Vision Paper: Challenges and Opportunities of Social Computing in Urban Agriculture in Global North and South Countries

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Abstract: The size of the world's largest cities is increasing; the urbanization process is complicated and different in developed and developing countries. However, if well managed, urban spaces may offer valuable opportunities for economic and social development. This vision paper investigates the current challenges and opportunities in Urban Agriculture (UA) and discusses if the adoption of Urban Computing (UC) and Information and communications technologies (ICT) can aid urban dwellers, farmers and planners to progress UA in Global North or Global South countries Like Germany and Brazil. We also illustrate our point of view by introducing some applications designed to aid urban and rural users to face the soils security issues.

Keywords: big data, soil security, food security, urban agriculture, urban computing, agroinformatics.

1 Introduction

The urbanization process is complex and entirely different in Global North developed countries and Global South developing countries (Zezza & Tasciotti, 2010; Hamilton et al., 2013; Orsini et al., 2013). The latter present high levels of unemployment, poverty, and food insecurity. The urban poor spend most of their income to feed themselves, and their children suffer levels of malnutrition that are usually smaller than those found in rural areas. Thus, to survive, millions of favela dwellers have resorted to growing their food on marginalized pieces of urban land: in backyards, along rivers, roads, railways, and under power lines (Badami & Ramankutty, 2015).

If well managed, urban spaces may offer valuable opportunities for economic and social development (Clinton et al., 2018). Urban agriculture (UA) is an interdisciplinary research topic which is gaining traction in many cities around the world. The movement is generating the highest amount of excitement and interest in Global North and South countries (d'Amour et al., 2017).

Developing agricultural capacity within or close to urban spaces either in developing and or developed countries such as Brazil and Germany have the potential to reduce social costs and environmental impacts, provide economic opportunities, increase access to healthful food, and better use or urban soils. Regardless of these potential advantages, there are several challenges to establishing the feasibility of urban production as compared to conventional agricultural practices, including space availability, production scalability, reuse of waters, labor costs, demographics (Santo et al., 2016).

UA presents formidable opportunities and challenges in many cities around the world. For instance, in the case of the city of Rio de Janeiro (Brazil), most of the inhabitants cannot take advantage of the natural resources and consume unconventional food plants (UFP) around them. Organic products and non-conventional food plants are still inaccessible from a logistical and financial standpoint for a large part of the population, especially urban favelas residents (Rekow, 2015 and Vieira et al., 2016).

On the other hand, in the last decade, the city of Berlin (Germany) has become a hot spot and the international "capital" of UA. It is very active when it comes to fostering a broad variety urban agriculture and gardening projects within the reunited city. Many of the endeavors are very light on the land, creating vegetable gardens that may be moved to accommodate the changes in urban spaces that characterize a developed city that is rapidly growing (such as Prinzessinnengarten and ROOF WATER-FARM (Steglich, 2017)).

Tackling these challenges seemed almost impossible years ago given the complexity of the cities and the different maturity level of information and communication technology (ICT), internet of thing (IoT) (Ng & Wakenshaw, 2017) and urban computing (UC) (Zheng et al., 2014). Nowadays, urban sensors, mobile technologies, autonomous vehicles, social networks, smart cities applications, and large-scale computing infrastructures have produced massive amounts of unstructured and semi-structured data (big data) in urban spaces of these countries.

This vision paper presents the opportunities and challenges of UA and UC in a transdisciplinary way. Hence, the central thesis of this essay is to present the dimensions of UA and UC and discuss if the adoption of data-centric techniques can aid urban dwellers to expand UA either in Global North or Global South countries and explore new joint-research possibilities. We also invite the readers to learn about the mobile application "Adubação Verde" (Silva, 2018) and OpenSoils[1] framework (Cruz et al., 2018a) which is one the first computational in the literature designed to aid researchers to face the challenges related with soils security considering the use of data provenance in agriculture (Cruz et al., 2018b) and the FAIR principles (Wilkinson et al., 2016).

2 Background

2.1 Dimensions of Urban Computing

The term urban computing (Kindberg et al. 2007; Kostakos & O'Neill 2010), it is still an imprecise concept with many open research questions (Zheng et al., 2014). UC is an interdisciplinary concept fusing the computing science with traditional fields like engineering, architecture, ecology, economy, and sociology in the context of urban spaces.

