SMALLDERS PROJECT

SMART **M**ODELS FOR **A**GRIFOOD **L**OCAL VA**L**UE CHAIN BASED ON **D**IGITAL TECHNOLOGIES FOR **E**NABLING COVID-19 **R**ESILIENCE AND **S**USTAINABILITY

D3.1

REPORT ON NETWORK RESOURCES AND ICT SKILL GAP ANALYSIS

The PRIMA programme is an Art.185 initiative supported and funded under Horizon 2020, the European Union's Framework Programme for Research and Innovation.

Project Information

Acronym: SMALLDERS

Title: **S**mart **M**odels for **A**grifood **L**ocal Va**L**ue Chain Based on **D**igital Technologies for **E**nabling Covid-19 **R**esilience and **S**ustainability

Coordinator: University of Calabria (Italy)

Programme: PRIMA. Thematic area Agro-food value chain. Topic 2.3.1

Start: 2022-05-01

Duration: 36 months

Web: https://mel.cgiar.org/projects/smallders

Consortium:

University of Calabria, Italy (UNICAL)

University of Parma, Italy (UNIPR)

University of Extremadura, Spain (UEX)

IMT Mines Ales, France (LSR)

Faculty of Science of Tunis, Tunisia (LAPER)

DELIVERABLE

Number: D3.1

Title: Report On Network Resources And ICT Skill Gap Analysis

Lead participant: University of Calabria, Italy (UNICAL)

Other participants: University of Tunis El Manar, Tunisia (LAPER)
University of Parma, Italy (UNIPR)
University of Extremadura, Spain (UEX)
IMT Mines Ales, France (LSR)

Work package: WP3

Dissemination level: Public (PU)

Type: Report (R)

Due date: 2023-10-31

Submission date: 2023-10-31

Contributors: Francesco Longo (UNICAL), Gianluca Gatti (UNICAL), Giovanni Mirabelli (UNICAL), Antonio Padovano (UNICAL), Vittorio Solina (UNICAL), Eleonora Bottani (UNIPR), Giuseppe Vignali (UNIPR), Gregory Zacharewicz (LSR), Sergio Rubio (UEX), Lilia Sidhom (LAPER).

Reviewer(s): IMT Mines Ales, France (LSR)

Document revision

Version	Date	Editor	Overview
First release	2023-09-30	Francesco Longo, Vittorio Solina	First version
Second release	2023-10-07	Francesco Longo, Vittorio Solina	Internal review
Third release	2023-10-11	Francesco Longo, Vittorio Solina	UNICAL and partners contributions and review
Review	2023-10-30	Oussama Ben-Ammar	Review from LSR

Final Release	2023-10-31	Francesco Longo, Vittorio Solina	Final version of the deliverable

Index

List of Figures

Executive summary

In the context of Task T3.1 of the SMALLDERS project, the consortium has carried out an investigation, aimed at discerning the depth of network resources available across participating countries. This assessment involves comprehensive surveys and the accumulation of data from an array of network databases. Concurrently, under the umbrella of WP3, the partners delve into the ICT competency levels of the SMALLDERS users. This exploration employs both a review of relevant scientific literature and the execution of direct user surveys. The final purpose is to present a thorough database delineating the multifaceted landscape of network resources and a comprehensive report that brings to the fore the disparities in ICT proficiency among users. This study will be necessary to ensure that network and user capabilities are balanced with the larger vision of the SMALLDERS project.

1 Introduction

The integration of blockchain, artificial intelligence (AI), and e-commerce channels in agriculture heralds a realm of possibilities for modernizing agricultural practices and supply chains. By incorporating these technologies, the SMALLDERS project aims to create a synergistic platform that adapts to varying technological infrastructures, ensuring inclusive access and utility across different regions. The SMALLDERS project foresees specific testbeds to be conducted in Italy, France, Spain, and Tunisia, each hosting a unique instance of the SMALLDERS platform to engage a broad spectrum of stakeholders, ranging from smallholders and citizens to policymakers and logistics providers. This deliverable is related to the Task 3.1 whose primary objective is to understand the readiness of each partner's to use Industry 4.0 enabling technologies, considering their specific technological and agricultural settings. This ensures that the SMALLDERS platform is tailored to provide an optimal experience for all involved parties.

As mentioned, the technological backbone of the SMALLDERS platform is enriched by blockchain technology, which champions certified real-time data sharing among diverse actors, fostering a trustful environment within the platform. This is particularly relevant in e-agriculture scenarios, where blockchain can streamline critical supply chain processes like data recording and monitoring, ensuring transparent and accurate tracking of agricultural transactions (Dey & Shekhawat, 2021). Furthermore, blockchain's impact on e-commerce is significant, as it can be a decisive factor for success by addressing various technological, legal, organizational, and consumer issues, potentially decentralizing sales channels and enhancing profit margins for producers (Treiblmaier & Sillaber 2021).

Integrated e-commerce channels within the SMALLDERS platform aim to decentralize sales avenues, which could potentially lead to increased profit margins for producers. Furthermore, the AI-enabled Knowledge Navigator on the SMALLDERS platform is envisioned to offer a personalized user interface experience, which is in line with the broader trend of employing AI alongside blockchain for digital transformation in various sectors, including agriculture (Tsolakis et al., 2022).

Moreover, the SMALLDERS platform's comprehensive technological suite is bolstered by QR Code systems, GPS-enabled tracking and advanced simulation models, encapsulating a novel approach to agriculture and food supply chain management (as foreseen by different research works, e.g., Awan et al., 2021). The analysis of each testbed encompasses an evaluation of the prevailing ICT infrastructure, an assessment of stakeholder technological proficiencies, and a comparative analysis vis-à-vis the project's Key Performance Indicators (KPIs). The analysis aims to ascertain the relative technological readiness of each region, identifying potential gaps between the platform's offerings and existing capabilities on the ground, thus ensuring a balanced integration of the SMALLDERS platform across all testbeds, considering the specific technological and agricultural landscapes of each region.

2 Network Resources and ICT Skill Gap in Modern Agriculture

The modernization of agriculture through the integration of Information and Communication Technology (ICT) is a burgeoning domain that holds promise for improving agricultural productivity and value chain efficiency. However, the realization of this potential is often stymied by a range of challenges, notably the gaps in network resources and ICT skills among the agricultural community.

In many developing regions, the sluggish adoption of ICT innovations in the agricultural sector is often attributed to poor technological infrastructure, inappropriate ICT policies, and a low level of user skills, especially among farmers. The effective integration of ICT in agriculture has been recognized to bring about substantial improvements in the agricultural value chain efficiency and productivity in developed countries, yet in many regions a major transformation is yet to take place due to these challenges (Ayim et al., 2022).

Farmers often express a need for timely availability of information on technology and market opportunities, yet regular extension services frequently fall short of meeting these needs due to the lack of ICT infrastructure and skills (Swaminathan & Swaminathan 2018). The higher growth desired in the agricultural sector can only be achieved with the proper application of ICT, necessitating adequate investments from both the public and private sectors to bridge the existing ICT skill gap (Shah, 2022).

Furthermore, smallholder farmers, who constitute a significant portion of the agricultural community in many regions, often rely on basic ICT tools like mobile phones and radios to access agricultural-related information due to the limited number of public extension service agents. This reliance on ICT tools underscores the critical need for improving technological skills among farmers to boost agricultural productivity (Ndimbo et al., 2023).

