Proceedings

Urban Agriculture: A Growing Field Of Research

Workshop at INTERACT 2013 – 14th IFIP TC13 Conference on Human-Computer Interaction, Cape Town, South Africa, September 2013

Edited by

Peter Lyle, Jaz Hee-jeong Choi, Shaun Lawson, Christopher Lueg, Alan Chamberlain,

Marcus Foth, Anna Meroni and Margot Brereton

Proceedings

Urban Agriculture: A Growing Field Of Research

Workshop at INTERACT 2013 – 14th IFIP TC13 Conference on Human-Computer Interaction

Edited by:

Peter Lyle, Queensland University of Technology

Jaz Hee-jeong Choi, Queensland University of Technology

Shaun Lawson, Lincoln University

Christopher Lueg, University of Tasmania

Alan Chamberlain, Nottingham University

Marcus Foth, Queensland University of Technology

Anna Meroni, Politecnico di Milano

Margot Brereton, Queensland University of Technology

A Volume in the Workshop Proceedings Series
of the INTERACT 2013 Conference

This publication is a Volume in the Workshop Proceedings Series of the INTERACT 2013 Conference.

Publication Data
ISBN: 978-0-620-58534-7
Editors: Peter Lyle, Jaz Hee-jeong Choi, Shaun Lawson, Christopher Lueg, Alan Chamberlain,
Marcus Foth, Anna Meroni and Margot Brereton
Publisher: INTERACT 2013
Place of Publication: Cape Town, South Africa
Date of Publication: November 2013

TABLE OF CONTENTS

#OSWARRAP: Open Systems Strategies linking FOSS & Open Knowledge to strengthen agriculture in Warrap State, South Sudan

Stephen Kovats, Eva Yayi, Eugenio Tisselli

r0g_agency for open culture and critical transformation gGmbH, Berlin
Community Empowerment for Progress Organisation / CEPO-SS Juba, South Sudan

Abstract. In many parts of the world new civil societies emerging from shattering conflict and revolution are facing the challenge to (re)construct nothing less than entirely new nations. Urgent calls to define political participation, state identity, economic self-determination, basic freedoms and reconciliation among resolute opponents have transformed seemingly local conflicts into issues of global concern. South Sudan, having gained independence from Sudan on July 9, 2011 must now tackle these herculean issues of post-conflict development and create a stable and viable democratic state. Agriculture and an extractives industry primarily based on crude oil reserves, form the nascent state's two pillars of economic and political raison d'être. Considering this scenario in the age of social networks, collaborative enterprise and open technologies the #OSJUBA - Open Sourcing South Sudan Initiative[1] is being developed to apply the methodologies of the world's diverse open source and open knowledge communities in creating rapid and innovative new forms of development in regions of lingering conflict and post-war society.

Keywords: Open Source, Post-Conflict Transformation, Agriculture, Open Knowledge, Open Systems, Open Data, South Sudan, ojoVoz, ICT4D, Community, Collaborative Systems, Innovation, Sustainability, Empowerment

1 Applying Open ICTs for Sustainable Agriculture in Post-conflict South Sudan

As a first step towards a comprehensive 'Open Systems Strategy' within the #OSJUBA - Open Sourcing South Sudan Initiative, the country's largest federal state Warrap has embarked on #OSWARRAP (Open Systems for Warrap State), as a model or pilot initiative to empower citizens, and strengthen peace and security through open source technologies and methodologies, open data and open government principles.

1 http://r0g-media.org/initiatives-2/

The Warrap leadership, faced with the challenge of "leading over one million young pastoralists from past conflict into the 21st century [2] is intent to strengthen open governance and create peace and prosperity to the advantage of all its citizens. The use of ICTs and open data are intended to act as implementation triggers for the open systems projects being developed in and for Warrap State in order to see and effectively create viable examples of what can be done on the ground in one of the most challenging post-conflict and nascent civil society contexts. In the spirit of multi-stakeholder collaboration, the #OSWARRAP initiative aims to bring together governmental and civil society organizations as well as Warrap citizens including farming and pastoralist communities, engaging them in a dialogue about the ways in which open systems solutions and their implementation can help in mitigating the state's identified key challenge areas which include[3]:

- conflict resolution, peace and security, in particular with regard to the deep-rooted post-war conflicts related to cattle rustling
- creating participatory, accountable, open governance
- empowerment of marginalized peoples, especially youth and women, as well as the social reintegration of former combatants
- rapid implementation of systems to enable education, communication and economic development
- sustainable, transparent and cost effective management of land and key natural resources (incl. water, forest, extractives)
- innovation in linking traditional with contemporary skills and knowledge

In the development of the #OSWARRAP initiative, South Sudanese agencies and ICT organisations are examining various social media, mobile technology and Community Informatics (CI) tools as key elements their open systems strategy. Given its ease of use, mobility and primarily non-text base interface, they will introduce ojoVoz[4] a rapid implementation FOSS platform consisting of mobile and web-side applications that help communities make their voices heard.

1.1 The ojoVoz FOSS platform: Knowledge base and citizen empowerment tool

As a practical example of what can be achieved when farmers and citizens in general are able to apply open media to directly address the issues that affect them, ojoVoz, an open source platform which consists of mobile and web-side applications aimed specifically at lowering the barriers of complexity and access to technology for non-

2 Warrap Governor H.E. Nyandeng Malek Dielic, speaking at the session on 'Open Solutions for Addressing Global Challenges', UNESCO WSIS+10 Review Conference, Paris, February 27, 2013 https://www.unesco-ci.org/cmscore/events/

3 key challenges as identified by Warrap Governor H.E. Nyandeng Malek Dielic in a preliminary memorandum for a Warrap State Open Systems Strategy, Berlin, March 2013

4 ojoVoz open source app developed by Eugenio Tisselli for Android 2.2+ (http://sautiyawakulima.net/ojovoz/)

expert users, is being introduced. The ojoVoz platform encourages face-to-face meetings using shared low-cost and readily hardware, and doing this in areas with low telecommunications coverage and limited infrastructure. ojoVoz has been successfully applied in projects such as 'Sauti ya wakulima' ('The voice of the farmers') in Tanzania[5], where a group of small-scale farmers used smartphones to document their observations of the effects of climate change, and communicate them to extension officers, local authorities and scientific researchers.

In Warrap State the preliminary focus area for the implementation of a community communication and knowledge base platform such as ojoVoz will be to identify, define as well as introduce the key agricultural challenges faced by civil society, i.e. cattle rustling and its related social, political and economic contexts[6]. ojoVoz could help communities create their own 'sharable memory' resources with which to build new narratives to address the challenges associated with the post-conflict transformation, moving a young population from armed conflict to peaceful economic development, as well as enabling new forms of communication with officials to improve government responsiveness with its citizens.

As such the ojoVoz Android mobile app allows non-expert users to easily take pictures, record sounds and upload them to a web server, along with descriptive keywords and geographical metadata. Correspondingly, the web-side application receives and organizes these multimedia messages, allowing users to browse them by following different criteria: time, keyword or geographical location. These messages and data can be created in any language, or by using icons and other non-text elements. By collaboratively documenting, discussing and sharing their common issues, small groups of people with specific interests can also use ojoVoz to strengthen their voice and create awareness. Every effort has been made to design ojoVoz so that its user interface can be quickly adopted by non-expert users. This is precisely what makes ojoVoz different from other similar platforms, and collaborative mapping tools which rely on greater ICT literacy and experience. In field trials, non-expert users were able to take up ojoVoz in a matter of minutes[7]. The philosophy of ojoVoz is that tools should make documentation tasks as simple as possible, so that complexity won't become a barrier for entry-level users. Moreover, ojoVoz has an offline feature, which is especially important when working in areas with low or no cellphone coverage. All the contents captured while offline can be uploaded later, when the phone enters a connected area.

---

5 http://sautiyawakulima.net/bagamoyo/about.php

6 i.e. Annette Weber "Transformation Backlog in South Sudan: Security Sector Reforms Stall in the Face of Growing Autocracy" (SWP, August 2013) http://www.swp-berlin.org/en/publications/swp-comments-en/swp-aktuelle-details/article/south_sudan_transformation_backlog.html

7 "Sauti ya wakulima: listening to the voices of the farmers in Tanzania." Research paper (2012) by Tisselli, Eugenio; Schläpfer-Miller, Juanita; Hilbeck, Angelika, Institute of Integrative Biology, CHN Universitätstrasse 16, 8092 Zurich

1.1 Preliminary methodology for creating an ojoVoz project for #OSWARRAP includes

- For each implementation identifying a specific challenge faced by the citizens of Warrap State:
  - - What is the nature or root cause of the problem?
  - - Who are the actors involved?
  - - What are its social, political and environmental implications?
  - - What are the potential dangers when dealing with this problem?
- Inviting a group of citizens to participate in a collaborative documentation of the problem:
  - - Explain the project and its possible implications.
  - - Provide adequate training in the usage of smartphones and web interface.
  - - Secure organizational logistics (ie. meeting space, access to hardware, internet connection)
  - - Identify, train and actively support a local coordinator
- Providing continuous monitoring and technical support
- Actively participating in the project discussions, reshaping the platform according to participants' feedback.
- Disseminating the project thoroughly (local and country-wide authorities and organizations, local and international press and broadcast media, social media)

1.2 Key Take-Aways

- The usage of FOSS ICT platforms in agriculture can be a crucial factor for strengthening farmers' empowerment.
- Open Knowledge and education through ICTs may help to address the challenges faced by government and citizens of Warrap State, South Sudan.
- Connecting traditional knowledge with Open ICTs to create new, sustainable and hybrid paths of cultural, economic and societal development

The government of Warrap State, headed by its Governor H.E. Nyandeng Malek Dielic, is interested in taking more initiative to help develop open ICTs to strengthen and support grassroots communities as well as rural pastoralists who make up a significant potion of the population.[8] It has been clearly identified that any future development of a vibrant, stable and prosperous civil society means that these people, who have been marginalised through war, corruption and harsh effects of misguided colonial development, are now essential in becoming part of the policy development process. The task of bringing diverse groups and organizations together, especially people from various backgrounds and ways of life - and who may have been, or still are, engaged either in the lingering conflict of the past decades, or through new

8 https://soundcloud.com/sourcefabric/governor-nyandeng-warrap-state

conflicts that have arisen through new pressures on agricultural, livestock and land development and transformation, is a major challenge in itself.

Where interaction with the government sometimes means asking for weapons to either protect your assets or attack your enemy (real or perceived) defining the role of government as a partner of its citizens must be achieved. The means to discuss ideas related to human rights, agriculture and social development are therefore aimed at these diverse groups and communities by using the prevalence of ICTs and social media in close collaboration with the creation of films and short video documentaries in the form of narrative public service announcements that can be accessed via a number of media, including radio. These are meant to augment the participative methodologies that dialogue and mapping platforms such as ojoVoz can create. Even using some of the visual and mediated language that prevailed as part of the propaganda campaigns from the 'days of struggle' before the Comprehensive Peace Agreement of 2005 and turning these into compelling, contemporary and progressive messages on the challenges faced by the country, the need to gain new skills and the engagement in collaborative practices can be employed as effective means of message creation.

Organisations such as the Juba based Kapital Movie[9] collaborative, a community based, non profit network of visionary young designers, documentarists and IT professionals who are interested in sharing and nurturing a vibrant civil society through the power of open media play a crucial role in the development of such hybrid Community Informatics (CI) structures[10]. As a group committed to empowering the communities they live and work in, Kapital Movie focuses it messages on health, peaceful methods of association and active conflict mitigation - in which agriculture, land grabs and cattle rustling pose major South Sudan post-independence challenges - through the power of films and short public message clips.

Together with development outreach organisations such as the Community Empowerment and Progress Organisation (CEPO) Kapital movie aims to share the skills of 'mediated message creation' through sound, image and video such that affected citizens are engaged directly in the production of expression and opinion which can be made available through publicly accessible online knowledge bases. Such 'open' knowledge bases can be understood and used as experiential basis material as 'community reconciliation' centers where the accumulated content responds to the many of parts of South Sudan that still engage in rudimentary and negative tribal activities such as inter-communal and criminal conflict that are exacerbated by the economic, social and political pressures that underpin the cattle raiding issue.

The establishment of resources such as a 'community reconciliation knowledge base' ideally would be networked with South Sudan's rural regions where information is collected. Resources, using mobile, open and energy self sufficient ICTs could be

9 Kapital Movie Industry Corporation, initiated by South Sudanese medical student and film maker Lagu Stephen Samuel, http://kapitalmovie.net/

10 http://en.wikipedia.org/wiki/Community_informatics, see also (Michael) "Gurstein's Community Informatics" http://gurstein.wordpress.com/

made accessible in order that the citizens, and their communities actively become the producers of the knowledge and experience illustrate, develop and offer solutions to solve some of these complex social, cultural and economic problems. In a recent and preliminary background research excursion to Warrap State, hosted and facilitated by the Warrap Government, and carried out by CEPO and Kapital Movie members, the desire for feedback by the government to the concerns raised by the citizens of Warrap was paramount. The direct collaboration of the government in the process of interviewing, recording and meeting directly with citizens in itself acted as catalyst to the task of knowledge and information collection. It also served as trust building measures in areas where information could also be considered a weapon or strategic device that may be used against citizens.

Taken as a broad methodology to help rural communities, especially those engaged directly in agricultural tasks platforms such as ojoVoz can thus be effective in helping to galvanize people's voice, bring them together, and initiate discussions because they are in fact able to control the process and see its outcomes - regardless of technical ability or level of literacy. As such the people's means of collaboration - even across seemingly antagonistic agricultural communities who are the backbone of Warrap's population and future - can become a process of governance and thus government itself.

