Urban agriculture and Eco-sanitation: the strategic potential toward poverty alleviation in the Gaza Strip

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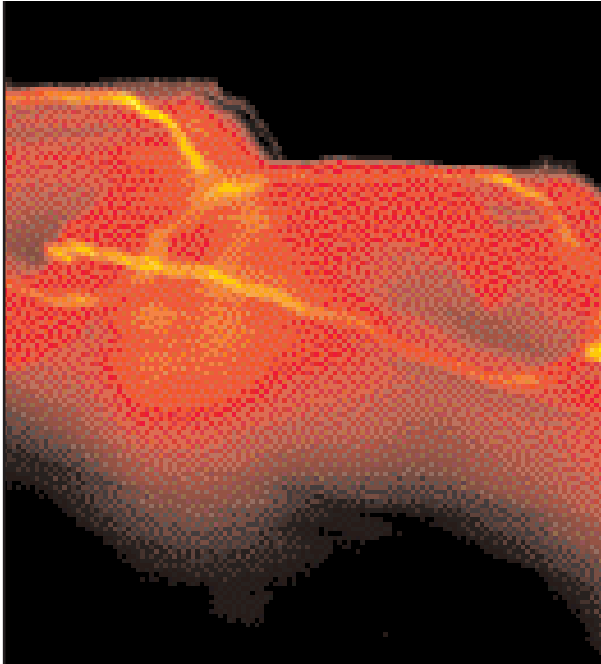

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Abstract

The rapid increase in urban population, land scarcity and the challenge of urban food security has accelerated the phenomenon of urban agriculture in terms of water resources in the Gaza Strip. Urban agriculture and the pressures it exerts on water supply have been largely ignored by planning institutions. Model analysis shows that there is illegal over exploitation of potable water resources (80 Million cubic meter/year) by farmers who use it for irrigation. The treated effluent is enough to irrigate more than 100 km^2 of permanent trees, equivalent to more than 50 million cubic meters of potable water. In addition, plans are proposed to convert 178 thousand tons of urban organic waste into useful material for agricultural production to boost farm profit. The questionnaire surveys undertaken in this study indicate that farmers are willing to use the treated effluent water.

Generally, in spite of the fact that urban agriculture is practiced widely in the Gaza Strip, planning for urban agriculture is almost non-existent, and it seems to have been neglected by water providing institutions. Farm profit analysis shows that urban agriculture principles have failed and should be reconsidered. Planners should promote urban agriculture and eco-sanitation in parallel to save potable water for domestic purposes – a key tool for alleviating poverty – and should initiate a new link between urban planning and the protection of precious water resources. The relevant institutions should put in place a clear policy to ensure waste is recycled and used sustainably for urban agriculture.

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Contents

1 Introduction

"In crisis". "Closed Borders". "Moving towards hunger". These are just some of the words and phrases that are often associated with the Gaza Strip. Gaza's population of approximately 1.4 million is still overwhelmingly centred in urban areas (PCBS, 2005). By all accounts, demographic pressures in the Gaza Strip in terms of population density, growth rate, poverty and unemployment are extraordinarily high compared to neighboring countries and regions.

Poverty and the economic dependency ratio increased in the Gaza Strip from 5.9 to 8.7 between the years 2000 and 2006. The pressure of a growing population, combined with limited availability of resources such as fresh water, places immense strain on the natural environment. Politicians and planners have the task of dealing with the many competing claims for the use of Gaza's scarce land in order to fulfill the growing demand for development in the region. Rapid urbanization, a consequence of high population growth and the low levels of control exerted in planning by planning institutions in surrounding urban areas, are a challenge to the urban planning process in the Gaza Strip.

Underlying Gaza's geographical, political, social and economical positions, there are different local, national and international factors that make it difficult for the nation to break its long and ongoing poverty cycle. Therefore, Gaza's residents have been using all possible means of saving their food needs. Urban agriculture is one of the most persistent approaches for supplying food in the Gaza Strip.

Urban agriculture is not a new or recent invention. However, only recently has urban agriculture become the focus of research and development as its scale and importance in the urbanizing world becomes increasingly well recognised (Van Veenhuizen, Prain & De Zeeuw 2001). A recent study by the United Nations Development Programme (UNDP) indicated that about 800 million urban residents worldwide are involved in urban agricultural activities as a strategy for survival. Between 1993 and 2005, urban agriculture increased its share of world food production from 15% to 33% (Smit, 1996).