Moreover, the digital divide in remote or rural areas creates inequalities regarding low ICT literacy, poor physical access to technology, and lack of awareness, which further exacerbates the ICT skill gap. This digital divide affects not only the agricultural sector but also the broader engagement of citizens with digital services, indicating a systemic issue that requires cohesive ICT policies and initiatives for digital inclusion (Chohan & Hu, 2020).

In light of these challenges, for the SMALLDERS project, addressing the network resources and ICT skill gap is imperative to harness the full potential of modern agriculture, fostering a conducive environment for the adoption of ICT innovations and enhancing the livelihoods and productivity of the agricultural community.

2.1 The Digital Transformation of Agriculture

The digital revolution in agriculture is facilitating a shift from traditional practices to more technologically advanced methods, thereby promoting enhanced productivity and sustainability. This transformation is characterized by the integration of cutting-edge technologies such as Artificial Intelligence (AI), Internet of Things (IoT), blockchain, and advanced data analytics. These technologies are central to enabling data collection and automated input applications, which in turn can potentially enhance production efficiency, reduce over-application of inputs, and lower operational costs (Khanna, 2020).

The chart in Figure 1 depicts the escalating volume of data produced by an average farm each day from the year 2000 up to projections for 2034. This exponential growth mirrors the ongoing digital revolution within agriculture, as farms shift from conventional methodologies to technologically-advanced practices. Over the years, the infusion of technologies such as AI, IoT, blockchain, and sophisticated data analytics has led to a surge in daily data points. For instance, in 2000, farms generated minimal data daily. However, by 2020, there was a noticeable uptick, reaching close to 3 million data points daily. The trend is projected to continue sharply upwards, nearing 4.5 million data points by 2034.

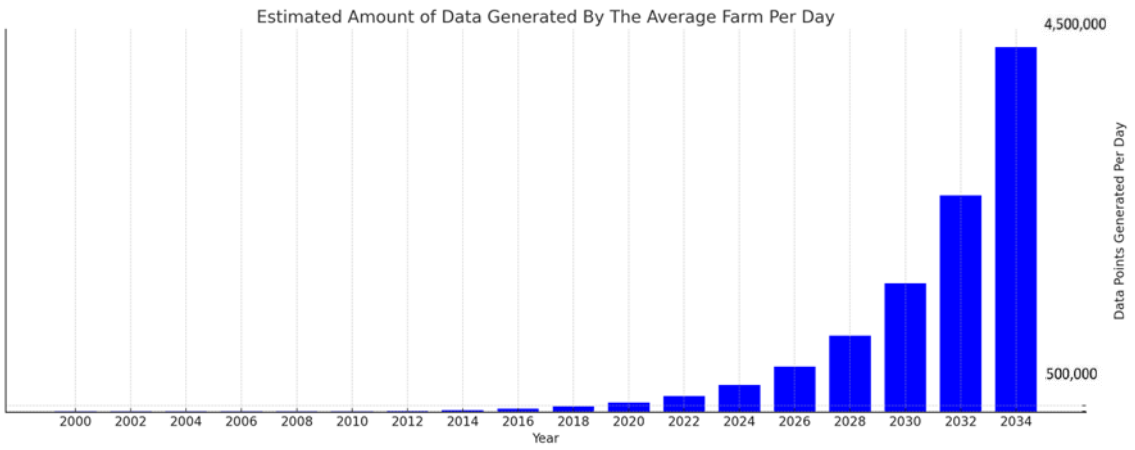

Figure 1. Statistics on the Amount of Data Generated by the Average Farm per Day (derived from Navulur et al., 2017)

Private entities, ranging from established agricultural enterprises to global tech giants and emerging startups, are championing this shift. Digital agriculture is not only transforming farming methods through innovative digital solutions but is also reshaping agricultural knowledge transfer. This includes the proliferation of digital extension services, increased use of social media for agricultural endeavors, and an uptick in digital literacy within the farming community. As a result, farmers can harness digital tools to forecast crop diseases, enhance irrigation accuracy, oversee soil quality, and make evidence-based decisions, bolstering crop yields and sustainability (Ali et al., 2023).

Furthermore, digital platforms are bridging the informational gap, linking farmers directly to consumers and ensuring traceability. This soaring tide of digital agriculture heralds a future marked by increased productivity, environmental sustainability, economic feasibility, and global interconnectivity. Yet, as the data indicates, it's vital to approach this digital transformation with an awareness of regional differences, preparedness of infrastructure, and existing skill discrepancies to guarantee that all players, especially small-scale farmers, can capitalize on the digital age's benefits (Qin et al., 2022).

2.2 Role of Network Resources in Agricultural Platforms

The emphasis on network resources within agricultural platforms like SMALLDERS is crucial as it lays the foundation for data-driven agricultural innovation. Digital

agriculture platforms provide an enabling environment for cross-sectoral, data-driven agricultural innovation across the entire agricultural and food technology innovation landscape (Runck et al., 2021). The incorporation of Internet of Things (IoT) alongside fog computing in agricultural platforms allows for large-area data collection and analysis, and the integration of limited network information resources, thus automating agricultural monitoring (Rejeb et al., 2022). By leveraging a wide spectrum of novel, data-driven technologies, digital agriculture aims to augment sustainability across food systems, spotlighting the importance of digital agriculture in enhancing efficiency in agricultural production and agri-food value chains (MacPherson et al., 2022).

Moreover, the operation of data sharing platforms in agriculture necessitates a community of stakeholders, a facilitatory system, and data on and for the community. In alignment with the SMALLDERS project's focus on Mediterranean and EU regions, these network resources become indispensable. They not only foster data-driven decision-making but also bridge the information gap, enhancing productivity and resilience within agricultural communities. By optimizing the use of network resources, the SMALLDERS project aims for a seamless transition into the digital era of agriculture, ensuring that the communities reap the maximum benefits from technological advancements.

2.3 Challenges of the ICT Skill Gap in the Agricultural Sector

The challenges associated with the ICT skill gap in the agricultural sector are extensive and multi-faceted. This gap stems from various factors including inadequate technological infrastructure, lack of appropriate ICT policies, and a low level of ICT literacy, especially among farmers in developing regions. The literature indicates that there is a notable gap in smallholder farmers' levels of ICT literacy capability, which invariably results in a digital divide and poverty among rural communities. This gap poses a barrier to the adoption of ICT in agricultural practices (Alant & Bakare, 2021). However, from the results obtained through a survey compiled by 160 Italian farmers, a good portion of them would be inclined to use the SMALLDERS platform, or think they could learn to use it (Figure 2). This is an excellent starting point, as well as a demonstration of the fact that, as highlighted by the questionnaire, small farmers perceive the rapid change in terms of technological evolution in the sector (Figure 3), and feel the need to

improve. The primary objective of this survey was to gauge the inclination of smallholders towards adopting a digital platform for their land management. The aim was to understand their readiness level and receptivity to this innovative initiative. Additionally, the survey sought to identify trends related to age, educational level, and other pertinent attributes such as the size of the land they own and their annual income. In fact, from the survey, it was detected that in cases in which the age of the small holder was more than 55 years, he disagreed with the use of the platform. Viceversa, the youngest range was definitely positive to adopt new technologies. Others results (Figure 4 and Figure 5), were clear about the fact that the majority of the farmers were convinced of the idea that the utilization of the SMALLDERS platform should be useful for their business and can increase their productivity. The questionnaire was administered anonymously, with the principal intent being to numerically evaluate, through a sample, the potential adoptions of the platform.