Participatory Technology Design for Urban Agriculture in South Africa

Angus Donald Campbell

University of Johannesburg, Senior Lecturer Industrial Design, Johannesburg, South Africa

acampbell@uj.ac.za

Abstract. As the population of South African cities rapidly increases, evidence of food insecurity of urban populations is also on the increase. Urban agriculture provides an opportunity to improve urban food security whilst reducing poverty, inequality and unemployment. This position paper identifies three problem areas in the current urban agricultural system in Johannesburg. It proposes methods, whilst exploring examples, that can better encourage participation, increasing skills and knowledge, and improve networking through considered design intervention between stakeholders in Johannesburg's food system through the use of appropriate technology.

Keywords: Urban Agriculture, Community Participation, Appropriate Technology, Participatory Technology Development, Industrial Design, South Africa

1 1 Introduction

The mass monoculture production and distribution of food, spurred on by the green revolution, has created a food system far removed from citizen 'average'. Highly processed foods blur the source of much of their content and the notion of seasonal or local food has almost become redundant [1]. This obfuscation of the food system has brought with it environmental degradation, introduced toxins into the food system and due to the commodification of food, affects international food prices and hence consumers pockets at the hint of a large drought. This highly technological, complex and hidden food system ultimately affects the poor and the marginalised most.

The latest South African census data indicates both an increase in South African urban population and levels of unemployment [2]. Both these indicators can have a detrimental impact on food security; namely the availability of and the ability to purchase healthy, culturally appropriate food [3]. There have been three national surveys of food security in South Africa undertaken between 1999 and 2008 [4], a comparison of these studies reveals a decrease in the level of food insecurity, however the statistics are still harrowing: almost 25% of South Africans are food insecure and the majority of children do not receive sufficient nutrient requirements [4].

There is a perception that food security is a rural problem based on the availability of food, hence by producing a sufficient quantity of food the problem should be eliminated [5]. This 'grow more' approach, as explained by The African Food Security Urban Network (AFSUN), does not aid the plight of the urban poor and highlights the complexity of finding solutions beyond "rural development" and "green revolutions" [5]. Leonie Joubert's recent publication The Hungry Season [6] together with a multitude of articles in the press [7] [8] [9] [10] are popularising the problems that South African cities and their citizens face with access to readily available, nutritious, culturally appropriate food. Statistics indicated that in the deprived wards of Johannesburg, up to 60% of households are mildly to severely food insecure [11], add to this the prediction that by 2050 60% of Africa's population will be urbanised [12] and the importance of a suitable and sustainable food supply in urban areas becomes clear.

The Food and Agricultural Organisation (FAO) of the United Nations promotes urban agriculture as being highly relevant to alleviating food insecurity in cities [13]. At the level of both the South African government [14] and city municipalities [15] [16] [17], policy and projects are in place to attempt to improve food security through urban agricultural initiatives even in the face of the reduction of available land for housing. Urban agriculture has been the focus of a few South African studies [18] [19] and research institutions11: evidence shows a direct link between access to healthier food and opportunities for additional income through urban agriculture. With almost 20% of South Africans using agriculture to supplement household food supplies [5], urban agriculture provides an opportunity in cities to impact on the three core problems in South African society: poverty, inequality and unemployment. There are however cultural, political and organisational issues that need attention in order for urban agriculture to improve food resilience in South African cities. This position paper will unpack some of these problems evidenced through my involvement in research projects in the Johannesburg region. I propose that better opportunities for participatory engagement between all the stakeholders in city food systems needs considered design intervention specifically with a focus on appropriate technology. Technology designed with and for local farmers provides a viable avenue to increase food production; and by encouraging local food production, using local skills, a much more resilient local food system can be designed [20].

2 Issues Facing Urban Agriculture in South Africa

One of the organisational issues facing urban agriculture in South Africa is the fact that it does not sit comfortably in any one government department: part Social Development; part Health; part Agriculture, Forestry and Fisheries (AFF); it also has

[11] Most notably: Siyakhana, www.siyakhana.org ; African Food Security Urban Network (AFSUN) www.afsun.org ; Food & Trees for Africa, www.trees.co.za ; Abalimi Bezekhaya, www.abalimi.org ; South African Food Lab, www.southernafricafoodlab.org ; Oranjezicht City Farm, www.ozcf.co.za ; Organic Farms Group, www.organicfarmsgroup.com

impact on Water Affairs; Human Settlements; Labour; Rural Development and Land Reform; Higher Education and Training; and Economic Development. In Johannesburg the Department of Health and Social Development manage projects with a focus on nutrition [21] [22] [16]; the Department of Economic Development has a project focused on organic farming [23]; and the Mayoral Committee on Food Resilience, as part of the City of Johannesburg, sitting under the project banner A City Where None Go Hungry [15], is now attempting to manage a range of co-operatives that to varying degrees are located in City Parks, the Department of Health and Social Development and AFF. This all leads to a fragmentation of focus and serious confusion for urban farmers on the ground trying to negotiate the quagmire of departmental authority.

In my work with grassroots urban farming organisations Rainbow Nation Farmers [24]; Noodgesig Farmers; Balimi Food Security Company [25]; Siyazenzela Phiri Organic and Natural Food Market [26]; and the Soweto Farmers Forum, one of the biggest difficulties for these organisations is finding community members willing to work on their farms. If money is not directly offered for services, and their reward is based on the successful outcomes of a seasonal crop, compensation seems too far removed and unpredictable for the majority of workers. Issues of ownership in terms of land tenure and inputs are also a problem for commitment; this becomes particularly difficult when farming takes place on government land without a lease (Noodgesig Farmers) or on land owned by schools and hence not zoned for agriculture (Siyanzenzela). Additionally there seems to be a social stigma attached to farming, this stigma may stem from childhood "gardening punishment" handed out by school teachers to try maintain discipline in classrooms; and/or the consideration of gardening as a "desperate" means to access food as a last resort; and/or the governments previous disregard for subsistence agriculture as relevant to economic participation[12]. Add to this the theft of electricity circuit breakers by the *Izinyoka-Nyoka* or illegal electricity connectors, leaving the farmers without pumps for borehole water, and the theft of fences by opportunistic recyclers, leaving their produce unprotected from hungry passers-by; the unpredictability of rewards for effort becomes all the more clear.

In addition to the issues listed above, urban farming is especially difficult with limited farming skills. Umezuruke Opara, the chair of research into post-harvest technologies at Stellenbosch University says that, "often these [small-scale] farmers lack access to the latest scientific knowledge about how to increase crop yield with existing resources, when to harvest to achieve good post-harvest quality, how to package and store their produce to extend storage life, and meeting market standards and consumer demand." [27]. Access to market for producers who are succeeding to produce is also a problem. The seasonality and unpredictability of crop production makes meeting sales agreements difficult, not to mention issues with maintaining quality control.

[12] The 2013 South African National Development Plan does however now very clearly support smallholder agriculture, as does the Johannesburg Mayoral Project A City Where None Go Hungry.

From the issues listed above, three problem areas can be clearly identified, namely encouraging participation, increasing skills and knowledge, and improving networking. I propose all three of these can be targeted through the use of appropriate participatory technology.

3 Participatory Technology

Surmounting the stigma of farming in urban areas is something that can only be addressed through a process of collaborative effort and slow change with tangible evidence of success. The power of participation in farming in Africa is not new; Paul Harrison's dated but seminal book The Greening of Africa discusses how the traditional African village facilitated participation prior to colonization [28]. In the complex environment of contemporary city centres such as a melting pot like Johannesburg, communities are a complex mix of migrants, ethnicities, tribes, and political leanings, and the concept of a "traditional" African village far removed from reality. Individuals are far more self-serving and distrusting than in familial clans, but even in such an emulsion, the power of grassroots communal action to increase political voice and participation in civil society should not be underestimated. Many case studies of successful communal farming action are documented under various participatory ground roots initiatives such as Farmer First [29], Participatory Technology Development [30], Participatory Research and Peoples Science [31]. The most powerful testimony to this is Roland Bunch's exploration of People-centred Agricultural Improvement [32]. Bunch is highly critical of paternalism created by give-aways highlighting the basic human nature that no-one really cares for anything they don't have an invested interest in. He proposes that enthusiasm is the driving force behind any developmental project and that the source of enthusiasm is through early recognisable success. The chances of success in an agricultural endeavour can be greatly increased through the use of suitable technologies and by increasing productivity; the viability of such a pursuit can visibly encourage participation and long-term sustainability.

Technology development for agricultural growth has often been seen as the transfer of technology and knowledge from either developed countries, institutions and practitioners to developing countries, institutions and practitioners. However, by simply transferring technology, little empowerment takes place for the recipients, and this creates a system of innovation that serves the current food system and the powers that control it. It also invokes a spectre of dependency, and this could cement developing country farmers as dependant on others who supposedly know 'better' what their development challenges are. For farmers and consumers in poor areas and newly emerging farmers, such as in the urban context, such technology is often inappropriate and does not help achieving outcomes that benefit both people and the environment. Participatory Technology Development [33] is aimed to build the capacity of farmers to conduct their own experiments, develop their own technology and make informed decisions on, demands of, and interventions into, the food system in order to realise their own interests. This does not take place in a vacuum and it is

important to acknowledge the social infrastructure necessary for innovation to take place. A designed social infrastructure can contribute to technology and other innovation by placing multiple stakeholders alongside each other in dialogue that would be able to make effective changes to the system. A multi-stakeholder intervention could innovate by the strategic incorporation of diverse stakeholders in the food system, from state agencies right down to communities themselves, and through such an intervention implement changes.

The Mayoral Committee on Food Resilience is valiantly attempting to organise urban agriculture in Johannesburg in a designed, top-down manner. Nabeel Hamdi describes the complexity of such an undertaking in terms of the unequal powers, unsymmetrical balance, weak links and fragmentation of the relationships between the state, the market and the community [34]. He goes on to expand this complexity into the relationship on a local, national and global level. This complexity withstanding, multi-stakeholder coalitions have also been shown to be very effective in helping to bring about change in agricultural and food systems [35] [36]. The TransForum project, undertaken in the Netherlands from 2004-2010, successfully used a Connected Value Development approach aimed at transforming perceived trade-offs into complements, by connecting the values held by the different stakeholders [35]. This approach is currently being implemented as part of a globally linked project that will share knowledge, innovations and expertise called the MetroAg Innoversity [37]. I am one of the Johannesburg representatives in this project, and although at the beginning stages of such an undertaking, we are already making significant steps to link farmers, knowledge based institutions, civil society groups and the government in Johannesburg.

Designers are well suited through their training in problem solving to be able to explore the global perspective of the various networks and stakeholders involved in food systems and providing designed opportunities for collaboration and path crossing. Such a systems design approach to collaboration can be enhanced through participatory approaches; many of these methods can be classified under the umbrella of social impact design [38]. Appropriate users, in this case urban farmers, undertake problem identification and problem solving while the role of the scientist/researcher/designer is more of a consultant to collaborate with, rather than to direct [31]. The design of the Seboko hail tunnel for the Rainbow Nation farmers by Kyle Brand as part of his Industrial Design Honours mini-dissertation at the University of Johannesburg is an example of the result of such a process [24]. Through a process of user group interviews, hail was identified as a major issue for the farmers due to the impact it had on their crop success. Brand was able to co-design a low-cost covering system with the farmers that allowed for local production, assembly and resulted in a product sufficiently flexible for their needs. The cover used invasive plant shoots (Black Wattle) as its major structural component whilst incorporating laser-cut joining mechanisms as the connectors. Standard hail protection covering was then attached to the armature through a mechanism integrated in the laser cut connector plates. The solution answered the farmers' needs with a low-cost product whilst maintaining a balance between high and low-tech componentry for manufacture and job creation.

From the other end of the technological scale, and notably with 650 million mobile

phone subscribers in Africa, Information Communication Technologies (ICT) are also facilitating change in African agriculture through the use of mobile apps [39]. *SokoniSMS64* uses sms's to provide farmers with market prices before the farmers travel long distances to market; *Kilimo Salama* ("safe agriculture" in Swahili) in Kenya provides "pay as you plant" micro-insurance to farmers; *iCow* from M-Farm helps farmers keep track of each of their cows through an online calendar; *Tigo Kilimo* in Tanzania gives farmers instant weather information and provide farmers with appropriate farming tips; and *CocoaLink* in Ghana provides farmers with information on farm safety, child labour, health, crop disease prevention, crop marketing and improvements in farming practices [39]. From another developing context, in India, a mobile app called *Nano Ganesh* "seeks to transform the way farmers manage their water systems by giving them the freedom to turn pumps on and off, from any location, with their mobile phone" [40]. These technologies developed on the back of the ubiquity of mobile phones in Africa and India, in some cases provide farm management tools for farmers, but in many cases enable knowledge transfer between 'experts' and farmers. These knowledge transferal applications would become all the more powerful through the integration of bottom-up knowledge transfer through wiki type applications. Paul Richards in his book *Indigenous Agricultural Revolution* was quick to note that many of the most successful innovations in crop production in Africa had local roots, highlighting that "there should be less of an emphasis on 'teaching' farmers how to farm and supplying 'improved' inputs, and more emphasis on how to foster and support local adaptation and inventiveness." [31].

4 Conclusion

The University of Johannesburg's involvement in the MetroAg Innoversity has prompted us to undertake semester-based design lab projects in collaboration with the Departments of Industrial Design, Anthropology and Development Studies and the Soweto Farmers Forum in 2014. These projects will be site specific, moving annually from one farmer to the next. They aim to document current issues faced by the farmers on each site and then, together with the farmers, explore design solutions. These will then be prototyped, field tested and evaluated in relation to their initial aims. The objective is that when the team move to the next site, the farmers are left with enough skills for them to continue experimenting and hence empowering their own emancipation whilst still remaining connected to the broader food system though the Soweto Farmers Forum. The impact that urban agriculture could have on reducing poverty, inequality and unemployment is clear. The problems identified in this paper of the complexity of encouraging participation, increasing skills and knowledge and improving networking for urban farmers are what this future design intervention aims to impact on through participatory technology development. Ultimately the resilience of the Johannesburg food system will be improved through incremental changes in current urban agricultural practice.