The main objectives of this research are: to highlight the existing urban agricultural random practices and their effect on Gaza's water crisis; to investigate marginal water resources and agricultural fertilizers, such as reuse of municipal waste water and organic wastes, and farmers willingness to change their current practices; to integrate urban agriculture into future urban planning processes and environmental management strategies; as well as promote urban agriculture in the Gaza Strip by considering it as one element of land use combination that offers a valuable functions in the alleviation of poverty.

2 Methodology

The study focuses on the Gaza Strip, one of the major urban centres in Palestine. The secondary data retrieval for this study was undertaken using relevant institutions or organisations involved in agriculture or related environmental activities in Gaza. A questionnaire for farmers was analysed in order to enrich and support the outcomes of the research.

Modelling of agricultural water demand

Modelling the available data (temperature, humidity, rainfall, sunshine hours, and wind speed) using CROPWAT, FAO 2004, gave an accurate reference of evapotranspiration and crop coefficient of Gaza's irrigated crops, from which the water requirement for each particular crop is estimated.

3 Results and discussion

Current agricultural behaviour patterns and water demand

Agriculture is the prevalent sector Gaza's economy and contributes to 32% of its economic production. In addition, it is a politically sensitive sector as all of its inputs such as, seeds, fertilizers and pesticides are imported from Israel. Therefore, any political crisis influences it directly while the agricultural sector is considered to be a main part of Palestinian life, over the last five years it's contribution to the national Gross Domestic Production (GDP) has reduced from 9.1% in 2000 to about 7.0% in 2005, the total production of agricultural crops was reduced by 3.06% between 2000 and 2005 the value added by the agricultural sector as a whole has reduced by 30.7% over the past five years.

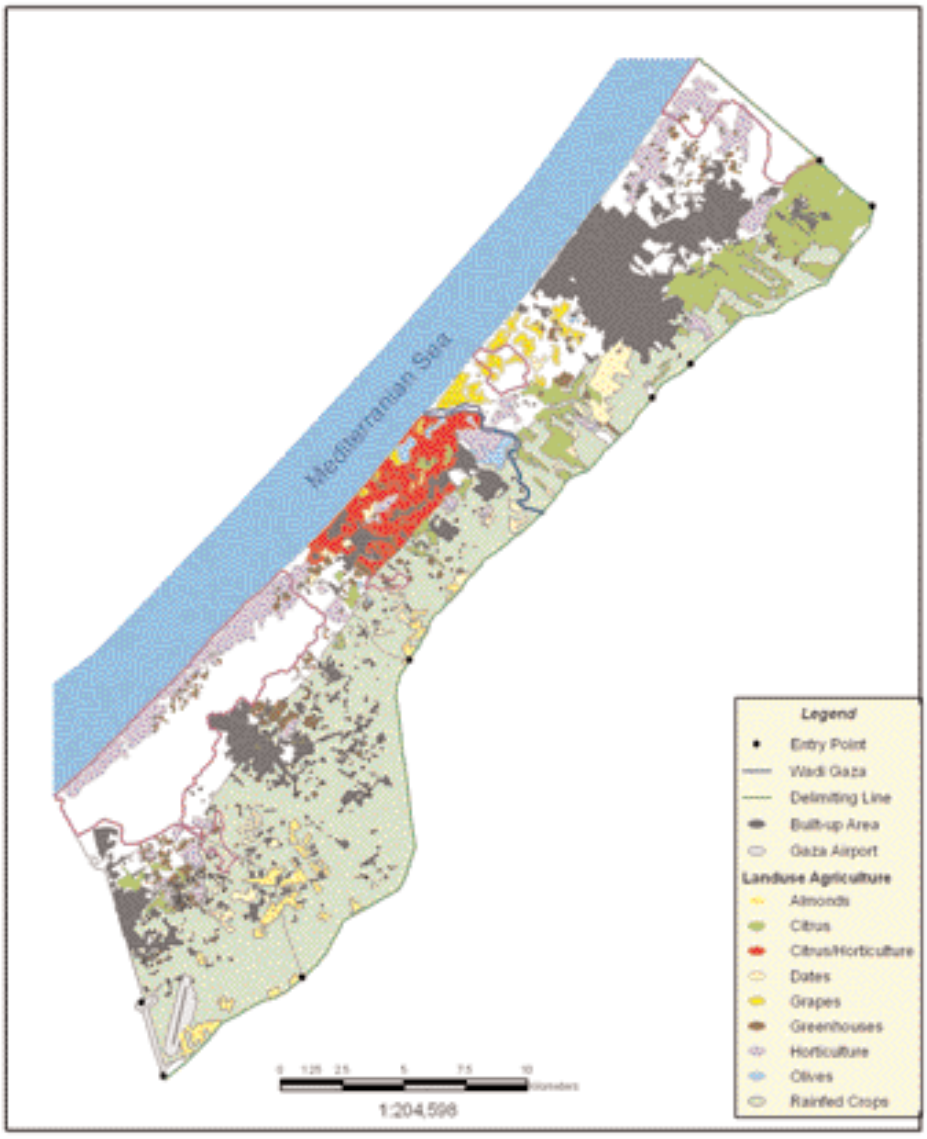
The direct and indirect losses of the agricultural sector from political measures was estimated by the Ministry of Agriculture (MOA) to have reached about US$ 345 million from the beginning of the year 2000 up to 2006 (PCBS, 2006).

