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Editorial

Food System Techniques and Agricultural Practices: Towards Environmental, Economical and Social Sustainability

Prof. Dr. El Sayed El Habbasha, Agronomist, Field Crops Research Department, National Research Center, Egypt. He is a member of a number of National and International Research Projects. He is a member of the Editorial Board of the Future of Food: Journal on Food, Agriculture and Society.

Agriculture faces many challenges, making it more and more difficult to achieve its basic targets, such as the production of food, feed, fiber and other goods. An increasing the population must also be taken into account. Global population size will increase from nearly seven billion today to more than eight billion by 2030; many people are likely to be wealthier, creating demand for a more varied, high-quality diets requiring additional resources to produce. On the production side, competition for land, water and energy will condense, while the effects of climate change will become increasingly apparent and global food systems are increasingly menaced by different stresses. The food system continues to provide plentiful and affordable food for the majority of the population in the world. Now the world population is at a unique time in history as diverse factors assemble to affect the demand, production and distribution of food through the next decades. The needs of a growing world population will need to be satisfied as critical resources such as water, energy and land become increasingly scarce. Agriculture must change to meet the rising demand of the people, to contribute more effectively to the reduction of poverty and malnutrition, and to become ecologically more sustainable and increase the prosperity and the level of well-being. There are two major ways which require categorical action on food production systems:

- Hunger remains widespread, more than one billion people experience hunger, they lack

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access to sufficient of the major macronutrients and may be another billion are suffer from 'hidden hunger', which important micronutrients are missing from their diet.
- Many food production systems are unsustainable, the global food system will continue to degrade the environment and compromise the world's capacity to produce food in the future, as well as contributing to climate change and the biodiversity destruction. There are many problems which are widespread i.e. soil loss due to erosion, loss of soil fertility, salination and other forms of degradation.

The food system is not a single designed structure, but rather self-organized groups of interactive parts. The food systems of different countries are now linked at all levels, from trade in raw materials to processed products and increase the efficiency of communication networks between different countries is very vital because this will make the process of import and export is easily and this will meet the desires of many people from the products. Besides on-farm production, capture fisheries and aquaculture are also important, and provide livelihoods, with about a billion people depending on fish as their main source of animal protein. Most of the economic value of food products, particularly in high-income countries, is added beyond the farm stage in food processing and in retail, which together comprise an important section of world economic activity. At the end of the food chain, the consumer exerts choices and preferences that have a recondite influence on food production systems and supply, while companies in the food system have great political and societal influence and can shape consumer preferences. The food system must become sustainable, whilst adapting to climate change and substantially contributing to climate change mitigation. There is also a need to redouble efforts to address hunger, which continues to affect so many of the world population.

Agricultural Practices are specific methods which are applied to agriculture to increase the amount of crop yield or the quality of the products or both at same time to create food for consumers or further processing that is safe and wholesome. These agricultural practices includes soil preparation, sowing methods and date, fertilization. In this direction these challenges can be tackled in part of a Good Agricultural Practice (GAP), practices that improve environmental, economic and social sustainability of on-farm production and results in safe and quality food and non-food agricultural products. GAP stands on four main columns : economic viability, environmental sustainability, social acceptability and food safety and quality. The Good Agricultural Practice approach can contribute significantly to implementing sustainable agriculture and rural development while addressing the demand-side priorities of consumers and retailers, the supply-side priorities of producers and labourers, and those institutions and services that are bridging supply and demand. While a Good Agricultural Practice approach may respond to the growing demands of increasingly globalization and incorporated agricultural sectors, it is also very important for local, national and international markets. In recent years, the concept of Good Agricultural Practice has evolved to address the concerns of different stakeholders about food production and security, food safety and quality, and the environmental sustainability of agriculture. These stakeholders include governments, food retailing industries, farmers and consumers who seek to meet specific objectives of food safety, food production, production efficiency, livelihood and environmental benefits. There are some benefits related to Good Agricultural Practice these benefits include, appropriate promotion and adoption of these practices from farm to fork will help improve the safety and quality of food and agricultural products, adoption of these practices will help promote sustainable agriculture and contribute to meeting national and international environmental and social development objectives and adherence to food quality and safety will protect people's health.

I am delighted to be a member of the editorial board of the "Future of Food: Journal on Food, Agriculture and Society". Herewith, we are pleased to publish our Volume 4 Number 2, on the theme of "Food System Techniques and Agricultural Practices". The selected research papers presented in this issue will provide further insight on food system techniques and agricultural practices in regional and global perspectives. Furthermore, this edition is enriched with book reviews that bring a critical outlook on thematic books.

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Tanzanian Food Origins and Protected Geographical Indications

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Food origins, Food security, Protected Geographical Indications

Abstract

As the world's population is constantly growing, food security will remain on the policy Agenda, particularly in Africa. At the same time, global food systems experience a new wave focusing on local foods and food sovereignty featuring high quality food products of verifiable geographical origin. This article argues that Geographical Indications (GI´s) hold the potential to help transform the Tanzanian agriculture-dependent economy through the tapping of value from unique products, attributing taste and colour to place or regional geography. This study aims to identify the existence and characteristics of food origin products in Tanzania that have potential for GI certification. The hypothesis was that there are origin products in Tanzania whose unique characteristics are linked to the area of production. Geographical indications can be useful policy instruments contributing to food security and sovereignty and quality within an efficient marketing system with the availability of government support, hence the need to identify key candidates for GI certification. Five Tanzanian origin products were selected from 14 candidate agricultural products through a scoping study. Rice from Kyela, Aloe vera, Coffee and Sugar from Kilimanjaro and Cloves from Zanzibar are some of the product cases investigated and provides for in-depth case study, as ´landscape´ products incorporating ´taste of place´. Interviews were conducted to collect quantitative and qualitative data. Data was collected on the production area, product quality perceived by the consumer in terms of taste, flavour, texture, aroma, appearance (colour, size) and perceptions of links between geography related factors (soil, land weather characteristics) and product qualities. A qualitative case study analysis was done for each of the (five) selected Tanzanian origin products investigated with plausible prospects for Tanzania to leapfrog into exports of Geographical Indications products. Framework conditions for producers creating or capturing market value as stewards of cultural and landscape values, environments, and institutional requirements for such creation or capturing to happen, including presence of export opportunities, are discussed. Geographical indication is believed to allow smallholders to create employment and build monetary value, while stewarding local food cultures and natural environments and resources, and increasing the diversity of supply of natural and unique quality products and so contribute to enhanced food security.

Introduction

An increasing number of agricultural local products, worldwide, are registered as Geographical Indications (GIs). Consumers worldwide demand products with more unique origin, which are connected to the land use systems producing particular qualities. GIs support the achievement of food security by increasing the ability of traditional farming communities to acquire income that supports exchange entitlements through trade policies (Blakeney, 2009).

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Figure 1 : The regions are Kilimanjaro (North), Mbeya (south) and Zanzibar (on the left of the map) both Unguja and Pemba
Source: Primary Education Support Project (PESP) Dar es Salaam, Tanzania *http://www.pesptz.org/images/map1.jpg*

In the current trade regime, GIs are confronted in quality forums with new social concerns and values, from biodiversity to food security. As per the FAO (2009) it explains how GIs determine and influence food security by providing better income for producers and creating better economic access to food. GIs generate local economic benefits through greater market access and equity in international trade, thereby improving conditions for small and local farmers to sell their products and buy their necessities (Dagne, 2012). GIs "contribute to food security in rural areas, as far as they are considered and implemented as a rural development tool, and not only a commercial or legal one (Petrics and Eberlin, 2009).
GIs have the potential as an economic policy instrument in helping to transform the Tanzania agriculture-dependent economy through exploiting the unique attributes of their quality products namely aroma, taste and colour. Tanzania has already demonstrated the capacity to tap into the organic world market. Therefore protecting Tanzania's unique agricultural products using GI could lead to higher value-added products through product differentiation based on quality, providing consumers with certified information regarding product attributes, and enhance and preserve the identity and cultural heritage of the specific region, where a product is produced (Blakeney et.al, 2012 and Dagne, 2014).

The objective is to identify the existence and characteristics of food origin products in Tanzania that have the potential for GI certification. The hypothesis is that there are origin products in Tanzania whose unique characteristics are linked to the area of production. The paper presents preliminary results from VALOR (Valorizing African Agriculture), a research project investigating conditions under which Africa and in this case, Tanzania food producers can add value by incorporating territory specific cultural, environmental and social qualities into marketing, production and processing of unique local, niche and specialty products.

Methods

Field studies were undertaken between June and August 2014, which is the harvest period for most of the crops. The study used different methods to collect data addressing the main objective. Five agricultural products namely, coffee (Coffea Arabica), aloe vera (Aloe

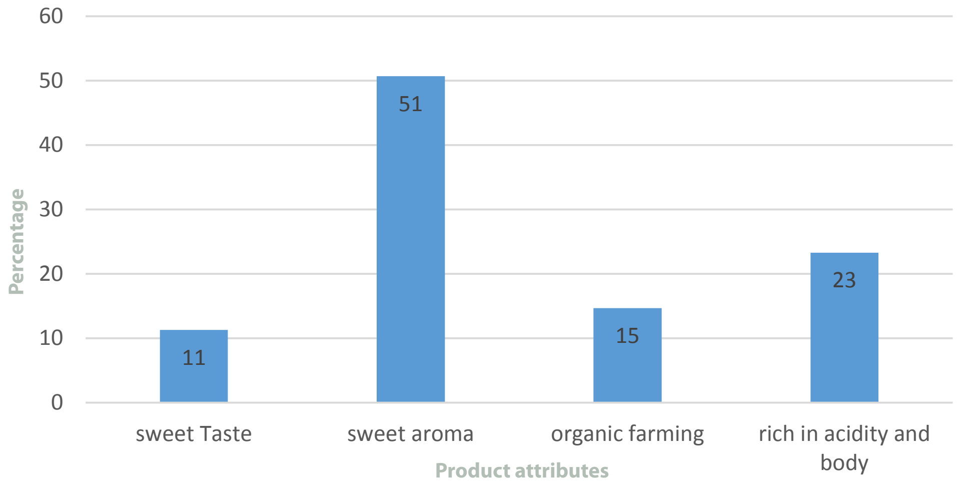

Figure 2: Sources of specific qualities of the products

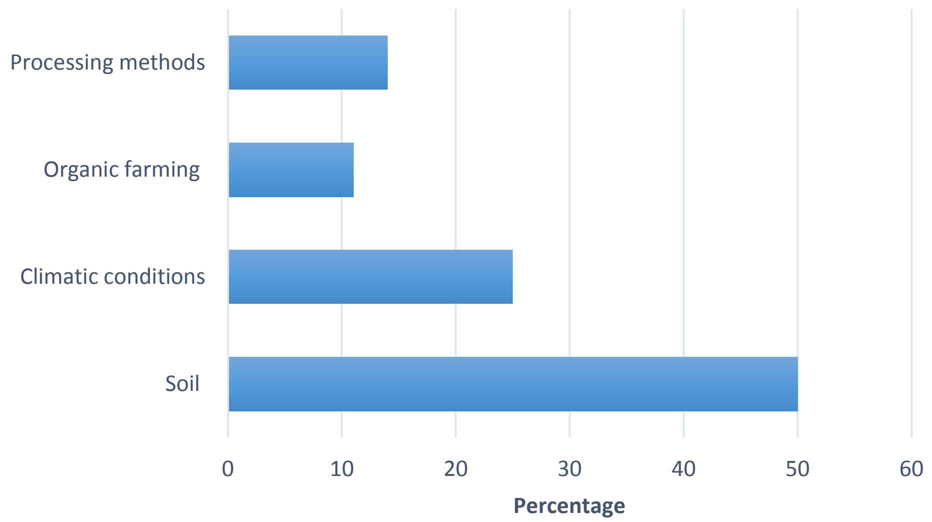

Figure 3:Kilimanajro Coffee Specific origin related attributes

barbadensis miller), rice (Oryza sativa), cloves (Syzygium aromaticum), and sugar cane (Saccharum officinarum), were selected from 14 candidate agricultural products through a scoping study. The selection was based on the following criteria: a) clear delimitation of production area, b) origin reputation of a product, c) quality perceived by consumer in terms of taste, flavour, texture, aroma, appearance (colour, size). Further, selection criterion includes market potential (prices comparing with similar products), geographical link (soil, land weather characteristics), agricultural system (organic, traditional methods) and collective actions (formal or informal producer organisation).

Fifteen key informant interviews from the ministry, Business Registration and Licensing Agency (BRELA) and district level were carried out in three study regions namely Mbeya, Moshi and Zanzibar (**Figure 1**)

To address the study objective, a semi-structured questionnaire to producers and processors was used to collect quantitative data. In addition, qualitative data was collected from five focus group discussions with producer associations, while direct observation was used for observing the cultivation methods and processing of the food products. In order to gather information about the product characteristics /attributes of the potential food origins in Tanzania (in three regions), an in-depth single case study methodology developed by Yin (2003) was used.

In accordance with FAO (2009), the special attributes investigated the included product unique characteristics, common rules for the production and handling of the

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product, marketing strategies, and geographical characteristics of the area. Complemented with short in-depth interviews with consumers on the awareness of the unique quality of the product, the price difference for the product they buy was compared with others in the same category, product seasonality and its demands and the availability of niche markets.

Results and Discussion

Mainland Tanzania doesn't have a legal framework on GIs, instead it has already recognised the potential of protecting its clove industry and has incorporated the GI law in its industrial act. The Business Registration and Licensing Agency (BRELA) and Ministry of Industry, Trade and Marketing are making efforts to have a comprehensive Intellectual Property Rights (IPRs) legislation along Trade-Related Aspects of Intellectual Property Rights (TRIPS) lines for mainland Tanzania.

For such a law to be feasible, there is a need to analyse the unique characteristics of the potential food origin GIs in the country. The products unique qualities are attributed to the area, in which these products are produced, see **Figure 2**, where interviews were conducted for respondents to identify the different quality-geography links. More than 50% of the respondents in the regions, where the products were produced claimed that most of the product quality was from the soil of the area, which is a geographical link to the product attribute.

GI awareness

Producers' awareness of the concept of GI was explored by asking them if they are aware of such a concept. The survey results showed that only 20% of the respondents knew the meaning or have heard of the term GI and 80% of respondents had no idea on GIs. When asked if they had ever seen any of the EU logos used to identify a GI product, only 2% of the interviewees said that they had seen such logo and the rest 98% had never seen the EU logos. Majority of the respondents were not aware of the concept of GI and were not aware of any attribution or link between product quality, reputation and characteristics of their territory. However, 95% of the respondents in Kilimanjaro and Kyela-Mbeya and 90% of the respondents in Zanzibar were aware of the unique quality attributes that products had.

Origin product cases

Kilimanjaro Coffee

Coffee from the Kilimanjaro region is distinguishable from other coffees (by aroma and taste) and easily recognizable for experts. Its particular quality is much attributed to the volcanic soil on which it is grown, at the slopes of mountain Kilimanjaro. The soil type is associated with a particular degree of acidity, which has been identified as one of the main contributors to the coffee quality. **Figure 3** results further showed that 51% of the respondents said coffee has a unique distinctive aroma and 23% said it was rich in acidity and body that distinguished Kilimanjaro coffee from other coffees produced in the country. Apart from the volcanic soil, other factors mentioned during the interviews contributing to the quality of the coffee is processing and de facto organic farming which is a widespread production method in the area. (United Republic of Tanzania (URT), 2012).

Kilimanjaro Sugar (TPC)

Sugar from the Kilimanjaro region is a well-known product in Tanzania and regarded as having excellent quality. The difference between TPC sugar and any other sugar produced in Tanzania results from quality control, according to one of TPC agronomists who was interviewed during the fieldwork.

The quality control process for the sugar starts from the planting sugarcanes, the crop requires low temperatures, low rainfall and low use of fertilizer such as nitrogen. The TPC agronomist during the interview, clearly stated that because of the high level of potassium in the soil due to the volcanic soil, sugarcane in Kilimanjaro requires little manure . The water for irrigation is rich in minerals that keeps the crops healthier and less susceptible to disease. The soil (volcanic) structure in the region is very favourable for production. The agro-climate conditions make the sugarcanes produced in the region of excellent quality that is highly controlled during processing. The sugar has specific unique characteristics, the colour is light brown and crystal size is smaller (Agriculture, 2014).

Cloves Zanzibar

Zanzibar's economy is based primarily on the production of cloves where export earning accounts up to 70 % of the country's Gross Domestic Product (GDP). The State Trading Corporation (ZSTC) acquires all of the cloves produced in Unguja and Pemba under legislation (Blakeney et.al, 2012).

Protection of the origin of Zanzibar cloves, can be based on a number of unique features identified during fieldwork by the researcher through interviews with respondents namely distinctive aroma, unique flavour, bitter sweet taste, brown reddish colour, distinctive size, slenderness, and oil content (low).

Kyela Rice

Among many other products, rice in Tanzania is one of the agricultural foods used in checking the level of food security in the country. There are many rice producing regions, however rice grown in the south of Tanzania, in Kyela district of Mbeya region, is quite different compared to other rice. Results suggest that the unique attributes of Kyela rice are its distinctive aroma and appealing taste. It was identified that the rice is grown in a highly fertile soil on the flood plains of Rungwe Mountain. This rice is mostly sold in the local market and very little exported (MOF, 2013).

Kyela rice has gained a very high reputation over the years in and outside the country. While it is the main staple food and main source of income to the Kyela people (Gideon, 2013), there has been misuse of the name as traders within the country are using the name Kyela to sell rice that is not Kyela rice, hence a need for the country to protect and enforce such products through GI .

Kilimanjaro Aloe Vera

Aloe vera in Tanzania is grown in Kilimanjaro and Tanga, it belongs to the family Asphodelaceae (Liliaceae) and is mainly cultivated for its thick fleshy leaves (Ogendo et.al, 2013). The Kilimanjaro Aloe vera plantation is based in the Kilimanjaro region, not far from the town of Moshi and on the hot plains below Africa's highest mountain; the snow-capped Kilimanjaro. There are 500 acres of rich fertile land on the hot plains below Mount Kilimanjaro, being the first plantation producing top quality juice for Africa at an affordable price with over five million Aloe barbadensis var. chinensis plants .

One company, Kibo Irrigation, cultivate Aloe vera in the Kilimanjaro area. The unique attributes are the plants genuine medicinal properties, with quality of the product being due to the volcanic soil in the region and the waters flowing the mountain Kilimanjaro. The Aloe vera juice is thick with a sweet bitter taste. Comparing it with imported Aloe vera products, it is of high quality with 99.7 pure aloe vera and with an affordable price to the consumers.

Organically produced, Kilimanjaro Aloe vera is processed using traditional production and harvesting methods that have positive effect on quality. Aloe vera contains numerous vitamins and minerals, enzymes, amino acids, natural sugars and agents that may be anti-inflammatory and anti-microbial. The combination and balance of the plant's ingredients are what purportedly gives it its healing properties.

GI and Food security

Food security does not relate only to quantity and volume but also to quality and consumers preferences, economic (price and income) and physical access (proximity) of food products (ARIPO and EU, 2012). Food security includes not only availability, but also accessibility of culturally appropriate food. Creating better economic access to food, can determine and influence food security (FAO, 2008) Geographical indication can enhance food security in a policy framework of food sovereignty, which focuses on three major priority areas: ensuring access to productive resources; mainstreaming agro-ecological production, and encouraging participation in trade and local markets. Geographical indication may be relevant to the guarantee of food sovereignty through measures that address each priority area (Teshager W Dagne, 2014).

In Tanzania, the government made a number of campaigns, programmes and reforms with the objective of attaining food security, some of the policies and programmes formed are the 1978 Public Works for food security, 1991 National Food and Nutrition Policy, 1991 National Food Security Programme, 2011 National Food Strategy and National Agriculture Policy of 2013.

Such policies and programmes are coordinated between agriculture and nutrition related ministries, namely the Ministry of Agriculture, Food Security and Cooperatives; Ministry of Livestock and Fisheries; Ministry of Industry, Trade and Marketing; Ministry of Health and Social Welfare; Tanzania Food and Nutrition Centre; and the Prime Minister's Office Regional Administration and Local Government.