References

1. Steel, C.: Hungry City: How Food Shapes Our Lives. Vintage, London (2009)
2. Statistics South Africa: Census of Commercial Agriculture, 2007: Gauteng: Provincial Statistics for Selected Products. In: Statistics South Africa. (Accessed February 08, 2011) Available at: http://www.statssa.gov.za/Publications/Report-11-02-08/Report-11-02-082007.pdf
3. FAO: An Introduction to the Basic Concepts of Food Security. (Accessed 2008) Available at: http://www.fao.org/docrep/013/al936e/al936e00.pdf
4. Labadarios, D., Mchiza, Z., Steyn, N., Gericke, G., Maunder, E., Davids, Y., PArker, W.-a.: Food Security in South Africa: A Review of National Surveys. Bulletin of the World Health Organization 89(12), 891-899 (December 2011)
5. Crush, J., Frayne, B.: The Invisible Crisis: Urban Food Security in Southern Africa. Research Report, African Food Security Urban Network, Cape Town (2010)
6. Joubert, L.: The Hungry Season: Feeding Southern Africa's Cities. Picador Africa, Johannesburg (2012)
7. Davids, N.: Chew on These Food Stats. The Times (2013)
8. Biénne, H.: Salad Sprouts in the City Bowl: Farming Flourishes on Former Bowling Green. Sunday Times (2013)
9. Sarah, W.: Want Food Security? Stop the Rot. Mail & Guardian (2013)
10. Mtyala, Q.: Food Security Summit on Government's To-Do List. The Times (2013)
11. De Wet, T., Patel, L., Korth, M., Forrester, C.: Johannesburg Poverty and Livelihoods Study. Research Report, Centre for Social Development in Africa, Johannesburg (2008)
12. United Nations Population Fund: State of the World Population 2011. In: United Nations Population Fund. (Accessed 2011) Available at: http://foweb.unfpa.org/SWP2011/reports/EN-SWOP2011-FINAL.pdf
13. Argenti, O.: Food for the Cities: Food Supply and Distributuion Policies to Reduce Urban Food Insecurity. Food and Agricultral Oranisation of the United Nations, Rome (2000)
14. South African Government: National Development Plan 2030 Our Future - Make it Work., National Planning Commission (2012)
15. City of Johannesburg: A City Where None Go Hungry: Operational Strategy Document., Johannesburg (July 2012b)
16. City of Johannesburg: City Has a Plan to Boost Farming. In: City of Johannesburg. (Accessed 2009) Available at: http://www.joburg.org.za/index.php?option=com_content&task=view&id=4109&Itemid=198
17. City of Johannesburg: 2012/16 Intergrated Development Plan: Committting to a Promising Fututre. In: City of Johannesburg. (Accessed 2012a) Available at: http://www.joburg-archive.co.za/2012/pdfs/idp/idp201216.pdf
18. Richards, R., Taylor, S.: Changing Land Use on the Periphery: A Case Study of Urban Agriculture and Food Gardening in Orange Farm. Research Report, UTRP South African Research Chair in Development Planning and Modelling, Johannesburg (2012)
19. Centre for Development Support (CDS): The Role of Urban Agriculture in Adressing Household Poverty and Food Security: The Case of South Africa. Reserach Report, CDS Research Report, LED and SMME Development, Bloemfontein (2009)
20. Campbell, A., Brand, K.: Design of Resileint Products for Small-scale Farming in South Africa. In : Agrindustrial Design: 2nd International Product and Service Design Congress

and Exhibtion on Agricultural Industries - Mediterranean / Food / Design Proceedings, Izmir, pp.278-286 (2012)

21. City of Johannesburg: Food Garden Planted on Roof. In: City of Johannesburg. (Accessed March 22, 2012d) Available at: http://www.joburg.org.za/index.php?option=com_content&view=article&id=7861:food-garden-planted-on-rooftop&catid=166:inner-city&Itemid=254
22. City of Johannesburg: Veggie Patch in Hillbrow. In: City of Johannesburg. (Accessed May 04, 2012c) Available at: http://www.joburg.org.za/index.php?option=com_content&view=article&id=7996:veggie-patch-in-hillbrow&catid=166:inner-city&Itemid=254
23. City of Johannesburg: City to Grow Organic Farming Sector. In: City of Johannesburg. Available at: http://www.joburg.org.za/index2.php?option=com_content&task=view&id=2376&pop=1.
24. Brand, K.: Seboko. In: Kyle Brand. Available at: http://www.kylebrand.com/2010/11/19/seboko/
25. Balimi Food Security Company: Background. In: Balimi Food Security Company. Available at: http://www.balimifoodsecuritycompany.org/
26. Horti Shop: News: LIttle Growers. In: Horti Shop. Available at: http://www.hortishop.co.za/news/
27. Wild, S.: Keeping Produce Fresh can be as Simple as Better Storage. Mail & Guardian, 16 (2013)
28. Harrison, P.: The Greening of Africa: Breaking Through in the Battle for Land and Food. Paladin, London (1987)
29. Scoones, I., Thompson, J.: Farmer First Revisited: Innovation for Agricultural Research and Development. ITDG Publishing, London (2009)
30. Haverkort, B., van der Kamp, J., Waters-Bayer, A.: Joining Farmers' Experiments: Experiences in Participatory Technology Development. ILEIA, Leusden (1991)
31. Richards, P.: Indigenous Agricultural Revolution. Hutchinson, London (1985)
32. Bunch, R.: People-centred Agricultural Improvement. In Harverkort, B., Van de Kamp, J., Waters-Bayer, A., eds. : Joining Farmers' Experiments. Intermediate Technology Publications, London (1991)
33. Uphoff, N., ed.: Agroecological Innovations: Increasing Food Production with Participatory Development. Earthscan Publications Ltd, London (2002)
34. Hamdi, N.: Small Change: About The Art of Practice and the Limits of Planning in Cities. Earthscan, Oxon (2004)
35. Reeger, B., Mager, S., van Oorsouw, Y.: License to Grow: Innovating Sustainable Development by Connecting Values. VU University Press, Amsterdam (2001)
36. van Latesteijn, H., Andeweg, K.: THe TransForum Model: Transforming Agro Innovation Toward Sustainable Development. Springer, Dordrecht (2011)
37. MetroAg Innoversity: Welcome to the MetroAg Innoversity. In: MetroAg Innoversity. Available at: http://metroaginnoversity.org/
38. Smithsonian Institution: Design and Social Impact: A Cross-Sectoral Agenda for Design Education, Research, and Practice. White Paper, Cooper-Hewitt, National Design Museum, New York (2013)
39. Schneider, S.: Five Ways Cell Phones are Changing Agriculture in Africa. In: Food Tank. (Accessed April 12, 2013) Available at: http://foodtank.org/news/2013/04/five-ways-cell-phones-are-changing-agriculture-in-africa

40. Alvarez, S.: Mobile Technology Helps Farmers Save Time, Water, and Electricity. In: Nourishing the Planet. (Accessed September 19, 2012) Available at: http://blogs.worldwatch.org/nourishingtheplanet/mobile-technology-helps-farmers-save-time-water-and-electricity/

Designing a Seasonality Application to Support Urban Agriculture Practice

Peter Lyle

Urban Informatics Research Lab, Queensland University of Technology,
130 Victoria Park Road, Kelvin Grove, Queensland, Australia

p.lyle@qut.edu.au

Abstract. This position paper describes the work in progress towards the goal of building a technical prototype that enables users – those who have little or no knowledge and experience engaging in urban agriculture – to receive information personalised to their location and situation, and allow them to ask questions and share experiences with others. We describe the design process thus far, informed by a survey and a workshop with experts in the field, before concluding with the future direction of this work.

Keywords: Urban Agriculture

1 Introduction

Knowledge and experience in gardening is crucial to enable effective gardening and production of food. We have explored two manifestations of urban agriculture communities and found a problem common to both in the form of limited resources (a dependence on volunteers) and limited knowledge of gardening practice. The first urban agriculture community was a city farm in Brisbane. The second is the local chapter of a grassroots movement aimed at planning and promoting permaculture in suburban spaces in and around Brisbane. While the city farm has some forms of income, both are reliant on a mostly volunteer workforce. As a result of this we see the development of technology that can help provide knowledge of gardening practice (in the form of seasonal planting, growing and harvesting information) that will be made available to the general public. The intent is that by providing a means by which people can increase their knowledge and share experiences around growing food in urban environments it will reduce the pressure on resources for more experienced urban agriculture practitioners.

This position paper describes our approach with regard to informing the design of a future application that will be developed to provide seasonality information relevant to an individual's context (their location, available space, focusing on what they would like to grow and eat). The application will also enable a level of social interaction with other users, with a focus on sharing their own experiences, as well as the opportunity to engage in questions and answers. The approach undertaken has

involved a short survey with a small sample size to understanding of how people prioritise and source information, which informed a workshop with three expert gardeners (community leaders who have practiced gardening since a young age, and have been involved in teaching, as well as supervising community gardens).

2 Background and Prior Work

Urban agriculture, the practice of producing food for consumption within urban and suburban areas [1], provides an opportunity to enhance the physical health, mental health, food security, and sustainability of a region e.g. [2-5]. For related work that shares the local context of Brisbane we must look at Odom [2], which explored other potential interventions technology designers could utilize, based on experiences with local urban agriculture communities. The design process itself will not sit in a vacuum and will consider other applications and communities such as 'Grow The Planet'[13], however the design itself must be tailored in both the information it provides and the platform it utilises for the context of this study in Brisbane, Australia.

3 Design Process

The process taken for the concept of a seasonality application has followed two stages, a short survey and an expert focus group. The survey asked a number of questions about where participants source their information and how they make decisions about how to garden, and how to determine if a particular food is 'in season'. The participants of the survey were sourced primarily from around Brisbane, advertised through existing contacts involved with urban agriculture and social networks. There were 36 respondents, and the results of the survey were used to help inform questions and guide the expert focus group that followed.

The expert workshop we conducted over two hours with three experts, who have all been gardening from a young age, for a mix of health, family and curiosity reasons, and have been involved in teaching and managing community gardens. After this an exercise was conducted to explore what are the most significant or important factors of understanding seasonality. After this they were given a hypothetical scenario of applying these decisions to a balcony garden, to see what questions or suggestions they would give (and how these would apply to the previous exercises factors). Finally we visited a local community garden, and give the experts opportunity to comment on how they perceived the operation (in terms of any obvious good or bad practices utilised by the owners, who resided in a nearby block of flats).

A key point of confusion at the workshop was the idea of seasonality, and that different factors sometimes overlap, an example of this would be the weather, which can incorporate 'temperature', 'humidity', 'soil temperature', 'sun exposure hours', 'does it get frost', distance to the coast. All this information together forms a climate profile of the intended growing location, and is quite dynamic information as weather

[13] growtheplanet.com

changes both throughout the year, and as the start and end point of seasons changes over time, which one expert attributed as an impact of climate change. Some of this information can be determined by looking at either past weather patterns or mining sets of previous bureau of meteorology data, however this does not take into account nearby trees, walls, or other structures which will impact sunlight coverage. This is further complicated as one of the experts suggested in a prior conversation that if, for instance, you were planting basil, outside of certain months of the year for Brisbane the climate would be too cold, however it would still be possible and likely to grow if planted next to a structure that absorbed and radiated heat from the sun, such as a concrete wall.

When exploring a nearby community garden, one of the experts explained how the importance in garden planning to remove 'rubbish' plants with those that '…have a purpose in life'. This is to say that making a decision to try and grow a given species of plant should not be a decision made solely on the environmental conditions, but should also consider how it might interact with other plants. An example of this would be when something can be grown that will encourage native wildlife, birds, or insects to interact with the growing area.

The experts cited nutrition as a reason people choose what to plant. While most fresh, locally grown produce is likely to be considered of a positive nutritional value, many people who ask questions of these experts will often be enquiring about different foods which can be grown that are high in specific minerals or vitamins (e.g. foliate or vitamin C).

Finally the idea that the deciding what to plant is largely about what will grow for a given set of conditions. This is not a simple yes/no question to answer, and any such design will need to incorporate and consider the fact that while you can try and present information in terms of what is more or less likely to grow for a given set of circumstances, it is not a definitive evaluation.

4 Future Direction

This work presents key implications for design of a seasonality application, and in order to further develop these criteria, further research into the specific needs and attitudes of both beginning and experienced gardeners will be performed utilising a convergent interviewing process. This will culminate in sufficient information to develop a prototype system for testing with users ranging from novice to intermediate gardening experience.

References

1. Smit, J., Nasr, J.: Urban agriculture for sustainable cities: using wastes and idle land and water bodies as resources. Environment and Urbanization 4, 141 (1992)
2. Odom, W.: "Mate, we don't need a chip to tell us the soil's dry": opportunities for designing interactive systems to support urban food production. Proceedings of the 8th

ACM Conference on Designing Interactive Systems, pp. 232-235. ACM, Aarhus, Denmark (2010)
3. Brown, K.H., Jameton, A.L.: Public Health Implications of Urban Agriculture. Journal of Public Health Policy 21, 20-39 (2000)
4. Chopra, M., Galbraith, S., Darnton-Hill, I.: A global response to a global problem: The epidemic of overnutrition. World Health Organization. Bulletin of the World Health Organization 80, 952 (2002)
5. Howe, J., Wheeler, P.: Urban food growing: The experience of two UK cities. Sustainable Development 7, 13-24 (1999)

Growing Friends by Growing and Sharing Garden Produce

Jinglan Zhang[1], Margot Brereton[1], Paul Roe

School of Electrical Engineering and Computer Science,
Queensland University of Technology, Australia

{jinglan.zhang, m.brereton, p.roe}@qut.edu.au

Abstract. Most urban agriculture literature focus on addressing access to healthy and affordable food and environmental issues via managing the urban farming chain which consists of production, processing, marketing, distribution and consumption. This paper focuses on a less acknowledged and documented aspect of individual urban farming: growing and sharing garden produce for recreation, well-being and friend making. This paper summarizes the experience of individual backyard farming and sharing as a way to interact with nature and people and explores ways to improve this experience, especially with the assistance of Information Communication Technology.