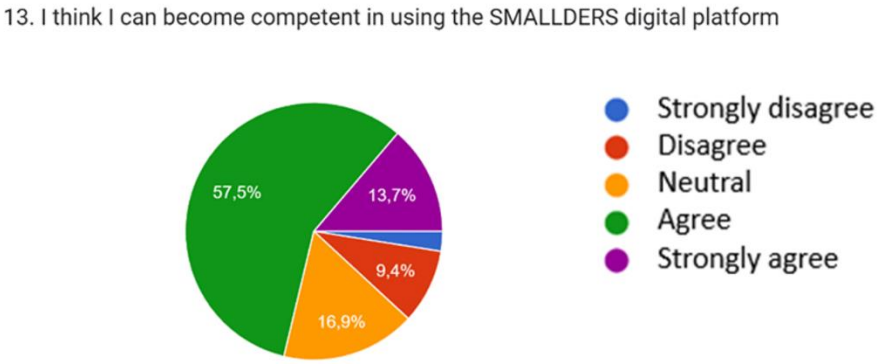

Figure 2. Pie chart that shows the desire to become competent in using the SMALLDERS platform

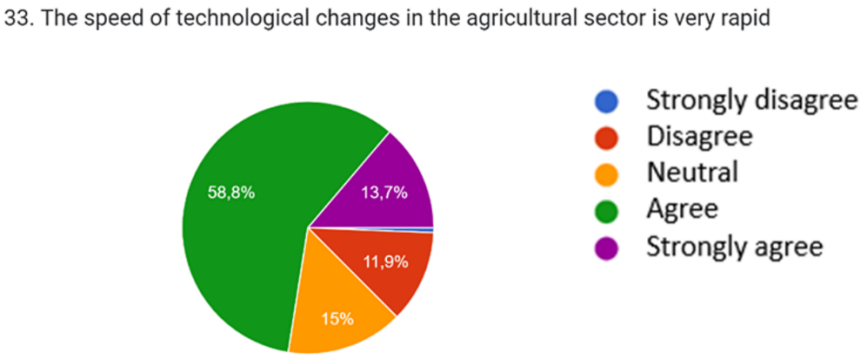

Figure 3. Pie chart that shows the awareness of smallholders that technological evolution in the agricultural sector is very fast

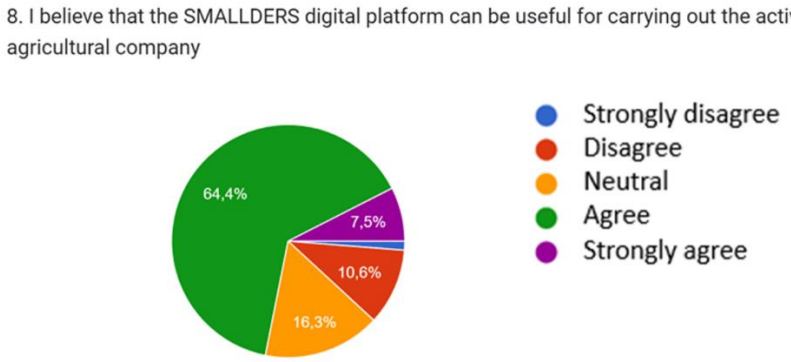

Figure 4. Pie chart that shows the farmers' belief that SMALLDERS can be useful for their businesses

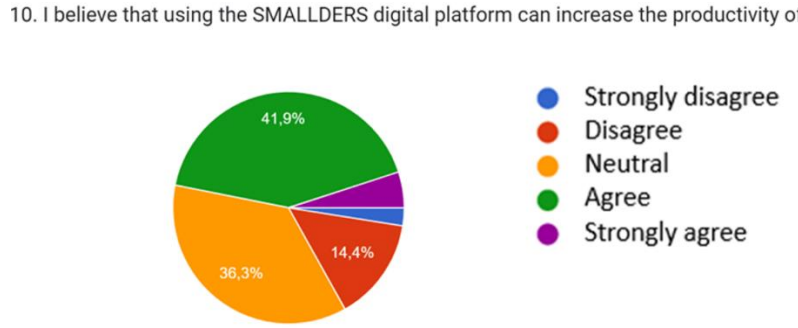

Figure 5. Pie chart that shows the farmers' belief that SMALLDERS can increase the productivity of their businesses

The effective application of ICT in agriculture is crucial for achieving higher growth in the sector. It is emphasized that adequate investments from both the public and private sectors are required to bridge the existing ICT skill gap. The integration of ICT is seen as a means to enhance communication and coordination across the entire agri-food supply chain (Shah, 2022).

In many countries, (e.g. sub-Saharan Africa), the lack of sufficient evidence on the effect of ICT on agricultural real output and export performance reflects the challenges posed by the ICT skill gap. The ICT infrastructure is deemed crucial for the overall development and performance of many sectors, including agriculture. However, the insufficient evidence suggests that the region might be facing challenges in assessing and addressing the ICT skill gap and its impact on the agricultural sector (Oyelami et al., 2022). Furthermore, recent advances in ICT are viewed as instrumental in elevating agricultural extension and support services. These technologies offer myriad opportunities to integrate with agricultural extension activities such as decision support systems, agricultural

production planning, and the automation of production practices. Yet, the skill gap may hinder the effective utilization of these advanced ICT tools and systems, potentially affecting the productivity and sustainability of agricultural practices (Uvasara Dissanayeke et al., 2020).

These challenges underscore the necessity for targeted interventions aimed at bridging the ICT skill gap in the agricultural sector. Such interventions could encompass comprehensive training programs, the development of user-friendly ICT tools, and the establishment of supportive policy frameworks to promote ICT adoption and literacy among agricultural communities.

3 Testbeds: Network Analysis

To demonstrate the capabilities and adaptability of the SMALLDERS platform, the project partners envision establishing and operating an experimental framework across four testbeds, situated in Italy, France, Spain, and Tunisia. Within every testbed, the SMALLDERS platform will be employed with an aim to engage all the relevant players encompassed in the relative framework, including Smallholders, Citizens, Critical Stakeholders, Freight Transport Companies, and Policymakers, to the fullest extent possible.

3.1 Testbed 1 (Italy)

Two firms, both having provided expression of interest to the project, will participate in the Italian testbed, located in northern Italy. The larger of the two, Ecornaturasì, encompasses over 500 smallholders specializing in organic farming. Within the project's scope, a selection of them will evaluate specific sensors to capture production data that will be deployed, to be authenticated, using Blockchain technology. Additionally, a smaller organic enterprise, Azienda Stuard, will be engaged in the project for sensor testing, blockchain implementation, and eventually, the development of a website for online sales.

3.1.1 ICT Proficiency and Network Infrastructure Assessment

The Italian landscape for the SMALLDERS project is illuminated by the country's ongoing commitment to digital transformation and innovation. As of 2021, the Italian ICT market stands at an impressive $35 billion, complemented by a digital market that touched $77 billion at the year's end[1]. According to data contained in the IDC Worldwide ICT Spending Guide: Enterprise and SMB by Industry, ICT spending in Italy will reach 84.2 billion dollars in value this year, rising to 96.4 billion dollars in 2026[2].