Kavishe (Kavishe, 1993) points out how the implementation of the agricultural policy and the strategy have not made a significant impact on food security. With the current absence of a national policy for GI products, the policy level clearly represent one barrier for pursuing food sovereignty security through valorisation of origin products. Hence, access to new markets in niche areas and a reinforcement of the national market is a key to the successful commercialization of GI/origin products.
Our hypothesis is that GI´s can be useful policy instruments contributing to food security and quality within an efficient marketing system and availability of government support. Food security not only relates to quantity and volume but also to quality, economic aspects (price and income) of food products. Considering this, by providing a better income for producers and creating a better economic access to food, can determine and influence food security (FAO, 2009).

Conclusion

Based on key informant interviews with origin food producers, the study revealed a potential for value addition by recognition of territory specific cultural, environmental and social Tanzanian origin product qualities into marketing, production and processing of unique local,

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niche and specialty products in the Mount Kilimanjaro and Mbeya regions of Tanzania. The origin product cases investigated indicated prospects for Tanzania to advance in exports of geographical indications products as well as in domestic markets. Price premiums on origin products registered with a GI may allow smallholders create further employment and build further monetary value, while stewarding local food cultures and natural environments and increase the diversity of natural and unique quality products.

Several origin products in Tanzania have potential for GI protection. Tanzania may potentially gain using GIs to market even some of its larger crops such as, bananas, and cashew nuts, as well as new non-traditional crops such as spices and oilseeds. Tanzania also has an option of using a GI approach for its handcraft and products made in specific regions, especially those made around the safari destination areas. This marketing tool is of use in South Africa for wines, where tourists get to visit the sites of manufacture as well as buy products such as "rooibos tea".

GIs could be used as economic agricultural policy instruments for the Tanzanian regional association producers to protect products and enable alliances of farmers of such products to earn a higher price for their products and thus more income to sustain their lives.

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Conflict of Interests
The authors hereby declare that there are no conflicts of interest.

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Adaptability of three newly introduced apricot (Prunus armeniaca L.) cultivars to Egyptian conditions

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Apricot cultivars, Chilling requirement, Heat units

Abstract

An experiment was conducted in 2013 and 2014 with three newly introduced cultivars of apricot (Prunus armeniaca L.), namely "Antonio Errani", "Tirynthos" and "Ninfa" to study their performance and adaptability under Egyptian conditions. Results indicated that calculating the chilling hours temperature at or below 15°C was more suitable than temperatures at or below 7.2°C and 10°C. The cultivar with a low chilling requirement started with the opening of vegetative and flower buds earlier when compared to other cultivars. Furthermore, the cultivar Ninfa required less heat units as compared to the other two cultivars. Thus, the accumulated growing degree-days (GDDs) from the time of the flower bud break l until fruit maturity was low in early matured Ninfa cultivar. However, Antonio Errani and Tirynthos cultivars were late in the date of fruit ripening. Meanwhile, there was no significant difference in the opening percentage of vegetative and flower buds, trunk circumference, fruit drop, fruit number and yield weight among cultivars during the two seasons. Conversely, the leaf drop of Antonio Errani cultivar was earlier while Ninfa cultivar started it's leaf drop later in the two seasons. Tirynthos gave the highest fruit weight, fruit size and fruit surface lightness. Meanwhile, the Antonio Errani cultivar was the highest in fruit firmness and total soluble solids. The appearance and behavior of cultivars under the study varied from one season to another with shoot length, leaf area, percentage of fruit set and acidity. It can be recommended from the present study that, Antonio Errani, Tirynthos and Ninfa cultivars are well adapted under Egyptian conditions. Further, fruits from the cultivars mature early and late in the season and can fulfill the demands of the market.

Introduction

Apricot (Prunus armeniaca L.) is a popular fruit and considered one of the more important fruits in the world. Research is being conducted all over the world to optimize production of high- quality apricots (Vachůn et al., 1995). It is not easy to incorporate traits such as heat and cold requirements, blossoming time, frost hardiness, disease resistance and high fruit quality into a single breeding program (Benedikova, 2004). Fortunately, during the last ten years, several apricot cultivars have been introduced to Egypt by the Central Administration of Horticulture, Ministry of Agriculture. These cultivars were early and medium maturing ones and available for sale in the local markets with high prices. Areas of apricot orchard in Egypt reached about 8570 ha with a production of about 92444 tons (Ministry of Egyptian Agriculture, 2013). Thus new cultivars need to be evaluated and selected that can perform well on a commercial scale under local environmental conditions oin Egypt (Tapor, 2002). Pedigree of "Ninfa" cultivar is a hybrid between (Ouaroy x p. dc Tyrinthe) and originated in Italy (Oguzhan et al., 2012). The pedigree of "Antonio Errani" cultivar was selected from Reale D, Lmola and has an Italian

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Figure 1 a: Antonio Errani - Pit, flesh and mature fruits of apricot cultivars

Figure 1 b: Tirynthos - Pit, flesh and mature fruits of apricot cultivars

Figure 1 c: Ninfa - Pit, flesh and mature fruits of apricot cultivars

origin (Oguzham et al., 2012). Antonio Errani, Tirynthos and Ninfa apricot cultivars were introduced from the Bari region in the south of Italy.

The aim of this study is to evaluate some new apricot cultivars that have been introduced from Italy recently. This research study facilitates proper recommendations of suitable apricot cultivars to Egyptian conditions.

Material and Methods

The present study was conducted through the 2013 and 2014 seasons to evaluate three new apricot cultivars recently introduced to Egypt. These cultivars were ''Antonio Errani'', (**Figure 1a**) ''Tirynthos'' (**Figure 1b**) and ''Ninfa'' (**Figure 1c**). The trees were three year old budded Manicot seedlings rootstock, pruned to the vase shape system and planted at 5 X 4 m apart and grown in sandy soil under drip a irrigation system in a private orchard at Khatatba region, Egypt. Each cultivar was represented by three trees uniform in size and vigor. The following variables were measured:

Chilling and heat requirements: Thirty shoots at one-year-old were tagged on each tree of each cultivar. These shoots were left unpruned to determine bud break date to calculate chilling hours and heat hours requirements. Degrees of temperature at the Khtatba region from the Central Laboratory of Agricultural Climate (CLAC) were recorded all year around by means of hygrothermorgraph (model H 311 weather Measure Corporation) in a weather shelter, placed 1.5 M above ground.

Determination of chilling requirements: In each season, temperatures were recorded every two hours all year round. Calculation of chilling hours was started in late fall when temperature dropped to 15°C (Nov. 20, 2013 and Nov. 18, 2014). The termination of vegetative bud was determined when about 50% of the total numbers of buds took the pyramidal shape. Conversely, the termination of flower buds was determined when about 50% of the total number of buds took the dome shape (Azza, 1995). The chilling requirements of vegetative and flower buds were calculated as follows:

Total hours at or below 7.2°C, 10°C and 15°C were recorded according to Weinberger (1950), Gilreath and Buchanan (1981), Sherman and Tyrene (1989) and Azza, (1995) respectively.

Heat units: Heat units were calculated when chilling was terminated and until the maturity of the fruit. Different stages of flower bud development (swelling bud, burst bud, pink balloon, advanced pink balloon, full bloom, petal fall, initial fruit set, final fruit set) as well as the beginning of pit hardening and fruit maturity in relation to accumulated heat units at each defined stage were determined for each cultivar. Heat units in terms of GDD from the predicted time of dormancy completion until fruit maturity were calculated as describe by Shallenberger et al., (1959) as per the equation 1 (Eq [1]):

$$GDD = \frac{(Tmin + Tmax)}{2} - T\ base \qquad \text{Eq. 1}$$

Where, T_{base} is 4.4°C (T_{base} = base temperature)

Vegetative growth

The same shoots previously selected for determination of chilling and heat units (30 shoots / tree) were used to determine the following measurements:

Date and percentage of vegetative bud opening: Date of vegetative bud opening per tree was determined at the opening of the bud burst. The opening percentage of vegetative buds (as a percentage of total number of vegetative buds) was determined 30 days after bud burst stage.

Shoot length (cm), leaf area (cm^2) and trunk circumference (cm): Shoot length and trunk circumference were measured using measuring tape at the end of the growing season (December). For leaf area determination, samples were taken from the fourth to the sixth leaf from the top of the selected shoot (three leaves per shoot X thirty shoots per tree) to measure their leaf area using LI-COR-Portable leaf area mater (LI-3000, LI-COR Inc., Lincolin, USA) and expressed it as cm^2.

Dates of leaf drop: Dates were taken when 50% of the leaves were dropped.

Flowering and fruiting

The above selected shoots per tree (30 shoots) were used to determine the following measurements:

Percentage of flower bud opening: Percentages of flower bud opening were recorded and determined at the completion of flowering (full bloom) of each cultivar and calculated using equation 2 (Eq. [2]):

$$\text{Percentage of flower bud opening} = \frac{\text{Number of opened flower buds}}{\text{Total number of flower buds}} \times 100 \qquad \text{Eq. 2}$$

The total numbers of flower buds were counted when they took the dome shape.

Dates of different stages of flower bud opening: Dates of the eight stages of flower bud development were recorded to be correlated with heat units required to reach each stage. These stages are:

1. Swelling bud
2. Burst bud
3. Pink balloon
4. Advanced pink balloon
5. Full bloom
6. Petal fall
7. Initial fruit set
8. Final fruit set

Fruit set percentage: The fruit set was determined by counting number of set fruits (after 30 days of full bloom). The percentage of the fruit set was calculated

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Table 1 : Chilling hours at or below 7.2°C, 10°C and 15°C of vegetative buds of selected new apricot cultivars in the years 2013 and 2014 seasons

Cultivar	2013 season				2014 season			
	Date of rest termination*	Chilling at or below			Date of rest termination*	Chilling at or below		
		7.2°C	10°C	15°C		7.2°C	10°C	15°C
Antonio Errani	Mar. 19	0	6	297	Mar.30	0	4	221
Tirynthos	Mar. 19	0	6	297	Mar.30	0	4	217
Ninfa	Mar.17	0	6	294	Mar.28	0	4	217

* Date of termination was determined when 50% of vegetative buds take the pyramidal shape

using equation 3 (Eq. [3]).

$$\text{Fruit set \%} = \frac{\text{Number of set fruit}}{\text{Total number of flowers at full bloom}} \times 100 \text{ — Eq. 3}$$

Fruit drop percentage: Fruit drop percentage was calculated every ten days starting from fruit set until fruit maturation. The fruit drop percentage was calculated using equation 4 (Eq. [4]).

$$\text{Fruit drop \%} = \frac{\text{Number of dropped fruit on a given date}}{\text{Total number of set fruits}} \times 100 \text{ — Eq. 4}$$

Yield

At the harvest time of each cultivar, the number of fruits per tree was taken for studying the following physical and chemical properties of fruits:

Fruit physical properties: Weight, size, height and diameter of fruit, flesh diameter and seed weight were determined. Flesh colour was recorded visually. Fruit skin colour measurement was taken using a Hunter Colorimeter (type DP-9000. In this system of colour representation the value b* describe a uniform negative for blue and positive for yellow (90º= yellow, 270º = blue). L* colour lightness were quantified at stimulus colormetery data, it was determined using chromameter model DP-9000, colour was represented by L (whiteness/darkness, ranged from 0 to 100 being (MeGuire, 1992). Stone freeness was determined as free semi free and cling size and the weight of the pips were recorded. Firmness was evaluated with a manual penetrometer (model Effegi FT 327, Italy) on two peeled opposite sides at the equatorial region of the apricot. Using an 8mm - wide plunger and expressed as LP/inch^2.

Fruit chemical properties: Total soluble solids in juice (T.S.S) were measured with a hand-held refractometer model 10419. Juice Acidity was determined according to A.O.A.C. (1970) and calculated as gram anhydrous citric acid/ 100 ml Juice.

Statistically analysis

The data of vegetative growth, flowering and fruit set during the 2013 and 2014 experimental seasons were subjected to analysis according to Snedecor and Cochran (1990) using the MSTAT program. Least significant ranges (LSR) were used to compare means of the treatments responses according to Duncan (1955) at a probability of 5%.

Results and Discussion

Chilling requirements

a) Chilling requirements of vegetative buds:

Available and estimated chill hours (C.H.) from dormancy onset until vegetative bud took the pyramidal shape (**Table 1**) equal at or below 7.2°C and 10°C with selected cultivars. However, it was varied at or below 15°C.

b) Chilling requirements of flower buds:

The available and estimated chill hours from dormancy onset until the flower bud took the dome shape were affected by cultivar and season at or below 15°C. Meanwhile, it was equal at or below 7.2°C and 10°C (**Table 2**).

In this respect, Campoy et al., (2010) mentioned that high temperatures during the chilling period have a negative effect on breaking the dormancy and shading of trees and reduces the incidence of radiation and the temperature in the apricot. Furthermore, Guerriero and Bartolini (1991) argued that apricot cultivation is greatly restricted by climatic conditions, especially related to chill accumulation in several growing areas with a significant influence on productivity.

c) Dates of vegetative bud opening:

The Ninfa culivar started opening in the first and second

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Table 2 : Chilling hours at or below 7.2°C, 10°C and 15°C of flower buds of selected new apricot cultivars in the years 2013 and 2014 seasons

Cultivar	2013 season				2014 season			
	Date of rest termination*	Chilling at or below			Date of rest termination*	Chilling at or below		
		7.2°C	10°C	15°C		7.2° C	10° C	15°C
Antonio Errani	Mar.5	0	5	281	Mar.10	0	4	197
Tirynthos	Mar.5	0	5	281	Mar.6	0	4	189
Ninfa	Mar.7	0	5	273	Feb.24	0	4	178

Table 3 : Dates of vegetative bud opening of selected new apricot cultivars in the years 2013and 2014 seasons

Cultivar	Dates of vegetative bud opening	
	2013 season	2014 season
Antonio Errani	Mar.19	Mar.30
Tirynthos	Mar.19	Mar.30
Ninfa	Mar.17	Mar.28

Table 4 : Opening percentages of vegetative and flower bud per shoot of selected new apricot cultivars in the years 2013 and 2014 seasons

Cultivar	Vegetative buds (%)		Flower buds (%)	
	2013 season	2014 season	2013 season	2014 season
Antonio Errani	40.22	45.56	77.98	49.58
Tirynthos	30.05	44.42	37.06	47.05
Ninfa	33.52	55.98	41.54	58.38
LSD at 5 %	**N.S.**	**N.S.**	**N.S.**	**N.S.**

seasons earlier than other cultivars (**Table 3**).

d) Opening percentages of vegetative and flower buds:

Results show that there is no significant difference between cultivars under study in the first and second seasons concerning opening percentages of vegetative and flower buds (**Table 4**).

In this respect, Massai (2010) mentioned that variations between years in apricot behavior could be so large to induce an unpredictable response of the trees to the changes in climate. This aspect became more significant and dangerous for many new cultivars characterized by self-incompatibility for which the need for the right pollinators is essential to guarantee an economical yield. The unpredictable blooming time, because of climatic variations, could induce a very poor fruit set in the years following a mild winter. Furthermore, as highlighted by Pennone et al., (2006), making an accurate field evaluation of new cultivars in different regions to guarantee proper income to growers is crucial.

Heat requirements

There were different stages of flowering and fruit growth in relation to heat units (H.U.) in the form of GDDs accumulated at each stage from flower bud opening until fruit maturity. These results are presented in **Tables 5** and **Tables 6** for two seasons under the study. It is obvious that the cultivar Ninfa required less heat units as compared with the other two apricot cultivars in the two seasons under study. Consequently, it is obvious that the accumulated GDDs from time of flower bud break until fruit maturity was low in early-matured cultivar.

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Table 5 : Heat units required for different stages of flower bud opening until fruit maturity of selected new apricot cultivars in 2013 season

Cultivar	Dates of D.S	Burst bud		Pink balloon		Advance pink balloon		Full bloom		Petal full		Initial fruit set		Final fruit set		Maturity	
		Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D
Antonio Errani	1/03	7	96	10	142.2	12	169.25	14	193.6	16	217.95	18	245.35	22	316.5	93	1338.85
Tirynthos	1/03	8	128	10	142.2	11	155.3	12	169.25	18	245.75	19	260.8	22	316.5	93	1414.55
Ninfa	28/2	6	100.75	8	134.5	11	178.0	12	191.95	14	214.65	16	240.65	18	268.05	87	1031.29

D. S. = Dome shape of flower bud
G.D.D. = Growing degree days

Table 6 : Heat units required for different stages of flower bud opening until fruit maturity of selected new apricot cultivars in 2014 season

Cultivar	Dates of D.S	Burst bud		Pink balloon		Advance pink balloon		Full bloom		Petal full		Initial fruit set		Final fruit set		Maturity	
		Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D	Days after D.S	G.D.D	Days After D.S	G.D.D	Days After D.S	G.D.D
Antonio Errani	6/3	11	130.95	16	199.35	20	245.65	25	306.15	28	346.75	31	394	38	494.8	93	1315.85
Tirynthos	1/1	8	112.75	12	160.95	15	195.45	19	240.35	22	277.1	32	397.75	40	512.7	102	1349.3
Ninfa	22/2	5	53.75	17	70.8	12	134.55	17	207.05	26	311.15	31	369.0	36	428.8	80	1176.9

D. S. = Dome shape of flower bud
G.D.D. = Growing degree days

In this respect, Rodrigo and Herrero (2002) mentioned that previous studies have examined the influence of climate on fruiting with different results. In apricots, a negative effect of warm pre-blossom temperatures (25°C) on fruit set and yields was detected. Ruml et al., (2010) referred that the effect of GDD thresholds on the harvest time of apricots is very important for each apricot producing region. The authors also reported that daily maximum temperatures were the most influential temperature variable for the ripening time of apricots.

Vegetative growth

The effect of cultivar on parameters related to vegetative growth and development namely shoot length (cm), leaf area (cm2) and trunk circumference (cm) are tabulated in (**Table 7**).

a) Shoot length: Ninfa cultivar had the significant shoot length in the first season. However, in the second season there is no significant difference (p=0.05) between cultivars shoot length.

b)Leaf area: In the first season, there is no significant difference (p=0.05) of leaf area between cultivars. Meanwhile, Ninfa cultivar showed the best significant value (p=0.05) in the second season than Antonia Errani and Tirynthos cultivars.

c)Trunk circumference: In both seasons under study, there is no significant difference (p=0.05) on trunk circumference between cultivars under study (**Table7**).

d) Dates of leaf drop: The leaf drop of Antonio Errani was intermediate while Tirynthos showed earlier leaf drop while, the cultivar Ninfa started leaf drop lately in the two seasons (Table 8). In this respect, Szalay and Molnar (2004) showed a good compatibility of the Prunus armeniaca L. seedlings with the many apricot cultivars and tree health status which was moderately better or the best.

