AGROSMART: COMPREHENSIVE FACILITATION PLATFORM FOR CLIMATE SMART AGRICULTURE

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Abstract

Small holder farmers are one of the most vulnerable subjects of the effects of climate change. Due to their attitude to plan and to follow natural rhythms, they are strongly affected by the increase in variability due to the changing climate. On this issue technology can help to increase resilience realizing climate smart agriculture. Standing to FAO, climate smart agriculture helps to guide actions needed to transform and reorient the agricultural system to effectively support development and ensure food security in a changing climate. AGROSMART offers the possibility to farmers to have adaptive crop management following the changes in environmental conditions: being based on a sensor network to monitor soil, air and meteorological conditions. Through an integrated database, the collected information allows farmers to follow up climate variability by a simple cell phone. The work will describe the main structure and the basic components of the platform and their connection with the climate smart concepts. The cooperative approach of the build-up phase will be also exposed. At its degree of development AGROSMART can offer a scalable model for climate smart farming on which technology and natural resource protection co-exist to improve and grant food security at a small farming scale.

I piccoli agricoltori sono uno dei soggetti più vulnerabili agli effetti del cambiamento climatico. A causa della loro attitudine a pianificare e seguire i ritmi naturali, sono fortemente influenzati dall'aumento della variabilità dovuto al cambiamento climatico. Su questo tema la tecnologia può aiutare ad aumentare la resilienza realizzando una *climate smart agriculture*. Secondo la FAO, la *climate smart agriculture* aiuta a guidare le azioni necessarie per trasformare e riorientare il sistema agricolo per supportare efficacemente lo sviluppo e garantire la sicurezza alimentare in un clima che cambia. AGROSMART offre la possibilità agli agricoltori di avere una gestione adattativa delle colture in base ai cambiamenti delle condizioni ambientali: essendo basato su una rete di sensori per monitorare le condizioni del suolo, dell'aria e meteorologiche. Attraverso un database integrato, le informazioni raccolte consentono agli agricoltori di monitorare la variabilità climatica da un semplice telefono cellulare. Il presente lavoro descriverà la struttura principale e i componenti di base della piattaforma e la loro connessione con i concetti di clima intelligente. Sarà anche esposto l'approccio cooperativo della fase di costruzione. Al suo grado di sviluppo AGROSMART può offrire un modello scalabile per un'agricoltura intelligente per il clima in cui coesistono tecnologia e protezione delle risorse naturali per migliorare e garantire la sicurezza alimentare su piccola scala.

Keywords
Climate Smart Agriculture, Climate Change, Adaptation, Small farming

Introduction

Recent estimations of the United Nations (FAO) (FAO, 2017) give some interesting insight into the state of food security in the world:15 million people in the world today are chronically hungry. After declining for over a decade, according to estimates dated to 2017, the world must, by 2050, produce 49 percent more food than in 2012 as populations grow and diets change.

Currently, around 80 percent of the world's low-income people live in rural areas and depend mostly on agriculture, fisheries or forestry as a source of income and food. In this scenario the continuous rise of temperature due to climate change and unpredictable weather events is threatening the progress towards eradicating hunger and ensuring the sustainability of our natural-resource base to achieve the 2030 Agenda for Sustainable Development. Furthermore, climate change led, land degradation and desertification, and water scarcity, which impacts rural poor - and mostly young, women and children, as first victims.

Small holder farmers are among the most vulnerable subjects of the impacts of these phenomena. Due to their attitude to plan and to follow natural rhythms, they are strongly affected by the increase in variability due changing climate. Adverse events increase the risk of crop damages and unfruitful yields. Disasters and crises indeed don’t just have immediate, short-term effects on small holders: they undermine livelihoods and national development gains that have taken years to build.

Climate change has then a negative impact on food security and is important to increase farmer resiliency in order to grant the common right to a sustainable food system.

The empowerment of small farmers goes toward the synergistic implementation of the Sustainable Development Goals, particularly on SDG 2 and SDG 3: they cannot be addressed even if simultaneously coping with climate change.

On the vision of this nexus even if agriculture is several times considered part of the problem, can turn as a part of the solution: the efforts toward the enhancement of farmers resilience led towards the increase in practice of climate smart agriculture.