[1] www.opensoils.org

UC seeks to understand the nature of urban and social phenomena to better plan the future of cities, improve the urban environment, and increase the quality of life of its inhabitants. According to Zheng et al., (2014), UC is situated at the intersection of three dimensions: urban spaces, human resources, and technology (Fig. 1).

Fig. 1 describes the flows of data within the UC dimensions and the knowledge generation. Each dimension generates massive amounts of unstructured data that are consumed by the "technology" dimension. Such dimension is composed of several computational technologies (such as web, computer-supported cooperative work (CSCW), cloud computing, IoT, IA, big data, deep learning, ethics, semantics, human-computer-interaction (HCI), mobile applications) that can compute the data and produce explicit knowledge used at the "human resources" dimension. The human resources dimension is composed of people that may perform different roles (such as urban dwellers, urban farmers, policy-makers, urban planners).

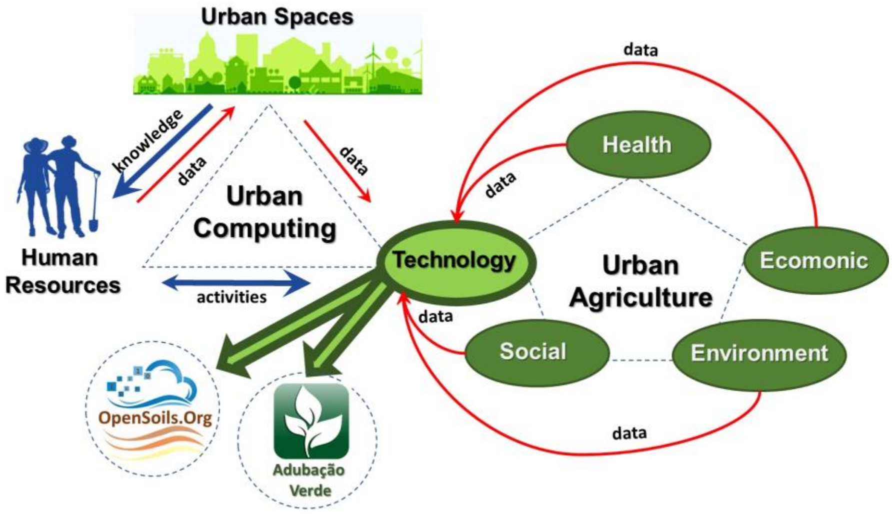

Fig. 1. Overview of the dimensions of the UC and UA, the flows of data, activities, and knowledge (blue and red arrows) and an example of UA/UC applications (*e.g.*, OpenSoils.org and the "Adubação Verde" app).

2.2 Dimensions of urban agriculture

Urban agriculture is the process of growing plants, raising animals and distributing food products, using soil resources and local materials from the urban spaces where the action takes place (FAO, 2018). UA is performed in small areas like backyards, terraces, rooftops, patios, along rivers, roads, and railways, or under power lines with the purpose of subsistence or small-scale sales in local markets. There are, however, more ambitious urban farming initiatives in community lots in gentrified urban spaces in Asia, Europe and North America (Badami & Ramankutty, 2015).

UA offers the potential of producing high-quality food at an affordable cost, have the potential to ameliorate urban environmental problems by increasing vegetation cover and therefore contributing to a decrease the urban heat island intensity and increase the reuse of waters. Mougeot (2000) pointed out that UA is grounded in five dimensions: economy, society, environment, health, and technology related to computational technologies (e.g., UC, ICT, CSCW and big data) (Fig. 1).

As far as we are concerned, on a conceptual level, dimensions produce lots of heterogeneous datasets that can be explored at the shared "technology" dimension, addressing several challenges of UA and UC. We stress that the "technology" is an extensive and evolving dimension because it may encompass several related topics like agronomic techniques (such as aquaponics, aeroponics, vertical farming, water reuse, soil security), social technologies and computational technologies, to name a few. Furthermore, the "technology" dimension operate as a platform upon which knowledge generation and social interaction occur.