Keywords: urban agriculture, backyard farming, garden produce sharing, grow food, grow friends.

1 Introduction

The majority of urban green areas are people's front and backyards, especially in Australia where urban areas are not overly crowded yet. It is quite popular that individual urban gardeners also grow food in their yards.

There are many publications on the specifics of how-to for urban farming such as seeding or weeding. Most urban agriculture literature such as [Smit,1996][14] focus on addressing access to healthy and affordable food and environmental issues via managing the urban farming chain which consists of production, processing, marketing, distribution and consumption. The comprehensive and introductory source is the Wikipedia site for urban agriculture[15].

This paper focuses on a less documented aspect of urban farming at individual scale: growing and sharing garden produce for recreation, well-being and friend making. We will investigate the motivation and benefits for individual backyard farming based on the authors' experience and observation. We will also discuss

[14] Smit, J., A. Ratta, and J. Nasr. (1996). Urban Agriculture: Food, Jobs, and Sustainable Cities. United Nations Development Programme (UNDP), New York, NY.
[15] http://en.wikipedia.org/wiki/Urban_agrictulture

challenges for garden produce sharing and explores potential ways to improve this experience.

2 Motivations and benefits for individual backyard farming

The idea of supplemental food production in backyard or cities is not new and has been used during war times in many countries when food shortage issues arose. For most individuals living in large cities especially in developed countries, food availability is not a major concern anymore except under emergency situations. Therefore, growing food at backyard is out of necessity for most people. However, there are still many gardeners who are very keen to grow food in their backyards. Below we explore and summarize the motivations for growing food in backyard based on our own experience and observations.

Tradition. Farming is the key development in the rise of human civilization so it is part of our heritage for most people. Farming is also a form of tradition where people want to feel more connected to the earth and hence enjoy growing things. Many Chinese families living in the rural area grow fresh vegetables in their own backyard and this tradition has lasted for thousands of years. Although it is hard to grow food in the dense residential area and with busy lifestyle in modern cities, the dream of growing fresh food in one's own place and being self-reliant remains in many people's heart.

Recreation and Well Being. Backyard farming is not just for growing herbs, vegetables or fruits, but also a way to interact with nature. Gardening is a very casual and fundamental activity and makes people more relax, calming and temporarily forget the stress from work or life. Gardening also increases people's outdoor and physical activity levels thus making them healthier. The ability to produce and grow food for oneself and being able to share them with others can improve the levels of fulfillment and self-pride of the growers.

Food Varieties and Quality. Produce from urban gardens are not only organic, they are also more flavorful and desirable than store bought produce, usually because they are more fresh and can be naturally ripe thus more tasteful. Furthermore, by growing our own easily maintained food such as mint, chillis, green onions and garlic, fruits and more we can bring freshness to our table and compensate the variety of food supply from the main super-markets.

Knowledge and Education. Residential farming not only improves our knowledge on farming and corresponding plant and animals, it also improves our dietary knowledge. It is a very good scheme for encouraging kids to be active and learn planning and problem solving with fun and hands-on activities. By growing food we also encourage appreciation of other green and sustainability issues at home such as collecting rain water for watering the garden, recycling kitchen wastes as fertilizers etc.

3 Growing friends via sharing garden produce

Sharing garden produce can lead to increased individual pride and improved social relationships within the circle of sharing. The wonderful feeling of closeness develops amongst friends, colleagues or neighbours in the process of produce sharing. For example, one of the authors shared some home-grown chillies with a colleague who is very impressed that she can grow vegetables well in a small backyard. In return, he shares with her two new types of chillies that she had never seen before. This sharing experience has not only improved our knowledge, but also improved the mutual understanding of colleagues.

Sharing garden produce normally improves the overall well-being of those involved via fresh food and sharing spirit. However, this also raises some concerns. The growers may worry about what will happen if people get bad response after consuming the food, whether they will like the food, whether they would allow others to collect food from home etc. Consumers may concern whether the backyard farming is safe e.g. whether pesticide is used or whether the city area is too polluted etc.

There are also other challenges in sharing garden food. For example, how to find a good match between growers, certain food and consumers? one man's food can be another man's poison. Another challenge is where and how to share fresh garden produce. Excess produce could potentially be distributed via local markets, food banks or through community services. However, local market is too expensive for most individual growers as the amount of excess food is usually small. A food bank for providing free and fresh food to the in-need is a good idea. However, fresh produce can easily perish and needs to be distributed in time thus pose high requirement on food-bank management. Road-side stall is another way to share excess produce. However, how can the stall information e.g location and food type, quality and quantity be sent to the potential consumers?

In our experience, direct peer-to-peer sharing in a local community e.g. neighbours, friends, or colleagues, is one viable option for sharing backyard farming knowledge and garden produce. Sharing in workplace is still the most convenient approach for sharing garden produce and related knowledge for the busy workers. We experimented this for several years and it is a lovely experience. The problem is how can we expand this lovely experience to a larger community or area? How can garden produce lovers know who are willing to share, what can they offer and where are they?

4 Existing applications of information technology in garden food growing and sharing

There are a growing number of projects worldwide that seek to enable citizens to not only grow and share food locally but also improve community connectivity. Information technology has been used in these projects at different levels with most of them using websites for sharing information.

- Detroit's Garden Resource Program Collaborative[16] aims to build connectivity between gardeners and strengthen their gardening community by providing to their members resources and education on gardening, policy, and food issues through workgroups, tours, field trips, and cluster workdays.
- The Monroe Sharing Gardens[17] is a community garden initiative which aims to grow local food and also build sharing spirit in the community. It shares excess garden produce via foodbanks and advertise the sharing information on their website. It relies on volunteers and is often short of helpers.
- The Sharing Backyards project[18] aims to address the lack of land issue and seeks to pair up growers with yard owners to not only grow food, but also grow relations. . It mainly relies on online-services to conduct the match-up between land owners e.g. senior citizens and growers who do not have land such as young high-rise building residents.
- The Brisbane Northey Street City Farm[19] promotes permaculture education and help growers via website, workshops etc.
- The Permablitz team[20] addresses the issue of lack of growing knowledge and time and help yard owners to design and construct suburban vegetable gardens for free. They mainly use a website to send information.
- The Edible Yards project[21] supports garden produce sharing via a website and information sessions to connect garden food growers and consumers.
- LocalDirt[22] provides buying, selling and finding local food services online, some tasks can be automated with modern information technologies.

We can see that physical food banks, community services and volunteers can help distribute the food to the in-needs for excess garden produce. We can also see that internet is playing an important role in disseminating information for garden food growing and sharing. However, we can do better and more with modern information technologies. Therefore, we propose to use digital noticeboards, social network, and modern web services, recommendation systems and location-based services to improve the backyard farming and sharing experience. For example, a digital noticeboard with web and location-based services can be used to automate buying, selling, sharing notifications among multiple sites and multiple users.

5 Conclusion

Individual urban farming is more for recreation and well-being and it improves the quality and variety of food available. Through growing and sharing, we are not only

[16] detroitagriculture.net/urban-garden-programs/garden-resource-program/
[17] http://thesharinggardens.blogspot.com.au/
[18] http://www.sharingbackyards.com/
[19] http://www.nscf.org.au/
[20] http://www.permablitz.net/
[21] http://edibleyards.com.au
[22] http://www.localdirt.com

encouraging sustainable resource use and contributing to solving the food security issue, we are also encouraging care about our land and environment and improving the relationship between people, especially within a local community such as colleagues, neighbours, or friends. Researchers and decision makers need to design new technologies, systems and policies to encourage sustainable backyard farming, improve the sharing experience in order to build a stronger, happier, and healthier community.

A design-oriented process & platform for inspiring and accelerating urban agriculture coalitions

Nikos Palavitsinis[1], Christine Geith[2], and Nikos Manouselis[3]

[1]Agro-Know Technologies, 17 Grammou Str., Vrilissia, Athens, 15235, Greece; palavitsinis@gmail.com
[2]MSUglobal, Michigan State University, East Lansing, MI, USA; cgeith@gmail.com
[3]Agro-Know Technologies, 17 Grammou Str., Vrilissia, Athens, 15235, Greece; nikosm@agroknow.gr

Abstract. Successful urban agriculture projects must effectively engage multiple stakeholders and use information systems to support learning and decision making. This paper shares a concept for a design process and technology toolkit being explored for an urban agriculture coalition in Detroit and its partners around the world. The concept combines the Green Ideas event format of AgroKnow with technology tools being used by MSUglobal to attract, motivate and engage regional stakeholders to accelerate successful urban agriculture initiatives.

Keywords: urban agriculture, multi-stakeholders, innovation, coalitions.

1 Introduction

A common challenge in developing community coalitions for urban agriculture is organizing effective activities and experiences that will engage multiple stakeholders in creating shared outcomes. Effective initiatives involve a wide variety of stakeholders. In addition, the complexities of urban agriculture lend themselves to taking advantage of available technology to enable evidence-based decisions by urban consumers, growers, processors, wholesalers and retailers.

The FoodPLUS Detroit coalition is a local multi-stakeholder group facilitating and accelerating a more sustainable food system. Michigan State University (MSU) is a facilitating member of FoodPLUS Detroit, and is also leading the Global Innoversity (http://metroaginnoversity.org/): a network of like-minded local coalitions including Detroit, Nairobi, Johannesburg, Hyderabad, Sao Paulo, Singapore and the Netherlands. MSUglobal is supporting these initiatives by exploring toolkits used by FoodPLUS Detroit and the Global Innoversity to attract, motivate and engage regional stakeholders. This paper presents the design of one such approach, based on the Green Ideas event format pioneered by AgroKnow and embedding in it a technology component being tested by MSUglobal in related projects.

2 Background

2.1 Context: FoodPLUS Detroit

FoodPLUS Detroit (http://www.msumetrofood.com/detroit-innovation-cluster.html) is a local partnership network in Detroit, Michigan, USA. It envisions a metropolitan food system that produces, processes and distributes food that is abundant, safe, healthy, affordable and accessible, while conserving energy, water and soil, and opening economic opportunities for many while enhancing diversity and social justice in the community. There are two distinct implementation strategies that uniquely reinforce each other: a new approach to multi-stakeholder cooperation and innovation and a new approach to participative knowledge development.

Multi-stakeholder engagement is one of the primary operating principles of FoodPLUS Detroit which is inspired by the operating principles of the Global Innoversity. This is made operational by including businesses, governmental units, societal/community groups, and knowledge institutions in all phases of system design, implementation and evaluation. Engagement demands more than participation: it demands involvement, sharing, co-creating, innovating, and learning together. FoodPLUS Detroit also focuses on action-learning, meaning that the action and the learning are intrinsically coupled. FoodPLUS Detroit organizes reflection and learning with and from their experiences and from each other. MSUglobal and AgroKnow have been exploring a potential action-learning toolkit for FoodPLUS Detroit that is technological, physical and social.

2.2 Process: Green Ideas

Green Ideas (http://greenideasproject.org) are interactive and engaging events that explore ways in which education and technology can catalyze green innovation. They are organized in the form of dynamic workshops that use a design-thinking approach to innovate new ideas with actionable next steps. Within a Green Ideas event, collaboration and ideation happen in stages (*harvest requirements*, *plant seeds*, *cultivate ideas*, *blossom & thrive*). Participants engage in activities throughout the experience, to accelerate meaningful collaboration.

3 Design-oriented Process

Figure 1 includes an overview of the Green Idea creative engagement process. Starting from the top left, the process includes the following steps:

- **Harvest Requirements.** During step one, the participants draw upon the experience of professionals and invited experts by interviewing them in relation to the goal(s) of the event. Their purpose is to take notes on the interviews, to inform the next phases of the event.

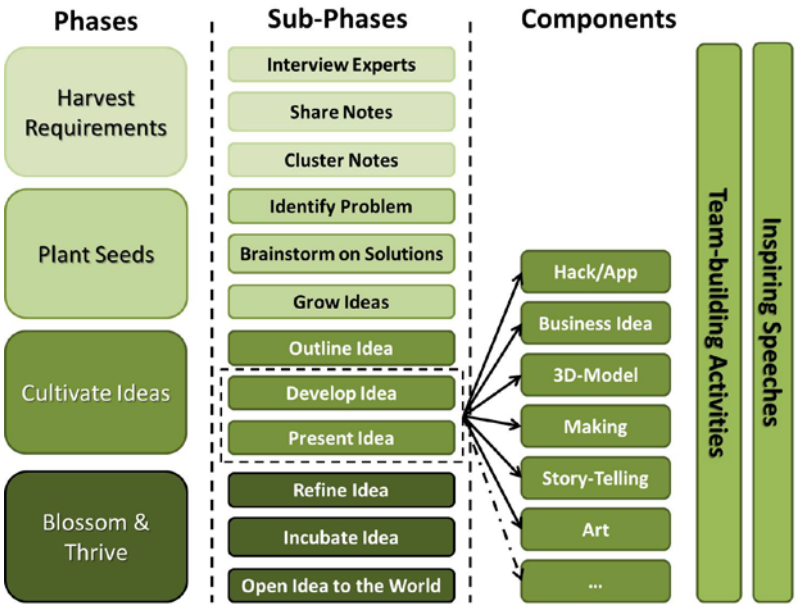


Fig. 1. The creative engagement process of a Green Ideas event

- **Plant Seeds.** In this stage, the participants revisit their notes, add new ideas, or elaborate more on the ones that inspire them. Then participants formulate concrete ideas that can be further developed. For this phase to be considered complete, each group must have one or two ideas that will be then "cultivated" and modeled into a coherent story.
- **Cultivate Ideas.** During this phase, participants choose the specific idea that they want to develop (i.e. cultivate) further. They describe the idea as clearly as possible: identifying a title and description and outlining the main components, and finally, creating a presentation. Types of activities include (depending on the type of expected outcome from each component): hacking/application development, business idea, 3D Model, making a DIY construction/invention, storytelling, art, etc.
- **Blossom & Thrive.** Finally, the participants have to prove that their ideas are sustainable and that there is a concrete plan of following them through to real-life implementation. They create a tentative schedule that will guide their deployment in real-life situations. Each group also identifies and describes a value proposition behind their idea, identifying their target audience and market that would be willing to finance and support their effort.