The concept of Climate Smart Agriculture

Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate (FAO,2019). As presented by FAO at the Hague Conference on Agriculture, CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes;

adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible (FAO,2019) .

The CSA approach starts from considering agricultural practices on the integrated landscape. Such approach follows the principles of ecosystem management and sustainable land and water use. as well as the assessment of repercussions on energy and local resources: on this way it fosters sustainability into its different dimensions (social, economic, and environmental) in the context where it will be applied.

Landscape management and the evaluation of environmental impact are the key elements that puts CSA in the vision of integrated agriculture climate solutions. By an integrated and holistic crop management, which considers carbon footprints and climate interrelationship and landscape protection, the CSA approach helps to foster cropping as possible carbon sinks, rather than carbon sources. Yields indeed are brought to render their ecosystem service potentials not only in terms of carbon sequestration and food security, but also in relation to the co-benefits for the communities that such approach brings.

Even this greater attention to ecosystem management CSA aims to a sustainable increase of agricultural productivity and incomes from crops and livestock while preserving the environment. Such effects will turn in a raise of food nutritional security leading to higher levels of food and nutrition self-sufficiency. A key concept related to raising productivity is sustainable intensification of production that will increase food production from existing farmland while minimizing pressure on the environment. (Sahu et al. 2020).

The CSA to be implemented need stakeholders from local to national and international levels to identify agricultural strategies suitable to their local conditions (Fig.1).

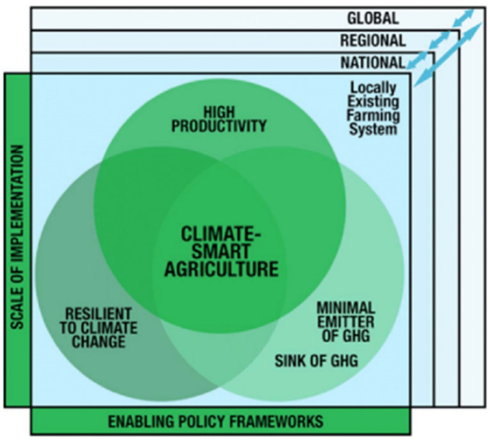

Figure 1. Climate Smart Agriculture at the crossroads of governance levels (Sigh et al., 2011).

Practices, policies and institutions cannot be necessarily innovative, but they have to be thought in the context of climate changes. What is really new is the fact that the multiple challenges faced by agriculture and food systems are addressed simultaneously and holistically (FAO, 2019). The problems of the implementation of climate smart agriculture are that the main information on climate change frequently is unfamiliar or inaccessible to farmers, herders, and fishers. Furthermore, by now the most part of projects of CSA are held by organizations, educational establishments, local NGOs in a fragmented and under-informed scenario.

So, climate smart agriculture can be effectively supported in its implementation by integrated platforms which help farmers to better understand climate change and to adapt to the variability of climate change adverse events. With an integrated approach that creates a nexus between knowledge sharing, remote sensors, renewable energy and biodiversity recover.

Such nexus is crucial to build farmers' resilience in managing climate related disasters such droughts, hailstorms, erratic rainfall, and floods. Furthermore, it helps to implement the adaptive cropping (Maggio and Sitko, 2019) and precision irrigation.

All these factors contribute to realizing a better crop diversity finally bringing to a higher level of food security even in less predictable conditions (Iijima, 2018).

The role of ICT to facilitate CSA implementation

Information and communication technologies have potentially the opportunity to strongly support agricultural and ancillary sectors growth. They represent a great innovative effort that can contribute in timely, accurate, pertinent information services to all categories of farmers. Particularly they can also attract youth farmers.

ICTs can be also very important to implement precision farming and soil health management, and for monitoring pesticides and diseases. Several cases of the use of ICT in agriculture can be found in literature in India and Africa (Panda,2018), and in particular strong interest lies in the Success of mobile based Agricultural Extension.

The advent of android phone/smart phone and its compatibility with different mobile apps has created opportunities for great applications of ICT in agriculture (Panda, 2016). As discussed in the previous paragraph the CSA application strongly depends on Knowledge management.

Referring to Knowledge management (KM) as the process of creating, sharing, using and managing the knowledge and information, ICT can play an elective role in KM, and thus to help farmers and communities to implement the three pillars of CSA.