The datasets in UA are composed of unstructured and heterogeneous data which is either machine or human generated (Fig. 1). Unstructured data do not have pre-defined models or is not organized in a pre-defined manner, it is typically text but may contain information such as dates, numbers, images, multimedia, and facts as well (Liu & Ozsu, 2009). Here, we summarize the data produced by each UC dimension (Table 1).

Table 1. Dimensions of urban agriculture.

Dimension	Description
Social	Consists of data about the social and urban spaces, such as youth development and education, food security, soil security, sociality integrated aging, gender participation, gentrification of depressed urban areas. When used aggregately with demographic data, these data sets can aid the visualization and mapping of city assets or understand urban anomalies.
Environment	Consists of meteorological data (humidity, temperature, pressure, wind speed, and weather conditions); air quality data (concentration of CO_2 NO_2, and SO_2); ecological data (awareness of food system ecology, stewardship, storm and waste waters management, soil improvement); soil data (profiles and boreholes). When used aggregately with sensors and satellite data, these data sets be used to identify a city's issues (such as polluted and drought/flooding areas, heat islands)
Economic	Consists of economic data representing a city's economic dynamics. For example, local economic stimulation, job growth, land use, job readiness, food affordability, carbon emissions, stock prices, transportation bottlenecks, housing prices, and people's incomes. When used aggregately, these data sets can capture the economic rhythm of a city, therefore predicting the future of the economy.
Health & Educational	There are already abundant educational and health care and disease data generated by schools, hospitals, and clinics. When used aggregately, these data sets can show the impact of education and food/soil quality change on people's health.

2.3 Soils Security

Soils security is an emerging concept of soil sciences that is related with the dimensions of UA and UC. It is motivated by sustainable development and tightly connected to the maintenance and improvement of the global soil resource to produce food, fibers and fresh water, human health, contribute to energy and climate sustainability, and to maintain the biodiversity and the overall protection of the ecosystem (Koch et al., 2013). Soils security has several dimensions (e.g., capability, condition, capital, connectivity, and codification) which are quite close to the environmental, social, and economic dimensions of UA. Soils security is a data-intensive research domain which life-cycle starts at the harvest of new soils data in the field and finish at scientist's visualization workstation or decision maker´s desk.

3 Challenges and Opportunities

Considering the merits of UA, urban farms are popping up across the mentioned countries. However, the benefits and limitations that urban planners, dwellers, and growers face must be fully understood and addressed if urban farms are to become widespread, profitable and even sustainable. Tables 2 indicates the main opportunities and challenges associated with the dimensions discussed in Section 2.

Table 2. List of challenges and opportunities associated with the dimensions of UA and UC.

Social	
Opportunities	**Challenges**
• Increase social interaction, strengthening social ties and facilitating new social connections and intergenerational relationships; • New meeting places for community members to cooperate, particularly important in cities where open green spaces are rare;	• Instigate different organizational structures and decision makers to support and the development of urban farming's; • Support initiatives led by lower-income communities, they usually experience disparities in access to land, political support, and government funding compared to UA efforts led and middle-class groups;
Environment	
Opportunities	**Challenges**
• Increase the biodiversity of the neighborhood. Urban food production also means that healthy, fresh produce is readily available to urban dwellers; • Micro-climate regulation (e.g., reduction in the urban heat island) through transpiration processes and reduction of emissions of greenhouse gas associated with food transportation; • Measure carbon sequestration by crops and vegetation through filtration of particulates by plants; Increase the recycling of organic wastes and urban soils.	• Soil management and fertilizer use practices by UA growers may not be ecologically sound; • Find reliable and safe water sources can be tricky. Technologies such as irrigation deliver water where and when it is desired can help conserve it. • Reusing wastewater and rainwater may provide additional water, but those sources must be monitored for contaminants, and perhaps treated.
Economic	
Opportunities	**Challenges**
• Increase employment and household, particularly for low-income and socially excluded populations;	• UA projects may offer job opportunities that require additional knowledge be-