4 Technology Components

We are embedding technological components into the Green Ideas process to create action learning tools for urban agriculture and food communities. We are currently testing two components:

- Targeting knowledge resources to create stronger foundations during the Harvest Requirements and Plant Seeds stages. As participants gather data through interviews at the event they can also bring in information from other sources such as examples, frameworks for analysis and business models. The Food Safety Knowledge Network (http://foodsafetyknowledgenetwork.org/) is one example where resources are automatically harvested from selected web sites and organized around specialized vocabularies and competency frameworks. The results are more useful for specialized knowledge than general search engine results.
- Facilitating participatory storytelling and sharing during the Blossom and Thrive stage with curation tools. It is critical to empower all participants to create and share their ideas and perspectives equally; not only during the event but also in the way the project is subsequently shared with the world. MSUglobal uses curation tools to share multiple points of view. For example, we used RebelMouse and Storify to curate the stories from a Global Innoversity event in Detroit (https://www.rebelmouse.com/globalinnoversity/). We used Thearit to curate stories about metropolitan agriculture (http://knowledgenetwork.alumni.msu.edu/metro-ag-course/metroagcourse.html).

5 Conclusions & Next Steps

We (the authors?) are exploring the proposed concept in partnership with FoodPLUS Detroit to develop a proof of concept so that the envisaged approach may actually inspire and accelerate innovation, specialized event protocols, technology tools, and knowledge sharing methods will be tested. It is expected that this proof of concept will help us identify where improvements to the process are needed and explore its usefulness with other metropolitan regions.

References

1. Palavitsinis N., Papageorgiou A., Gavrilut L., Protonotarios V., “Green Ideas: A Social Generator of Green Solutions, Deconstructed”, in Proc. of the Joint Congress of EFITA, WCCA and CIGR VII (EFITA’13), Turin, Italy, June 24-26, 2013.
2. Manouselis, N., Vignare, K., Thanopoulus, C., Geith, C. “An Open and Scalable Infrastructure for Food Safety”, forthcoming in the Journal of Asynchronous Learning Special Issue on Online Learning and Open Educational Resources for Development.
3. Vignare, K., Geith, C., Collins, B., Weebadde, P., “How Organizing Knowledge in Meaningful Ways Enhances Search and Supports Independent Learning”, in Metadata and Semantic Research Communications in Computer and Information Science, Springer, Vol 240, 2011, pp. 324-336.

Strategies for Sustainable Urban Agriculture
A Public Private Partnership Approach

Francis Wambalaba[1], Peter Mutia

Sustainable Development Initiatives Center
United States International University

fwambalaba@usiu.ac.ke, petermutia@hotmail.com

Abstract. The main purpose of this paper is to conceptualize strategies for developing a sustainable process for enhancing urban agriculture in major urbanized areas in the East African region. Primarily, this paper uses the three capital cities of Nairobi, Kampala and Dar es Salaam as pilot case studies. Specific objectives for the concept include strategies towards: 1) Development of urban Agri-based social enterprises; 2) promotion of urban safe fresh produce; and 3) enhancement of the urban landscape. The concept envisions the use of Public Private Partnerships, Co-op associations and resident neighborhood associations as the primary infrastructure for mobilizing participation and ownership. The ultimate result would be a strategy for enhancing urban agri-based social enterprises, urban green spaces and urban food supply. The primary stakeholders would therefore be the city council officials, environmental and local government agencies, neighborhood resident associations, urban fresh produce farmer groups, select retailers and researchers.

Keywords: Urban Agriculture, Agri-based Social Enterprise, Safe Produce, Urban Landscape, Public Private partnership, Urban Greenspaces, Urban Food Supply

1 Background

According to UN Habitat (2010), in 2009, Africa's total population exceeded one billion, of which 395 million, almost 40 per cent, lived in urban areas, anticipated to grow to one billion in 2040, and to 1.23 billion in 2050, by which time 60 per cent of all Africans will be living in cities. And the 3.4% growth rate makes Africa the fastest urbanizing continent in the world and will cease to be rural by 2030. This means Africa's share of the world's urban population will increase from 10 to 17% between 2000 and 2015 (UN Population Division 2001). Consequently, the resulting paving of these cities has become a source of heavy runoff, low water percolation, and climate warming. Odhiambo (2012) citing (Castell, 2010; Tibaijuka, 2007) argues that human settlement exerts pressure on green spaces and loss of biodiversity in wetlands and loss of agricultural land. Secondly, given the illegal status accorded to urban farming

practices, urban residents have not only been constrained from producing healthy foods for marketing, but also for their own subsistence. This has meant less greenery, limited fresh food supplies, and more human idling, especially of recent urban immigrants. Thirdly, with limited food supply, unscrupulous "Urban Petty Farmer Traders (UPFTs) have resorted to unhygienic production methods which contribute to various kinds of health hazards. In addition, these UPFTs often risk their meager investments by illegally encroaching and squatting on public and private lands without assurance of gaining the harvest. These results in lost harvest, wasted energy, and sunk investments.

However, urban farming presents an existing opportunity to build on. Urban agriculture potentially plays a beneficial role in terms of the urban economy, urban food supply and urban development in general (Smit et al.1996). Although largely an informal economic activity, urban farming provides employment as well as an income for those involved. This income can be realized directly through the sale of crops or indirectly because less food has to be bought. At the town or city level, urban farming contributes positively to the provision of affordable food for poorer urban dwellers. However, because of its generally low productivity, the sector's potential in terms of food supply and employment is much higher than presently appreciated, as various studies have indicated (Nugent 2000). Food producers in town, especially those in vulnerable groups, benefit directly in terms of increased food security (Armar-Klemesu 2000).

2 Background

The main purpose of this paper is to develop strategies for conceptualizing a sustainable process for enhancing urban agriculture in the major urbanized areas in the East African region. Specific objectives for the concept include strategies towards:

- Development of urban Agri-based social enterprises
- Promotion of urban safe fresh produce
- Enhancement of the urban landscape

With respect to the development of urban Agri-based social enterprises, it is anticipated that the key stakeholders to be engaged would include city council, local government and environmental agencies, existing urban neighborhood associations and farmer groups, and select retailers. These would be tasked to create a PPP Co-op to improve the livelihoods of its members and enhance urban livability. Urban livability will contribute towards the later two objectives as follows. With respect to promotion of urban safe fresh produce, the co-op will develop codes of conduct and contribute towards development of public standards to govern the industry so as to increase supply of fresh produce with improved food safety. It will also create opportunities or critical mass for pertinent participative legislative process. With respect to enhancing the urban landscape, it is anticipated that controlled growth of urban fresh produce would moderate the appearance of the urban landscape, including the temperatures. As an action research, baseline studies will be done prior to

implementation which will be followed by monitoring and periodical data collection to assess the impact of the co-op.

The concept envisions the use of Public Private Partnership and Co-ops as a strategy for enhancing urban food supply, green spaces and social enterprise. The concept aims to advocate for responsible safe urban agriculture through formation of urban farming co-ops in the respective capital cities that would serve as a model for other urban areas in the respective countries and hopefully emulated across the continent. To assure sustainability, it is anticipated that the Co-ops would develop codes of conduct and standards to avail safe fresh produce in the market, create market outlets, create loan schemes for its members, and engage the youth and unskilled urbanites in urban farming. The Co-ops would also provide a platform for empowerment of the urban farmer to advocate and lobby for an improved legal system. The primary stakeholders would be the respective city council officials, environmental and local government agencies, neighborhood associations, urban fresh produce or farmer groups, select retailers and researchers.

3 Significance of the Concept

Even though studies indicate that 22% of Nairobians have access to urban land and 20% use it to grow crops, it is anticipated that this project will initially affect about 150,000 farmers directly in Nairobi alone, 60% of unemployed youth, and consumers of 1000 tons of fresh produce. The numbers for Dar es Salam are estimated at 10-20% of the urban population (Bryceson 1993 and URT 1992b). The numbers for Kampala are expected to be similar. Indirectly, the project is expected to moderate the urban landscape, reduce health hazard incidences arising from unsafe fresh produce, bolster neighborhood associations and create further opportunities for downstream employment.

4 Methodology

The focus countries in phase one will be the three East African Community member countries of Kenya, Uganda, and Tanzania, while phase two will scale up to the other three member countries of Rwanda, Burundi and Southern Sudan.

Key allies will include Universities (Michigan State University, University of Makarere, Sokoine University), respective city councils (Nairobi, Kampala, Dar es salaam, Kigali, Bujumbura and Juba), local environmental and local government agencies, local neighborhood associations or equivalent in the respective capital cities, and fresh produce outlets, especially farmers markets and select local supermarket retailers. Representatives of these stakeholders would form the core working group in each participating capital city.

Table 1: Objectives and Indicators Matrix

Specific Objectives	Indicators
Development of urban agri-based social enterprises	• Development of stakeholder's partnership agreements and coordination guidelines. • 3 cooperatives formed and registered (Nairobi, Kampala, Dar es Salaam);
Promotion of Urban safe, fresh produce.	• Development of standards on good agricultural practices; • At least 200 members of the Coops certified for good agricultural practices; • Partnerships agreements signed between the urban farmers and retailers, credit providers and input providers; • Operating code of conduct and draft standards developed. • Instrument and process for assessing increase in the quantities of produce from the urban farmers developed;
Enhancement of the urban landscape	• A GPS based measurement system developed for assessing improvement in green spaces. • Instrument for assessment of adjacent climate warming developed. • At least 1% increase in acreage of land under vegetative cover (farming); • 1 policy brief on urban agribusiness.

5 Literature Review

In **Sub-Saharan Africa**, farming in towns is a common feature (Obudho & Foeken 1999). It is estimated that 40% of the urban population in Africa is involved in urban agriculture (Mougeot 1994). Studies show that urban farming in Africa is undertaken wherever land is available (Foeken,Sofer and Mlozi, 2004). In built-up areas, this 'backyard farming' or 'on-plot farming' or on land belonging to someone else ('off-plot farming'), on government, institution or private individual's lands. Farming is particularly common in the peri-urban zones. In these zones, both small-scale and large-scale farming can be found. However, as the urban centre grows, these areas gradually lose their rural character and farming becomes increasingly of the other two types. Although numerous studies have been done (see Obudho & Foeken 1999), knowledge about urban agriculture in Africa is still fragmented because the majority focus on only one or two aspects of urban farming and have mostly been carried out in one specific urban centre (usually the national capital) or even a specific part or project within that centre.

In **East Africa**, urban farming has expanded enormously over the past two decades due to the economic crises. For the poor, food security is usually the main motivation for farming in town, and for some it is a survival strategy, selling their produce, partly to meet other basic household needs, or because they are perishable and cannot be stored, or because storage space is not available. For middle-income and high-income

households, commercial considerations are usually more important than among the poor, although the consumption of self-produced vegetables and milk is often highly valued. Their primary reason for selling their produce is the same as for the poor, namely income subsidization.

In **Kenya**, studies indicate that 22% of Nairobians have access to urban land and 20% use it to grow crops which then means that 75,000 urban households grow crops within the City. About 7% of the households in Nairobi keep livestock in towns and 20% keep bees. Based on the available statistics, at least 150,000 people in Nairobi are involved in agriculture one way or the other. According to the Njenga, Gathuru and Karanja (2004), the poverty levels in Nairobi are at an estimated 60-78% and set to increase to 65% if the current trends continue (Ministry of Agriculture, 2002). The Ministry of Agriculture data indicates that urban farming can play a crucial role towards improved livelihoods of the urban poor. For example in Nairobi city farmers cultivate crops such as kale (sukuma wiki), tomatoes, beans, cowpeas, maize, Irish potatoes, sweet potatoes, arrow roots and bananas amongst many others. Estimates from the Ministry indicate: 50,000 bags of maize and 15,000 bags of beans are produced in Nairobi annually; a quarter million chickens are reared within Nairobi and about 45,000 goats and sheep; 42 million liters of milk are produced within Nairobi annually; In 1998 there were 24,000 dairy cattle in Nairobi, worth roughly one billion shillings; about 180,000 trays of eggs were produced in Kasarani Division of Nairobi alone, worth Kshs. 27 million and 610 tonnes of kale was produced in Dagoretti, Langata and Westlands Divisions of Nairobi. Mwangi (1995) found that farming households in a slum area are somewhat better off in terms of both energy and protein consumption when compared with non-farming households. Moreover, growing food helps improve the quality of people's diets by providing fresh fruit and vegetables. The study offers a very concise and general summary of some of the findings of studies undertaken to date.

