulate this transformation process?

As in other areas of life, digital technologies will inevitably become incorporated into different areas of food systems, driving their transformation, even in the absence of a specific plan to foster this transformation. Given the fact that this transformation process is imminent, it is crucial to **ensure that it takes place in a timely manner**, allowing all of its benefits to take precedence over the aforementioned potential threats. Proactive planning to facilitate digital transformation must be undertaken, by implementing mechanisms that recognize and tackle the barriers that are inherent to each system and territory.

The political sector, at both the international and local levels, has a nondelegable role to play in terms of facilitating and driving the digital transformation of food systems. Efforts to drive a digital transformation should be supported by a state policy, aimed at generating the necessary conditions and means for developing and fully capitalizing on digital technologies (IDB 2021, World Bank 2021). At the same time, policy makers can also benefit from digital technologies (<https://www.oecd.org/agriculture/topics/technology-and-digital-agriculture/>). In addition to the key role of governments, the transformation process will require the involvement and **coordinated work of all stakeholders** involved in the food system, especially private developers and final users.

3.2 How can this transformation process be triggered?

The digital transformation of food systems must involve two main efforts: (1) **fostering the development of digital technologies based on the needs, contexts and cultures of the different stakeholders**, to ensure that relevant solutions beco-

me increasingly available; and, even more important, (2) **facilitating the requisite means and processes for the effective use of available technologies**, spanning from lowering access barriers to devices, connectivity and applications to the building of digital skills, capacities and experiences. To ensure that these efforts are successful, all actions undertaken should form part of a master plan that has been previously agreed upon and that is aimed at driving the digital transformation of food systems.

In developing this plan, two key aspects should be considered: (1) different public and private stakeholders must engage in agreed-upon and coordinated efforts (e.g., for infrastructure development, capacity building, technical support, etc.; FAO 2019), in which each stakeholder may play an irreplaceable and complementary role (details in Table 2); and (2) all actions should be tailored to the specificities of the target case, given that priorities, possibilities and barriers with respect to digitalization can vary greatly (e.g., the digitalization of medium and large market-oriented farmers versus small subsistence farmers, the digitalization of governments versus the digitalization of farmers, etc.; IDB 2021, Recommendation No. 6).

■ **TABLA 1. ROLES THAT VARIOUS FOOD SYSTEM STAKEHOLDERS CAN PLAY IN DRIVING THE DIGITAL TRANSFORMATION PROCESS.**

STAKEHOLDER	MAIN ROLE	DESCRIPTION
MULTILATERAL AGENCIES	Guide and connect	Raise awareness in the countries of the need for transformation and guide the development of strategies to drive this process, while fostering and coordinating cooperation actions among countries and stakeholders.
GOVERNMENTS-POLITICAL UNITS	Foster and facilitate	Establish digitalization as a state policy, offering resources, regulations and incentives for the development and even more so for the adoption of digital technologies. Digitalize own administrative processes (digital government).
GOVERNMENTS-TECHNICAL UNITS	Foster and assist	Establish digitalization as a key agenda item, with a focus on the development of basic knowledge and technologies inclose coordination with private developers, and on the creation of support teams.

<p>KNOWLEDGE CENTERS (PRIVATE AND PUBLIC UNIVERSITIES, INSTITUTES)</p>	<p>Foster and assist</p>	<p>Contribute to the development of basic knowledge and technologies in close coordination with private developers. Foster dialogue and cooperation among stakeholders and offer capacity-building programs.</p>
<p>PRIVATE DEVELOPERS</p>	<p>Guide and assist</p>	<p>Channel development towards meeting user needs, working closely with government technical units, knowledge centers, and decision makers. Provide support in adopting technological solutions (including capacity building).</p>
<p>NON-GOV-ERNMENT CHAIN-RELATED ORGANIZATIONS (CHAMBERS, UNIONS)</p>	<p>Facilitate</p>	<p>Facilitate interactions between stakeholders, especially developers and users, generating opportunities for exchanges, testing and dissemination of experiences. Facilitate capacity-building processes.</p>

3.3 Proposed concrete actions to drive the transformation process (from the perspective of the FSS Champions)

Based on the above, the actions included in the following list (which is not meant to be exhaustive) could be proposed to achieve concrete progress with respect to the digital transformation of food systems in general and agricultural systems in particular:

- Establish digital transformation and its promotion as a priority item (state policy) on the agenda of policy makers and private decision makers;
- Foster and support cooperation among stakeholders (of a given country, value chain, etc.) to align their goals, objectives and commitments with respect to digital transformation;
- Assist stakeholders (primarily policy makers) in defining and implementing public investment plans and incentives as well as adapting the roles of traditional public R&D institutions, in order to drive the transformation process;
- Develop networks comprised of leading representatives of public and private stakeholders who are committed to and can promote and support the transformation process;

- Develop networks comprised of leading representatives of public and private stakeholders who are committed to and can promote and support the transformation process;

 - Connect technology developers and users to foster the joint development and testing of technologies based on their capacities and experiences;

 - Propose and support the development of programs for capacity-building in generic and specific digital skills (e.g., a specific technology);

 - Promote and disseminate concrete digitalization opportunities, coordinating support for interested parties (through the involvement of providers of solutions); and

 - Identify or generate successful digitalization experiences that can be shared and can serve as inspiration for new experiences.
-

None of these actions can be carried out effectively without the involvement of all relevant stakeholders in each territory and system. This will allow for guaranteeing a full understanding of potential barriers to digitalization in each context and, in turn, for designing and executing efficient initiatives that respond to these actions. Lastly, most of the actions proposed could be geared towards each of the various stakeholders involved in the food system (farmers, processors, input providers, retailers, agricultural departments and official services of governments, among many others).