Flowering of cultivar

Duration of flower bud opening from bud swelling until fruit set: The dates of different stages of flower bud opening, petal fall and fruit set varied from cultivar to cultivar (**Tables 9 and 10**). The cultivar in the two seasons under study which showed the earliest swelling bud burst stage. In the full bloom stage Ninfa bloomed on the same date as Tirynthos cultivar in the first season. However, in the second season Ninfa was the earliest

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Table 7 : Shoot length, leaf area and trunk circumference of selected new apricot cultivars in the years 2013 and 2014 seasons

Cultivar	Shoot length (cm)		Leaf area (cm²)		Trunk circumference (cm)	
	2013	2014	2013	2014	2013	2014
Antonio Errani	45.00	48.33	34.29	30-May	29.00	31.00
Tirynthos	48.33	52.00	43.57	31.88	31.00	32.67
Ninfa	53.33	62.33	36.57	38.73	30.67	34.00
LSD at 5 %	**2.63**	**N.S.**	**N.S.**	**4.25**	**N.S.**	**N.S.**

Table 8 : Dates of Leaf drop of selected new apricot cultivars in the years 2013 and 2014 seasons

Cultivar	Dates of Leaf drop	
	2013 season	2014 season
Antonio Errani	Dec .15	Dec.9
Tirynthos	Dec.1	Dec. 5
Ninfa	Dec.22	Dec.19

Table 9 : Dates of different stages of flower bud opening, petal full and fruit set of selected new apricot cultivars in 2013 season

Cultivar	Swelling bud	Burst bud	Pink balloon	Advanced pink balloon	Full bloom	Petal fall	Initial fruit set	Final fruit set
Antonio Errani	Mar. 5	Mar.7	Mar.9	Mar.11	Mar.13	Mar.15	Mar.17	Mar.21
Tirynthos	Mar. 5	Mar.8	Mar.9	Mar.10	Mar.11	Mar.17	Mar.18	Mar.21
Ninfa	Mar.2	Mar. 5	Mar.7	Mar.10	Mar.11	Mar.13	Mar.15	Mar.17

cultivar. As for fruit set, Ninfa was earlier by 4 days when compared with Tirynthos and Antonio Errani in the first season. Morever, in the second season, Ninfa was earlier than Antonio Errani by 8 days and earlier than Tirynthos by 5 days. These results agree with Sottile et al., (2006) who mentioned that Ninfa apricot early production, so considered one of the most important cultivars in Italy. Massai (2010), in his work, mentioned that the average blooming time of Antonio Errani and Ninfa cultivars in Italy were Mar. 13 and Mar. 8 in 2006 and 2007 seasons at Imola; Ancona and Matera regions. Massai (2010) found that the blooming time of Antonio Errani was delayed by 5 days when compared with the Ninfa cultivar. Legave and Clauzel (2006) recorded the high sensitivity of Antonio Errani and Ninfa cultivars to the environmental conditions.

Fruiting

Percentage of fruit set: on the percentage of fruit set and fruit drop are tabulated in (Table 11). In the fruit set percentage there is no significant difference (p=0.05) between cultivars under the study in the first season. However, in the second season the cultivar Ninfa reached the highest significant fruit set percentage. Meanwhile, Antonio Errani and Tirynthos had no significant difference (p=0.05) in the fruit set. Regarding the fruit drop percentage, there is no significant difference among cultivars during the two seasons.

In this respect, Sottile et al., (2006) highlighted that high fruit set cultivar Ninfa is confirmed as being very sensitive to fruit thinning. Furthermore, Legave (1978) mentioned that the lack of winter chilling hours is also

Table 10 : Dates of different stages of flower bud opening, petal full and fruit set of selected new apricot cultivars in 2014 season

Cultivar	Swelling bud	Burst bud	Pink balloon	Advanced pink balloon	Full bloom	Petal fall	Initial fruit set	Final fruit set
Antonio Errani	Mar.10	Mar.16	Mar.21	Mar.25	Mar.30	Apr.02	Apr.05	Apr.12
Tirynthos	Mar.06	Mar.08	Mar.12	Mar.15	Mar.19	Mar.22	Apr.01	Apr.09
Ninfa	Feb.24	Feb.26	Feb.28	Mar.05	Mar.10	Mar.19	Mar.24	Apr.04

Table 11 : Fruit set and fruit drop percentage of selected new apricot cultivars in the years 2013 and 2014 seasons

Cultivar	Fruit set (%)		Fruit drop (%)	
	2013	2014	2013	2014
Antonio Errani	30.56	21.67	50.00	66.67
Tirynthos	31.39	32.06	38.89	72.22
Ninfa	44.60	53.19	25.07	29.83
LSD at 5 %	**N.S.**	**21.16**	**N.S.**	**N.S.**

an important factor for increasing flower bud abscission. At the same time, Balta et al., (2007) found that the yield in apricot production is closely associated to fruit set and fruit drop. Regular high fruit set and low fruit drops are desired outcomes for apricot growing. There exists a limited information on fruit set and drops in apricots in the references although they affect the yield. Moreover, Alburquerque et al., (2004) argues that the irregularity of yield is one of the main problems among apricot varieties which is often erratic. Climatologically events prior to and during flowering are considered as the main determinant for fruiting success. However, problems related to poor yields are more pronounced in apricot than in other fruits and the causes are poorly defined. It is well known that many factors come into play before flowering and these influence productivity. One of these is the number of flower buds produced.

Dates of fruit maturity and harvest period

The dates of fruit maturity and the harvest period for the apricot cultivars in the years 2013 and 2014 are tabulated in (Table 12). The maturity and harvest date of Ninfa was earlier than Antonio Errani and Tirynthos in both seasons. In this respect, Sottile et al., (2006) mentioned that Ninfa short fruit development period, early-ripening and harvest (Lo Bianco et al., 2010). These results are in harmony with those obtained by Massai (2010) who found that ripening time of Ninfa was (20-30 May), while Antonio Errani was (14- 16 June) and Tyrinthe (12 May) (Oguzhan et al., 2012).

Yield weight per tree

There is no significant variation among cultivars under study in fruit number and yield weight per tree in the two seasons (Table 12). In this respect, LicznarMalanczuk and Sosna (2009) found that the apricot trees started cropping in the third year after planting and the significantly highest crop per tree and largest fruit were recorded with cultivar “Hargrand”. Also, LicznarMalanczuk and Sosna (2013) mentioned that flowering, fruit set and yield of apricot trees influenced by weather conditions and genetic component of cultivar.

Fruit physical and chemical properties

The physical and chemical properties of Antonio Errani, Tirynthos and Ninfa apricot cultivars are tabulated in **Tables 13** and 14. **Figure 1a, 1b and 1c** also supports the above properties showing pit, flesh and mature fruits of each cultivar used for the study.

Physical properties

Fruit weight: Results indicate that the different cultivars varied in their fruit weight at maturity. The cultivar Tirynthos gave the highest and significant values both during the two seasons.

Fruit size: Cultivar Tirynthos show the significantly highest values (p =0.05) in fruit size for both seasons (**Table13 and Table 14**).

Flesh diameter: In the first season, there is no significant difference between all cultivars under study. However, in the second season Antonio Errani gave the highest and significant value (p =0.05) followed by Tirynthos.

Fruit length and diameter: Tables 13 and 14 show that in

Table 12 : Dates of fruit maturity; harvest period and yield per tree of selected new apricot cultivars in the years 2013 and 2014 seasons

Cultivar	Dates of fruit maturity		Harvest period (days)		Yield / Tree No. of fruit		Yield / Tree Weight (kg)	
	2013	2014	2013	2014	2013	2014	2013	2014
Antonio Errani	May 21- June 9	June 7- June 17	20	10	238.00	268.67	4.47	5.52
Tirynthos	May 19-June 9	June 7- June 17	18	10	241.67	277.67	5.49	5.62
Ninfa	May 7- May29	May 17- June4	22	18	281.67	318.00	4.85	5.73
LSD at 5%	-	-	-	-	**N.S**	**N.S**	**N.S**	**N.S**

Table 13: Fruit physical and chemical properties of selected new apricot cultivars in 2013 season

Cultivar	Fruit Weight (g)	Fruit Size (cm³)	Flesh Diameter (cm)	Fruit Length (cm)	Fruit Diameter (cm)	Color Fruit b*	Color Fruit L*	Color Flesh	Seed Adherence	Fruit Firmness	T.S.S	Acidity
Antonio Errani	20.58	17.53	0.80	3.67	3.50	20.61	41.53	Yellow redish	Free stone	7.36	21.33	1.27
Tirynthos	20.30	21.50	0.67	3.80	3.57	28.70	47.51	Yellow redish	Free stone	3.14	17.83	1.45
Ninfa	18.03	17.60	0.60	3.13	3.50	23.53	42.98	Yellow	Free stone	2.56	14.50	0.92
LSD at 5 %	1.12	1.51	0.06	0.31	N.S	1.02	2.25	-	-	1.10	0.58	N.S

NS : Not significant at 5% probability level

Table 14 : Fruit physical and chemical properties of selected new apricot cultivars in 2014 season

Cultivar	Fruit weight (g)	Fruit Size (cm³)	Flesh diameter (cm)	Fruit Length (cm)	Fruit Diameter (cm)	Color Fruit b*	Color Fruit L*	Color Flesh	Seed Adherence	Fruit Firmness	T.S.S	Acidity
Antonio Errani	18.87	16.57	0.77	3.63	3.57	20.86	41.54	Yellow redish	Free Stone	6.75	20.33	1.31
Tirynthos	22.58	22..30	0.80	3.43	3.50	28.95	48.34	Yellow redish	Free Stone	2.23	17.50	1.57
Ninfa	17.04	16.27	0.67	3.27	3.40	27.85	41.69	Yellow	Free Stone	3.48	14.17	0.93
LSD at 5 %	2.84	1.91	N.S	N.S	N.S	1.41	1.78	-	-	1.27	0.94	0.12

NS : Not significant at 5% probability level

the first season there is no significant variation among cultivars in fruit length. Meanwhile, in the second season fruit length increased significantly (0.05) with Antonio Errani and Tirynthos more than Ninfa. On the other hand, fruit diameter in the two seasons, showed no significant difference (p =0.05) among cultivars under study.

Colour

Fruit surface colour (b*): An increase in skin colour occured with Tirynthos cultivar in both two seasons (**Table 13 and Table 14**).

Fruit Surface lightness (L*): Results revealed that the cultivar Tirynthos gave the lightness in the two seasons. On the other hand, Antonio Errani and Ninfa cultivars were recorded the lowest lightness both in two seasons. Fruit flesh colour: Yellow radish cultivar included Antonio Errani and Tirynthos cultivars. Ninfa was yellow in colour. Seed adherence: All cultivars under the study were free-stone (**Table 13 and Table 14**).

Chemical properties

Fruit firmness: The highest significant fruit firmness occurred in cultivar Antonio Errani. Meanwhile, Tirynthos and Ninfa cultivars were equal in low fruit firmness in the two seasons (**Table 13 and Table 14**).

Total soluble solids: The cultivar Antonia Errani showed the highest significant values of TSS followed by Tirynthos. Meanwhile, Ninfa cultivar showed the lowest significant values in both two seasons.

Acidity: In the first season, the cultivar Tirynthos gave the highest significant acidity followed by Antonio Errani and Ninfa. In the second season, there was no significant difference (p =0.05) among cultivars.

In this respect, Sottile et al., (2006) found that Ninfa cultivar has early production together with acceptable fruit quality. Sensorial properties for apricot fruit are influenced principally by the sugars, and volatile compound contents, colour, size, texture (Ruiz and Egea, 2008), firmness, attractiveness and taste (Gurrleri et al., 2001). Visual characteristics, firmness and balanced fruit flavor are currently the predominant characters in fresh apricot markets (Madrau et al., 2009). Also, Kader (1999) considered the mean values of T.S.S. over 10% as the minimum value for consumer acceptance for apricots which is the case in our cultivars.

Conclusion

The results of this study clearly demonstrate that calculating chilling hours temperature at or below15°C was more suitable than temperature at or below 7.2°C and 10°C. The chilling requirement and heat units of "Ninfa" cultivar less than "Antonio Errani" and "Tirynthos". "Ninfa" early ripening and harvest while "Antonio Errani" and "Tirynthos" are late thus can be fulfilling the demands the Egyptian market. The results also confirm that there is variation among cultivars under study in fruit quality; fruit weight, size, colour, firmness, TSS and acidity. Generally, it as the case in our apricot cultivars which acceptable to Egyptian consumer. The study demonstrated that "Antonio Errani", "Tirynthos" and "Ninfa" cultivars suitability to Khatatba region, Egypt. Therefore, it could be recommended cultivate these cultivars under the same conditions.

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Conflict of Interests

The authors hereby declare that there are no conflicts of interest.

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Soil-less systems vs. soil-based systems for cultivating edible plants on buildings in relation to the contribution towards sustainable cities

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Soil-less, soil-based, hydroponics, urban agriculture

Abstract

Food production and consumption for cities has become a global concern due to increasing numbers of people living in urban areas, threatening food security. There is the contention that people living in cities have become disconnected with food production, leading to reduced nutrition in diets and increased food waste. Integrating food production into cities (urban agriculture) can help alleviate some of these issues. Lack of space at ground level in high-density urban areas has accelerated the idea of using spare building surfaces for food production. There are various growing methods being used for food production on buildings, which can be split into two main types, soil-less systems and soil-based systems. This paper is a holistic assessment (underpinned by the triple bottom line of sustainable development) of these two types of systems for food production on buildings, looking at the benefits and limitation of each type in this context. The results illustrate that soil-less systems are more productive per square metre, which increases the amount of locally grown, fresh produce available in urban areas. The results also show that soil-based systems for cultivation on buildings are more environmentally and socially beneficial overall for urban areas than soil-less systems.

Introduction

Urbanisation has resulted in more than half of the world's population living in cities. For the first time in history, in mid-2009 the world's population has become more urban than rural (R. C. Allen, 2009). Urban areas rely on external resources to function, including food, water and energy, where this reliance makes cities global risk areas for human habitation (Kraas, 2003) due to issues that could occur in the supply chains (e.g. food security where there is a risk that people are no longer able to access healthy food easily (FAO, 1996)) and in parallel to this, due to issues with unhealthy urban environments that degrade people's health and quality of life. Increasingly people have become interested in reducing this reliance by re-integrating the production of resources in cities, including producing food (urban agriculture). Creating healthier places for people (and other creatures) to live in is also on top of the agenda for the future sustainability of cities where the importance of green spaces and infrastructure has been highlighted (Kirby & Russell, 2015). Green infrastructure also increases biodiversity in urban areas (Newton, Gedge, Early, & Wilson, 2007). The benefits of continuous pockets of spaces for wild life inspired the "My Wild Street" project in Bristol, UK where front gardens in a dense urban street were transformed into havens for wildlife (WT, 2015).

Integrating green spaces and vegetation into urban areas also helps cities function more efficiently and sustainably by: helping the retention of storm water to contribute to sustainable urban drainage (Sheweka & Magdy, 2011), purifying air pollution (Ottele, van Bohemen, & Fraaij, 2010) and shading hard surfaces to help alleviate

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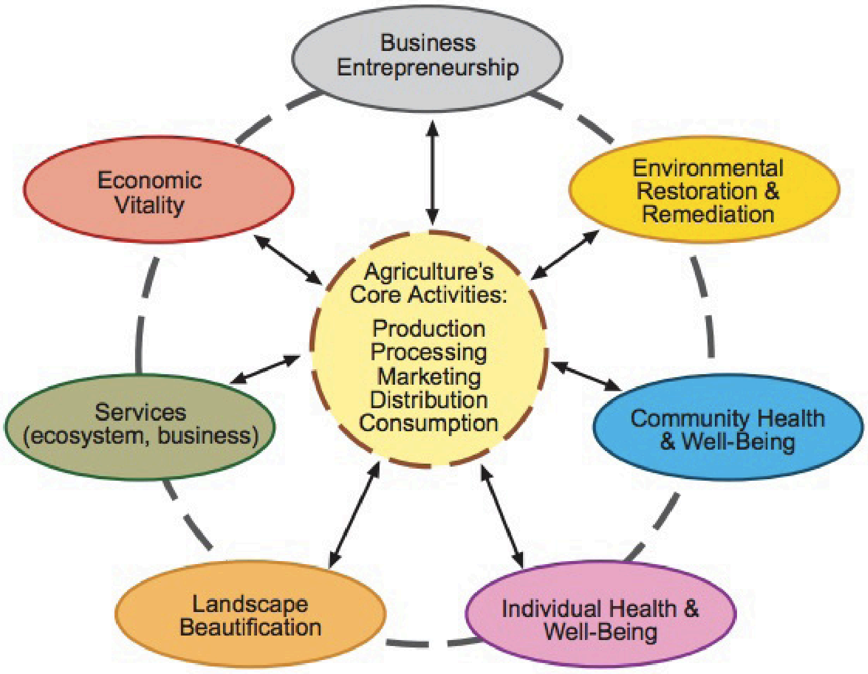

Figure 1: Diagram from the USA's Council for Agriculture, Science and Technology representing urban agriculture as a system (Butler & Maronek, 2002, p. 14)

the urban heat island effect (Mavrogianni et al., 2009)

There is the contention that if people are more involved with food production it will help improve their diets (J. O. Allen, Alaimo, Elam, & Perry, 2008; Benton, 2014; Kortright & Wakefield, 2011; Lovell, 2010; Wakefield, Yeudall, Taron, Reynolds, & Skinner, 2007) and also increase their pro-environmental behaviour (Mayer & Frantz, 2004) such as reducing the food that they waste (Benton, 2014). The definition of urban agriculture from the USA's Council of Agriculture, Science and Technology is:

> Urban agriculture is "a complex system encompassing a spectrum of interests, from a traditional core of activities associated with production, processing, marketing, distribution, and consumption, to a multiplicity of other benefits and services that are less widely acknowledged and documented. These include recreation and leisure activities, economic vitality and business entrepreneurship, individual health and well-being, community health and well-being, landscape beautification, and environmental restoration and remediation." (Butler & Maronek, 2002, p. 6)

The definition above is illustrated in **Figure 1**, which is a summary of the benefits urban agriculture can give to cities.

In dense urban areas, land for urban agriculture and green spaces are in competition with land for buildings (offices/housing etc.), so people are increasingly integrating food production and green spaces within and on buildings (Delor, 2011; Despommier, 2011). Vertical farms (Despommier, 2011) and building integrated agriculture (Delor, 2011) look at using internal spaces to grow food on and within buildings. Spare building surfaces such as rooftops, walls, windowsills and balconies have also been used for food production. There are various cultivation systems that can be used for cultivating food on buildings. These systems can be split into two types: soil-less systems and soil-based systems. Both types of systems can be in open air or within enclosed spaces using natural light in greenhouses and/or artificial light in warehouse type spaces. This paper is an assessment of these two types of systems in relation to cultivating edible plants on buildings.

Methods

In this paper, soil-less and soil-based systems for cultivating food on buildings have been assessed using specific criteria relevant to an urban context and a building context, underpinned by the environmental, social and economic discussions above. This section of the paper will explain the choice of criteria and their relevance.

Choice of criteria

Each criterion is split into three categories which are the triple bottom line of sustainable development (environmental, social and economic (Elkington, 1994)). The criteria are based on the benefits that these systems can contribute towards the sustainability of cities. The criteria are shown in **Table 1**.