Considering that the Gaza Strip has a total area of 365 km^2, with a width ranging from 6 to 12 km and length of 45 km, most of the agricultural areas are located within and surrounding the denser residential areas (Map 1). Therefore, this type of agriculture could be classified as urban agriculture due its location; moreover some of the green houses are irrigated from the municipal water network within, the residential areas. Fruit trees and vegetables are cultivated within and close to, the built up areas, while rain fed crops occupy the eastern area of the Strip where the majority of the land is state owned. Farmers used to cultivate this land to feed their animals without having tangible agricultural infrastructure or irrigated water consumption.

Agriculture has passed through several stages of expansion and land reduction. The cultivated area increased from 170 to 198 km^2 from 1966 –1968. In 1978, the cultivated area was reduced to 179 km^2 and the forest areas and sand dunes were reduced from 32% to 22%, mainly due to the increase in size of urban areas. The current total amount of cultivated lands in the five Gaza Governorates observed a remarkable increase (the total cultivated was 146 and 167 km^2 in 2004 and 2005, respectively) in comparison to the areas recorded in previous years, which witnessed an observed decline since the mid 1990's, including a drastic decrease in the production of citrus fruits, which were considered to be the main consumer of water.

This change mainly occurred because of: the expansion of construction in urban areas, particularly in Gaza City; the deterioration of the quality of irrigated water especially in the middle and the southern areas; and due to the socio-economic factors and restrictions imposed on the farmers. The remarkable current increase in agricultural lands is attributed to the great desire of many farmers to reactivate their farms by planting new varieties of citrus fruits in order to replace the old ones, and the move towards intensive agriculture, which was obviously recorded in the increase of greenhouses all over the Gaza Strip.

Map 1 Built up areas and the existing location of each individual crop in the Gaza Strip (adopted from MOP, 2005).



The water allocated for irrigation has never been measured, and farmers do not have any measurement devices on their wells to determine the exact amount abstracted for irrigation.

In current farming practice, citrus fruit, olives, other fruits and vegetables are irrigated with either an extra or a lesser amount of water than is actually required for evapotranspiration due to absence of research in this field. Agricultural water demand is therefore estimated from the available cultivated areas multiplied by the irrigation water quota allowed for each crop - this is calculated by using the CROPWAT model. Water consumption for vegetable crops accounts for 47.7 Million Cubic Meter per year (MCM/yr), which constitutes around 58% of total water demand for the agricultural sector. Citrus fruit, olives, almonds and other fruits consume around 33 MCM a year, which represents 40% of total water demand (Table 1).

The total water demand for agriculture and domestic use accounts for 80 and 47 MCM, respectively. These values match with the findings of Metcalf and Eddy, 2000, who claim that the total water demand for the agricultural sector represents 58% of total water demand, while the model shows that agricultural consumption represents 63% of total water demand in the Gaza Strip. The livestock water demand is calculated as being 2 MCM, although it is a minor figure in comparison to agricultural and domestic demand (PWA, 2005 and MOA, 2001).

Because vegetables in general consume the highest water quota, water consumption for each vegetable type, total production cost and farm profits (Table 2) were evaluated to investigate the feasibility of using the groundwater for irrigation. While crops which are cultivated in green-houses are the most profitable, they also consume the highest quota

Table1 Cultivated area and water requirement of each crop in the Gaza Strip (Adopted from MOA, 2004, Arial satellite images and CROPWAT model).

Crop Type	Area cultivated* (dunam)	Water requirement		
		m^3/dunam**	106 m^3/year	% of total
Citrus	12,600	900	11.34	14.0
Olives	22,897	700	16.00	20.0
Date Palm		Only small area remaining		
Almonds	3,163	400	1.35	1.7
Fruits	10,333	400	4.13	5.0
Vegetables (Protected)	21,382	650	13.89	17.3
Vegetables (Unprotected)	47,044	700	32.93	41.0
Flowers	514	1500	0.77	1.0
Ornamental	132	500	0.07	0.1
Field crops	36,562	Rain fed	0.00	0.0
Total	154,627	–	80.48	100

*Data from MOA and checked by Arial satellite images
**Results of CROPWAT model

Table 2 Production and farm profit of Green houses, open field and rain fed crops
Source (calculated from MoA, 2004).