• Increased property values surrounding urban gardens, particularly in gentrified neighborhoods; • Entrepreneurial UA may attract venture capital and make profitable business opportunities, particularly in repurposed urban spaces.	yond technical farming skills, which may need more staff or higher labor costs; • UA projects may require financial and political support; several projects cannot survive on profits from produce, mainly if incorporating other social missions.
Health & Education	
Opportunities	**Challenges**
• Engage, activate and train youth and educators in schools; youth can play an essential role in increasing knowledge and understanding about healthy eating and gaining access to fresh food; • Learn about the provenance of food, agricultural processes, nutrition, and sustainability;	• Develop UA projects which provide comprehensive education beyond technical farming skills require additional expertise, which may require more staff, time and elevated labor costs; • UA projects may not be supplying enough food to communities in which they are located;

3.1 Examples of UC/UA applications in Global South Countries

OpenSoils is an example of application described by the common "technology" dimension shared by UC/AC. OpenSoils is an open, elastic, provenance-oriented and lightweight computational e-infrastructure that collects, stores, describes, curates, harmonizes soil data resources and delivers knowledge to the users. It adopts the official Brazilian soils classification and stores large datasets of soils profiles/boreholes; generate soils reports; offer data and web services and curated documents and open data sets. OpenSoils is the first open science-based computational framework of soils security in the literature. According to Cruz et al. (2018b). Today, OpenSoils has three primary uses:

(i) Offer diverse, integrated, timely and trustworthy digital repositories with georeferenced data to researchers, farmers and decision makers (*e.g.,* statistical studies of the quality of soils, soils mapping, soils usage recommendation, evaluation of contamination by heavy metals and organic waste management system).

(ii) Offer free computational tools to aid city planners, agronomists, rural/urban farmers to make better decisions using high-quality harmonized data (*e.g.,* studies to erosion, risk of landslides, risk of flooding, potential for agricultural use of soils; environmental and economic and ecological zoning, insurance of agronomic enterprises, land classification for irrigation; support in the recommendation of fertilizers and limestone).

(iii) Help citizens (*e.g.,* students, professors or researchers) to increase their knowledge about Brazilian soils, the infrastructure can connect to other sites like the Brazilian Soils Museum, where users can explore the collection of soil monoliths, soil artifacts, soils images, soils maps and browse the large datasets of curated soils data.

“Aducação Verde” 2 is another example of the use of “technology” dimension shared by UC/AC. It is a mobile application designed to increase the use of green manure (adubação verde in Portuguese) among the Brazilian (urban or rural) small farmers. It offer easy to use information to field agronomist and mainly disseminate the usage of ecological management practices that can be employed in organic agriculture, such as the use of mulch and organic fertilizers, to increase the yield of crops without impacting production costs.

Green manure (Espíndola et al., 1998) favor agricultural activities, which are characterized by the minimal use of external inputs and a limited amount of mineral fertilizers, on small properties. The application was developed by a multidisciplinary team composed of agronomists and system developers. One part of the team conducted the field experiments in Seropédica, RJ, Brazil (22º 46’ S and 43º 41’ W), from January to December 2017, the experiments were conducted using a split-split-plot scheme (5m x 3m x 2m), with four replicates with 25 species of the Leguminosae, one of the botanic families most used in green manure. The other part of the team used the botanical data collected from these experiments used in the development of the mobile application and deliver to small farmers.

4 Concluding Remarks

In this work, we presented the dimensions of UA and UC and showed how they could be connected. Besides, we listed the challenges and opportunities of UA projects in the Global North and South Countries and finally illustrated how these challenges can be faced with the use of low-cost devices and applications (*e.g.,* OpenSoils and “Adubação Verde”). The projects we have reported in the previous sections have the potential to aid several rural and urban communities. However, we stress that few projects are being conducted in the area. Besides, we advocate the need to embrace the emerging UC and ICT trends, such as the rise of social networking applications, big data, data science and the increasing ubiquity of mobile technology and real-time sensor networks to name a few, to deliver more products to urban dwellers.

This vision paper was written in the hope that sharing the underlying thinking and expectations as well as hopes and aspirations of a group of interdisciplinary researchers will enable a new level of constructive study that contributes to pushing the UA and soils security agenda forward.

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[2] The app is available at https://play.google.com/store/apps/details?id=siufrrj.adubacaoverde

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