A significant driver behind this growth is the surge in investments in cloud computing, reflecting the broader trend of the digital transformation that has been prioritized by both the government and private enterprises. The "national cloud" for public administration has shown exponential growth. Its market value has almost tripled from $1.4 billion in 2015 to an overwhelming $3.9 billion by 2021. This momentum is likely to continue, especially with Infrastructure cloud services

[1] https://www.trade.gov/country-commercial-guides/italy-information-and-communications-technology-ict
[2] https://www.lineaedp.it/report/spesa-ict-in-italia-le-previsioni-2023/

(IaaS) and platform cloud services (PaaS) poised for higher growth. It's notable that 60% of large Italian companies have adopted at least one IaaS, signaling a matured ICT readiness.

Emerging technologies like the Internet of Things (IoT) are also on the rise, in fact IoT market is expected to grow at 26.8% CAGR from 2022 to 2029, it means that it will reach over USD 176.25 billion by 2029[3].

The integration of IoT in various sectors, especially agriculture, combined with the advent of 5G connectivity, suggests a promising synergy for the objectives of the SMALLDERS project in Italy.

The assessment of network infrastructure for Italy is a crucial component within the scope of the SMALLDERS project. Understanding the distribution, quality, and accessibility of internet connections in the Italian agricultural sector is essential for the project's successful implementation. As Italy continues its journey of digital transformation, disparities in connectivity across different regions become more evident. By mapping out the internet connectivity in the Italian testbed area, the aim is to illustrate the present state of network resources in the areas involved into the experimentation, respectively for the Ca' Magre (Ecornaturasì) in Figure 6 and Azienda Stuard in Figure 8.

Concerning the analysis at both Ca' Magre (Ecornaturasì) and Azienda Stuard, additional examinations were conducted utilizing the tool provided by the region's leading mobile network operator, Wind Tre Mobile, in this particular zone of Italy. As depicted in Figure 7 and Figure 9, the areas encompassing the farms is almost completely covered in orange, and looking at the picture legend, it represents that have 5G connectivity available for both locations.

This visualization will be instrumental in both setting a baseline and pinpointing potential challenges and prospects in fostering the digital integration of agriculture throughout Italy.

[3]https://exactitudeconsultancy.com/it/rapporti/16127/internet-di-cose-robotiche-mercato/

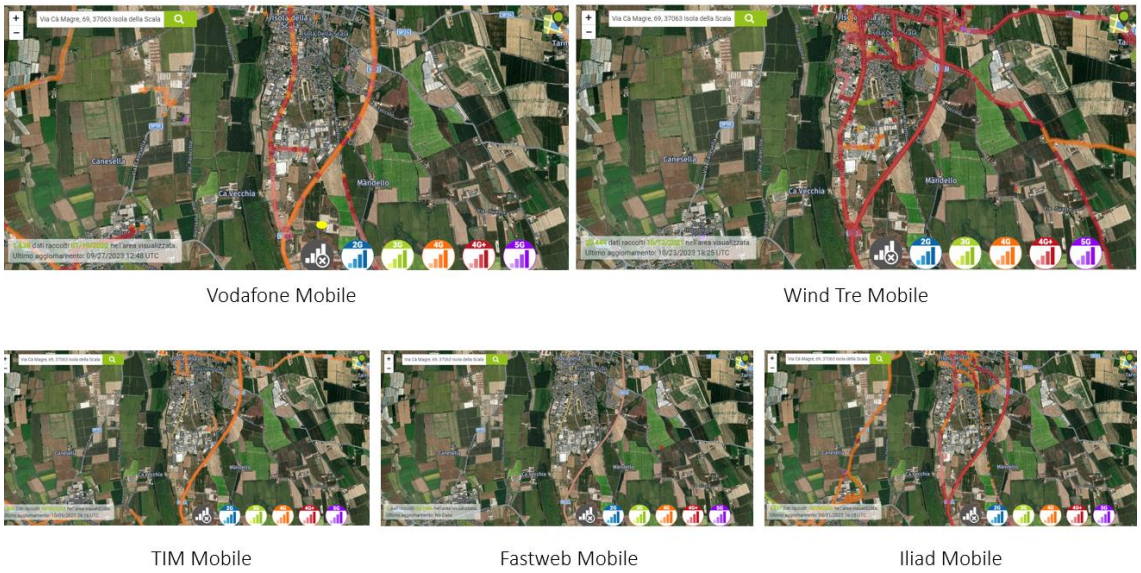

Figure 6. Map representing the coverage of the 2G, 3G, 4G and 5G mobile network in the 'Ca' Magre' (Ecornaturasì) site[4]

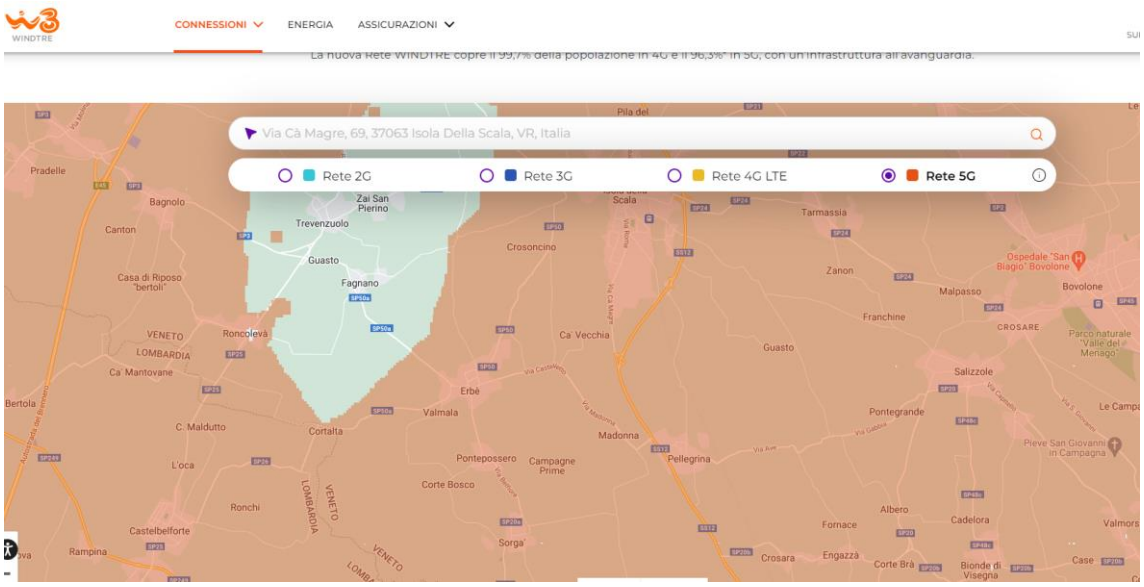

Figure 7. Map representing the coverage of the most advanced mobile network in the 'Ca' Magre' (Ecornaturasì) site[5]

[4]https://www.nperf.com/it/map/IT/-/-/signal/?ll=41.549433941803954&lg=12.570000000000016&zoom=5
[5]https://www.windtre.it/copertura-4g-lte-5g-internet-veloce/