Table 1 (a) : Explanation of assessment criteria chosen for comparing soil-less systems and soil-based systems for cultivating edible plants on buildings in relation to their contribution towards creating sustainable cities - **Environmental**

Criterion	Explanation of relevance
Environmental	
Can contribute to sustainable urban drainage	Hard surfaces in urban areas are not able to absorb water, thus during heavy rainfall, urban drainage systems are under pressure to drain water away, which can lead to flash floods and/or mixing of storm water with sewage, thus sustainable urban drainage (SUD) strategies try to slow down water from heavy rain before it enters drains (DEP, 2010). Thus the ability for water retention of the systems will be assessed.
Can contribute to alleviating the urban heat island effect	The urban heat island effect is a phenomenon where urban temperatures are a few degrees hotter than their surrounding rural areas due to an increase in hard surfaces that absorb heat in combination with air pollution creating a mini greenhouse effect (EPA, 2012). Vegetation in urban areas can help create surfaces that reflect heat and provide shade (Mavrogianni et al., 2009). The ability of the systems to help alleviate the above will be assessed.
Ease of using organic fertiliser from urban waste streams	Cities produce a lot of organic waste that can be utilised for cultivation rather than sent to landfill sites. Methods of cultivation within cities can tap into these waste streams as a source of organic fertiliser for the plants (Garner & Keoleian, 1995). The ability for each system type to be able to do this will be assessed.
Contribution to biodiversity	Spaces for biodiversity are important for healthy urban areas for humans and other creatures, flora and fauna (Francis & Lorimer, 2011). Green spaces integrated on buildings can help contribute to biodiversity in urban areas (Newton et al., 2007). The systems will be assessed in relation to the above.
Water efficiency	The efficient use of water is becoming increasingly important due to water scarcity in many parts of the world and especially in urban areas (Lee, Jordan, & Coleman, 2014; WFN, 2012). Products, including crops, have a water footprint, which is the amount of embodied water used in their production. Thus water efficiency of systems for cultivating edible plants on buildings is important and will be assessed for each system type.
Waste water is a pollutant to ecosystems and groundwater	As with industrial agriculture, the wastewater from systems for cultivating edible plants on buildings should be managed effectively in order to prevent the pollution of groundwater with excess minerals (Kumar & Cho, 2014). This will be assessed for each system type
Visual amenity	Plants are seen as visually appealing, thus integrating plants on buildings can increase the visual amenity of places. Soil-less and soil-based systems will be given a score related to their visual amenity.
Highly impacted by urban air pollution	Studies have shown that crops can take up pollutants in urban environments such as trace metals, which are damaging to human health (Säumel et al., 2012). Soil-less and soil-based systems will be scored according to their vulnerability to this issue.
Specialist nutrient solution not needed in order to achieve nutrient rich produce	Crops grown in soil using organic methods are nutritionally superior to crops grown inorganically in soil using chemical fertilisers (SA, 2015). Soil-less and soil-based systems will be scored according to achieving crops that are high in nutrition.
Reliance on fossil fuels for energy	Due to climate change (IPCC, 2007) and peak oil (ASPO, 2010), the use of fossil fuels for energy has become a global issue. Soil-less and soil-based systems for cultivating edible plants on buildings will be scored according to their energy in usage.
Embodied energy	Soil-less and soil-based systems will be scored according to their embodied energy in manufacturing and transporting of parts and embodied energy of products brought in during cultivation.
Reliance on back-up energy supply in case of power outages	A cultivation system that is reliant on a source of energy for the plants to survive is reliant on a back-up energy supply. Soil-less and soil-based systems will be scored according to whether they need a back-up energy supply.
Can grow crops in a range of climatic conditions	Methods for cultivation on buildings can be affected by climatic conditions due to loss in productivity and/or higher risk of disease (Orsini, Kahane, Nano-Womdim, & Gianquinto, 2014).
Soil as a finite resource	Soil is seen as a finite resource that needs to be managed sustainably in order to feed the growing world population and contribute to reducing greenhouse gas emissions (FAO, 2015). Soil-less and soil-based systems will be scored against how they would contribute to this issue.
Reconnecting with the natural world	People who live in cities are disconnected with nature. Connecting with the natural world is important for increasing pro-environmental behaviour (Mayer & Frantz, 2004). Soil-less and soil-based systems will be scored according to how they can reconnect people with nature.

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Table 1 (b) : Explanation of assessment criteria chosen for comparing soil-less systems and soil-based systems for cultivating edible plants on buildings in relation to their contribution towards creating sustainable cities - **Social**

Criterion	Explanation of relevance
Social	
Amount of knowledge needed in order to produce nutritionally rich crops.	There is a lack of horticultural knowledge amongst people who live in cities (FLP, 2010). Soil-less and soil-based systems will be scored according to the level of knowledge needed to grow good quality crops.
Social acceptance	Cultivation in urban areas in general may not be socially accepted due to issues with pollution uptake. Soil-less and soil-based systems will be scored according to their social acceptance.
Resilience to neglect	Neglect is an issue due to the transient nature of urban populations. Soil-less and soil-based systems will be scored according to their resilience under neglect.
Provides an amenity space for urban dwellers	Amenity space is important in urban areas for the physical and mental health of urban dwellers (NA, 2010). Soil-less and soil-based systems will be scored according to their contribution to amenity space.
Increasing access to affordable, fresh produce	Productivity levels of cultivation systems become important when the aim is to produce as much local, fresh produce as possible for urban dwellers in order to improve diets. This is often the case in poorer urban areas where people are not able to easily access fresh produce due to transport limitations to larger food retailers (food deserts) (Viljoen, 2005). Soil-less and soil-based systems will be scored according to how well they empower people to have access to fresh produce.

Table 1 (c) : Explanation of assessment criteria chosen for comparing soil-less systems and soil-based systems for cultivating edible plants on buildings in relation to their contribution towards creating sustainable cities -**Economic**

Criterion	Explanation of relevance
Economic	
Productivity	Soil-less and soil-based systems will be scored according to their productivity per square metre.
Cost to start up in comparison to each other	The cost of start up for each system is important and initial capital available can affect the type of growing system that can be used.
Cost to maintain in comparison to each other	The cost of maintenance for each system is important as the garden should be able to work financially.
Weight	The weight of each system type will be compared. Weight is an important factor due to structural limitation on buildings.
All types of crops can thrive in the system	The system types will be compared in relation to the types of crops that grow productively in the systems. There is more flexibility for the grower if they can grow a large variety of crops.

Each system will be given a score out of 3 for each criterion discussed in **Table 1** below, where a score of 0 means that the system is not able to meet this criterion at all, 1 means the system is able to meet this criterion in part, 2 means the system is able to meet this criterion but at a higher effort in general (effort is assessed according to cost, maintenance time and level of knowledge needed to achieve this benefit) and 3 means the system is able to meet this criterion very easily. The scores will be shown in brackets throughout the sections below. An example is given below of one criterion and how the scores were given:

Water Efficiency: Soil-less system is scored 3 as they can loop water around the system (more explanation of this in the sections below). Soil-based systems are scored 2 as they can be very water efficient but specialist knowledge is needed to make a soil-based system that is very water efficient. The scoring system in this paper is limited as the amount of specific details available for cost, maintenance time and level of knowledge are not specified, but are designed to give a general idea for each system type. The scoring system in this paper is limited as the amount of specific details available for cost, maintenance time and level of knowledge are not specified, but are de-

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Table 2 : Examples of soil-less cultivation of food on buildings

Name	Gotham Greens, Greenpoint	Sun works rooftop greenhouse	Rooftop Garden	Arbor House, Sky Vegetables	UrbanFarmers AG	Window farms
Location	Brooklyn, New York, USA	Manhattan School, New York, USA	Bologna, Italy	Bronx, New York, USA	The Hague, Netherlands, Rooftop and 6th Floor	N/A
Type	Hydroponic rooftop greenhouse	Hydroponic and soil based rooftop greenhouse	Hydroponic and soil-based	Hydroponic rooftop greenhouse	Rooftop Aquaponics	Indoor vertical window hydroponic systems
Funding	Private	State	Research	State	Private	Private
Commercial/ Community/ Educational/ Individual	Commercial	Educational	Research project	Commercial/Educational	Commercial/Educational	Individual
Year built	2010	2010	2014	2013	Construction due to finish in 2016	N/A
Size (m²)	1393 (GothamGreens, 2015)	Unknown	216 (Orsini, Gasperi, et al., 2014)	743 (Wall, 2013)	1200 total: 330 vegetables and fruit growing, 370 fish farm, 250 processing and packaging and 250 events and tours (HD, 2015)	1-May
Controlled environment (lighting, temperature and humidity)	Yes	Yes	No	Yes	Yes	No
Irrigation	Pump irrigation system	Pump irrigation system	Pump irrigation system	Pump irrigation system	Pump irrigation system	Pump irrigation system
Nutrients used	Water soluble mineral salts and micronutrients (Loria, 2015)	Various including water soluble mineral salts and micronutrients and vermiculture solutions	Water soluble mineral salts and micronutrients and soil with granular fertiliser once per year	Water soluble mineral salts and micronutrients	Nutrients from fish	Water soluble mineral salts and micronutrients
Productivity (kg/m²/year)	65 (GothamGreens, 2015)	N/A	15-Feb	Unknown	Unknown	Low (Gorgolewski, Komisar, & Nasr, 2011)
Crops grown	Salads, leafy herbs and tomatoes	Kale, Arugula, basil, broccoli, beets, cabbage and lettuce (NYSW, 2011)	Cantaloupe, tomato, chilli pepper, eggplant, lettuce, watermelon, chicory, black cabbage	Greens and herbs like lettuce, kale and basil (Wall, 2013)	Unknown	Salads and leafy herbs
Cost (per m²)	$574 (Pasquarelli, 2014)	Unknown	Unknown	Unknown	Unknown	$70 if using plastic bottles for a two-column system to $280 for a two-column ready made kit.

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signed to give a general idea for each system type.

Soil-less systems for cultivating edible plants on buildings: evaluation of benefits related to and contribution towards more sustainable cities

Soil-less systems for cultivating edible plants on buildings use horticultural technologies called hydroponics (mineral nutrient solution instead of soil), aeroponics (nutrient mist) or aquaponics (nutrient solution from tanked fish). **Table 2** shows some examples of soil-less systems. Removing soil from the growing process means that nutrients can be directly given to the plant roots, which speeds up their growth rate, making yields much higher (4 times more (Jenkins, Keeffe, & Hall, 2015)) than growing in soil under the same conditions (Muro, Diaz, Goni, & Lamsfus, 1997) (Score 3 for Productivity). These productivity levels make soil-less technologies a profitable and financially viable form of cultivating edible plants on buildings as there is more yield per square metre (Wilson, 2002). The productivity levels also mean that these systems can reduce the carbon footprint of cities in relation to food due to reduced food miles (Astee & Kishnani, 2010). Some crops are not as productive in soil-less systems than others and thus do not make financial sense to grow in a soil-less system (Score 2 for crop types).

Soil-less systems use water in two different ways; they either recirculate the water continuously around the system or run the nutrient solution through the system once and dispose of the water (run-to-waste). By circulating the nutrient solution within a closed system, hydroponics can use 4 times less water compared to the same yield from industrial field agriculture (Astee & Kishnani, 2010) (Score 3 for water efficiency). Periodic samples of the water used in a hydroponic system should be tested in order to monitor the build up of toxins in the system and other indicators such as the PH of the water.

Both systems will eventually lead to the need to dispose of wastewater. The waste solution can pollute ecosystems and groundwater (Kumar & Cho, 2014) thus needs to be treated before entering waste water systems. Recirculating systems use less water and also produce less wastewater so they would work better in an urban setting (Score 2 for pollution in wastewater).

Soil-less systems use electric pumps to circulate water to the plant roots, so are reliant on a source of energy to function. This can be partly supplied by renewable technology which is demonstrated on The Science Barge in New York, USA (Nelkin & Linsley, 2009). This use of electricity increases the embodied energy of crops grown in hydroponic systems (protective cropping, such as greenhouses, can carry approximately 84% higher emissions, due to heating, lighting and the structures themselves (Denny, 2014)) in comparison to locally grown soil-based crops, thus the use of renewable energy sources is beneficial in order to reduce this embodied energy and reliance on fossil fuels of soil-less systems.

The use of renewable energy may affect the economic sustainability of a soil-less system (Score 2 for Reliance on fossil fuels). A back up of energy should be installed for soil-less systems as power outages of even a few hours can destroy an entire crop in the system as the roots do not have a buffer (such as soil) to stay alive (Score 2 for back up energy supply). **Table 2** shows that most soil-less systems have been designed under controlled environments (also known as protected cropping) such as greenhouses. This may be because soil-less systems can produce higher yields under controlled environments where the lighting and temperature can be controlled creating the possibility to grow food all year. One negative affect of this is the added weight of the system if glass is used (the weight could be reduced by using translucent plastic, although the aesthetics of this would need to be considered carefully as urban greenhouses would be highly visible by urban dwellers) (Score 2 for weight). Growing spaces in controlled environments also do not provide the visual amenity benefits (which in turn has health benefits (Kirby & Russell, 2015; Ulrich, 1984)) of integrating green spaces and infrastructure in dense urban environments if the plants are not visible to city dwellers. A view of vegetation may be more valuable in dense urban areas than a view of a greenhouse.

Another negative affect of this is that putting the plants under controlled environments means that the biodiversity benefits obtained from growing the plants in an urban setting are no longer achieved. Soil-less systems grown in open air are not as productive as systems in controlled environments, but they are able to contribute to biodiversity for more mobile species in urban areas such as bees and butterflies (Score 1 for contribution to biodiversity). Open-air soil-less systems would also provide exposed vegetation thus increasing vegetated surfaces in urban areas, which helps alleviate the urban heat island effect (Score 1 for alleviating urban heat island). An advantage of growing in controlled environments in urban areas is that it reduces the pollution uptake of the crops as they aren't exposed to air pollution and other sources of pollution from an urban setting (Score 3 for pollution uptake).

Soil-less systems can also produce nutrient comparable or superior crops, compared with soil-grown crops, with precise nutrient solutions used and stringent management of the system undertaken (Hayden, 2006). The right nutrient solution and knowledge can be difficult for growers to access, especially in low-income situations such as in economically developing countries (Orsini, 2014b). Issues with achieving good nutritional content in soil-less systems has led to these systems sometimes not being as socially accepted as soil-based systems (Specht et al., 2014) (Score 1 for social acceptance).

Organic water-soluble nutrient solutions can be used in hydroponic systems, such as vermiculture produced from food waste, where the nutrient content of these solutions should be checked regularly and supplemented with other water-soluble organic materials in order to achieve comparable or superior nutrient content in crops compared with soil-based systems (Wilson, 2002) (Score 2 for nutrients in crops). Mineral nutrient solutions are less time consuming to use in order to achieve successful results, but the nutrients are mined (sometimes from non-renewable sources), refined and imported (sometimes from long distances), which increases the embodied energy and ecological footprint of the final crops (Score 1 for embodied energy). The use of specialist equipment also increases the embodied energy and start up costs (Score 1 for start up costs).

Aquaponics are also a solution for a less energy intensive source of nutrients, where waste-water from tanked fish is used to feed the plants. The external source of nutrients in an aquaponics system is the food for the fish. This can be home made, but similar to hydroponics nutrients, they need to be carefully formulated to ensure there is a balance of nutrients for the plants and the fish (TAS, 2015). The nature of needing specially formulated nutrients for hydroponic and aquaponic systems provides a potential business opportunity to supply local, organically formulated products to sell to growers (Score 1 for organic fertiliser). A negative effect of this is that specialist knowledge is needed to grow edible plants in a soil-less system in order to yield nutrient rich crops, thus this may socially exclude urban dwellers who don't have this knowledge and/or the financial resources to pay for the materials needed (Specht et al., 2015) (Score 1 for specialist knowledge needed). This requirement may impact on inspiring garden visitors who may like to replicate a growing system on a building surface of their home but may feel that they do not have the specialist knowledge to do it. Soil-less systems may be more appealing to technically orientated people where they feel they are in more control of their planting system. It could be argued that the world's population is becoming increasingly more technically orientated due to the increased use of computing technology. It could also be argued that inspiring urban dwellers to grow food using high-tech systems could disconnect them further from the natural world and an understanding of how our actions impact the planet (Score 1 for reconnecting with the natural world).

The specialist equipment, staff and energy needed to cultivate crops using soil-less systems also means that the prices of crops may not be affordable without subsidy for poorer communities in urban areas, who are vulnerable in terms of easy access to affordable fresh produce and have higher rates of obesity (ibid) (Score 2 for easy access to fresh produce). Small-scale hydroponic systems have been designed for domestic use where common waste products can be used to set up the system, but they produce small quantities of food (Gorgolewski et al., 2011), which negates one of the key benefits of using a hydroponic system (productivity). Soil-less systems for cultivating edible plants on buildings contribute to sustainable urban drainage if rainwater collection from surface run-off is designed into the system. This is a requirement for rooftop greenhouses in New York City, USA (NYCDCP, 2012) (Score 2 for SUDs). Water can be stored on the building (although this would add extra weight to the structure) or stored at ground level and pumped back up.

Soil-less systems are not as socially accepted as soil-based systems as they are a technology that people are not familiar with (Specht et al., 2014), and where they may not be sure about the quality of the crops (Gorgolewski et al., 2011). **Table 2** highlights that soil-less systems for cultivating edible plants on buildings are a concept that have very recently become reality, thus there aren't many examples showing their success in practice, but there is confidence that they could work (Score 1 for social acceptance). Any crop could be grown in a hydroponic system but some produce higher yields than others (Loria, 2015; Orsini, Gasperi, et al., 2014) (Score 2 for types of crops). Soil-less systems that use a nutrient solution as the substrate cannot function above certain temperatures due to reduced concentration of oxygen in the nutrient solution (Orsini, Kahane, et al., 2014). These systems are also not recommended in areas where diseases can be spread by mosquitoes (ibid). Soil-less systems that use specially designed substrates do not have the issues above.

Due to the high productivity levels of soil-less systems, they could be used in rural areas to replace some areas of industrial soil-based farming in order to give the soil time to restore its fertility (Vogel, 2008). In an urban context, soil-less systems for cultivation on buildings could be used where it is difficult to access clean urban soil to put on the building (Score 2 for soil as a finite resource). Soil-less systems are not able to function if they are neglected. The system will stop performing its function to produce food, and other functions. This highlights the

Figure 2: Food Chain, LA, USA, Edible Vertical wall (GR, 2008)

importance of soil-less systems to be set up with a resilient business plan to ensure the success of the system. If a household decides to set-up a soil-less growing system rather than a soil-based growing system, they will need to consider who will look after their plants when they are away from home (e.g. on holiday), as it would not be as simple as the neighbours coming to water the plants, although it could be simple if they arrange for a specialist company to look after their plants (Score 1 for resilience to neglect).

Soil-less systems are not able to be in the form of green, amenity spaces without the loss of productive space as they need specialist knowledge and monitoring to operate successfully, thus visitors need to come at allocated times and for allocated tasks. In dense urban areas, productive green spaces that can also be amenity spaces are a valuable contribution to creating healthy cities. This highlights a potential area for further research, where it can be assessed how soil-less systems could also perform as amenity spaces for urban dwellers without the loss of productivity (Score 2 for amenity space). The maintenance costs are higher for soil-less systems on buildings, as more monitoring is required from specialist staff and nutrients are more costly (Score 2 for maintenance costs).

Soil-based systems for cultivating edible plants on buildings: evaluation of benefits related to and contribution towards more sustainable cities

Soil-based systems for cultivating edible plants on buildings are systems that integrate soil, compost or specially designed lightweight soil-based growing medium on building surfaces or within buildings. This is essentially growing crops in containers (large containers in the case of an intensive green roof, and container systems designed for mounting to walls in the case of edible vertical walls (**Figure 2**) where the containers are on the surface of a building.

Table 3 shows examples of soil-based systems. As well as the soil retaining water, containers for growing food on buildings can be designed with water-reservoirs to retain some water within the system for times of drought. The drainage layer is important for both holding water and draining it away from the building surface. Soil-based systems contribute to sustainable urban drainage as they can retain storm water and release it gradually (Score 3 for SUDs). The irrigation systems for soil-based systems are similar to growing in soil at ground level (hand-watering, automatic pumps with irrigation pipes, seep hoses etc.) (Score 2 for water efficiency).

The source of nutrients for soil-based systems are within the growing medium and need to be replenished every few weeks, depending on the type of growing medium, during the peak of a growing season for fruiting crops and fully replenished annually; similar to growing in soil at ground level and far less seldom than soil-less systems. Artificial fertilisers can be used as well as organic fertilisers. As with soil-less systems but with less technical expertise required, soil-based systems can utilise the urban waste streams and use composted food and green waste as a source of nutrients to replenish the containers (Grard et al., 2015).