4.

DRIVING TRANSFORMATION THROUGH THE CREATION OF A “CHAMPION CASE”: DIGITALIZING AGRICULTURE IN LAC

Agriculture in Latin America and the Caribbean (LAC) is key for feeding the world. LAC is the world’s largest net exporter of food; as such, it plays a key role in global food security and, in turn, in food prices. The region is also the world’s main provider of ecosystem services (Morris et al. 2020). Likewise, due to its agro-ecological and socio-cultural conditions, it is one of the regions with the greatest potential for future agricultural growth. Lastly, it has incredibly diverse agricultural systems (in terms of products, producer profiles, biological diversity, etc.) that resemble those in other regions of the world.

Fostering the digital transformation of agriculture in LAC could prove very interesting, not only because it can make significant contributions to the achievement of the SDGs (given the region’s global impact), but also because it can yield valuable lessons with respect to mechanisms that can be applied in other regions of the world. Various multilateral and local public and private organizations in LAC can collaborate in designing and implementing a strategic program to drive the digital transformation of agriculture in LAC, in accordance with the guidelines described in Section 3. The program could unify and enhance the impact of current initiatives and promote new actions (prioritizing cases or value chains in which digital interventions could have the greatest impact; IDB 2021) to effectively foster a digital transformation. This would allow for consolidating concrete actions aimed at transforming food systems in accordance with the needs set out in the FSS call for proposals.

6. MAIN REFERENCES

- **Basso B., Antle J.** 2020. Digital agriculture to design sustainable agricultural systems. *Nature Sustainability* 3, 254-256.
- **Camill P.** 2010. Global Change. *Nature Education Knowledge* 3(10):49.
- **Fabregas, R., Kremer M., Schilbach F.** 2019. Realizing the potential of digital development: the case of agricultural advice. *Science* 366, 1328. DOI: <http://dx.doi.org/10.1126/science.aay3038>
- **FAO** (Food and Agriculture Organization of the United Nations). 2019. Tecnologías digitales en la agricultura y las zonas rurales (Trendov N., Varas S., Zeng M.). Available at: <http://www.fao.org/3/ca4887es/ca4887es.pdf>
- **GSMA.** 2020. Digital Agriculture Maps: 2020 State of the sector in low and middle-income countries (Phatty-Jobe A., Seth A., Norton K.). Available at: <https://www.gsma.com/r/wp-content/uploads/2020/10/GSMA-Agritech-Digital-Agriculture-Maps-2020-1.pdf>
- **IDB** (Inter-American Development Bank). 2021. Landscaping the agritech ecosystem for smallholder farmers in Latin America and the Caribbean (Loukos P. and Arathoon L.). Available at: <https://publications.iadb.org/publications/english/document/Landscaping-the-Agritech-Ecosystem-for-Smallholder-Farmers-in-Latin-America-and-the-Caribbean.pdf>
- **IICA** (Inter-American Institute for Cooperation on Agriculture), IDB (Inter-American Development Bank), Microsoft Corporation. 2020. Rural connectivity in Latin America and the Caribbean: A bridge to sustainable development during a pandemic (Ziegler S.). Available at: <https://repositorio.iica.int/handle/11324/12896>
- **IICA** (Inter-American Institute for Cooperation on Agriculture), IDB (Inter-American Development Bank), Microsoft Corporation. 2021. Habilidades digitales en la ruralidad un imperativo para reducir brechas en América Latina y el Caribe (Ziegler S.). Available at: <https://repositorio.iica.int/handle/11324/14462>
- **Klerks L., Rose D.** 2020. Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways? *Global Food Security* 24, 100347.
- **Lajoie-O'Malley A., Bronson K., van der Burg S., Klerkx L.** 2020. The future(s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents. *Ecosystem Services* 45, 101183.
- **OECD** (Organization for Economic Co-operation and Development). nd. Bridging the digital divide. Available at: <https://www.oecd.org/site/schoolingfortomorrowknowledgebase/themes/ict/bridgingthedigitaldivide.htm>

- **United Nations.** 2019. Project Breakthrough. Available at: <http://breakthrough.unglobalcompact.org/disruptive-technologies/digital-agriculture/>
- **World Bank.** 2016. Will digital technologies transform agriculture in developing countries? (Deichmann U., Goyal A., Mishra D.). Available at: <https://openknowledge.worldbank.org/handle/10986/24507>
- **World Bank.** 2020. Future Foodscapes: Re-imagining Agriculture in Latin America and the Caribbean (Morris M. et al). Available at: <http://documents1.worldbank.org/curated/en/942381591906970569/pdf/Future-Foodscapes-Re-imagining-Agriculture-in-Latin-America-and-the-Caribbean.pdf>
- **World Bank.** 2021. What's Cooking : Digital Transformation of the Agrifood System (Schroeder K., Lampietti J., Elabed G.). Available at: <http://hdl.handle.net/10986/35216>



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