Crop	Production (kg)	Total gross out put	Total cost	Farm profit	Water requirement m^3/dunam/yr
	USD ($)				
	Green houses				
Tomato	15000	2667	2112	555	800
Cucumber	10000	2000	1435	565	650
Jews iuallow	1500	1333	478	855	200
Local hot pepper	3500	1944	1361	583	700
Eggplant	6500	2167	1307	860	800
Carnation	100000	6667	6143	524	1500
	Open field (irrigated)				
Strawberry	3500	3111	2874	237	1000
Local hot pepper	3000	800	482	318	700
Squash	2000	667	382	285	480
Spinach	2500	667	329	338	480
Sweet potatoes	3000	533	549	-16	800
Spring potatoes	3500	778	554	224	480
Broad beans	800	622	210	412	360
Bees	850	568	210	358	300
Cucumber	2500	833	374	459	360
Okra under tunnel	800	1244	831	413	600
	Rainfed				
Wheat	300	113	23	90	0
Barley	300	93	22	71	0
Bees	450	173	76	97	0

of irrigated water, in particular carnations which consume more than 1500 m^3/dunam/yr (one dunam = 1000m^2). The current water tariff (0.16 \$/m^3) is considered by the Ministry of Agriculture in the total cost of crop production. This value represents only the cost of pump operation and fuel. Water as an asset, in light of Gaza's water crisis, has never been evaluated. For instance; carnations and strawberries (cash crops) are the two main agricultural products exported from the Gaza Strip.

Carnation's farm profit is nearly 530 \$/dunam, while its water consumption is 1500 m^3/dunam (Table 2). That means that the Gaza Strip exports water in the form of carnations for 0.35 \$/m^3, and in the form of strawberries for 0.24 \$/m^3. Calculations for the common exported vegetables are shown in Table 3. It is worth to

mention that the, Palestinian Authority imports around 5MCM/year from Israel, paying around 0.5 $/m^3 for domestic use. In other words, water value in form of the crop should be more than the price of imported water (0.5 $/m^3) otherwise it is not feasible to cultivated the crop with regards to water resource management.

Carnations and strawberries are the two crops most affected by political changes and the closure of passages. Moreover, their water value is less than the price of imported water. Other green-houses and open field crops, such as tomato, eggplant, squash, spinach, potatoes, broad beans, cucumber, okra and local hot pepper play an essential rolen maintaining food security in the Gaza Strip during the closure of passages. Additionally, they are considered to be the only means of income for many local farmers from the local market. Rain fed products secures the feeding of the animal production sector.

Table 3 Water value in the form of each individual export crop

Water value in the form of crop= Net farm profit / water consumption
Water value in the form of crop: $/m^3
Net farm profit: $/dunam
water consumption: m^3/dunam

Type of agriculture	Crop	Water value in the form of crop ($/m^3)
Green houses	Tomato	0.69
	Cucumber	0.87
	Jews iuallow	4.28
	Local hot pepper	0.83
	Eggplant	1.08
	Carnation	0.35*
Open field	Strawberry	0.24*
	Local hot pepper	0.45*
	Squash	0.59
	Spinach	0.70
	Sweet potatoes	-0.02*
	Spring potatoes	0.47*
	Broad beans	1.14
	Bees	1.19
	Cucumber	1.28
	Okra under tunnel	0.69

* Less than the price of imported water (0.5 $/m^3)

Urban agricultural principals have emerged at the intersection of a number of debates, including poverty alleviation, economic empowerment, household food security and improved nutrition, sustainable urbanization and the conservation of the natural environment. But it can easily utilise existing government resources, such as state owned land and support services (World Bank 2000). Drescher (2002) argues that the urban food system is not sufficiently reflected with in the urban planning process in many countries. Accordingly, those living in urban areas are not passive food recipients, because in many locations they are actively involved in food production. Urban agriculture should therefore be reflected as a means of formal land use in urban planning, land-use and water resources management.

Urban agriculture in the Gaza Strip is contradicting these principles and showing consumption of natural water resources As proven from the calculations, farmers are selling the state water assets in the form of carnations, strawberries and sweet and spring potatoes with lower prices than those attached to the the import price of water (Table 3). Unless eco-sanitation (re-use of treated waste water and organic wastes) is properly considered in the Gaza Strip, importing agricultural product will be the most feasible means of preserving water resources.