For intensive green roofs or larger containers, mulching practices can be used at the beginning of the growing season, such as mulching with matured horse manure

Table 3 : Examples of soil-based cultivation of food on buildings

Name	Eagle Street Rooftop Farm	Food Chain, Skid Row Housing Trust	Brooklyn Grange, Flagship farm	RISC Roof Garden	Gary Comer Youth Center
Location	Brooklyn, New York, USA	Los Angeles, USA	New York, USA	Reading, UK	Chicago, USA
System type	Green roof	Green wall	Green roof	Green roof	Green roof
Type of growing medium	Rooflite (compost, rock particulates and shale) (Gorgolewski et al., 2011)	BioSoil (soil specially formulated beneficial bacteria) (Irwin, 2012)	Rooflite (compost, rock particulates and shale) (Gorgolewski et al., 2011)	Soil	Soil
Funding	Private	Private	Private	Charity	Private
Commercial/ Community/ Individual	Community/Educational	Community	Commercial	Educational	Community/Educational
Year built	2009	2008	2009	2002	2006
Size (m²)	560	17 (GR, 2008)	3994	200 (Richards, 2008)	760 (Gorgolewski et al., 2011)
Controlled environment (lighting, temperature and humidity)	No	No	No	No	No
Irrigation	Hand watering	Pump irrigation system	Seep hoses from mains water	Hand-watered from mains water	Rainwater collection and mains water by hand a seep hoses (Gorgolewski et al., 2011)
Nutrients used	Compost	Compost	Compost	Compost	Compost
Productivity (kg/m²/year)	Unknown	Unknown	6.1 (Brooklyn-Grange, 2015)	Unknown	0.6 (Gorgolewski et al., 2011)
Crops grown	Cucumbers, hot peppers, tomatoes, eggplants, spinach, radishes, kale, swiss chard, carrots, peas, beans, salad greens (lettuces, mustards, arugula) herbs (sage, tarragon, oregano, parsley, chives, cilantro, dill), flowers (cosmos, zinnias, calendula, tobacco, daisys, hops) corn and squash (ESRF, 2010)	Tomatoes, cucumbers, strawberries, bell peppers, hot peppers, tomatillos, spinach, parsley, leeks, edible lavender, eggplant, zucchini, Sugar Baby watermelon, a variety of herbs, lettuce varieties, radish, and legumes (GR, 2008)	Leafy greens, tomatoes, peppers, kale, chard, chicories, ground cherries, eggplants, pac choi, herbs, carrots, turnips, radishes, beans (Brooklyn-Grange, 2015)	185 species of plants (RISC, 2015)	Variety including cabbages, lettuces, carrots, sunflowers and strawberries (Gorgolewski et al., 2011)
Cost (per m²)	$10 (Gorgolewski et al., 2011)	Unknown	$5 (Gorgolewski et al., 2011)	Unknown	Unknown

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or compost made from food and garden waste (Richards, 2008) (Score 3 for nutrients in crops). Growing in soil-based systems on buildings needs similar gardening skills required for growing at ground level in a garden. This makes soil-based systems accessible to a higher number of urban dwellers due to the less technical knowledge needed (Score 3 for specialist knowledge needed) and the lower cost of the materials required. Due to the basic knowledge that is required for this method of cultivation, food production in soil can help empower local communities to take control of the food that they eat by demonstrating how they could grow their own food (Lovell, 2010). Growing in soil is similar to how plants grow in the natural world thus when growing in soil, people are reconnecting with nature and increasing their understanding of natural systems (Score 3 for reconnecting with nature).

Some soil-based systems can also require high initial investment costs if any of the following are required; the building surface needs to be structurally reinforced, access needs to be created to the building surface, if an intensive green roof and/or other things (such as sheltered space). **Table 3** shows that the cost to start up soil-based systems on buildings are much less than soil-less systems (Score 2 for start up costs). Most soil-based systems for cultivating edible plants on building have been designed as open-air systems, which can provide valuable biodiversity corridors within dense urban areas for many different types of flora and fauna (Dunnett, Nagase, & Hallam, 2008) (Score 3 for contribution to biodiversity). Open-air soil-based systems also help alleviate the urban heat island effect by increasing the amount of vegetated surfaces in urban areas (Score 3 for alleviating urban heat island). Vegetable gardens can also be used as amenity spaces without needing to lose productive spaces (Score 3 for amenity space).

Due to many soil-based systems being in open air, there is a concern that pollution in urban areas may increase pollutants within the crops. It has been found that older green roofs that have been planted with inedible plants have accumulated high levels of pollution in the growing medium over time which can then pollute urban water systems (Jarlett, 2013). A study in Berlin assessed the amount of trace metals taken up by edible plants in urban areas, where it was found that barriers from traffic (such as buildings and foliage) strongly reduces the heavy metal content of crops (Säumel et al., 2012). The study found that although most of the crops grown in the city had higher trace metal content than supermarket bought crops, the trace metal content of green beans, kohlrabi, basil and thyme where higher in the supermarket products compared to the field samples in the inner city, showing that supermarket products also contain trace metals (ibid) (Score 2 for pollution uptake). The choice and location of crops grown in cities is important for the health of urban dwellers. The run-off from green roofs should be monitored periodically in order to assess the level of pollutants, which can vary depending on the type and age of the growing medium (Harper, Limmer, Showalter, & Burken, 2015; Jarlett, 2013). Further research is needed on how urban crops are affected by air pollution and other pollution they are exposed to in urban areas. Soil-based systems are less reliant on a source of energy for the plants to survive, thus they use less energy and do not need power back up (Score 3 for reliance on fossil fuels and Score 3 for power back up).

The materials used for constructing and waterproofing a soil-based system will have an embodied energy, but much less high-embodied energy materials are needed in comparison to soil-less systems and a higher percentage of the material needed is compost/soil, which can have a low embodied energy if sourced within urban areas (Score 2 for embodied energy). Soil-based systems for cultivation on buildings can use compost made from urban municipal waste and build up a layer of nutrient-rich soilover time on a building, which could add to the much needed fertile soil on the earth (FAO, 2015) (Score 2 for soil as a finite resource). If an open-air soil based system is neglected, it will continue to function as a vegetated surface, with benefits such as; storm water retention, biodiversity, amenity space, shading building, alleviating the urban heat island effect and aesthetics (for people who think wild gardens look beautiful). They may also still function as productive spaces if perennial crops were planted such as herb bushes and fruit trees (Score 2 for resilience to neglect).

Table 3 shows that soil-based systems are not as productive per square metre as soil-less systems, thus reducing the amount of fresh produce available (Score 2 access to fresh produce). All types of crops can be grown in soil-based systems on buildings depending on the soil depth and climatic conditions, but it is more cost-effective to grow high value crops (Score 2 for crop types). The maintenance costs are lower for soil-based systems on buildings, as nutrients can be sourced for urban waste products and highly specialised staff are not required (Score 3 for maintenance costs).

Results of comparative analysis

Soil-less and soil-based systems for cultivating edible plants on buildings were introduced and given scores in the sections above using existing examples of systems. The analysis was underpinned by the triple bottom line

Table 4 (a) : Soil-less system vs. soil based systems for cultivating edible plants on buildings. Points are given out of 3 for environmental, social and economic benefits to urban areas - **Environmental**

Criterion	**Soil-less systems**	**Soil-based systems**
Environmental		
Can contribute to sustainable urban drainage	Yes if rainwater is collected (2)	Yes if not within an enclosed environment or rain water is collected (3)
Can contribute to alleviating the urban heat island effect	Not normally but yes if not within an enclosed environment (2)	Yes if not within an enclosed environment (3)
Ease of using organic fertiliser from urban waste streams	Low (1)	High (3)
Contribution to biodiversity	Not normally but a little if not within an enclosed environment (1)	A lot if not within an enclosed environment (3)
Water efficiency	High (3)	Medium (2)
Waste water is a pollutant to ecosystems and groundwater	No if treated (2)	No with management and monitoring (3)
Visual amenity	Not normally but high if the plants are clearly visible (2)	High if the plants are clearly visible (3)
Highly impacted by urban air pollution	Yes if not within an enclosed environment or barriers provided between source of pollution and growing space (3)	Yes if not within an enclosed environment or barriers provided between source of pollution and growing space (2)
Specialist nutrient solution needed in order to achieve nutrient rich produce	Yes (2)	No (3)
Reliance on fossil fuels for energy	High (reliance on fossil fuels can be low if renewable energy sources are used) (2)	Low (3)
Embodied energy	High(1)	Medium(2)
Back-up energy supply needed in case of power outages	Yes (2)	No (3)
Can grow crops in a range of climatic conditions	No (1)	Yes (3)
Soil as a finite resource	Opportunities to promote soil fertility restoration with appropriate management and policies (2)	Opportunities to promote soil fertility restoration with appropriate management and policies (2)
Reconnecting with the natural world	Low(1)	High(3)
Total environmental score (total score 45)	27(60% of total score)	41(91% of total score)

of sustainable development and the roles of urban agriculture for sustainable cities of the future. **Table 4** provides a summary comparison of soil-less systems and soil-based systems for cultivating edible plants on buildings. Using the scoring system, soil-based systems are 25% more beneficial overall to urban areas and on buildings than soil-less systems. Soil-based systems are 31% more environmentally beneficial for urban areas and on buildings, 33% more socially beneficial and equally economically beneficial in comparison to soil-less systems for cultivating edible plants on buildings.

Discussion: Key difference in benefits and methods of selecting systems

This paper has found that soil-based systems for culti-

Table 4 (b) : Soil-less system vs. soil based systems for cultivating edible plants on buildings. Points are given out of 3 for environmental, social and economic benefits to urban areas - **Social**

Criterion	Soil-less systems	Soil-based systems
	Social	
Specialist knowledge needed	High (1)	Low (3)
Social acceptance	Low (1)	High/Medium (2)
Resilience to neglect	Low (1)	Medium (2)
Provides an amenity space for urban dwellers	Not normally but yes with the loss of productive spaces (2)	Yes (3)
Increasing access to affordable, fresh produce	High if affordable (2)	Medium if affordable (2)
Total social score (total score 15)	7 (47% of total score)	12 (80% of total score)

Table 4 (c) : Soil-less system vs. soil based systems for cultivating edible plants on buildings. Points are given out of 3 for environmental, social and economic benefits to urban areas - **Economic**

Criterion	**Soil-less systems**	**Soil-based systems**
	Economic	
Productivity	High if within an enclosed environment (3)	Medium/low depending on maintenance regime and skills level of gardener (2)
Cost to start up in comparison to each other	High (1)	Medium/low (2)
Cost to maintain in comparison to each other	Medium if well designed (2)	Low (3)
Weight	Low if open air, high if in an enclosed environment due to weight of structure (glass, steel etc.). Translucent plastic could reduce the weight. (2)	High (1)
All types of crops can thrive in the system	Yes but productivity per square metre for some crops is not cost effective (2)	Yes depending on the depth of the growing medium and the value of the crop (2)
Total economic score (total score 15)	10 (67% of total score)	10 (67% of total score)
Total overall score (total score 75)	44 (59% of maximum score)	63 (84% of maximum score)

vating edible plants on buildings are more beneficial for urban areas from an environmental and social perspective due to; the biodiversity benefits, providing amenity space, ease of using urban waste as a fertiliser to achieve nutrient rich produce, creating a connection with the natural world and basic level of knowledge needed to grow good quality produce. Soil-less systems for cultivating edible plants on buildings grown in controlled environments are much more productive per square metre than soil-based systems, thus they are able to provide much more local, fresh vegetables and fruit to urban areas, where these crops can be accessible to all

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communities if they are affordable. Making the crops affordable to everyone would increase the payback period for the capital invested in the system. If it is not possible to reduce the price of the produce for access to poorer communities, then it would be more beneficial to grow in a lower cost soil-based system if access to affordable fresh produce is priority for the given location as a soil-based system would also give the above environmental and social benefits.

The environmental, social and economic challenges for each site should be weighted in terms of priority in order to help with the decision of which system to use. For example, if access to green space, mental and physical health, healthy food literacy, biodiversity and affordability are priority in a particular urban community, then it may be more beneficial to use a soil-based system. In contrast, if productivity per square metre is important, such as growing on the rooftop of a supermarket in a wealthy area where other green spaces are available, then a soil-less system may be more beneficial.

The decision of using soil-less or soil-based systems can also be aided by looking at the location from an urban planning scale; dense urban areas may benefit more from soil-based systems on buildings due to the environmental and social benefits discussed above. Peri-urban areas such as suburbs may benefit more from some soil-less systems on buildings, as there are more green spaces available around the buildings. Access to local, fresh produce could be greatly increased for increasing urban populations. Depending on land values in peri-urban areas, it may be more financially viable to use a ground level space for soil-less cultivation.

Conclusion

This research has highlighted that:

- Soil-less systems are more productive per square metre, which increases the amount of locally grown, fresh produce available in urban areas.
- The produce grown in soil-based systems is more affordable than soil-less systems.
- Soil-based systems for cultivation on buildings are more environmentally and socially beneficial overall for urban areas than soil-less systems.

Future Research

This paper is only beginning the comparison of soil-less systems and soil-based systems for cultivating edible plants on buildings. Cultivating food on buildings and how we can do this is key to making every element of a city multi-functional and contribute to its sustainability and habitability. One criterion may be more important for a project than another criterion, for example for a business, productivity may be more important than amenity space. A study that weights the scores depending on the importance of each criterion for a given site may show which system would be more suitable for different projects.

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Conflict of Interests

The authors hereby declare that there are no conflicts of interest.

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Local Seafood Availability in San Diego, California Seafood Markets

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California fisheries, local food movement, seafood supply chain, seafood security, food equity, urban and waterfront infrastructure

Abstract

Like many developed coastal cities, San Diego, California has strong geographic and recreational ties to the adjacent ocean, but weak culinary ones. Less than 10% of the seafood consumed in the U.S., and San Diego in particular, is domestic. The popularity and abundance of farmers' markets and other local markets in San Diego indicates an interest among producers and the public alike in cultivating local, diverse food systems, but this trend has been slower to catch on for seafood. The goal of this project was, therefore, to define and begin to understand the influences on the patterns of locally sourced, domestic seafood availability in San Diego. This study focused on seafood availability in seafood markets including researching market websites and contacting seafood counter managers to determine the general frequency (consistent, occasional, none) at which the markets sold seafood produced by San Diego fishermen or aquafarmers. Seafood market locations were mapped, and demographic and spatial information was gathered for each market's zip code. The results of the study revealed that only 8% of San Diego's 86 seafood markets consistently carried San Diego-sourced seafood, and 14% of markets carried it on occasion. Increased density of these local seafood markets was correlated with proximity to the coast, with almost 80% of the markets located within 2 km of the coast. Neither per capita income nor racial diversity was correlated with local seafood market density, indicating that factors contributing to coastal isolation matter more than wealth or diversity in determining where local seafood is sold. The geographic disparity in local seafood availability may be due to a variety of factors, including a small fishing fleet, prevalence of imported seafood, limited waterfront and urban infrastructure needed to support a local seafood system, and a lack of public awareness about local fisheries. Information gleaned from this study can inform further investigation into the influences on local, equitable seafood systems, as well as help consumers, producers and marketers to make informed decisions about seafood purchases and marketing efforts.

Introduction

San Diego, California, USA is a coastal city of about 1.3 million people with a vital fishing heritage and history. Once dubbed the "Tuna Capital of the World, employing more than 40,000 people directly or indirectly in the [tuna fishing] industry" (Ellis, 2008, p. 217), the County is now home to just 130 local commercial fishermen (Leschin-Hoar, 2014; Gilmore, 2011). The once thriving fishing industry has dwindled in part due to decreased awareness of the fishing community, its long heritage, and its products (Golden, 2012; Talley & Batnitzky, 2014). There is a push to revitalize commercial fisheries industry in San Diego in order to help reduce seafood trade deficits, bolster economies and job growth, and ensure availability of fresh, responsibly-sourced seafood for all

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San Diego residents (Paxton, 1994; Weber & Matthews, 2008; Pitcher, Kalikoski, Pramod, & Short, 2009; Schwartz, 2009; Helvey & Wick, 2013; Loring, Gerlach, & Harrison, 2013).

The city's proximity to the Pacific Ocean should make locally caught seafood easily accessible, but less than 10% of the seafood consumed by San Diegans (and Americans at large) is domestic, and diets are species poor, with most of what is eaten coming from just three species: tuna, salmon, and shrimp (National Fisheries Institute, 2014; National Marine Fisheries Service, 2012; Talley & Batnitzky, 2014). The popularity and abundance of farmers' markets and other local-food markets in San Diego (San Diego County Farm Bureau, 2016) indicate a widespread interest among producers and the public alike in cultivating local, diverse food systems. However, this trend has been slower to catch on for seafood (O'hara, 2011).

Local food systems depend upon the traceability of products, including information on the source of a product, the pathways that product took to reach consumers, and where consumers can purchase responsibly-sourced and healthful food. While this information is often available for land based foods (e.g., Golan, et al., 2004; Levinson, 2009), it is largely lacking for seafood (Jacquet & Pauly, 2008). Long international supply chains, illegal, unreported and unregulated (IUU) fishing, mislabeling (or lack of labeling) of seafood products, and questionable third party certification schemes are all factors that complicate the traceability of seafood supply chains (FAO, 2012; Helyar et al., 2014; Jacquet & Pauly, 2008; Jacquet et al., 2010). This study's focus on determining the availability of locally caught seafood in San Diego speaks to this lack of transparency in the seafood supply chain, and contributes to local knowledge of the routes seafood may take in San Diego. This knowledge is crucial for both consumers and producers to make informed choices about food selection and marketing, such as identifying areas or communities where fresh seafood is in demand but not available (Johnson, 2007; Pieniak, Vanhonacker, & Verbeke, 2013). This information is also needed to develop and begin to test hypotheses about the barriers and trade-offs to secure, local food networks (Opara, 2003; Abatekassa & Peterson, 2011).

The goal of this study was, therefore, to provide a snapshot of locally sourced, domestic seafood availability in San Diego, and better understand some of the social influences on observed patterns of local seafood distribution. This goal was met by i) defining distributions of seafood markets, ii) determining the general sources of seafood sold at these markets, and iii) testing relationships between the abundance of local seafood markets, and distance from the coast, per capita income, and racial diversity.

Methodology

Study area

This study was conducted from January 2015 through June 2015, and focused on the City of San Diego, as defined by the nine City Council districts (excluding Imperial Beach; **Figure 1**). Within this boundary, there are a total of 30 zip codes. If a zip code only partially fell within a City Council district, then the whole zip code was included in the area of study.

Seafood markets

A market or restaurant was defined as a "seafood market" if it had the word "seafood" in its name, or if it housed a dedicated, staffed fresh seafood counter that sold "fresh," uncooked seafood to the public. The markets were divided into seven categories: Fishermen's Market (a market owned and operated by commercial fishermen), Restaurant-Market (a retail market within a restaurant), Ethnic Market (a specialty market that primarily sold ethnic foods), Individual Market (a single store), Small Chain (≤5 markets owned by the same party), Large Chain (≥6 markets owned by the same party), and Wholesale/Distributor (an establishment that sold seafood primarily to markets, who then sold it to consumers). Maps were then created using ArcGIS® 10.3. The name, address, phone number, website address, and type of market were imported into ArcMap™, market addresses were geocoded using ArcGIS® toolbox, and markets were mapped on ArcGIS® basemaps; software and basemaps are the intellectual property of Esri and are used herein under license.

Availability of local seafood

Each seafood market's website was researched and the seafood counter manager was contacted directly, by phone or in person, to determine the general frequency at which the market sold seafood produced by San Diego fishermen and aquafarmers (referred to as "San Diego seafood"). All of the distributors that were mentioned by market managers were also contacted in order to determine how often the distributors carried San Diego seafood; this information was used to assign a local seafood availability category to the seafood market. The following categories were assigned to each of the markets, according to the answers received:

- *Consistent* – the market contact confirmed that one or more San Diego-sourced products were available in the market throughout an average year.