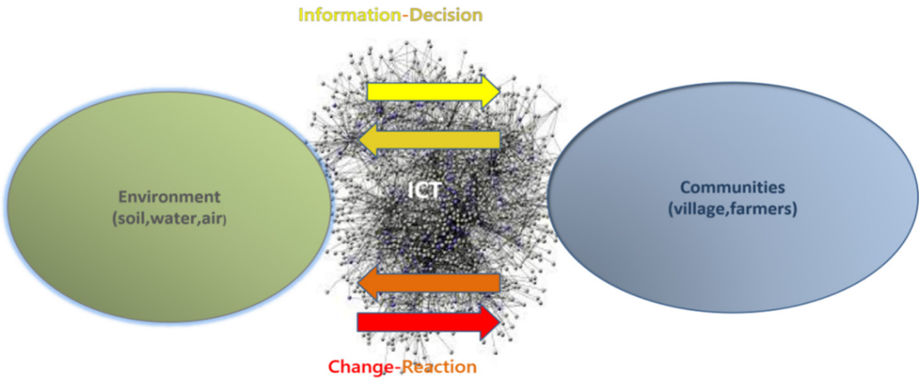

Figure 2. Feedback-loops between "communities", "decision-makers" and "environment" (Vito, 2018).

In a theoretical framework ICT system act upon "feedback-loops" between "communities", and "environment" (Fig. 2) catalyzing participation, empowerment and the perception of local knowledge. Through ICTs the "boundary conditions" of a context are better known due to the strengthening of the information-decision mechanism. Going much deeper, the action-reaction mechanism, considerations about resilience could be also advanced.

The reinforcement of the action-reaction mechanism and the catalyzation of the feedback-loops between environment-communities-decision makers could reflect on faster and better responses of communities to environmental changes like extreme events and climate change. Thus, explained in other words this means an enhancement of resilience.

Even if the extreme interest in ICTs, the major challenge for their real application on CSA, is how to involve farmers and how to address the heterogeneity of the farmers community. CSA application brings a radical change in the cognitive domain of farmers, even if traditional knowledge is integrated. It also implies a spatial change in crop lands, passing by big extensive courts to smaller connected yards (Panda,2016). The use of ICT for CSA can improve the quality of the yard production especially when usual farming calendars cannot cope with the unpredictability of climate change conditions.

By sensors, and data sharing platforms it is possible to provide real time data and perform automated alerts to support crop planning. Furthermore, ICT platforms can give access to information about plant features that could help in better crop choices and selection, standing the environmental conditions that could constantly monitored by sensor nodes (Patil and Kale, 2016). The application of ICT for CSA indeed requires attention also to social socio-economic conditions, facilities availability, social capital etc., of the farmer's community and thus appropriate strategies of facilitation technology ownership are needed.

Network reliability could be an issue for the real effectiveness of these applications, furthermore ICT services should be built upon local access points, taking care about possible digital divides especially for the most vulnerable groups like women and low-income farmers (Aker et al., 2016).

AGROSMART: a platform for climate smart agriculture

AGROSMART is a proposal for an ICT platform in support of Climate Smart Agriculture. It is based on a sensor network that allows to monitor soil, air, and meteorological conditions: through an integrated database, the collected information is made accessible to farmers to follow up climate variability by a simple cell phone.

The stored data also help to pilot a set of solar pumps for a sustainable and variance-compliant irrigation.

The irrigation system is thus in support of an agro-ecological vision of farming, that will help to increase biodiversity and crop richness.

The interaction with the platform is indeed bilateral as the farmers can insert crop management tips, experiential feedbacks and advice based on the local land knowledge. In such a way AGROSMART offers a complete toolkit that uses the information exchange as a paradigm of resilience enhancement.

AGROSMART represents a scalable model for climate smart farming on which technology and natural resource protection co-exist to improve and grant food security at a small farming scale.

Agriculture is at the central point of both SDG 2 and SDG 13 and offers the possibility of acting on climate change on the idea of agriculture as part of the solution.

Particularly, AGROSMART will have 3 main impactful effects on this issue:

- It fosters climate smart agriculture at different level: the open-access structure of AGROSMART allows its services to be used by different groups of farmers, from the biggest to the small holders, offering them the possibility to both find and provide useful information, contributing to provide feedbacks and tips that finally lead to progresses in implementing CSA for the whole users community.
- It improves the cross connectivity of the levels giving the bi-directional interaction that AGROSMART provides to users, farmers of different groups can interact among each other and furthermore they can interact with experts, scientific sources, data providers creating connection and trust in implementing innovative techniques related to CSA.