Vodafone Mobile | Wind Tre Mobile

TIM Mobile | Fastweb Mobile | Iliad Mobile

Figure 8. Map representing the coverage of the 2G, 3G, 4G and 5G mobile network in the 'Azienda Stuard' site[6]

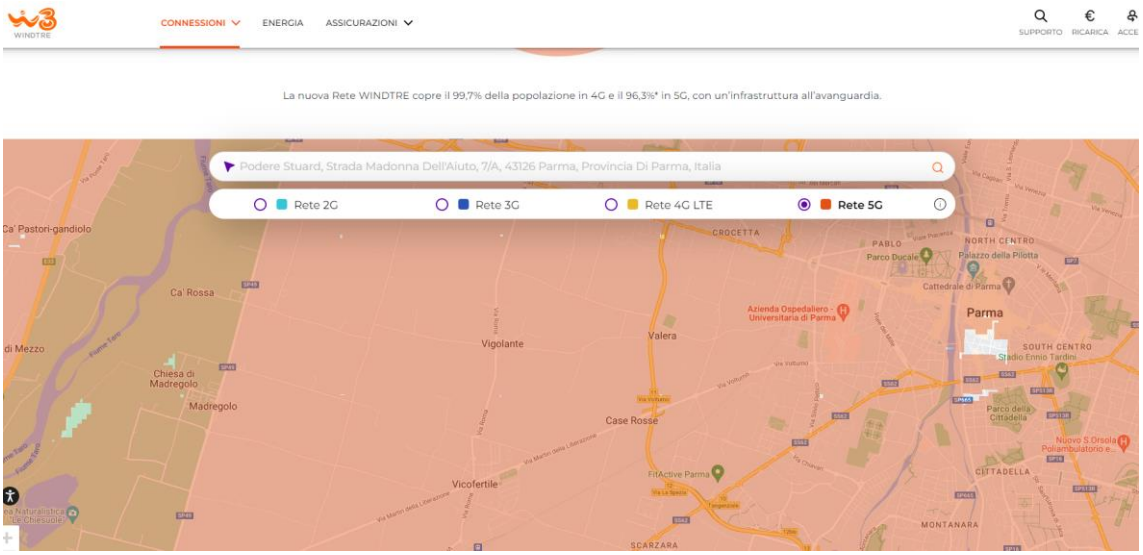

Figure 9. Map representing the coverage of the most advanced mobile network in the 'Ca' Magre' (Ecornaturasì) site[7]

3.2 Testbed 2 (France)

Le Potager d'Aubrespin, situated in Saint Gervasy, exemplifies a sustainable agriculture model, focusing on the cultivation and provision of seasonal fruits and vegetables. The establishment adheres to organic and ecologically sound agricultural practices, eschewing the utilization of detrimental pesticides or

[6]https://www.nperf.com/it/map/IT/-/-/signal/?ll=41.549433941803954&lg=12.570000000000016&zoom=5
[7]https://www.windtre.it/copertura-4g-lte-5g-internet-veloce/

synthetic chemicals, thereby ensuring the integrity and wholesomeness of the produce.

Central to its operational ethos is a steadfast commitment to sustainable farming methodologies, which not only enhance the soil fertility but also contribute to a larger ecological balance. The emphasis on gustatory quality is evident, with a meticulous approach ensuring that only ripe and nutritionally dense products make it to the consumers. The farm-to-table model adopted here minimizes the transit time, thereby preserving the nutritional profile and the natural taste of the produce.

3.2.1 ICT Proficiency and Network Infrastructure Assessment

The landscape of Information and Communication Technologies (ICTs) in France has witnessed significant evolution in the last decades, with these technologies becoming central to daily life and playing an expansive role in cultural access. Digital equipment, including computers, consumer electronics, and internet connections, has become more affordable, leading to their widespread adoption (Bonnaud, *2021)*. The surge in high-speed internet connectivity and technological innovations further enhanced the accessibility and functionalities of ICTs. However, despite this growth, the adoption of these technologies still varies depending on users' educational background, income levels, and age.

A surge in agricultural technology is evident in France, with numerous start-ups developing algorithms, software, satellites, drones, artificial intelligence, and robots. These technologies are being used to remotely carry out tasks such as weeding, pesticide spraying, livestock monitoring, and disease detection. In Figure 10 is shown the dissemination of some actors that decided to invest in digital agriculture, coming from different organizations, such as research and higher educational institutes, government agencies, agricultural technology (AgTech) companies, farmer unions etc., and that work together by means of associations (e.g. Robagri), networks (e.g. RMT Naexus, DigiFermes, Fermes Leader), or living labs (e.g. Occitanum)(Bellon-Maurel et al., 2023).

Figure 10. The French research and capacity building ecosystem on digital agriculture (Bellon-Maurel et al., 2023).

The notion of the digital divide – the gap between those who have access to digital technologies and those who don't – is gradually shrinking in France. This increase in computer and internet penetration can be attributed to the declining costs of computer hardware, greater ICT exposure in educational settings, and the widespread use of new technologies in every fields. The digital divide still persists, especially among specific demographics such as the elderly, low-income groups, and those with limited education.

The evaluation of network infrastructure for France is an important element within for the SMALLDERS project. Gaining insight into the distribution, quality, and accessibility of internet connections in the French agricultural sector is fundamental for the project's successful execution. A comprehensive map of the French testbed area (Figure 11) reveals the internet connectivity for the area containing the site "Le Potager d'Aubrespin", and going deeper into the research (Figure 12), considering the flagship mobile operator in this area of France, Bouygues Telecom, also in this case the network coverage is more than acceptable. In fact, as observable from the legend in figure, in the majority of

the region is guaranteed almost the 4G/4G+ coverage, even reaching 5G coverage in some areas.

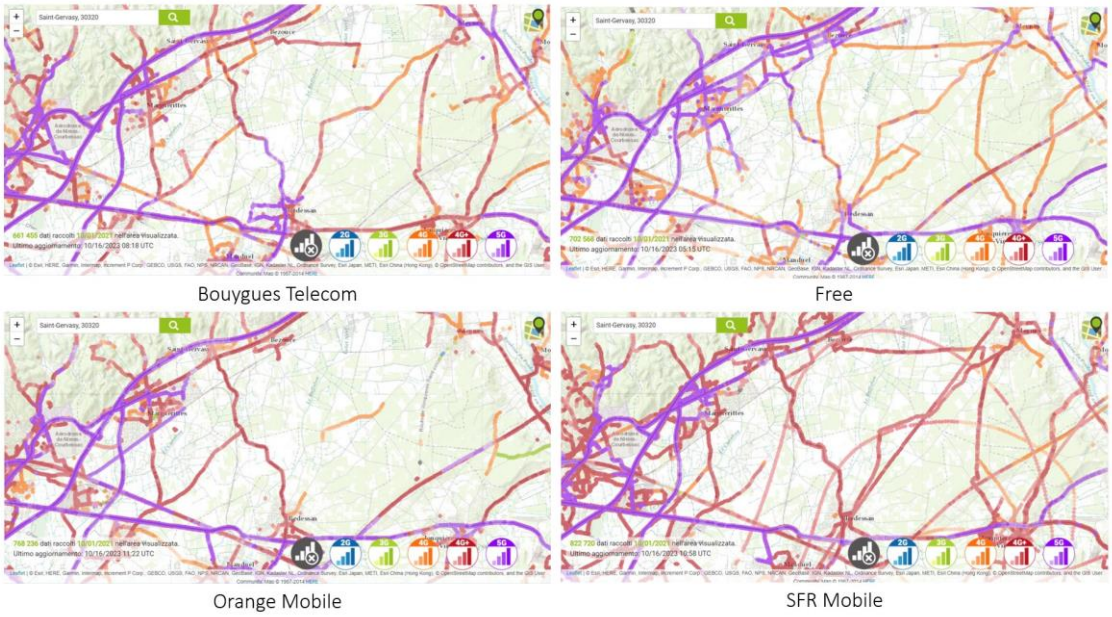

Figure 11. Map representing the coverage of the 2G, 3G, 4G and 5G mobile network in the 'Le Potager d'Aubrespin' site[8]