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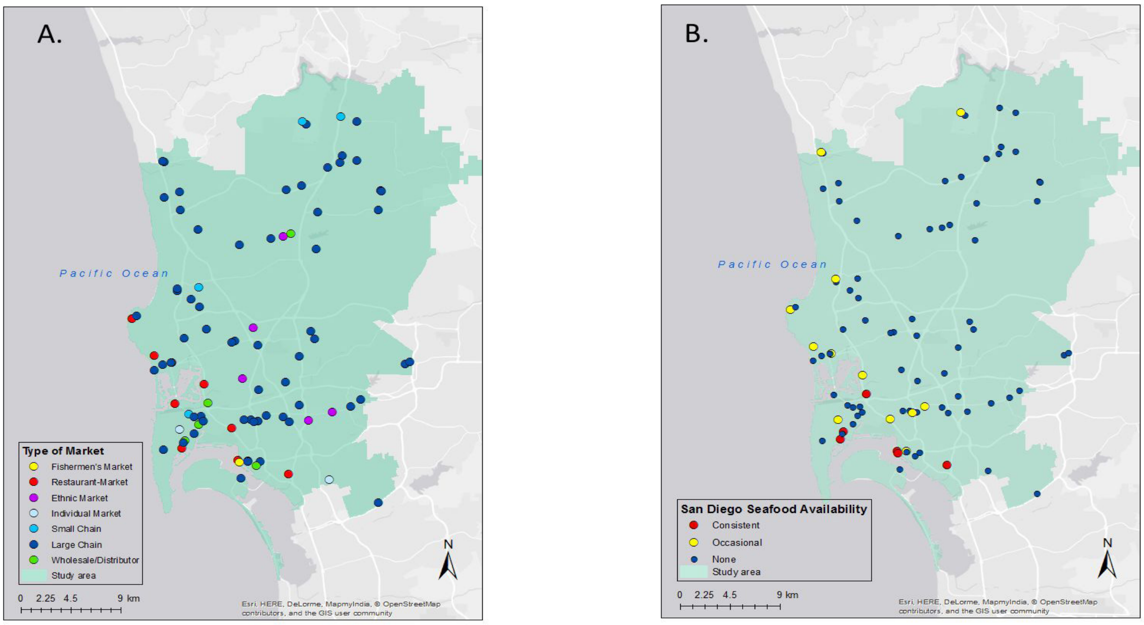

Figure 1: Maps of the City of San Diego, California showing distributions of the types of markets containing seafood counters (**A**), and the frequency at which the seafood markets carried San Diego-sourced seafood (**B**). Data are from January to June 2015.

- *Occasional* – the contact stated that one or more San Diego-sourced products were available occasionally during an average year, and/or said that products were potentially San Diego-sourced. (Products *potentially* came from a San Diego producer if products were sold to the market from a distributor who confirmed that it at least occasionally purchased that species from San Diego producers).
- *None* – the market contact confirmed that none of their available seafood came from San Diego producers.

Zip code characteristics

Demographic and descriptive data for each zip code were gathered from the website city-data.com ("City Data," 2013) and the U.S. Census Bureau's database "American FactFinder" (U.S. Census Bureau, 2014). These data included land area, population size, per capita income, and population by race for each zip code. Shannon-Wiener's diversity index (normalized) was used to calculate the racial diversity of each zip code from the demographic data collected ($H' = -(\Sigma[p_i * \ln(p_i)])/\ln(S)$ where p_i is the proportion of the population of a specific race within a zip code to the total population of that zip code, and *S* is the total number of categories used to group people by race within that zip code.) The normalized version of Shannon-Wiener's diversity index gives a value between 0 and 1, where numbers closer to 1 represent more even, diverse communities, and numbers closer to 0 represent communities more dominated by one group (Hurlbert, 1971; Gotelli, 2008; Ramezani, 2012). The density of markets (number of markets per area of each zip code) was calculated, as well as the distance from the nearest edge of each zip code to the coast, either to the Pacific Ocean, Mission Bay or San Diego Bay, whichever was closest.

Statistical analysis

Relationships between seafood market density and available geographic and demographic variables (distance from coast, income, H' for racial diversity) were explored using stepwise, multiple regressions (Zar, 2009). Regression criteria were $p \leq 0.10$ to enter the model and both $p > 0.05$ and $R^2 < 0.05$ to be removed. Relationships between distance from the coast and both income and racial diversity (H') were explored using simple, polynomial regressions (Zar, 2009). All regressions were run using JMP Pro®12 (2015). Descriptive statistics, H' and correlation graphs were created in Microsoft Excel© 14.5.

Findings and Discussion

The seafood in San Diego's seafood markets

A total of 86 seafood markets served the city of San Diego's 1.3 million residents in the first half of 2015 (**Figure 1 A**). Only 8% of seafood markets consistently carried San Diego-sourced seafood, while 14% carried it on occasion (**Figure 1B**), or at least likely did. The source of seafood

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Table 1: Results of regression analyses. Forward stepwise multiple regressions tested for re lationships between density of (A) seafood markets and (B) local seafood markets, and the distance from the coast, annual income, and racial diversity. Only distance from the coast met the criteria to remain in the model. Simple polynomial regressions tested for relationships between (C) racial diversity, (D) income, and the distance from the coast. Data are from January to June 2015.

	R^2	p	F	df (n)
A. Density of seafood markets				
distance from coast	0.18	0.02	6.1	1,28 (30)
B. Density of local seafood markets				
distance from coast	0.12	0.01	7.6	1,28 (30)
C. Racial diversity (H')				
distance from coast	0.54	<0.01	15.5	2,27 (30)
D. Income (per cap annual)				
distance from coast	0.20	0.04	3.5	2,27 (30)

purchased by markets from a distributor was often uncertain. If the market manager mentioned buying from a distributor who in turn had claimed to buy from San Diego fishermen, then we assumed that San Diego seafood was, by chance, at least occasionally available. This uncertainty revealed the need for improved traceability of the seafood supply chain and product source, if we hope to make informed decisions about seafood choices and local seafood systems.

There was only one fishermen's market, and one fisherman who consistently sold at several of the city's farmer's market; these were the only venues where consumers could buy San Diego's catch directly from producers. Most (80%) of seafood restaurant-markets carried San Diego seafood at least occasionally, while nearly 50% each of seafood wholesalers, individually owned markets, and small chain grocery markets reported carrying San Diego seafood occasionally or more frequently. None of the five ethnic markets and only 7% of large chain stores carried San Diego-sourced seafood; these two market types comprised 72% of all seafood markets in San Diego.

Distributions of local seafood

Each zip code throughout the city had at least one seafood market of some type, indicating a citywide demand for fresh seafood, but this study revealed a geographic inequity in the supply of San Diego seafood. The density of all seafood markets (no. km^2), as well as the density of markets selling local seafood (either consistently or occasionally), decreased with distance from the coast (**Figure 2A; Table 1**). In fact, 79% of markets selling San Diego seafood (and 100% of markets selling San Diego seafood consistently) were located within just 2 km of the coast. Neither per capita income nor racial diversity was correlated with the density of local seafood markets (comparison of **Figures 2A and 2B; Table 1**).

This link between local seafood access and distance does not mean that vulnerable communities are not among those lacking access to local seafood. Per capita income was lowest and racial diversity peaked in zip codes that were at intermediate distances (5-10 km) from the coast (**Figure 2B; Table 1**), revealing that this highly diverse, often underserved mid-city region of San Diego does not overlap with the distribution of local seafood availability (**Figure 2A**). Ethnic markets and large chain grocery stores, which generally did not offer locally caught species, were the main stores servicing this area. Similarly, large chain grocery stores with imported seafood were nearly the only sources of seafood available to low

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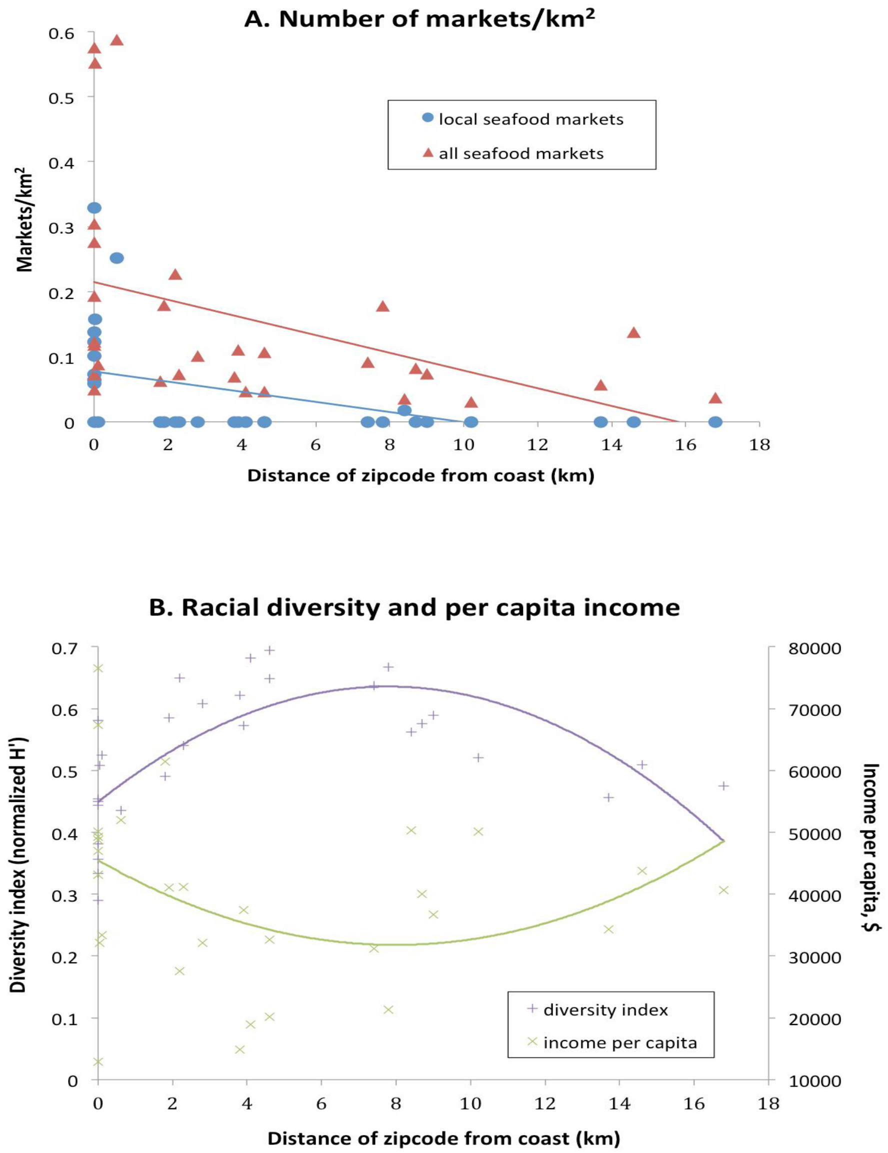

Figure 2 : Relationship between distance of a zip code's nearest edge to the coast of the Pacific Ocean, Mission Bay, or San Diego Bay (km) and both (**A**) the number of local and all seafood markets, and (**B**) racial diversity (H') and per capita income ($).

diversity, middle class inland San Diego.

Potential limitations on local seafood access

A small fishing fleet, prevalence of imported seafood as compared with domestic seafood, limited waterfront and urban infrastructure needed to process and/or distribute local seafood, and lack of awareness of local fisheries are a few possible explanations for limited access to San Diego seafood based on the relatively few markets in San Diego that carry local seafood, and the strong association between these markets and proximity to the coast.

Small fleets. The relatively small number of 130 commercial fishermen in San Diego is itself a barrier to expanding access to locally sourced seafood. In 2014, the 1.3 million San Diego residents likely consumed 8.6 million kg of seafood, about eight times the amount of seafood landed in San Diego that year (based on an estimated 6.6 kg of fresh, commercial seafood consumed by the average American during 2014) (California Department of Fish and Wildlife, 2015; National Marine Fisheries Service, 2015). It is clear that the current, small fishing fleet could not supply enough local seafood to keep up with the demand of the entire city. Moreover, over half of California's commercial fishermen will retire within the next five years, with not enough qualified people to fill these jobs (Gilmore, 2011; Society for Human Resource Management, 2013; Leschin-Hoar, 2014). Efforts, such as formal apprenticeship programs and supporting regulatory strategies, are needed to overcome the barriers to entry for new fishermen, which include costly permits and gear, limited numbers of fishery permits, and lack of formal training (Lerman, Eyster, & Chambers, 2009; Unified Port of San Diego et al., 2010; Gilmore, 2011; Shoffler, 2016).

Prevalence of imported seafood. About 90% of the seafood consumed in the United States is imported from overseas (National Oceanic and Atmospheric Administration, 2016). In 2014, $20.2 billion worth of seafood (2.5 billion kg) was imported into the U.S. By comparison that same year, the U.S. exported $5.3 billion, almost the same value of seafood as it landed ($5.5 billion for 4.3 billion kg) (National Marine Fisheries Service, 2014). The broad availability of imported seafood is in part a function of the globalized food system, which puts local fishing fleets, like San Diego's, in competition with large, industrialized international fishing outfits (Greenberg, 2014; National Oceanic and Atmospheric Administration, 2015). This uneven competition, coupled with other factors that disproportionately impact smaller fleets, may have catastrophic effects on small fishing communities. For example, the post World War II decline in San Diego's flourishing tuna industry was a result of a steady increase in the import of foreign caught tuna, in combination with restrictions implemented at home to reduce interactions between marine mammals and purse seines (widely adopted in the late 1950s), and limits placed on the extent of fishing grounds for the San Diego fleet (Schoell, 1999; Sullaway, 2008; Showley, 2012). Additionally, because of their national scope, large chain grocery stores do not often purchase products from local producers, instead utilizing large-scale "distribution centers that collect and deliver food products to individual retail stores" (Abatekassa & Peterson, 2011, p. 51). Chain supermarkets have established, long-term relationships with distributors who collect goods from producers who can meet the supermarkets' insurance, price, and volume requirements (Abatekassa & Peterson, 2011). These entrenched food pathways limit expansion and support for local food systems, often resulting in few places for consumers to buy fish caught by local fishermen, as observed in San Diego.

The availability of local seafood in this globalized market-dominated system may also be low due to low local retention of catch. Over one third of U.S. commercial landings are exported abroad (National Marine Fisheries Service, 2014; Greenberg, 2014, introduction). The extent to which San Diego landings are kept within the area is somewhat unclear and varies with species. Some San Diego fishermen testified that only 20 to 25% of their catch stays in San Diego (Shoffler, 2016). Similarly, a recent study revealed that 95 to 99% of San Diego-caught California spiny lobster and 90% of market squid are shipped abroad, primarily to the Chinese market (Shoffler, 2016; Masury and Tripp, 2016). Regardless of the exact percentage of San Diego catch that is retained in the area, it is clear that retention could be improved to better meet the demand of the city's residents. For example, supplies can be increased with a more efficient distribution throughout the greater San Diego region of locally caught species, in particular species that are inadvertently caught (e.g., "trash fish"; Oko, 2011) and those that were once desirable, but are now largely exported for uses other than direct consumption (e.g. market squid, sardine) (Ueber & MacCall, 2005). Efforts like direct marketing, where fishermen sell directly to consumers and the food service industry, can also help to increase local retention of local catch, while allowing fishermen to capture more of the value added to their product and collectively build resilience to socio-ecological vulnerabilities (Johnson, 2007; Stoll, Dubik, & Campbell, 2015). Direct markets allow for more local sales of a greater diversity of local seafood because people are more apt to try novel foods when presented with the choices and the ability to hear about sourcing and preparation from producers (Talley & Batnitzky, 2014)

Waterfront and urban infrastructure. Even with more fishermen and fish there remains, however, a noted lack of waterfront infrastructure used for docking, offloading, maintaining boats and gear, holding and refrigerating catch, and direct marketing of catch along the San Diego coast (Halmay, 2013). Recent efforts have restored some waterfront infrastructure in San Diego, including provision of dock space for the fishermen's market, as well as the replacement of one dock with a new crane and hoist, and the installation of an ice machine and a live holding tank (Unified Port of San Diego et al., 2010). These upgrades are, however, relatively few given the size and needs of the fleet, controlled by non-fishermen entities, and installed in a location where few commercial fishermen dock (Harvey, 2013). The increased establishment and upkeep of fishermen-owned and operated waterfront infrastructure will help overcome this infrastructural barrier to establishing local food systems, and forge pathways between San Diego fishermen, and the San Diego consumers, retailers, and distributors who have been largely choosing imported seafood (Gloucester Community Panel, 2003; Culver, Richards, & Pomeroy, 2007; U.S. Department of Agriculture, 2015).

Urban infrastructure that can support a local fishing industry and food system is also needed. The most common urban planning strategies implemented in the U.S. to promote local community-based food production and to improve equitable access to local food products involve preserving rural agricultural land, supporting urban farms and community gardens, and improving consumer access to farmers' markets (Hodgson, 2012; e.g., Marin County Community Development Agency, 2007). Less emphasized are strategies for supporting local and regional food distribution and processing networks (Hodgson, 2012). Because the production side of local marine seafood systems is restricted to the coast, it may be more important to promote local distributional and processing infrastructure to encourage retention and consumption of local seafood in San Diego, although this may reduce the added revenue fishermen reap from direct marketing their catch. Local distribution companies may help bridge the gap between fishermen and local markets, and establish those trusted relationships between producers, distributors, and retailers that are missing on a local scale (Abatekassa & Peterson, 2011).

Public awareness. Lastly, the significant difference between the seafood species that are regularly consumed by San Diegans, and the species that are caught by San Diego fishermen, likely contributes to the low consumption of local seafood (Talley and Batnitzky, 2014). San Diego fisheries include some mainstream species, including higher trophic level finfish like tuna and swordfish, but also many less well-known fisheries (invertebrates such as Kellet's whelk and wavy turban snail, and coastal groundfish and pelagics, such as rockfish, sablefish, and Pacific mackerel) (Talley & Batnitzky, 2014; Tuna Harbor Dockside Market, 2016; California Department of Fish & Wildlife, 2015). The very narrow San Diego seafood diet – compounded by prevalent, inexpensive imports of mainstream species – results in an egregious lack of awareness of the species landed locally (Talley & Batnitzky, 2014). This lack of awareness and dietary adventurousness is likely a deterrent to selling locally caught species throughout the city, and may partially explain why local seafood is not widely available. As mentioned above, direct marketing serves as a potential solution to this problem, as consumers may be more likely to try new foods when they have personal relationships with the producers, are presented with information about sourcing and preparation, and are offered the chance to taste new items (Zepeda & Deal, 2009; Talley & Batnitzky, 2014).

Conclusion

The information provided by this study provides a snapshot of the current conditions of the availability of local, San Diego-sourced seafood in San Diego markets. The large majority of markets carrying local seafood are located within 2 km of the coast, cutting off most of this coastal city from its own seafood. Solutions to improving local seafood availability include training a new generation of fishermen, and increasing the social capital and infrastructure needed to boost direct sales, local retention rates, and equitable distribution of locally caught seafood. Raising consumer awareness about local fisheries through direct marketing experiences and outreach efforts will contribute to a stronger demand for locally caught species and support of the local fishing industry.

The results of this study, as well as the limitations and potential solutions discussed above, reveal that there are many remaining research needs within San Diego's seafood system. Uncertain, but likely important, are the impacts of law, policy, local history, global and local economics, marketing, and zoning or land use configurations on the growth of the fishing industry, the supplies and public demand for local seafood, and on the distribution and equitable access to local seafood products. Further, socio-economic analyses are needed to understand the trade-offs, barriers and opportunities associated with strengthening the local seafood system.

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Conflict of Interests
The authors hereby declare that there are no conflicts of interest.

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Research Paper

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Use of farmer-prioritized vertisol management options for enhanced green gram and tomato production in central Kenya

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Green gram, Tomato, Vertisol, Household income, Kirinyaga Kenya

Abstract

Green grams (Phaseolus aures L.) and tomato (Solanum lycopersicum L) are widely grown in the vertisols of the Mwea Irrigation Scheme alongside the rice fields. Green grams can fix nitrogen (biological nitrogen fixation) and are grown for its highly nutritious and curative seeds while tomatoes are grown for its fruit rich in fibres, minerals and vitamins. The two can be prepared separately or together in a variety of ways including raw salads and/or cooked/fried. They together form significant delicacies consumed with rice which is the major cash crop grown in the black cotton soils. The crops can grow well in warm conditions but tomato is fairly adaptable except under excessive humidity and temperatures that reduce yields. Socio-economic prioritization by the farming community and on-farm demonstrations of soil management options were instituted to demonstrate enhanced green gram and tomato production in vertisol soils of lower parts of Kirinyaga County (Mwea East and Mwea West districts). Drainage management was recognized by the farming community as the best option although a reduced number of farmers used drainage and furrows/ridges, manure, fertilizer and shifting options with reducing order of importance. Unavailability of labour and/or financial cost for instituting these management options were indicated as major hindrances to adopt the yield enhancing options. Labour force was contributed to mainly by the family alongside hiring (64.2%) although 28% and 5.2% respectively used hired or family labour alone. The female role in farming activities dominated while the male role was minimal especially at weeding. The youth role remained excessively insignificant and altogether absent at marketing. Despite the need for labour at earlier activities (especially when management options needed to be instituted) it was at the marketing stage that this force was directed. Soils were considered infertile by 60% but 40% indicated that their farms had adequate fertility. Analysis showed that ridging and application of farm yard manure and fertilizer improved fertility, crop growth and income considerably. Phosphate and zinc enhancement reduced alkalinity and sodicity. Green gram and tomato yields increased under ridges and farm yard manure application by 17-25% which significantly enhanced household income.