In **Tanzania's** towns, urban agriculture is very common and involves the raising of livestock (dairy cattle, chickens, goats, pigs, etc.) and the cultivation of crops (maize, cassava, legumes, vegetables, fruits, etc.). Past surveys undertaken in Dar es Salaam show that the number of urban households practicing farming in the city or in the peripheral areas has always been around 15% to 20% (Bryceson 1993). Figures for other towns are somewhat contradictory. For instance, according to the 1967 population census (cited in Bryceson 1993), 10% of the households in Mwanza were engaged in urban farming, but a survey carried out in the same period by Heijnen (1968) mentions 35% for married and 25% for unmarried respondents. In 1988, 15% of the Mwanza (urban) population was recorded as being involved in farming in town (URT 1992a). A nation-wide survey in the early 1990s reported that for 12% of urban household heads (both male and female), farming in town was their primary economic activity (URT 1992b). Howorth et al. (2001) present some figures that clearly indicate the importance of the sector in Dar es Salaam. Thus, in the 1990s, almost a quarter of the city's total land was being used for agricultural production. Very large amounts of larger livestock and chickens were recorded in 1990 and an estimated 100,000 tons of food crops were being produced annually for the local market, with 20% of the total working population being involved in urban agriculture one way or the other, thus

making the sector the city's second largest employer contributing US$ 25 million (excluding animal husbandry) to local economy (Amend and Mwaisango, 1998).

In **Uganda**, *w*ith the exception of a small group of commercially-oriented farmers, urban agriculture in Kampala represents a form of semi-proletarianism, or relying on a measure of cash income (labor market participation or petty trading) as well as on home-production for direct consumption. There are two distinctly different forms of agriculture within the city. The first occurs within the central city, the older suburbs, and City Council housing estates. It represents a long-term movement away from sole reliance on labor market in both the formal and informal sectors of the city's economy for livelihood, with increased effort devoted towards production for direct consumption. The second occurs within the newer suburbs and the peri-urban areas within the city -- areas in which farming has always been a prevalent activity. It represents movement towards either the labor market or informal trade, but a reluctance to become entirely dependent on either. An estimated 35% of households in the entire city are involved in agriculture. Given that the average size of household engaging in urban farming is considerably larger than the mean for the city as a whole, this implies that subsistence production alone directly affects the livelihood or diet of something like half of Kampala's residents (Foeken, Sofer and Mlozi, 2004). The most common crops grown are starchy staples (cassava, sweet potatoes, yams and plantains), but fruits, vegetables, poultry, maize and beans are all grown as well. However, urban agriculture in Kampala is technically illegal, although the bylaws banning the practice are only erratically enforced, and have little impact on farming.

But without a managed process, urban agriculture has been considered by many – and policy makers in particular – as an environmental hazard. Livestock can cause bad smells, noise, erosion and traffic accidents, and may be a source of diseases. Crops are sometimes irrigated with contaminated water, while those cultivated along roadsides are prone to air pollution. Since urban farming tends to be more intensive than rural farming, the use of chemical fertilizers, pesticides and insecticides can have a negative impact on the urban environment, causing pollution in not only the plants but also the soil and groundwater. The recycling of sewage and urban solid waste by turning them into compost is frequently put forward as a kind of panacea for both urban crop production and the improvement of the urban environment.

6 Concluding Observation

In view of the prevalence and socio-economic benefits of urban agriculture, and in consideration of potential hazards, it is critical that a strategy is developed to capitalize on benefits while mitigating hazards. The main purpose of this paper is therefore to conceptualize strategies for developing a sustainable process for enhancing urban agriculture in the major urbanized areas in the East African region. The concept envisions the use of Public Private Partnerships, Co-op associations and resident neighborhood associations as the primary infrastructure for mobilizing participation and ownership. The ultimate result would be a strategy for enhancing urban agri-based social enterprises, urban green spaces and urban food supply.

Specifically, the concept strives to advocate for responsible safe urban agriculture through the formation of urban farming co-ops in the respective capital cities that would serve as a model for other urban areas in the respective countries and hopefully emulated across the continent. On the overall, it is being argued that while there is potential economic, environmental and social contribution of urban agriculture, it will need a well-coordinated strategy for social entrepreneurship, planned land use and legal structures put in place by taking advantage of existing but uncoordinated practices.

REFERENCES

Armar-Klemesu, M.: Urban Agriculture and Food Security, Nutrition and Health. In: Bakker, N., Dubbeling, M., Gündel, S., Sabel-Koschella, U., & De Zeeuw, H., (eds.) Growing Cities, Growing Food: Urban Agriculture on the Policy Agenda, pp 99-118. Deutsche Stiftung Für Internationale Entwicklung (Dse), Feldafing (Germany): (2000)

Amend, J., & Mwaisango, E.: Status Of Soil Contamination and Soil Fertility – The Case of Urban Agriculture in Dar es Salaam: Dar es Salaam Urban Vegetable Promotion Project. Government Printers, Dar Es Salaam (1998)

Birgsten, A., & Kayizzi-Mugerwa, S.: Adaptation and Distress in the Urban Economy: A Study of Kampala Households, World Development. Elseview, vol. 20 (10) Pp. 1423-1441 (1992)

Bryceson, D.F.: Liberalizing Tanzania's Food Trade: Public and Private Faces of Urban Marketing Policy, 1939-1988. James Currey, London (1993)

Foeken, D., Sofer, M., & Mlozi, M.: Urban Agriculture in Tanzania, Issues of Sustainability. African Studies Centre, Leiden, The Netherlands (2004)

Howorth, C., Convery, I., & O'keefe, P.: Gardening to Reduce Hazard: Urban Agriculture in Tanzania. Land Degradation and Development vol. 12, pp 285-291 (2001)

Jacobi, P.: Importance of Vegetable Production in Dar Es Salaam, Tanzania. Dar es Salaam: Urban Vegetable Promotion Project, Government Printers, Dar es Salaam (1997)

Kiango, S., & Likoko, T.: Vegetable Production on Open Spaces in Dar Es Salaam City. Dar es Salaam: Urban Vegetable Promotion Project, Government Printers, Dar Es Salaam (1996)

Likwelile, S.B.: Poverty Reduction Initiatives in Tanzania: Path Taken, Lessons Learnt and Future Challenges, Paper Presented at the University of Dar es Salaam Annual Convocation Symposium, 15-16 May 2003 (2003).

Ministry of Agriculture.: Draft National Urban and Peri-Urban Agriculture and Livestock Policy. Government Printers, Nairobi (2012)

Mlozi, M.R.S.: Information and the Problems of Urban Agriculture in Tanzania: Intentions and Realizations, University of British Columbia, Vancouver (1995b)

Mwangi, A.M.: The Role of Urban Agriculture for Food Security in Low Income Areas in Nairobi, African Studies Centre. Food and Nutrition Studies Programme, Report No. 54, Leiden (1995)

Mwangi, A.M., & Foeken, D.: Urban Agriculture, Food Security and Nutrition in Low-Income Areas in Nairobi, Kenya. African Urban Quarterly vol. **11**(2-3): 170-179 (1996)

Obudho, R.A., & Foeken, D.: Urban Agriculture in Africa, A Bibliographical Survey. African Studies Centre/Centre for Urban Research, Asc. Research Report 58, Leiden The Netherlands (1999)

Smit, J., Ratta, A., & Nasr, J.: Urban Agriculture: Food, Jobs and Sustainable Cities. United Nations Development Programme (UNDP), New York (1996)
Stevenson, C., Kinabo, J., & Nyange, D.: Urban Horticulture in Tanzania. A Situation Analysis of the Production, Marketing and Consumption of Fruits and Vegetables in Dar es Salaam, Dodoma and Arusha. Dar es Salaam: Urban Vegetable Promotion Project, Government Printers, Dar es Salaam (1994).
Stevenson, C., Xavery, P., & Wendeline, A.: Market Production of Fruits and Vegetables in the Peri-Urban Area of Dar es Salaam. Dar Es Salaam Urban Vegetable Promotion Project (1996)
URT: National Human Settlements Development Policy, Dar es Salaam: United Republic Of Tanzania, Ministry of Lands and Human Settlements Development. Government Printers, Dar es Salaam (2000)
URT: 2000/01 Household Budget Survey. Government Printers, Dar es Salaam (2002c)
URT: 2002 Population and Housing Census – General Report, Dar es Salaam, President's Office Planning and Privatization, National Bureau of Statistics, Central Census Office. Government Printers, Dar es Salaam (2003)
URT: 1988 Population Census, Mwanza Region, Bureau of Statistics, Government Printers, Dar es Salaam (1992a)

Designing Geospatial Applications in Support of Traditional Agricultural Practices in Urban Settings

Judith van der Elst, Heather Richards-Rissetto[1,2]

[1]3D Optical Metrology Unit, Bruno Kessler Foundation, Trento, Italy
[2]Dept. of Anthropology, University of New Mexico, Albuquerque, NM, USA

{jvandere@icloud.com; heathmr@unm.edu}

Abstract. Traditional farming in New Mexico, USA, relies on a gravity based irrigation system, known as *Acequias*. Most of these have existed for centuries; an *acequia* is both to a physical irrigation ditch and community of people who own water rights distributed through the system. Growing population and urbanization has lead to increased water demands that are threatening traditional farming. This paper presents a participatory project employing geospatial technologies to support the maintenance of the *acequia* system and its cultural context. Working with *acequia* communities, we designed a strategy—grounded in local cultural traditions—to promote and preserve environmentally-sustainable urban agriculture.

Keywords: Traditional farming, geospatial applications, urbanization.

1 Introduction

Sustainable water management practices are increasingly necessary in order to support community development and cohesion in the context of rising population and environmental change. Traditional farming practices are recognized as more sustainable than modern farming technologies, however, in global food production, sustainability is usually not a first priority [1,2]. In New Mexico, traditional farming is threatened by growing water demands that are not necessarily related to food production, especially in urban settings. While water in New Mexico is traded as a commodity, water rights for traditional agricultural communities, until recently, have been protected [3]. Due to increasing water demands these rights are currently contested, forcing farmers to demonstrate their water needs in order to secure their −individual− water rights. Because the *acequia* system is community-based and relies on the (voluntary) participation of its community members to sustain the system as a whole, a management system to avert these threats and maintain cultural integrity is paramount. Using a participatory approach, we have collaborated with *acequia* communities to design a Geographic Information Systems (GIS) and to train community members to use and maintain the GIS as well as other geospatial

technologies such as GPS and Google Earth. General objectives for design were outlined by community representatives during the initial stage of the project.

1.1 Value of traditional farming practices in urban agriculture

Urban agriculture is a response to demands for environmentally-sustainable healthy, local foods as well as the result of urban encroachment on traditional farming communities. In his book "Stuffed or Starved" Raj Patel [1] describes the context of global food production arguing that small-scale, organic farming is the best way to address global health problems and challenges. This assessment is supported by findings of the International Assessment of Agricultural Knowledge, Science, and Technology for Development [2].

Patel's discussion of the socio-economic and political aspects of global food production point out a marginalized (stakeholder) position for both farmers and consumers, whereas large food corporations are disproportionally powerful in deciding food prices and food product. To address this imbalance, farmers and consumers from around the world have initiated a variety of food activism movements. These efforts demonstrate the variety in which urban and peri-urban agriculture is organized, ranging from ad-hoc communities to traditional communities that comprise both opportunistic and more systematic efforts [1].

In New Mexico, the infrastructure supported by the acequias forms a vital component in maintaining and expanding urban agricultural efforts. Particularly important is the system's demonstrated value in water replenishment and soil health. The South Valley (SV), an unincorporated area of Albuquerque (New Mexico's largest city) is an ideal case study for several reasons: (1) the area is experiencing urban encroachment, (2) the area will soon undergo adjudication to prove water usage/needs, and (3) the area's continued use of acequias offers a local tradition of sustainable agriculture that has ensured irrigation of the floodplain, maintaining soil moisture and nutritive value.

1.2 Why geospatial application – technology in support of traditional farming – is a good thing

More participatory projects are using geospatial technologies to empower local communities [4]; however, it is essential to be aware of the needs, interests and motivations of the local, regional, and global stakeholders. As we have argued elsewhere [5], it is important to keep in mind that communities are not homogeneous; thus, to best serve the interests of a community many internal issues may exist that need to be identified and addressed in the design stage of a project. Nonetheless, a range of technologies are available that can be adapted to fit the common needs/goals of a community whether its members seek to achieve food sovereignty or simply produce local, healthier foods.

According to the IAASTD report [2], the current challenge is to increase agricultural productivity in a sustainable manner, while simultaneously addressing the needs of small-scale farmers in diverse ecosystems. To address this challenge the

IAASTD report lists several objectives. We list those that are relevant to the participatory project described in this paper. They include: (1) Empower marginalized stakeholders to sustain the diversity of agriculture and food systems, including cultural dimensions; (2) Provide water, maintain biodiversity, sustain the natural resource base and minimize the adverse impacts of agricultural activities on people and the environment; (3) Manage effectively the collaborative generation of knowledge among increasingly heterogeneous contributions and the flow of information among diverse public and private AKST (Agricultural knowledge, science, and technology).

Generally speaking, participatory projects explicitly address objective #1 and #3 because they seek to empower communities to become partners of equal standing in negotiation processes, particularly by increasing access to information and communication channels. In regard to objective #3, we contend that access to computing devices and networks (i.e., internet) alone are not enough to empower communities [6]. To meet the challenge of sustainable agricultural productivity, the digital divide where "an inequality between groups in terms of access to, use of, or knowledge of information and communication technologies" must be minimized [7]. While it is essential that communities have knowledge of information and access to communication technologies, in our case study, access to the internet was not the primary issue; instead, the main problem was access to geospatial technologies and the knowledge of how to use them [5]. We attempt to overcome this problem and achieve the IAASTD objectives by emphasizing educational training of geospatial technologies to ensure continuity of the project after the design and implementation stage. Our strategy is to: (1) Design applications that can be easily used by community members—this requires (a) flexibility in design, to serve diverse needs of members and (b) cultural knowledge and research skills; and (2) Provide training for select members to independently maintain and expand the system in future—this requires (a) creative solutions in educational models, (b) short and long-term vision for management and cultural continuity, and (c) understanding the motivation of different stakeholders.