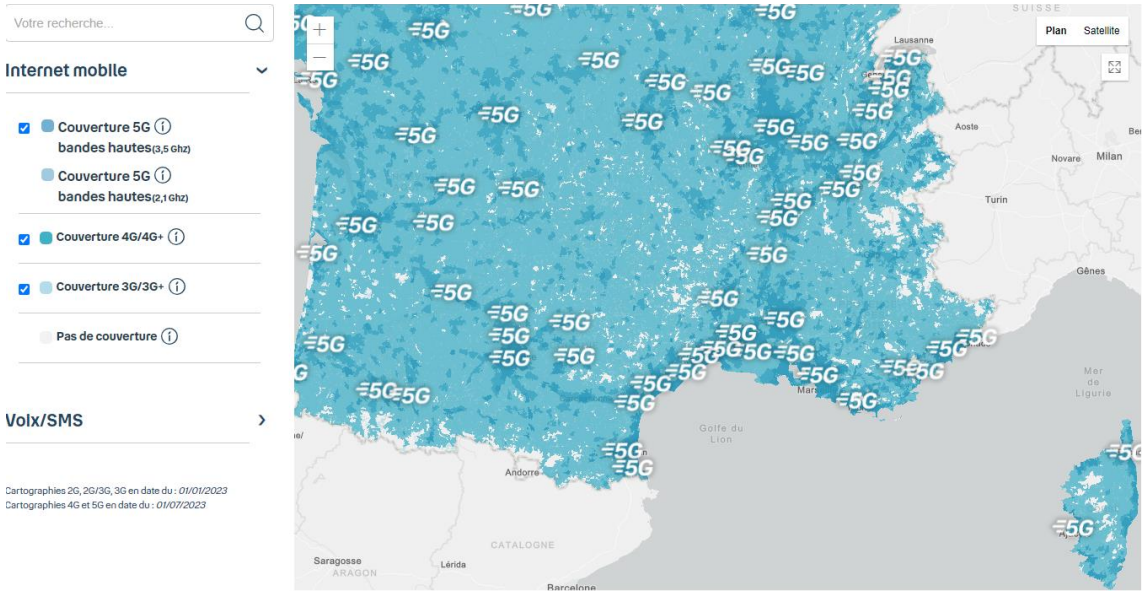

Figure 12. Map representing the coverage of the most advanced mobile network in the 'Le Potager d'Aubrespin' site[9]

[8]https://www.nperf.com/it/map/FR/-/-/signal/?ll=46.437856895024204&lg=2.1972656250000004&zoom=5
[9]https://www.bouyguestelecom.fr/reseau/cartes-de-couverture-reseaumobile?address=Votre+recherche...VF6G%2BJQ%2C+30320+Saint-Gervasy%2C+Francia&address-btn=#

3.3 Testbed 3 (Spain)

The case study designated for execution within the ambit of the SMALLDERS project is focused on the Fruit Growers Association from Extremadura (AFRUEX, Asociación de Fruticultores de Extremadura, afruex.com). AFRUEX embodies a professional consortium encompassing 90% of the fruit growers in Extremadura, with 60 direct members who collectively represent a community of over 5,000 fresh fruit cultivators. These members are unified in their objective to structure and enhance the fruit growing sector in Extremadura, while championing quality production that adheres to ecological equilibrium. AFRUEX amalgamates more than 14 fruit and vegetable producers' organizations, cooperatives, agricultural transformation entities, and other social formations, culminating in over 30 Fruit and Vegetable Centrals.

Currently, AFRUEX encapsulates within its membership a cumulative annual yield exceeding 285,000 tons of fresh fruit, including but not limited to plums, cherries, nectarines, peaches, pears, quinces, apricots, and persimmons, alongside dried fruit. Given these production magnitudes, fruit cultivation remains the paramount generator of agricultural employment in Extremadura, thereby fostering rural area development and population retention therein. Essentially, fruit cultivation emerges as a crucial sector within the regional economy, particularly amidst the challenging pandemic years, with substantial hurdles anticipated to be surmounted through collective resolve and coordinated efforts. The association AFRUEX exhibits interest in the SMALLDERS project, discerning a synergy between the project's objectives and their own aspirations, thereby rendering it a valuable testbed for evaluating the goals and functionalities delineated in the SMALLDERS platform.

3.3.1 ICT Proficiency and Network Infrastructure Assessment

Spain's ICT sector is demonstrating resilience, bouncing back swiftly from the global health crisis, bolstered by EU recovery funds. With Spain being a great economy in the EU, niche industry solutions find substantial prospects within its private domain. Notably, U.S. firms are acknowledged as pivotal contributors to innovation in this arena.

The bulk of ICT hubs—over 70%—are concentrated in Madrid and Catalonia. There are around 30,000 ICT enterprises in Spain, collectively contributing 3.2% to its GDP. Spain's focus on 5G, cloud computing, AI, and cybersecurity is evident, with significant investments slated for enhancing digital infrastructure and transformation. Plans like the Digital Strategy 2025 and the Spanish Government Recovery, Transformation, and Resilience Plan underscore Spain's ambition in fostering digital advancements, with an impressive projected investment of USD 17.25 billion.

For instance, endeavors to expand broadband access in rural areas highlight Spain's commitment to inclusive digital transformation. Plus, the surge in data center investments by major tech giants, such as AWS and Google, signifies the potential for growth in cloud services. This landscape suggests an opportunistic environment, especially for U.S. SMEs offering cloud, AI solutions, and other ICT services, as Spain marches ahead on its digital journey.[10]

Spain, with its dynamic ICT landscape, stands at the crossroads of innovation and growth. The country's commitment to digital transformation is evident through its consistent investments in infrastructure and adoption of cutting-edge technologies. Also in this context, an in-depth assessment of network resources and maps is necessary (Figure 13 and Figure 14). As observable in Figure 13, in fact the 4G+ coverage is high (green zone) for the majority of the area, and medium (purple zone) only for a little section. For the 4G instead, it was high for almost the entire area.