Introduction

Green grams (Phaseolus aurous L.) and tomato (Solanum lycopersicum L) are widely grown in the vertisols of the Mwea Irrigation Scheme alongside the rice fields in Kenya. While green grams are grown for its seed which are highly nutritious; tomatoes are grown for its fruit and can be prepared together to form various delicacies. Green-grams contain a portion of every amino-acid and is rich in Calcium, Phosphorus, Magnesium, folate and Vitamins A and C. It also has low fat protein (14g per cup), high fiber (0.15g per cup) and a low glycemic index

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that lowers the risk of diabetes and is easily digestible. It also has several curative abilities and useful for the sick (e.g. against cholera) and expectant and lactating mothers. The crop can also fix nitrogen and is adaptable to drought conditions and inferior soils. Tomato has fibers, minerals and vitamins C and K and is used as raw salads and/or cooked/fried with most vegetables. It has antioxidants that have curative abilities against breast, colon and prostate cancers. The crop grows well in warm conditions but is fairly adaptable except under excessive humidity and temperatures that reduce yields.

Vertisols and vertic soils which are associated with glaring limitations to crop production due to their chemical and physical properties cover 43 million hectares in 28 countries in Africa (Broncyijk, 1991). These and other associated soils in the highlands of East Africa, occur at altitudes of 1000-3000 m above sea level and in Kenya occupying 5% of the country's landmass (2.8 million hectares) of which about 80% located in Arid and Semi-Arid Lands (ASALs) (Debele, 1983). In these areas mean monthly maximum temperatures rarely exceed 30°C and the minimum temperature is usually below 15°C. In the single peaked rainfall areas, the temperatures are relatively high during March and May. In the rainy months of June to September, the mean maximum temperature is around 20°C. In the highlands of East Africa receiving bimodal rainfall (example Nairobi, Kenya), temperatures are more or less uniform throughout the year (Virmani, 1987).

Some of the most common management problems of vertisols include; poor drainage and water logging, runoff and soil erosion, difficult tillage and unsuitability for land preparation implements and low organic carbon and nitrogen (Dudal R and Bramao, 1965; Tekele, Dinky and Lascano, 2012). There are various challenges and limitations encountered while attempting to use vertisols related to their associated shrinking, swelling and cracking dynamics that need to be taken into account (Tekele, Dinky and Lascano, 2012). Jutzi (1988) and Baudyapadhyay et al., (2003) outline conservation of water using tied-ridges, excess water storage and evacuation, gulley control and split-application of nitrogenous fertilizers as options for enhancing productivity of vertisols.

Macharia et al., (1998) attempted to develop an appropriate drainage system to remove surplus water early in the season to allow early and timely planting of crops for maximum yield, the development of appropriate land-shaping implement for the removal of surplus soil surface water, and the determination of economically suitable fertilizer types and rates for application on different crops grown. One option they recommend is that of addressing water harvesting and drainage issues tackled together in dry-land Vertisol areas. This should be followed by an introduction of crops tolerant to water logging and perennial fruit trees. Animal power has been suggested to be able to reduce labour requirements for "early" (before rainfall onset) land preparation and instituting additional structures amongst other required activities (Latham and Ahn 1987). This option can however be also challenging since even the livestock may be too weak due to shortages of pasture preceding the on-coming season. It is therefore particularly commendable to use low-cost inputs (fertility, labour) especially noting the usually low resource availability amongst the populations residing in semi-arid areas in Africa (Food and Agricultural Organisation, 1972). Vertisols in semi-arid lands in the Ethiopian highlands have been reported to be able to sustainably produce at least 2 crops per year when correct and timely management options that is, use of ox-plough for land preparations to enhance surface drainage, use of new cropping systems and low cost phosphates sources and legumes for nitrogen are pursued (Virmani, Sahrawat and Burford, Undated). Virmani (1987) indicates that the appropriate functionality of vertisols would depend on cultural, socio-economic and ecological potential of any targeted area.

In an attempt to overcome these problems there is widespread use of animal power for tilling but this can only commence after the first rains when the soil can be penetrated by the plough so plough/planting is practiced and a secondary pulse crop is planted two or three weeks later. These causes delayed planting with resulting loss in yield potential. It is therefore pertinent to identify a mechanized means for land preparation. A tractor hire service for each country could essentially solve this problem. Investigations on vertisol management in Kenya have previously focused on influencing biophysical characteristics with a test crop to determine if these lead to any changes in crop performance (Ikitoo, 2008, Sigunga, 1997).

Previously some management strategies have been attempted including a feasibility study in 2010-2012 (District Agricultural Engineer, 2014). Later water harvesting was done by use of constructed water pans using soil compaction instead of sheet linings. These were not successful because the vertisols were found to be 3 meter deposits overlying highly filtrating soils. Also attempted was installation of PVC pipes from the major rivers to irrigate these areas for crop production but there were financial constraints. Crops grown in the areas in order of importance include maize, beans, bananas, fruit trees rice and agriculture. However, some water working water pans (5,000m3) have been constructed in April 2012 which can be used in these proposed activities.

Table 1 : Selected household characteristics in vertisol occupied target area

District	Division	Total area		Targeted	
		km^2	Area	Population	House-holds
Mwea East	Tabere	512,8	85,3	9818	2688
Mwea west	Kangai	39,3	13,1	3719	1236

This work entailed a study of management options which addressed problems of waterlogging, low response to fertilizer and hence low crop production, low fertility through instituting ridges and application of nitrogen fertilizers and farm-yard manure in lower Kirinyaga County (Mwea East and Mwea West districts) where vertisols occupy over 50% of the districts. The objective of the work was to evaluate biophysical and economic implications of using prioritized-vertisol management options in Mwea. Specifically, this included; to investigate, using a check-list, the socio-economic problems associated with green gram and tomato production in vertisols, to demonstrate a handful of the vertisol management options with farmers and other stakeholders and to show-case enhanced soil, crop and economic characteristics associated with management options.

Materials and Methods

Study Area

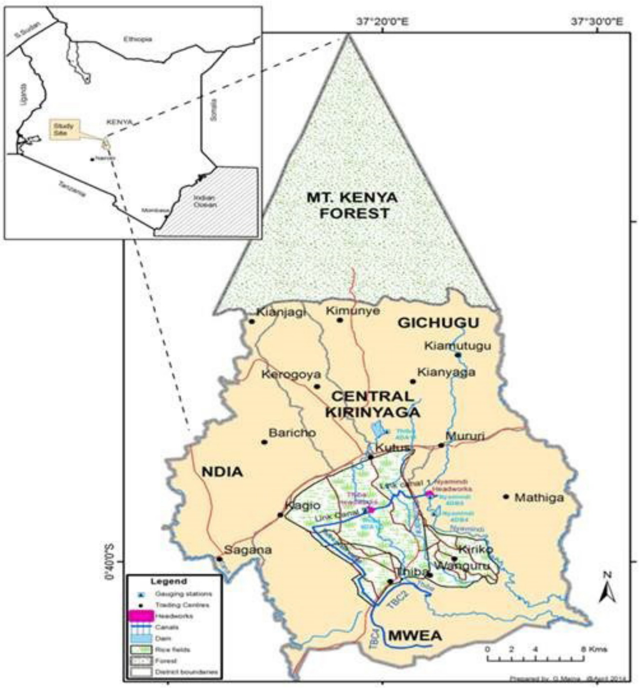

Figure 1: Location of Mwea, Kirinyaga (Source: Serede et al., 2015)

The area of study comprised of Kirinyaga central district which covers 35,880 km^2 as a pilot vertisol covered area. The district has a population of 104,437 with a density of 733.2 persons per square km (**Figure 1**). It mainly lies across a number of agro-ecological zones namely UM1, LH1, and Tropical Alpine zones in the upper reaches of the district. Vertisols in Kirinyaga central occur in two locations namely Kanyekini and Koroma which cover 11,840 Km2 which is about 30% of the total area. The experiments were laid in the vertisol areas of Kirinyaga County where farmers practice rain-fed subsistence farming. They mainly grow maize, green grams, cowpeas and tomatoes. **Table 1** shows some selected population characteristics of vertisol occupied zone in Kirinyaga.

Questionnaire

A questionnaire developed through consultation with scientists, administrative personnel and farmers attempted to address socio-economic aspects related to the general management of vertisols was administered to a sample of 95 farmers (which was 63.3% of the targeted number; that is 150). The intended interviewees who were selected randomly from the list of the 3,924 households provided by the local extension office were deemed to be representative of the residents who practiced available management options in the vertisol-occupied area. The above outlined characteristics are represented for the institution of the on-farm demonstrations whose results were deemed applicable to the household characteristics in the target area.

Administering of the questionnaire was done by the scientists, local technical assistants and extension personnel. The Statistical Package for Social Sciences (SPSS) Version 20 was used to analyze the questionnaire data collected by a socio-economic scientist.

On-farm demonstrations

Two (2) trials were instituted in three seasons that is, 2 in the long (March-June) rains of 2013 and 2014 and 1 in short (November-February) rains of 2013/14 at Mwea East and Mwea West districts belonging to identified farmers' groups which were Kiamanyeki United in Mwea East, and Ngothi Village SHG in Mwea West. Green grams were used as the test crop at Kiamanyeki while tomato

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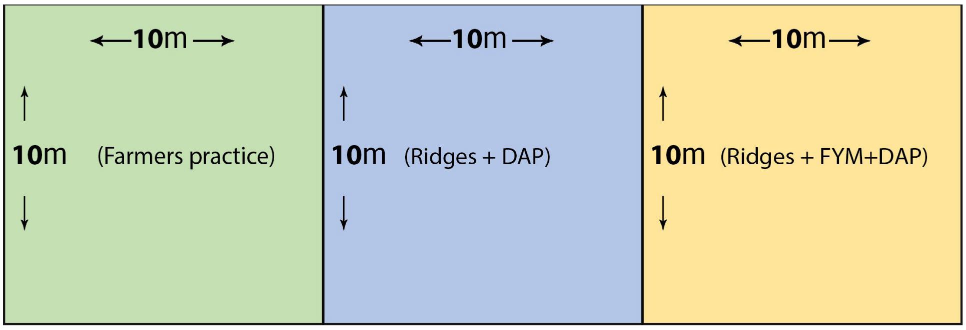

Figure 2: Treatments for the Vertisol trials

was used at Ng'othi. The 2 groups represented a total of 90 households (total number of members within the groups). Three vertisol management strategies were laid at each of the sites represented by the farmer groups. These were represented by (a) Farmer practice; (b) Ridges + Di-ammonium phosphate (DAP) and (c) ridges + FYM + DAP in 10 by10 m plots (**Figure 2**).

The test crops used were green grams (Variety N26) and tomato (Safari variety). Ten (10 t/ha) of FYM provided by the farmer group was ploughed into the plot before planting. The spacing for the green grams was 45 x 20 cm while the tomato was spaced at 100 x 50 cm and these crop-specific inter-row spacing constituted the ridge spacing in the two ridging plots. The green-gram rows were 15 while those of the tomato were 14. The ridges were also constructed as per crop spacing with at least 6" height. Diamonium phosphate (DAP) was applied at 70kg/ha at planting. The depth of the ridges was at least 6 inches high and the planting of the seed was done along the slope of the ridges (neither on top nor on the bottom of the ridges). Crop protection schedule was carried out as the need arose with applying pesticides.

The plot with FYM was applied at the rate of 70kg per plot which is equivalent to the documented recommended rates of 10t/acre and was provided by the farmers. This was applied and dug into the soils before instituting the ridges and furrows for sowing the seeds. Basal DAP fertilizer was applied at planting in the two intervention plots at the rate of 70 kg per hectare. The farmer practice plot remained with their usual practices in farms.

An initial soil fertility characterization status at the beginning of the experiment was taken to determine later if there will be any changes as a result of interventions instituted. Additional soil samples were taken to determine changes if any for analysis.

Data was collected from a net plot of 10 m x 10 m with the following measurements.

1. Date of planting
2. Days to emergence
3. Height at 30 days after emergence
4. Days to 50% flowering
5. Days to harvest (indicate first date of harvest in case of tomatoes)

Economic evaluation of crop yields obtained against costs of production (including fertilizers prices, and labour input for its application, cost of farm yard manure and its application, and labour for instituting ridges) was carried out to determine effects of different instituted management options. Some costs remained constant and these included, land preparation, planting, spraying, weeding and harvesting in all the three plots and they were not included in the calculation.

Results

Household characteristics

About 80% of the farmers interviewed were males while the rest were females. Farms which were mainly hired (82%) varied in sizes between 2 to 8 acres with the majority falling between 2 to 5 acres while half of which was used for farming by all the households. Household sizes varied between 1 and 8 with 37% having five members. Majority of the households (80 %) had between 2 and 5 persons with other categories having fewer members (**Figure 3**).

Crop choices

The farmers reported growing rice (about 60%), maize (23%), tomato (13%) and green grams (3.1%) as main crops in declining order of importance. These crops were grown mainly for generation of income (54.7%) and food (29.4%). **Figure 4** shows green grams grown under farmers' practice. Appropriate agronomic practices (use of certified seeds, nutrition, moisture and pest management and cropping pattern) are important requirements for managing utilization of vertisols.

Management options

The management options instituted and are popular included structures such as ridges and furrows, fertilizers and manure or their combinations against farmers practice to compare crop performance and soil physical char-

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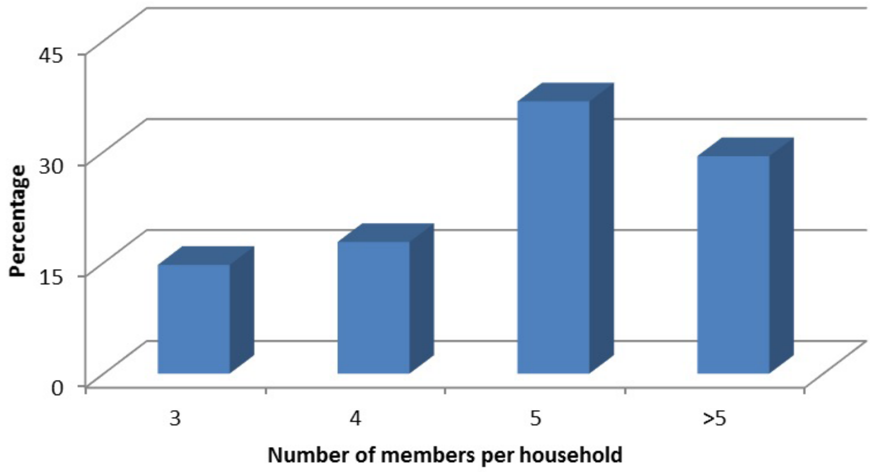

Figure 3: Categories of household composition in Mwea

Figure 4: Green grams showing farmers' practice

acteristics. Nine management options were identified by farmers as indicated in **Table 2** with manure/FYM, drainage, fertilizer and shifting options in decreasing order of importance.

Source of labour

The labour in the farms were both from the family and hired (64.2%) although 28% used hired labour alone while only 5.2% used family labour alone. Supplementing labour was recognized as a yield enhancing option except for two farmers who said they would not enhance yields. Of the farm activities, males dominated while females and youth disappeared almost completely at marketing. The male role was minimal at weeding while the youth role remained insignificant and altogether absent at marketing (**Table 3**).

84% of the farmers however did not appreciate constraints in labour with only 15% recognizing that as a constraint. 74% used the ox-plough while 25.2% used both the plough and hand labour. There were no constraints in accessing and/or controlling animal power in 50 households but 44 households had some difficulty in accessing these.

Tools

No issues arose due to hire and maintenance costs in majority of the households except one where this problem arose and no credit facilities existed for these services. Spares for tools were expensive and lowering these costs was suggested as a measure to sort this.

Fertility

On fertility, 60% responded that their soils are not fertile enough while 40% indicated enough fertility. However, all used fertilizers of one form or a combination of various types. Seventeen households prioritized the use of Calcium ammonium nitrate (CAN) while 40 households used mainly sulphate of ammonium (SA). Farmers who had used Di ammonium phosphate (DAP), Muriate of

Table 2 : Vertisol management options in Mwea

Management option	# responses	%	# using options	%
Drainage	61	64.21	27	28.42
Manure/FYM	14	14.73	42	44.21
Fertilizer use	4	4.22	14	14.73
Shift planting options (including, population, planting date etc)	2	2.11	7	7.36
Water harvesting/Irrigation	4	4.22	Not mentioned	NA
Ridging/Furrows/Terraces	2	2.11	1	1.11
Use tolerant/Suitable crops	1	1.05	Not mentioned	NA
Avoid use of unfavourable area/period	2	2.11	Not mentioned	NA
Use tractor/Ox plough	1	1.05	Not mentioned	NA

Table 3 : Distribution of gender roles in various activities in Mwea

Activity	% Male	% Female	% Youth
Land preparation	66.3	25.3	2.1
Planting	55.8	37.9	3.2
Weeding	52.6	38.9	3.2
Harvesting	54.7	41.1	3.2
Marketing	90.5	6.3	0.0

Table 4 : Agronomic results of on-farm trials in Mwea

Treatment	Farm/Site	Planting date	Plant height (cm)	Days to flowering	Days to maturity	Yield ton/ha
Farmers practice (1)	Kia-manyeki	4/16/2013	12.5	44	91	1.7
	Ngothi Farm	4/22/2013	13.0	45	91	2.1
Ridging and DAP (2)	Kia-manyeki	4/16/2013	17.0	44	91	3.8
	Ngothi Farm	4/22/2013	11.0	49	96	2.9
Ridges +FYM +DAP (3)	Kia-manyeki	4/16/2013	22.5	44	91	3.1
	Ngothi Farm	4/22/2013	9.0	52	98	3.7

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Figure 5: Well managed green gram field (Notice poorer performance mid-left)

Table 5 : Intervention-enhanced soil chemical characteristics at Mwireri farm

	Management Practices	Ridges + DAP + FYM	Ridges + DAP	Farmers' practice
Fertility status	pH	7.34	7.46	7.29
	Tot N%	0.25	0.24	0.23
	Org C. %	2.44	2.35	2.30
	K me %	0.18	0.16	0.16
	Ca me %	9.09	8.01	5.01
	Mn me %	0.33	0.29	0.23
	Na ppm	1.18	0.98	0.60
	Ec mS/cm	1.04	0.72	0.79

Potash (MOP), and Mavuno each agreed these would improve soils for better crop performance.

On-Farm Demonstration

Crop performance

Table 4 shows the results of the on-farm demonstration plots . The plant height for green grams (Kiamanyeki) was higher in the two intervention plots by 4.5 and 10.0cm for treatments 2 and 3 and yielded higher, that is 123% and 82% respectively. There was however no difference in days-to-flowering in the three treatments. At Ngothi, although the tomato plant heights were lower for the plots to which FYM and DAP were applied; these flowered later and yielded higher by 38% and 76% for the respective applications. **Figure 5** shows the performance of green grams under FYM application on the foreground compared to the non-FYM application portion immediately behind it.

Table 5 shows some enhanced differences shown in the various management options. Both DAP application and FYM enhanced pH, Tot Nitrogen (N), Organic Carbon, Potassium (K), Calcium (Ca), Manganese (Mn), Sodium (Na) and Electrical conductivity (Ec) of soils at Mwireri farm.

Economic evaluation

Results of economic evaluation are shown in **Table 6.** With farmers' practice whereby local seed is used and neither FYM, DAP nor ridging is done, there was yield of 2.1kg and 1.7kg of tomato and green gram respectively. When, however, ridges were instituted along with DAP the yields jumped to 3.8kg and 2.9kg for the respective crops and would bring an additional income of Ksh 467, 695 and 104, 345 per acre for ridging + DAP and Ksh 397, 930 and 134,880 per acre for ridging + FYM + DAP for the respective crops. These translated to 178% and 143% and 144% and 185% more income for the respective intervention options and crops.