- It creates the enabling environment for a network of actors to catalyse CSA: implementing connectivity among multiple users and experts it finally turns into a network of practitioners of CSA. Such environment creates the condition to activate more and more users by cross-contamination of new farmers by former farmers that had experienced the platform.

Beside the technological fashion, AGROSMART, wants to create resilience and CSA implementation by coupling an ICT platform with a Community of Practice (Wenger, 2010).
Community of Practices (CoPs) is a concept often used to define informal learning groups (Li et al., 2009), made by volunteers and professionals who share a common interest or concerns to final grow in their practice (Wenger, 2010).
The peculiarities of learning process in (CoPs) are they pass from the possession of knowledge to experience knowing, from holding information to micro-learning by doing, from unwilling subjects to motivated members (Wenger, 2010).
ICT platforms can create the enabling structure for communities of practice, allowing the networking and also adding the possibility to receive data from environmental variables. For these reasons, AGROSMART can represent an innovation toward a community based, and experience learning capillary implementation of CSA. Such features can lead to a more reactive and long-term resilience of farmers, fostered by the support of an ICT platform for adaptive agriculture (Bakare, 2020).

Basic Structure

Figure 3 resumes the basic concept structure of the possible platform for AGROSMART

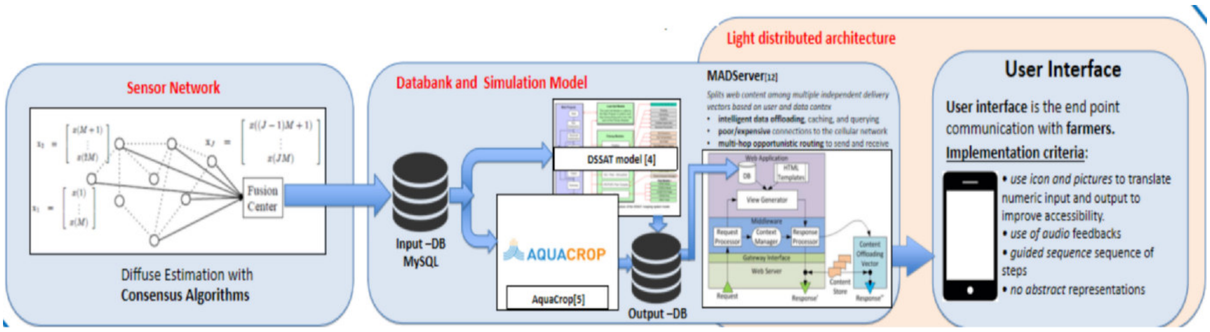

Figure 3. Basic Structure of AGROSMART

At the ground level a network of sensors represents an environmental information source, and the mobile devices are the endpoints. In between a set of predictive models withstand wider decision support systems for farmers taking the inputs from the sensors and the outputs for the mobile devices. Field sensors are important elements in order to furnish data for testing and validation of the simulation models. They can gather different types of data, from the soil to the atmospheric variables in order to feed the predictive algorithms of the model part. At the end point the information is provided to farmers appropriate interfaces, allowing them to remotely exploit data coming from simulation models to perform agricultural strategies that are more adaptive to climate change. Beside the mere exploitation of data, Web 2.0 social media communities (Facebook, Youtube and instagram profile, Website), fosters the connection of different users under AGROSMART framework.

The actual structure of AGROSMART allows it to be the base for CSA Communities of Practice by joining *information* and *competences* with *experiences*, that are the key pillars of the CoPs capacity building implementation (Wenger, 2010).

Co-creative generation

The generation of the basic structure of AGROSMART, happened through a co-creative process among representatives of different stakeholders (university, farmers, professionals, engineers...).

The seed group was made by 10 members, and very heterogeneous in terms of nationality, cultural background, and education. The idea came responding to the collective question to build something about SDG13 related to agriculture (Figure 4). The group composition wanted to match different expertise and needs in order to figure out the best multi stakeholder solution.