[10]https://www.trade.gov/country-commercial-guides/spain-information-and-communication-technology-ict

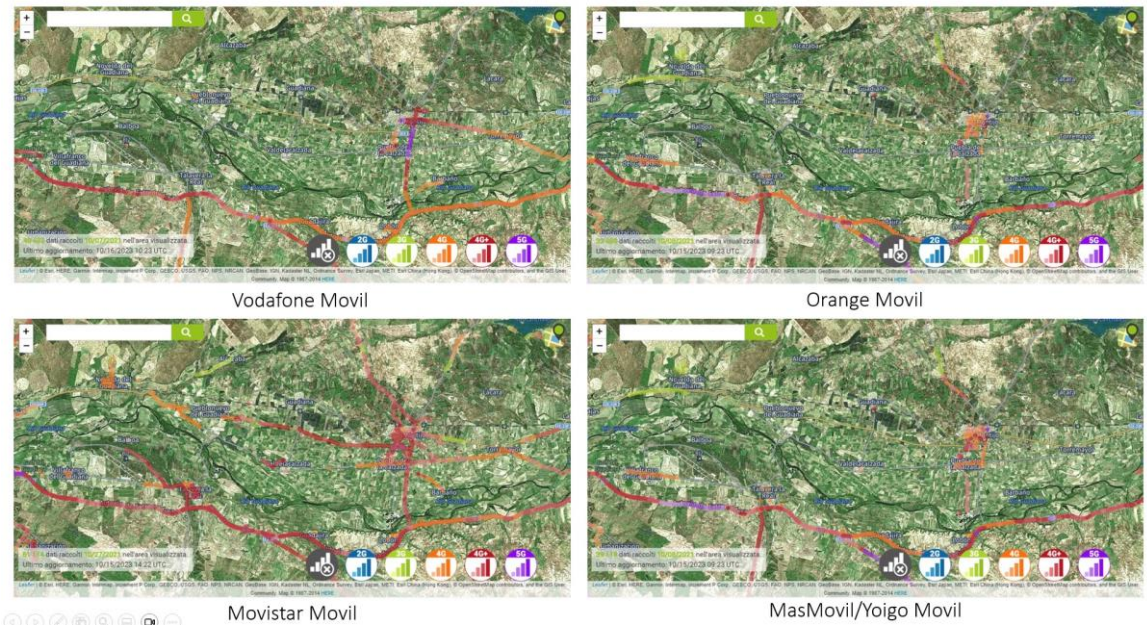

Figure 13. Map representing the coverage of the 2G, 3G, 4G and 5G mobile network in the 'AFRUEX' site[11]

Figure 14. Map representing the coverage of the most advanced mobile network in the 'AFRUEX' site[12]

[11]https://www.nperf.com/it/map/ES/-/-/signal/?ll=36.13787471840729&lg=-6.899414062500001&zoom=5

[12] https://www.movistar.es/particulares/coberturas/movil/

3.4 Testbed 4 (Tunisia)

The agricultural landscape in Tunisia is distinctly characterized by its geographical divisions: the northern region (encompassing areas like Bizerte, Tunis, Cap Bon, etc.), the central zone (comprising Sousse, Sfax, Kairouan, etc.), and the southern territory (including Gafsa, Gassrine, etc.). Within the ambit of the SMALLDERS project, a case study is earmarked for execution in the north-eastern sector of Tunisia, specifically within the locale referred to as "Cap Bon." More precisely, the study area extends from Hammamet to Béni Kiar and spans from Maamoura to Kélibia. This region is celebrated for its diverse attributes on multiple fronts. It's identified as an urban agricultural hub, notably acclaimed for being the citadel of citrus production in the nation, contributing to 70% of Tunisia's overall citrus yield.

A substantial population of smallholders reside in this area, many of whom are engaged in family farming ventures. The agricultural pursuits of these smallholders are multifaceted. Commonly, they are involved in cattle and sheep rearing, typically managing a modest herd ranging from 5 to 15 animals. The agricultural spectrum in this region also encompasses a variety of crop cultivations, including market gardening, citrus farming, along with a host of vegetables and fruits.

However, the region exhibits a notable deficiency in product processing activities. More often, the farmer's produce is routed through distribution channels, destined for marketplaces or manufacturers who then process and channel the products to both small and large retail outlets. A conspicuous gap exists in the direct engagement between smallholders and the end consumers, as well as critical stakeholders. The logistics, often managed by familiar Freight Transport Companies, remain a common choice among various farmers within the vicinity. The nexus between the agricultural community and policymakers is essentially door-to-door, albeit the interactions between these entities are sporadic and lack a regular cadence.

3.4.1 ICT Proficiency and Network Infrastructure Assessment

Tunisia is making great strides in its ICT efforts, marking significant nationwide initiatives in electronic infrastructure, including the development of cyber

technologies and parks, and introducing support measures for both established software companies and startups ICT in the making. This kind of effort is very important because some recent studies revealed that Africa still must face important challenges in terms of Digital technology adoption in the agricultural sector. Mhlanga and Ndhlovu (2023) have recently explored the level of digitalization in African farming and found that many challenges should be addressed such as limited expertise and training, data privacy and security concerns, significant resistance by farmers. According to Engås et al. (2023), there is a "digital divide" in many parts of Africa, i.e., an unequal access to and use of ICTs.

Figure 15 and Figure 16 show the maps relating to the internet connection with the various operators in the testing area. Also in the case of Tunisia, different mobile network operators were analyzed (Orange Mobile, Ooredoo Mobile, TT Mobile), and also in this case the area of interest resulted sufficiently covered with a 4G connection.

Figure 15. Map representing the coverage of the 2G, 3G, 4G and 5G mobile network in the 'Cap Bon' site[13]

[13]https://www.nperf.com/it/map/TN/-/-/signal/?ll=33.96158628979 91&lg=9.558105468750002&zoom=6

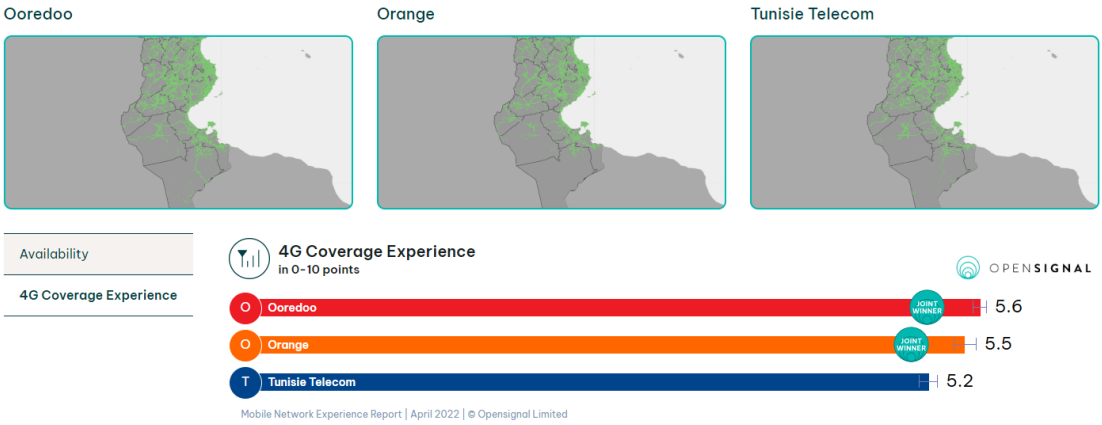

Figure 16. Map representing the coverage of the most advanced mobile network in the 'Cap Bon' site[14]

[14]https://www.opensignal.com/reports/2022/04/tunisia/mobile-network-experience

4 Conclusions

In the T3.1, the consortium conducted a detailed evaluation to ascertain the depth of network resources available across participating entities. A comprehensive survey instrument was employed to gather significant insights, while separate efforts were directed towards accumulating data from network databases. Within the parameters of WP3, a systematic analysis was initiated to assess the ICT competency levels of SMALLDERS users. This approach combined a review of existing scientific literature with direct user feedback mechanisms. The landscape of network resources was cataloged, providing a comprehensive view of the available infrastructure. The data across Italy, France, Spain, and Tunisia highlights the role of network infrastructure in advancing digital agriculture with respect to the geographic positioning of planned project testbeds. Significant 4G/4G+ and 5G coverage observed in these regions lays a solid foundation for digital integration in agriculture. The analysis indicates that Italy possesses the most advanced network infrastructure with 5G connectivity among the assessed regions. However, given that France, Spain, and Tunisia exhibit satisfactory 4G/4G+ coverage, this level of network infrastructure is deemed adequate for fostering digital integration in agriculture within the scope of the SMALLDERS project. Furthermore, a report was compiled, highlighting the disparities in ICT proficiency among users. This research and analytical process ensured a balanced alignment between network capabilities and user proficiencies, fully aligning with the strategic objectives of the SMALLDERS initiative.