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Table 6 : Economic evaluation of the instituted options at Mwea

Interventions	Inputs	Rate/Unit used/ obtained	Cost per unit	Total cost/income
Farmers practice	Seed (green grams)	0.5 kg	Not used	-
	(Tomato)	0.5 kg Tin	Not used	-
	Ridging	4 Man days	Not done	-
	DAP fertilizer	50 Kg	Not used	-
	DAP application	Man day	Not used	-
	Tomato yield	2.1* Tons	125,000KES	262,500KES
	Green gram yields	1.7* Tons	38,500KES	65,450 KES
Ridges + DAP	Seed (green grams)	0.5 kg	400 KES	400 KES
	(Tomato)	0.5 kg Tin	600 KES	600 KES
	Ridging	4 Man days	260 KES	1040 KES
	DAP fertilizer	50 Kg	2,500 KES	5000 KES
	DAP application	1 Man day	260 KES	260 KES
	Tomato yield	3.8* Tons	125,000KES	475,000KES
	Green gram yields	2.9*Tons	38,500KES	111,650 KES
Ridges + DAP + FYM	Seed (green grams)	0.5 kg	400 KES	400 KES
	(Tomato)	0.5 kg Tin	600 KES	600 KES
	Ridging	4 Man days	265 KES	1040 KES
	DAP fertilizer	50 Kg	2,500 KES	5000 KES
	DAP application	1 Man day	265 KES	265 KES
	FYM application	1Ton	265KES	265 KES
	Tomato yield	3.1* Tons	25,000KES	387,500KES
	Green gram yields	3.7* Tons	38,500KES	142,450 KES

Discussion

Socio-economic evaluation

In view of the farm sizes being predominantly small (2-5 acres); it is important that there are significant economic returns to the management interventions used. Enhanced productivity is applicable more to male-headed households (80%) than female headed households

(20%) and hired farms (82%) than those which are self-owned (18%). It is recommended that high-value crops like tomato be grown in order to realize the areas potential for even alleviating the prevalent food insecurity. Other reasons given by farmers for choice of crops they grow included resistance to water logging, suitability for the environment and higher yields. International Soil Reference and Information Centre (2015), for example, also report increased wheat and hoarse bean yields of 150% and 300%, respectively under improved vertisol management options.

Management options

Despite having several (9) management options at the farmers discretion (**Table 2**) only a reduced number used drainage and furrows/ridges while a higher number used manure, fertilizer and shifting options. It is necessary to institute strategies in farmers' fields with a quick maturing crop variety (green grams) since rice is already established and researched adequately by Mwea Integrated Agricultural Development (MIAD) centre working within the National Irrigation Board (NIB).

Labour

High labour demand and cost for instituting these options was mentioned by all the farmers as a hindrance to adoption but they were recognized as yield enhancing options except for two farmers who responded that they would not enhance yields. Due to the labour constraints instituting and maintaining ridges as a management option would be most sustainable for households having 5 members per household (37% of the population i.e. 142 households) (**Figure 1**).

Despite the need for labour at earlier farm activities (especially when management options need to be instituted) it was at the marketing stage that this force was directed. Goe (1987) Jutzi et al., (1987) and Macharia et al., (1998) have indicated animal traction and improvised plough implements respectively to enhance land preparation and ridging and eventual yield improvement in vertisols.

On-farm evaluation

The plant height for green grams (Kiamanyeki) was generally higher in the ridging + DAP and the ridges + DAP + FYM treatments. This can be attributed to better nutrition and water management in the two intervention plots. At Ngothi, these two interventions extended the flowering period and ensured higher tomato yields. Ikitoo (2008) and Sigunga (1997) report similar enhanced crop yields in vertisols in Kenya. Improvements in soil chemical characteristics were also reported with pH, total N, organic carbon K and C but also major economic returns in crop production. Use of organic inputs such as FYM should be particularly enhanced to improve crop nutrition since it is not only available but currently underutilized.

Conclusion

The socio-economic survey reveals that challenges associated with crop production in vertisols are dependent on household characteristics such as members per household, farm sizes and the manner in which family and hired labour are utilized. Interventions should therefore particularly be targeted to medium sized farmholds (i.e. 2-5acres), the youth and households with 5 members per household to have high impact.

If local seed is used and neither FYM, DAP nor ridging is done on vertisols at Mwea, both tomato and green gram yields and income would remain relatively low and even uneconomical to raise. When, however, the ridging + DAP are instituted with additional extra labour the yields and incomes would increase by 81% and 19% for tomato and green grams respectively. A further institution of FYM to the vertisols would increases these yields and income by 48% for tomato and by 29% for the green grams.

Despite having several soil management options at his/her disposal a few simple agronomic combinations that are manageable and demonstrated and up/out scaled by all stakeholders gives representative results that can be easily adopted under the farmers' socio-economic conditions. A clearly enhanced soil, crop and economic conditions arise from using these management options as is demonstrated that would cover the constraints of labour and physical impediments recognized in the vertisols.

Acknowledgement

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Conflict of Interests

The authors hereby declare that there are no conflicts of interest.

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By FOFJ Editorial Staff

Sharing and Caring - 5th International Food Sharing Festival in Berlin, Germany

Photo Credit : *offenblen.de*

Food sharing is combined with cultural context, values, ethics and the understanding of social demands and problems. Some countries are enriched with varieties of food-sharing practices. From day to day life-styles to festival-oriented sharing practices, food sharing can be observed in most societies. Although, with modernization and individualism these social practices are in a phase of decay. Some social movements forward and mobilize the social group to re-think food-sharing and re-shape it with real world-hunger issues. With several workshops, lectures, camps events and video programs, the 5th International Food sharing Festival was held from 12.08.2016 to 14.08.2016 in Malzfabrik, Berlin. The aim was to combat food waste. Participants could gain fruitful experiences and knowledge on the diverse work of food sharing and were offered many other exciting topics concerning sustainability and social issues. You can find more information at the workshop official webpage in *http://www.foodsharing-festival.org/*

Special power in wheat?

Photo Credit : *https://www.uq.edu.au*

A recent discovery turns half a century of plant biology on its head. This provides an opportunity for scientists to lead to better, faster-growing, better-yielding wheat crops in geographical areas where wheat currently cannot be grown. A research team led by Queensland Alliance for Agriculture and Food Innovation researcher Professor Robert Henry and his team published a research paper based on their research in *Scientific Reports*, showing that new photosynthesis occurs in wheat seeds as well as in plant leaves which can adapted to arid climate condition.

Please find the published paper at *http://www.nature.com/articles/srep31721*

Home

Hut in the swamps of the White Nile near Bor, Jonglei, South Sudan (Photo Credit: *www.yannarthusbertrand2.org)*

A film review by Forouq (Zahra) Kanaani

Director: Yann Arthus-Bertrand
Producers: Denis Carot, Luc Besson
Film title: Home
Production Company: Europa Corp
Production year: 2009
Country: France
Language: Many international languages
Official language: *http://www.homethemovie.org/*

As a result of human industrial activities in recent centuries, the global average temperature increased from 0.6° to 0.9° Celsius (1.1 to 1.6° F) from the early 1900 to year 2005 and according to estimation, it will rise further (NASA). On the other hand, deforestation, over-consumption of natural resources, air and water pollution and all similar activities which lead to environment destruction, are reducing the survival chances for next generation of human beings.

To prevent serious environmental problems in the future many policies should be created; but there are some very important sections which which are common in all these policy making plans and this part is raising public awareness of the ecological issues.

There are many different strategies to inform people about the dangerous consequences of environment ruination, but making documentary movies is one of the best methods, due to the visual perspective which they provide for their onlooker (Norris, 2010). The film is a 93 minutes colorful and harmonious movie which was released in 5 June 2009, World Environment Day, without copy right. It takes a wide

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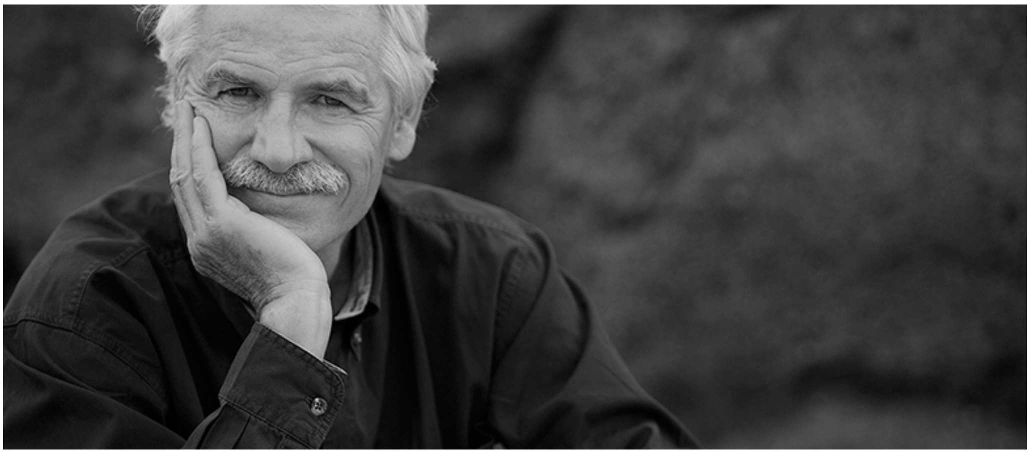
Photo credit: *http://www.human-themovie.org/*



"The key of 'The Earth from Above,' and of 'Home' is to show the beauty of the planet, and thereby to promote love for it."

Yann Arthus-Bertrand

look into the vast vision of our environment and the natural resources which is the most crucial basis for all being's life. The director, Yann Arthus-Bertrand is a photographer, journalist, reporter and environmentalist. In his movie "Home", he tries to direct the attention of viewer to the extreme beauty of our planet and the hazards that threaten the resources.

In this regard, he created amazing scenes of places showing wonderful wild life, nature and daily life of various habitats. Extraordinary camerawork, stunning aerial shots and visual effect combining with pleasing music make such a glorious film which gently takes the watchers under its spell. Home starts with a simple scientific explanation about the beginning of life on the earth and gradually goes to depict different elements which our lives are formed from. The documentary emphasizes the importance of atmosphere and the gases it consists of, water and its different resources, diverse biomes like tundra, taiga, desert and rainforest and eventually, the ruinous agricultural and industrial activities of human being and the probable harmful outcome of these practices.

Stated in detail, the film shortly explains many different subjects related to our natural surroundings; for instance, the spectator is informed step by step about the way life started in oceans million years ago; how it turned to more advanced living beings; why plants, soil and other biological chain elements matter; what the importance and function of different ecological biomes is and how all this natural resources should be preserved from annihilation. Meanwhile, the narrator addresses the audience by explaining the history of human civilization and blames the way this civilization devastates the planet. There is a delicate style of narration which observes this demolition process without taking any serious action to stop it.

The film takes a critical stance towards conventional methods of agriculture and husbandry and accurately shows these practices and industrial practices lead to world-wide natural damage. The film puts the blame on the development formation of megacities and their energy consumption pattern, the extra luxury cloned shapes of their suburbs, as well as their contamination impacts, providing the example of Los Angles in the United States of America and

Chittagong's port, Bangladesh (Photo Credit: *www.yannarthusbertrand2.org*)

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City (Photo Credit: *www.yannarthusbertrand2.org)*

Dubai in United Arab Emirates. In this regard, the director highlights the inequality of global resources in the term of natural, as well as monetary assets by reminding how capitalist states use (or even better to say abuse) the very-limited natural resources to manipulate their surrounding in the most unsustainable way which is also not necessary at all.

on the film then looks at the fishery industry, and documents overfishing problems and its terrible effects on marine reproduction cycle and life. By showing the simple life of some tribes and the way they value their limited fresh water resources, the film maker gives a profound tribute to these people and their culture. This appreciative point of view and addressing the tough ecological situation they are struggling with, shows consideration for these people and the unfair conditions they have to tackle to survive.

The film maker continuously illustrates various locations in the world and investigates the non-environmentally friendly practices of different people as well as states . Putting condemnatory statements on many inappropriate development schemes shows director's point of view and his sensibility to the challenges our beautiful planet is facing. The film indicates the global warming issues and the problems it may cause worldwide. It provides examples of massive reductions in ice cap thickness over the ladt 40 years, sea-level rises and catastrophes like floodingto indicate the serious environmental obstacles we should tackle to survive, if we are not going to change our current devastative development strategies, as soon as possible.

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Forouq (Zahra) Kanaani has obtained a Bachelor degree in "Agricultural Engineering, Agronomy and Plant Breeding" from University of Tehran and then, she finished her M.Sc. studies in "Agronomy" in Iran in the year 2013, while in her Master thesis, she investigated the organic practices to suppress the competitor plants on the crop field. Currently, she is pursuing a second Master degree on "Sustainable International Agriculture Science" from University of Göttingen and University of Kassel and tries to make her contribution in agroecological area, hoping to solve global food and water problems.

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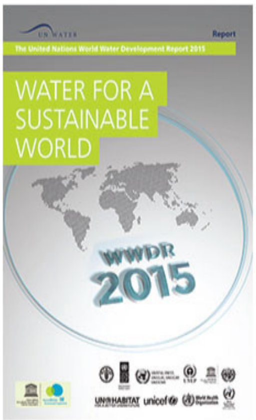

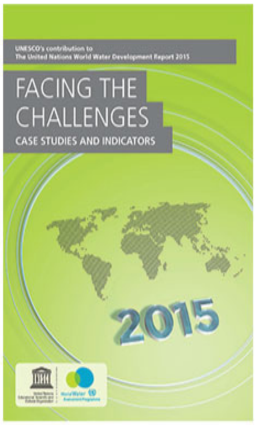

The United Nations World Water Development Report 2015: Water for a Sustainable World

A report review by Jessica Lucinda Amprako

Report title: The United Nations World Water Development Report 2015: Water for a Sustainable World
Year of Publication: 2015
Publisher: United Nations Educational, Scientific and Cultural Organization,
Place of Publication: Paris, France
ISBN: 978-92-3-100071-3

Water plays a fundamental role in human activities. It is useful in agricultural, health sectors and has created employment for many, improving standards of living. Conversely, an increase in economic and population growth, changing eating habits and rural and urban drift puts pressure on water resources. This review addresses the issues of water management in a sustainable approach as documented in the (UNWWD) report. Generally, the report explains how water, which is a limited resource, is being distributed in different parts of the world. Again, the services that utilise water and the effect they have on its use is further elaborated. Alternative actions to reduce the pressure on the use of water is discussed and further insight on the different measures and corrective actions people across the globe take to control its misuse are suggested. Some contributions toward a sustainable use of water are suggested, such as promoting an economic, social and environmental stable ecosystem.

In the first chapter of the report, factors that put pressure on water resources, the effects of ineffective governance for the provision of quality fresh water and the implications on urbanization and economic growth are presented. Due to high salaries, there has being an increase in the production of food and an increase in food industries. The improvement of social well-being has resulted in high energy consumption to meet the demands of the growing population. The authors explain with examples such as the consumption of more meat and the introduction of larger family sizes to indicate the change of lifestyle among other new developments which utilise water. With a stabilising economy there has been a dramatic increase in industrialization. Thus, the authors emphasize on the controlling these factors towards a sustainable development.

In the next three chapters of report, the authors explain how the social, economic and environmental indicators are controlled by the limited water resources and its management. Since potable water supply is critical for health, the provision of quality water is paramount for healthy living. About 70% of water is used for agricultural purposes while some are used in the industries. It implies that water contributes to economic productivity and the well-being of the society. For a continuous supply of water, the authors suggested managerial alternatives. These include improved irrigation technologies and improved sanitation. They reduce the intake of scarce water supply and increase productivity consequently. The impact of the difference between the status of the rich and the poor, women and children in most countries lead to disproportionalities in the distribution of water. As water is a basic for living, rules and policies are advised to create equal access to this resource. In addition, the authors suggest that these interventions are tuned to the preservation and protection of the ecosystem. As such, a constructive approach of re-using treated waste water and treating polluted water before disposal are encouraged.

The subsequent section in the report addresses the de-

photo credit: UN News Centre

"Tackling water challenges an 'urgent task' as world moves forward on sustainable development goals – UN deputy chief"

Jan Eliasson
(United Nations Deputy Secretary-General)

velopmental challenges between water and sustainable action. The increase of human settlement and lack of national policies on water calls for stringent policies on sustainable action. Most countries depend on hydroelectric sources of energy which results in the destruction of water bodies to create dams killing aquatic species and destroying fresh water used for drinking purposes. The authors assert that adopting alternative energy sources to maximise power supply. Furthermore, the continuous burning of fossil fuels and emission of carbon dioxide due to urbanization and industrialisation contribute to most water-related disasters and causing climatic change. Alternatively, the authors emphasise on these principles as a panacea towards sustainability.

From a regional perspective, the report shows an overview of the problems faced in Europe, Asia and the Pacific regions, Latin America and the Caribbean, Africa, the Arab regions and North America in the use of water uses, such as the influence on consumption patterns and the improvement of national water policy. With the proposal for a sustainable development goal for water by UN-Water in 2014, quality water supply, good sanitation and hygiene, water governance and wastewater management are being undertaken globally (Connor et al., 2015). The authors believe that this new approach will create a better development in social and economic and environmental pertaining to water use.

To conclude, one can say that the entire report informs about the effects human activities such as the increase of world population, high income gains and industrialisation affects the demand of fresh water globally. Many readers are not aware of the pressure globalisation, migration and urbanisation place on water resources and how this menace can be tackled sustainably. Sustainability advocates are therefore reminded in this report of their responsibility in water management as well as for many other decision-makers in water resource protection.

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The United Nations World Water Development Report 2015: Water for a Sustainable World. Retrieved on July 21st 2016 from *http://www.unesco-ihe.org/sites/default/files/wwdr_2015.pdf*

SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD

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1. Yam Kumari Kandel (Nepal) Reporter - *Global Press Journal*. at *https://globalpressjournal.com/asia/nepal/nepal-aims-to-reduce-massive-waste-of-produce-by-improving-handling-storage/*
2. Caterina: *take-online.de* (2013)
3. foodsharing-festival at. *www.offenblen.de- http://www.foodsharing-festival.org/*

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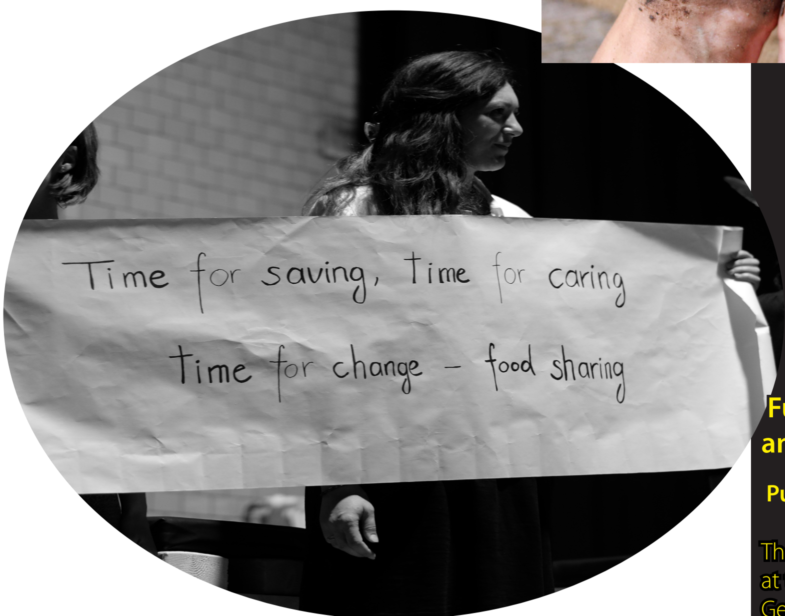
Reasons and Impacts of Food Wasting

Foodsharing as a Social Innovation



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Future of Food: Journal on Food, Agriculture and Society

Published on 29 August 2016

The Department of Organic Food Quality and Food Culture at the University of Kassel, Germany and the Federation of German Scientists (VDW), Germany