2 Geospatial Design in support of urban agriculture

Participatory project that employ geospatial technologies are referred to as Participatory GIS (PPGIS) [4]. Our PPGIS is a university-community partnership with a strong community involvement. Its key-defining element is the educational component, designed to ensure system maintenance beyond the initial design and implementation stage.

Geospatial applications are ideally suited to address many of the challenges facing urban communities, particularly challenges related to water and agricultural management issues arising from urbanization. Acequias, also called community ditch associations, are political subdivisions in New Mexico, where water has always been a scarce resource. Current demands to move water out of traditional communities to what some consider 'higher economic uses' such as industry and sprawling cities are

threatening water security, and consequently the survival of acequias communities [8]. Due to increasing water demands, historic water rights are currently under review and adjudications (legal process to settle water rights) are underway. The implication for traditional water use is that every person claiming water rights needs to prove that he/she is indeed in need of water for beneficial use, at present, but more importantly, that this was true in the past, tested at certain benchmark dates. Failure to provide the necessary documentation during adjudication can lead to loss of water rights, rights that will subsequently go to the highest bidder.

A PPGIS offers a strategy to manage both adjudication and urbanization. For example, GPS can be used to map acequias (ditches) and GIS can integrate current and historical data to assist in general water management, expanding urban agricultural efforts, and documenting long-term water use to support water rights in adjudications. Moreover, GIS can assist in the expansion of urban agriculture (via traditional techniques), for instance, helping to identify potential agricultural plots (e.g., overlaying aerial imagery on zoning data). Along these lines, GIS can serve community activism providing maps to argue for using these – often vacant plots – as agricultural fields or gardens, based on location, access to traditional water system, soil condition, or other relevant variables. Importantly, geospatial technologies, as part of participatory efforts for sustainable design and urban planning, can help engage younger generations in urban agriculture that offers access to healthy, local foods while achieving sustainable water management.

2.1 Urban and (vs.) Rural settings

We collaborated with two communities—one urban and one rural. The objective was to gather information from different contexts that would help to design a GIS that could serve the needs of distinct communities with a common goal—promote sustainable agricultural practices and preserve cultural traditions through the acequia system. While the two communities sought similar information, the means of acquiring disseminating, and accessing information were different. For instance, within the urban setting (SV), community members are able to participate in the creation of GIS data using an online application that makes use of Google Earth or download information about local acequias. In contrast, in the rural setting, many people do not have access to the internet (or sufficient bandwidth), and thus, it was necessary to employ other ways to encourage participation and disseminate data (e.g., paper maps).

Our efforts in this participatory project are meant to be a step toward the community objectives of owning and managing a community-based GIS that serves (1) the needs of community members in adjudication procedures, (2) as an information system for storing and disseminating cultural information about traditional agricultural practices, and (3) as a tool to assist in developing and promoting urban agriculture that is grounded in sustainable, traditional practices. To give an example, community members can use the GIS to establish and publicize (via maps) ditch cleaning schedules. While such information is often personally relayed in rural communities, in urban areas where many people rely on mobile apps and

computers for daily tasks, an online digital system cannot only facilitate acequia organization and maintenance, but also foster wider community participation.

In practice, the project results indicate that to develop a Participatory GIS for to serve multiple yet related purposes, a flexible data dictionary is required to account for and integrate diverse data types (particularly the need to integrate GPS and modern geographic data layers with historical data required for benchmark dates), historical/modern, spatial/non-spatial, and the GIS needs to accommodate both state law and acequia law criteria.

2.2 Design and Participation through Collaboration and Education

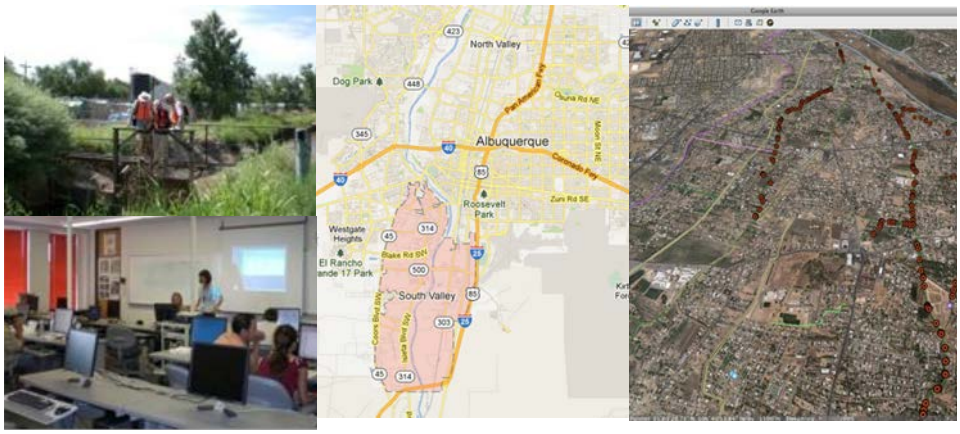
The educational component was designed through community meetings, workshops, and reconnaissance field surveys. Our participation strategy has seven interrelated stages [5]. They are:

1. Identify Community Needs
2. Establish Strategic Alliances between Different Organizations
3. Conduct Field Visits and Create a Plan of Action
4. Organize/Attend Workshops and Community Meetings
5. Develop/Use a Range of Tools for Community Input
6. Intensive Short Course- Train Community Members in the Use of GPS/GIS
7. Evaluation Process: Student and Community

We emphasize that community meetings and workshops are critical to garner community engagement. At these meetings, we proposed an educational model focused on (1) information exchange and communication and (2) providing communities with tools and resources that will allow them to create their own digital content and systems. We also proposed a strategy to bring together traditional university students and community members to encourage long-term relationships between academia and communities. During the course, students would learn about community goals and the challenges they face and then work with community members to formulate potential solutions. This process would facilitate knowledge exchange between students and community members—students have knowledge about geospatial technologies and community members about agricultural production, land-use, community factions, and cultural traditions.

This preliminary work resulted in a course comprising field and lab training that took place during the summer of 2008. The objective of the course was to provide

traditional students as well as non-traditional students (members of the community) with training in data collection by means of GPS as well as integration those and other available data, such as digitization of land-grant, assessor, or other historic maps as well as digitization of land-use from a time-series of aerial photos into a GIS. The geospatial training was framed within the ongoing community mapping efforts (see South Valley Regional Acequia Association website for community developments [9]).



South Valley, NM Community tools

2.3 Sustainable systems – What makes good design –remaining challenges

The case study demonstrates that geospatial technologies can be coupled within traditional farming practices to meet the current challenges facing farmers and small-scale food producers. Applications can be customized to specific needs, but it essential that the design is well thought out. We return to the challenges posed by IAASTD report [2]:

1. Empower marginalized stakeholders and ensure cultural continuity: by providing community the same data and tools as other stakeholders
2. Provide water, maintain biodiversity, sustain natural resource base: this is facilitated through better data management that can be easily updated
3. Manage collaborative generation of knowledge: system is accessible and new information can be easily integrated.

While geospatial and other digital technologies offer promising solutions to these challenges and in particular for urban agriculture, we cannot overstate the importance of community involvement to ensure long-term success. Community members must be involved in all phases of the project from developing research objectives to determining data types to data collection to database and user-interface design. As we hope the case study shows, a PPGIS framework incorporating (1) community

members in design process from initial project stages, (2) education—putting technology in community-hands, and (3) a team with technical, cultural, and management expertise are key elements to assist urban communities as they seek to secure water rights for traditional, sustainable agricultural practices. We advocate educational strategies that provide communities with the tools and skills required to define their specific needs, in terms of system hardware, software, and content, and then enable them to execute solutions to achieve objectives and solve problems. In this sense, the digital divide is narrowed as communities become both consumers and producers of content knowledge [10].

References

1. Patel, R. Stuffed and Starved: the hidden battle for the world food system, Melville House, Brooklyn, New York (2012)
2. McIntyre, Beverly D., Hans R. Herren, Judi Wakhungu, Robert T. Watson, Agriculture at a Crossroads, IAASTD International Assessment of Agricultural Knowledge, Science and Technology for Development, Synthesis Report, Island Press, Washington, DC. (2009)
3. 1848 Treaty of Guadalupe Hidalgo, Nicholas Philip Trist Papers, 1795-1873, Manuscript Division, Library of Congress
4. Craig, W. J., Harris, T. M., & Weiner, D. Community participation and geographic information systems, Taylor and Francis, New York. (2002)
5. Van der Elst, J., H. Richards-Rissetto, J. Garcia, Creating Digital Heritage Content: Bridging Communities and Mediating Perspectives. In Digital Culture and E-Tourism: Technologies, Applications and Management Approaches, pp. 139-157, edited by M. Lytras, P. Ordonez De Pablos E. Damiani, and L. Diaz. Information Science Reference (IGI Global Publishing): Hershey and New York. (2010)
6. BlueRibbonTaskForce. (2010). Sustainable Economics for a Digital Planet, Ensuring Long-Term Access to Digital Information Sustainable Digital Preservation and Access. Final Report, Feb. 2010.
7. 2004, Chinn, Menzie D., Robert W. Fairlie, “The Determinants of the Global Digital Divide: A Cross-Country Analysis of Computer and Internet Penetration.” Economic Growth Center, Yale University, Center Discussion Paper No, 881, March 2004.
8. http://www.lasacequias.org/ website of New Mexico Acequia Association (NMAA)
9. http://www.southvalleyacequias.org/ website of South Valley Regional Acequia Association (SVRAA)
10. Kress, G. (2010). Multimodality, A social semiotic approach to contemporary communication.
11. London and New York: Routledge.

A system to assist subsistence farmers in optimal crop planning decision

Oluwole Adekanmbi[1], Oludayo Olugbara[2]

[1,2]KZN CoLab, Durban University of Technology, Durban, South Africa

1adekanmbioluwole@gmail.com, 2oludayoo@dut.ac.za

Abstract. This paper proposes a web system based on crop-mix optimization to assist subsistence farmers to optimally plan for meager agricultural input resources available. The purpose of agricultural crop planning decision is to guarantee sufficient food resources for the population. However, feeding a world of about 10 billion people remains a grand challenge. In order to reduce complete reliance of people on government or cooperation to provide food resources, household or individual gardening, which can be regarded as subsistence farming is an attractive alternative to guarantee sufficient food production. In subsistence farming, food production is often limited to a backyard, a windowsill farm or a small portion of land for the sole purpose of planting crops for food consumption. Subsistence farming provides a panacea to overcome food insecurity, eradicate poverty, hunger and diseases as well as reduce high costs of foods and high rate of unemployment. However, subsistence farming is generally facing the problems of land allocation, resource management and lack of agricultural knowledge by individuals desiring to engage in subsistence farming. As a result, subsistence farmers need appropriate tools and systems to assist in optimal crop planning decision.

Keywords: Crop, farm, Objective, Optimal, Planning, Subsistence.

1 Introduction

This paper proposes a web system based on crop-mix optimization as an effective way of supporting individuals desiring to engage in subsistence farming to optimally plan for available quantity of agricultural inputs. The crop-mixed approach can ensure food security against total crop failure and maximize returns from limited input resources [1]. Most agricultural problems can be practically formulated as optimization problems to deal with conflicting decision criteria in agricultural systems. The crop planning system being proposed can help to access, record, monitor, display and replay information of farming operations using multi-sources data that may not be easily available to individual farmers. The system also can provide the means to build knowledge and facilitate human resources development in agricultural sector. The proposed system contributes to millennium development goal

of food security because subsistence farming provides a panacea to reduce unemployment, overcome food insecurity and eradicate poverty, hunger and diseases.

The increasing growth of human population worldwide calls for sustainable agriculture to meet the primary need of the population [2]. The constantly increasing human population and human activities have intensified pressure on land use, making it particularly germane for optimal planning. The amount of crops being produced by agricultural farms will influence profit earned on farms and market prices. On one hand, if a farm produces plenty of crops, market prices of crops will decrease to favour consumers. On the other hand, if a farm produces in a small amount, market prices will increase and consumers will have to buy crops at more expensive prices. The one possible way to reduce the costs of food production and the complete reliance of people on government to provide sufficient food resources is subsistence farming. This type of farming is aimed at food production by individuals and any surplus may be sold to buy other goods. However, subsistence farming is generally facing the problems of land allocation, resource management, lack of agricultural knowledge and inaccessibility to important farming information, which demand for optimal planning of input resources.

2 Crop-mix Planning Model

The optimal crop-mix optimization planning model is designed to maximize the total crop production that can be produced by minimizing the total planting area. The objective is to make effective use of the available limited resources in determining hectare allocation, amongst various competing crops that are to be grown in the year. Suppose an individual cultivates a variation of crops in different seasons and has different land types such as single or double land type. The yield rate, production cost and contributions are functions of soil characteristics, region, crop being produced, crop pattern and cropping method. For a single-cropped land, there are a number of alternative crops from which the crop to be cultivated in a year can be chosen. Similarly, there are many different combinations of crops for double-cropped and triple-cropped lands. Different combinations of crops give different crop patterns as outputs.

Rasul and Thapa [3] suggested 12 indicators that were categorized into ecological and economical sustainability indicators to measure the sustainability of agriculture. Ecological sustainability was assessed based on five indicators of land-use pattern, cropping pattern, soil fertility management, pest/disease management and soil fertility. Economic sustainability was assessed based on three indicators of land productivity, yield stability and profitability, which is further accessed based on four indicators of input self-sufficiency, equity, food security and risks/uncertainties. Although many indicators have been developed, they do not cover all aspects of sustainability. Moreover, because of variation in biophysical and socio-economic conditions, indicators used in one country are not necessarily applicable in other countries. The content of the indicators system is different from each other for different countries, regions and development stages and is of great subjectivity [4].

Based on the indicators pointed out in [3], the model applied land-use pattern, cropping pattern, land productivity and yield stability from the crop planted to measure agricultural sustainability.