References

Dey, K., & Shekhawat, U. (2021). Blockchain for sustainable e-agriculture: Literature review, architecture for data management, and implications. *Journal of Cleaner Production*, *316*, 128254. https://doi.org/10.1016/j.jclepro.2021.128254

Treiblmaier, H., & Sillaber, C. (2021). The impact of blockchain on e-commerce: a framework for salient research topics. *Electronic Commerce Research and Applications*, *48*, 101054. https://doi.org/10.1016/j.elerap.2021.101054

Tsolakis, N., Schumacher, R., Dora, M., & Kumar, M. (2022). Artificial intelligence and blockchain implementation in supply chains: a pathway to sustainability and data monetisation? *Annals of Operations Research*. https://doi.org/10.1007/s10479-022-04785-2

Awan, S., Ahmed, S., Ullah, F., Nawaz, A., Khan, A., Uddin, M. I., Alharbi, A., Alosaimi, W., & Alyami, H. (2021). IoT with BlockChain: A Futuristic Approach in Agriculture and Food Supply Chain. *Wireless Communications and Mobile Computing*, *2021*, 1–14. https://doi.org/10.1155/2021/5580179

Ayim, C., Kassahun, A., Addison, C., & Tekinerdogan, B. (2022). Adoption of ICT innovations in the agriculture sector in Africa: a review of the literature. *Agriculture & Food Security*, *11*(1). https://doi.org/10.1186/s40066-022-00364-7

Swaminathan, M., & Swaminathan, M. S. (2018). ICT and agriculture. *CSI Transactions on ICT*, *6*(3-4), 227–229. https://doi.org/10.1007/s40012-018-0209-9

Shah, D. (2022). Role of Information and Communication Technology in Agricultural Development of India. *Review of Market Integration*, *14*(2-3), 113–132. https://doi.org/10.1177/09749292221119286

Ndimbo, G. K., Yu, L., & Ndi Buma, A. A. (2023). ICTs, smallholder agriculture and farmers' livelihood improvement in developing countries: Evidence from

Tanzania. *Information Development*, 026666692311652. https://doi.org/10.1177/02666669231165272

Chohan, S. R., & Hu, G. (2020). Strengthening digital inclusion through e-government: cohesive ICT training programs to intensify digital competency. *Information Technology for Development*, *28*(1), 1–23. https://doi.org/10.1080/02681102.2020.1841713

Khanna, M. (2020). Digital Transformation of the Agricultural Sector: Pathways, Drivers and Policy Implications. *Applied Economic Perspectives and Policy*. https://doi.org/10.1002/aepp.13103

Navulur, S., Sastry, A. S. C. S., & Prasad, M. N. G. (2017). Agricultural Management through Wireless Sensors and Internet of Things. *International Journal of Electrical and Computer Engineering (IJECE)*, *7*(6), 3492–3499. https://doi.org/10.11591/ijece.v7i6.pp3492-3499

Runck, B. C., Joglekar, A., Silverstein, K. A. T., Chan-Kang, C., Pardey, P. G., & Wilgenbusch, J. C. (2021). Digital agriculture platforms: Driving data-enabled agricultural innovation in a world fraught with privacy and security concerns. *Agronomy Journal*. https://doi.org/10.1002/agj2.20873

Rejeb, A., Rejeb, K., Abdollahi, A., Al-Turjman, F., & Treiblmaier, H. (2022). The Interplay between the Internet of Things and agriculture: A bibliometric analysis and research agenda. *Internet of Things*, *19*, 100580. https://doi.org/10.1016/j.iot.2022.100580

MacPherson, J., Voglhuber-Slavinsky, A., Olbrisch, M., Schöbel, P., Dönitz, E., Mouratiadou, I., & Helming, K. (2022). Future agricultural systems and the role of digitalization for achieving sustainability goals. A review. *Agronomy for Sustainable Development*, *42*(4). https://doi.org/10.1007/s13593-022-00792-6

Alant, B. P., & Bakare, O. O. (2021). A case study of the relationship between smallholder farmers' ICT literacy levels and demographic data w.r.t. their use and

adoption of ICT for weather forecasting. *Heliyon*, *7*(3). https://doi.org/10.1016/j.heliyon.2021.e06403

Oyelami, L. O., Sofoluwe, N. A., & Ajeigbe, O. M. (2022). ICT and agricultural sector performance: empirical evidence from sub-Saharan Africa. *Future Business Journal*, *8*(1). https://doi.org/10.1186/s43093-022-00130-y

Uvasara Dissanayeke, Pahan Prasada, & H. V. A. Wickramasuriya. (2020). ICT-Based Information Systems in Agricultural Extension and Their Economic Implications: Sri Lankan Perspectives. *Springer EBooks*. https://doi.org/10.1007/978-981-15-3673-1_15

Ali, A., Hussain, T., Tantashutikun, N., Hussain, N., & Cocetta, G. (2023). Application of Smart Techniques, Internet of Things and Data Mining for Resource Use Efficient and Sustainable Crop Production. *Agriculture*, *13*(2), 397. https://doi.org/10.3390/agriculture13020397

Qin, T., Wang, L., Zhou, Y., Guo, L., Jiang, G., & Zhang, L. (2022). Digital Technology-and-Services-Driven Sustainable Transformation of Agriculture: Cases of China and the EU. *Agriculture*, *12*(2), 297. https://doi.org/10.3390/agriculture12020297

O. Bonnaud, "National recovery plan for the electronics industry in France; importance of training in the field," *2021 30th Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE)*, Prague, Czech Republic, 2021, pp. 1-5, doi: 10.1109/EAEEIE50507.2021.9530990.

Bellon-Maurel, V., Piot-Lepetit, I., Lachia, N., & Tisseyre, B. (2023). Digital agriculture in Europe and in France: which organisations can boost adoption levels? *Crop and Pasture Science*. https://doi.org/10.1071/cp22065

Mhlanga, D., & Ndhlovu, E. (2023). Digital Technology Adoption in the Agriculture Sector: Challenges and Complexities in Africa. Human Behavior and Emerging Technologies, 2023. https://doi.org/10.1155/2023/6951879

Engås, K. G., Raja, J. Z., & Neufang, I. F. (2023). Decoding technological frames: An exploratory study of access to and meaningful engagement with digital technologies in agriculture. Technological Forecasting and Social Change, 190, 122405.