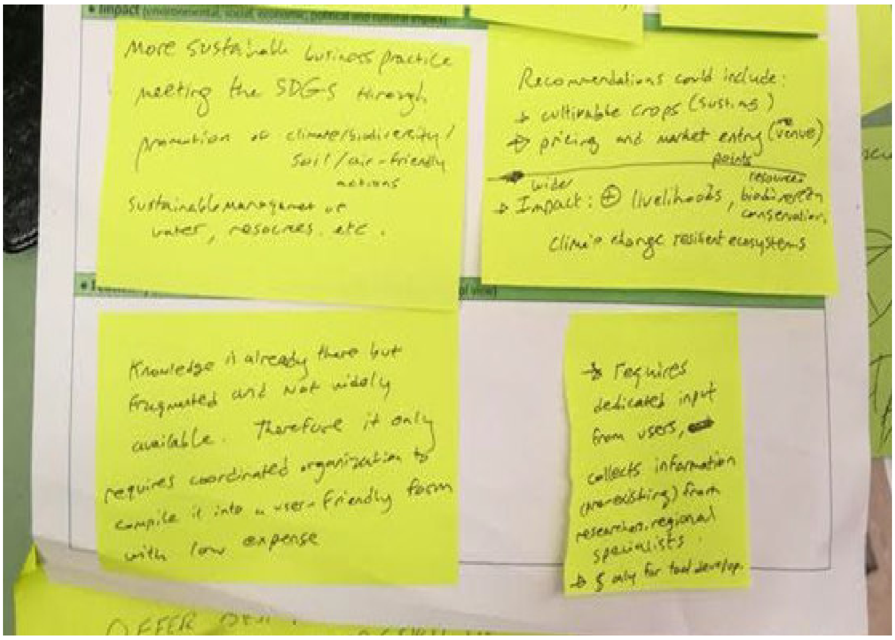

Figure 4. Post-it work on Co-creation with AGROSMART

The development process consisted in essential 3 phases:

A. **Problem identification:** seed group members have been called to define the main problems related to agriculture in unpredictable conditions, envisioning SDG13. Lack of information, availability of data, crop mismanagement resulted as the main identified problems.

B. **Solution Brainstorming:** the group has been asked to come out with a solution for the identified problems that could help to foster SDG 13 on the field. Through facilitation tools and co-creation methodologies like open-space (Maruani and Amit-Cohen,2007), fishbowl and mind-mappings, the group of different stakeholders came out with a first draft of the idea of AGROSMART.

C. **Implementation strategy:** the draft IDEA of AGROSMART has been refined in a third phase. Furthermore, in the implementation phase, after the technological set up, an implementation strategy based on the Community of Practices has been designed.

The collaborative challenges of designing a multi-stakeholder solution have led to the current version of AGROSMART. Co-design methodologies have been used to enhance the collaboration skills among the seed-group members.

The final outcome of the process resulted in a very cross-disciplinary solution, that valorized the synergies among different points of views.

The community-based approach

Beside the technological tool, the creation of Communities of Climate Smart Farmers couples the AGROSMART platform: the introduction to the new technology, the ownership will proceed by collective session on the use of the tool and sharing the information on Climate Smart Agriculture with support of the Community Based Organization (CBO, 2020). In general Community based organizations (CBO) act on the local level in order to enhance life quality of its residents. The principal objective of CBO is to create and empower social equality under several aspects.

The communities can be supported by the platform which allows the exchange of peer-to-peer knowledge on best practice, experiences, case studies and difficulties on the implementation of climate smart solutions, but also can be the place to gather together farmers and transfer them knowledge, skills and capacity on CSA and AGROSMART.

Conclusions

Rural areas are expected to face the major impacts on water availability and supply, food security, infrastructure, and agricultural incomes, due to climate change. The subsequent high variability of climatic conditions reflects in a change in timing of plant growth, causing hard management of production cycles for the farmers.

The impact of this phenomenon is particularly strong in low-income countries, where instruments to develop effective agricultural adaptation strategies could lack. In these scenarios, a possible support comes from ICT technologies. The role of ICT to enhance food security and support rural livelihoods is increasingly recognized and was officially endorsed at the World Summit on the Information Society (WSIS) 2003-2005.

These technologies in association with mathematical models, should provide useful tools to predict high variable environmental conditions, hence allowing a better harvest management. AGROSMART enhances this feedback loop between environment and communities.

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