The optimization model can be designed either as a farm level or a wide crop planning. The model was implemented for a farm level planning incorporated with the data collected from South African grain information service and South African abstract of agricultural statistics [5]. In South Africa, like any other developing countries, where the majority of farmers are smallholders and average land holding size is less than one hectare, the immediate concern of farmers for agricultural development is how to increase crop yields, incomes, food security and reduce the risk of crop failure [6]. The overwhelming majority of farmers lack the proper distribution of lands in different season for crop cultivation and adequate supply of productive resources. Consequently, in view of biophysical and socio-economic conditions in the study area, environmental, economical and social aspects of sustainable agriculture were selected in South Africa.

2.1 Indices

The model indices are *i* is a crop that can be considered for production, *j* is a crop combination made up from *i*.

2.2 Input Parameters

The input parameters to the model are

$C_{i,j}$ is the cost required of per unit area for crop i of crop combination j,

$G_{i,j}$ is yield-rate that is the amount of production in metric tons per hectare of crop i of crop combination j,

L is the available domain of land,

W_c is the working capital (ZAR), which indicates the total amount of money that can be invested for cropping, m is number of alternative crops for land,

M_j is a crop in each j for land, j = 1,…,m.

2.3 Variables

The decision variable to the model $X_{i,j}$ is the area in hectare of land to be cultivated for crop *i* of crop combination *j*.

2.4 Objective function 1

Given the choice of profit maximization and constraints that a farm faces in the production process, the farm attempts to produce a specific level of output that requires maximizing crop production, which can be expressed mathematically as follows:

Maximize

$$F_1 = \sum_{j}^{m} \sum_{i \in M_j} G_{i,j} \times X_{i,j} \tag{1}$$

2.5 Objective function 2

From the socio-economic perspective, besides meeting food demand in the society, attention for cultivating profitable crops is dependent on proper allocation of planting area. Crop production maximization will therefore require minimizing the planting area as follows:
Minimize

$$F_2 = \sum_{j}^{m} \sum_{i \in M_j} X_{i,j} \tag{2}$$

2.6 Constraints

The bi-objective functions considered are to be solved subject to three essential constraints described as follows:

Land constraint: The sum of lands used for a given type of land must be less than or equal to the total available land of that type.

$$\sum_{i} \sum_{j} X_{i,j} \leq L \tag{4}$$

Capital constraint: The total amount of money that can be spent for crop production must be less than or equal to the working capital.

$$\sum_{j}^{m} \sum_{i \in M_j} C_{i,j} \times X_{i,j} \leq W_c \tag{5}$$

Non-negativity constraint: The decision variables must be greater than or equal to zero:

$$X_{i,j} \geq 0 \quad \forall \; i,j \tag{6}$$

3 Model Implementation

The Generalized Differential Evolution 3 (GDE3) optimization method was implemented in the proposed system to solve the optimal crop planning model described by Equations 1-6. The implementation was done using C-sharp programming language in Visual-Studio version 2010 on an HP PC with Pentium dual core processor having 2.30GHz clock speed and 4GB of RAM. The interested reader should refer to [7] for more details about the GDE3 optimization method. The validation of the GDE3 method was done with 10000 fitness function evaluations. The combination of parameters chosen for the method is appropriate to have a reasonably good performance. This can be corroborated by checking the original sources of the GDE3 method.

The functional requirements of the proposed web system are captured using Unified Modeling language (UML) use cases diagram. UML is an accepted Object Management Group (OMG, http://www.omg.org) modeling language standard, which is well established and used in industry and research. Figure 1 shows use case diagram of the proposed system, which identifies, clarifies and organizes the essential requirements of the system. The use case diagram is represented by two extended actors (physical and logical actors) and some use cases. The physical actor represents a household farmer as a user who visits the system for optimal cropping decision support. The logical actor represents a role played by a human user to assure the maintenance of web system.

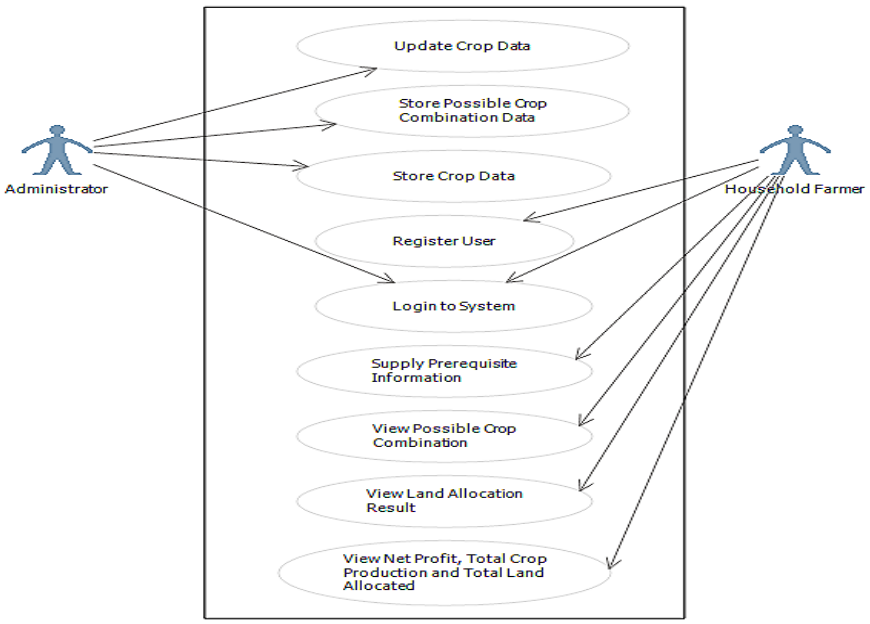


Fig. 1. Use case diagram of the crop planning system

On receiving inputs from a farmer, the system can initiate four main tasks, view crop combination group, view possible crops combination, allocation of land to possible crops combination and displaying of total crop production and total land use. Figure 2 shows the UML activity diagram for the optimal crop planning process.

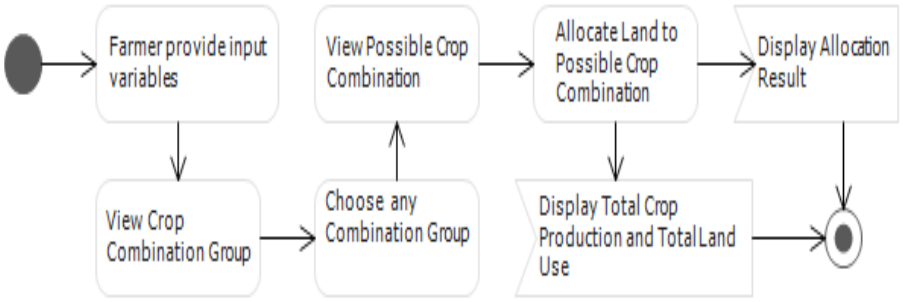


Fig. 2. The activity diagram of the crop planning system

4 System Description

The system was tested with a scenario where a household farmer has a working capital of R10000 with the land mass of 1 hectare. The farmer chooses to plant cotton and maize with all crops that could be together planted with cotton and maize on a

triple-cropped land. The farmer, using our system is able to view crops combination groups, which consist of crops that could be planted with the selected crops (cotton, maize). The farmer can select any of the crop combination group of his choice to view the number of possible crops combinations that could be obtained using our system. Figure 3 shows the screen shot of the whole process.

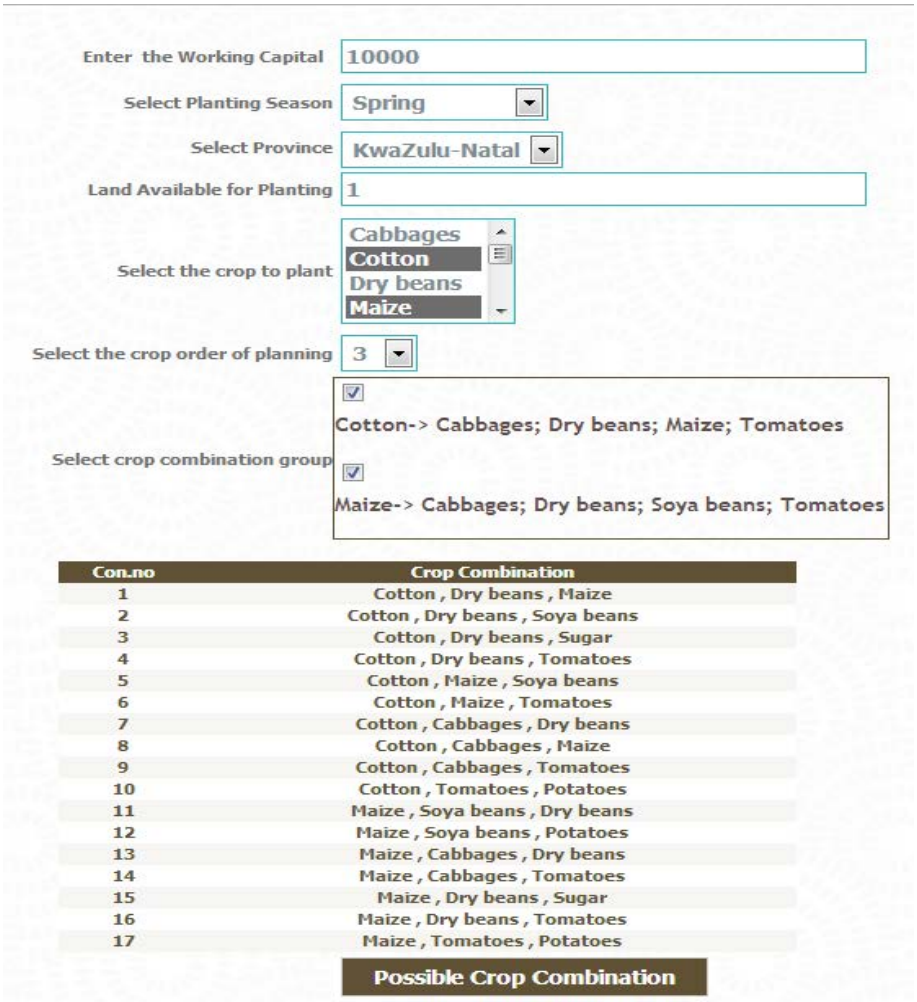


Fig. 3. Capturing inputs into crop planning system

The crop planning system allocates a land potion to each crop combination and produces the result in Figure 4 to give the allocated land area for each possible crops combination.

Con.no	Crop Combination	Allocated Land Potion (ha)
1	Cotton, Dry beans, Maize	0.053535382
2	Cotton, Dry beans, Soya beans	0.051579819
3	Cotton, Dry beans, Sugar	0.050574144
4	Cotton, Dry beans, Tomatoes	0.053764994
5	Cotton, Maize, Soya beans	0.051453829
6	Cotton, Maize, Tomatoes	0.052105788
7	Cotton, Cabbages, Dry beans	0.050436255
8	Cotton, Cabbages, Maize	0.051946508
9	Cotton, Cabbages, Tomatoes	0.050326661
10	Cotton, Tomatoes, Potatoes	0.053539963
11	Maize, Soya beans, Dry beans	0.051171848
12	Maize, Soya beans, Potatoes	0.051352205
13	Maize, Cabbages, Dry beans	0.052403023
14	Maize, Cabbages, Tomatoes	0.051149658
15	Maize, Dry beans, Sugar	0.052543936
16	Maize, Dry beans, Tomatoes	0.058001233
17	Maize, Tomatoes, Potatoes	0.051986122

Fig. 4. Land allocation per crops combination

The crop planning system also shows the optimal that is the best crop production per total land utilization. Figure 5 shows this result.

Total Crop Production (Tons)	Total Land Used (ha)
30.4358729388885	0.887871369022213

Fig. 5. Optimal crop production and total land utilization

5 Conclusions

This work suggests that an approach based on crop-mix optimization provides a useful means for aiding optimal crop planning decision. The suggested approach can help subsistence farmers to efficiently utilize the available meager resources, including planting area, time and money. The approach combines indigenous farming with information technology to optimize crop production, support efficient planning and help subsistence farmers to determine the possible combination of crops to plant on the same planting land year by year. The model has the capability to support large scale farming. Besides the optimization of total crop production and land use, the system can be used for maximizing net profit both at a farm level and wide crop planning. In the future, we plan to deplore the implementation of this approach as mobile web services to make the approach more useful to anyone desiring to engage in subsistence farming. The model has the

References

1. Lewandowski, I., Härdtlein, M., and Kaltschmitt, M. (1999): 'Sustainable crop production: definition and methodological approach for assessing and implementing sustainability', Crop science, 39, (1), pp. 184-193.
2. Tanko, L, Baba, K.M., Adeniji, O.B. (2011): Analysis of the competitiveness of mono-crop and mixed crop enterprises in farming system of smallholder farmers in Niger State, Nigeria. International Journal of AgriScience Vol. 1(6): 344-355.
3. Rasul, G., Thapa, G. B. (2004): 'Sustainability of ecological and conventional agricultural systems in Bangladesh: an assessment based on environmental, economic and social perspectives'. Agri. Syst., 79, pp. 327-351.
4. Bellows, B. (1994): 'SANREM Research Report. Proceedings of the Indicators of Sustainability Conference and Workshop'. Washington State University, Arlington, Virginia, USA.
5. AAS, 2012. Abstract of agricultural statistics: 2012. National Department of Agriculture, Pretoria. http://www.nda. agric.za/
6. Pretty, J. N. (1995): 'Regenerating Agriculture: Policies and Practice for Sustainability and Self-Reliance'. Vikas Publishing House Pvt. Ltd., New Delhi, India
7. Kukkonen, S., and Lampinen, J. (2006): 'Constrained real-parameter optimization with generalized differential evolution', in Editor (Ed.): 'Book Constrained real-parameter optimization with generalized differential evolution' (IEEE, 2006, edn.), pp. 207-214.