Eco-sanitation: re-use of municipal wastes in agriculture

Human and municipal solid waste contains a significant amount of nutrients that can aid the production and growth of food and non-food crops. Re-using municipal waste water and solid waste in urban agriculture can affectively reduce waste treatment and disposal, provided that public health is not impaired. The integration of urban agriculture into urban environmental sanitation planning is therefore of utmost importance. The reuse potential of different waste products as a function of crops, soil and climate conditions, (including health, socio-cultural, economic, and reuse policy aspects) have to form an integral part of future environmental sanitation strategies that in the areas that suffer from a lack of natural resources and complain of severe water crises, such as the Gaza Strip.

Urban producers could achieve real efficiencies by making productive use of under-utilized resources such as vacant land, treated waste water, recycled waste and unemployed labor. Sufficiently treated waste water is used worldwide for urban agricultural activities. This water resource can make a valuable contribution towards the availability and affordability of water for urban agricultural activities (Hassan 2002).

> “…sufficiently treated water waste is used worldwide for urban agricultural activities…”

Treated waste water and reuse potential

The water waste collected from the whole of the Gaza Strip is fed into three main treatment plants; Beitlahya, Gaza and Rafah with total capacity of 20,000, 75,000 and 16,000 m^3/day (total of 40 MCM/year) by the year 2010, respectively (PWA, 2005).

Currently, partially treated waste water is discharged to the sea without any significant re-use. As stated in the proposed regional plan for the Gaza Strip (MOP, 2005), the three main treatment plants should be transferred to the eastern border of the Gaza Strip, and should work with treatment technology to produce treated effluent of a quality fit for fruit trees irrigation, according to Ministry of Environmental Affairs (MEnA) standards (MEnA, 2001). The treatment plants are planned to be connected with a main carrier that would transfer the treated effluent to where it was needed (Map 2). Although the eastern side of the Gaza Strip, which has an area of 123 km^2 is currently a potential area for seasonal rain fed crops (Map 1), only 36.5 km^2 is currently cultivated (Table 1).

A consequence of transferring the waste water treatment plants to the eastern side by the year 2010, and the availability of treated waste water is that, around 50 km^2 of fruit trees, which are cultivated within and surrounding the residential areas (Map 1), could be transferred to the eastern side of the Gaza Strip if new policy to keep the production of fruits with least cost, and the re-use of treated effluent faraway from the residential areas (Map 2) for health and safety reasons, is put into practice. As shown in Table 1, the water demand for the irrigation of fruit trees (citrus, olives, and fruit trees) accounts for 33 MCM/year, which is less than the produced treated effluent. This approach will save around 33 MCM of the groundwater for domestic use. Moreover, it will reduce the costs of fruit production, and as a consequence will increase farm profits, considering the water resources crisis. It will also optimise the use of state owned land on the eastern border.

In many countries in the Middle East, including the Gaza Strip, groundwater is used for agriculture. Due to the limited availability and overexploitation of groundwater, many countries are looking for alternative resources for irrigation in order to preserve the amount of groundwater available for domestic purposes (Sana'a university, 1992).

Public acceptance of using treated waste water for irrigating agricultural produce is a crucial aspect in ensuring the success of any re-use project. Therefore, a sample of 12 large farm owners with citrus and fruit trees (1500 dunam) were questioned using a questionnaire especially designed to fulfill this purpose. The majority of farmers (10) agreed completely with using the treated effluent; the remainder agreed conditionally, assuming that the general public will not accept the produce which has been irrigated by treated effluent. Marketing the produce is their concern. Most of the farmers show understanding of the water crisis in the Gaza Strip and have attended public awareness workshops.

In a similar questionnaire, this time focusing on all farm types (fruit and vegetables), conducted by Tubail K et al. 2003, a sample of farmers was questioned. The majority of farmers (86.1%) agreed completely with using the treated waste water for the irrigation of 2856 dunam (80.7%) of the total targeted area. Most

of the interviewed farmers (89.9%) were willing to pay for treated waste water.

Rainwater harvesting from the roofs of green houses and houses in the neighbourhood should become a standard pattern in local water resources management. The total amount of water harvested from the roof of one dunam of green houses is estimated to be 300m^3/season (Al-Najar et al., 2005). As shown in Table 2, this amount of harvested water could be enough to irrigate one dunam of bees, cucumber or Jews iuallow.

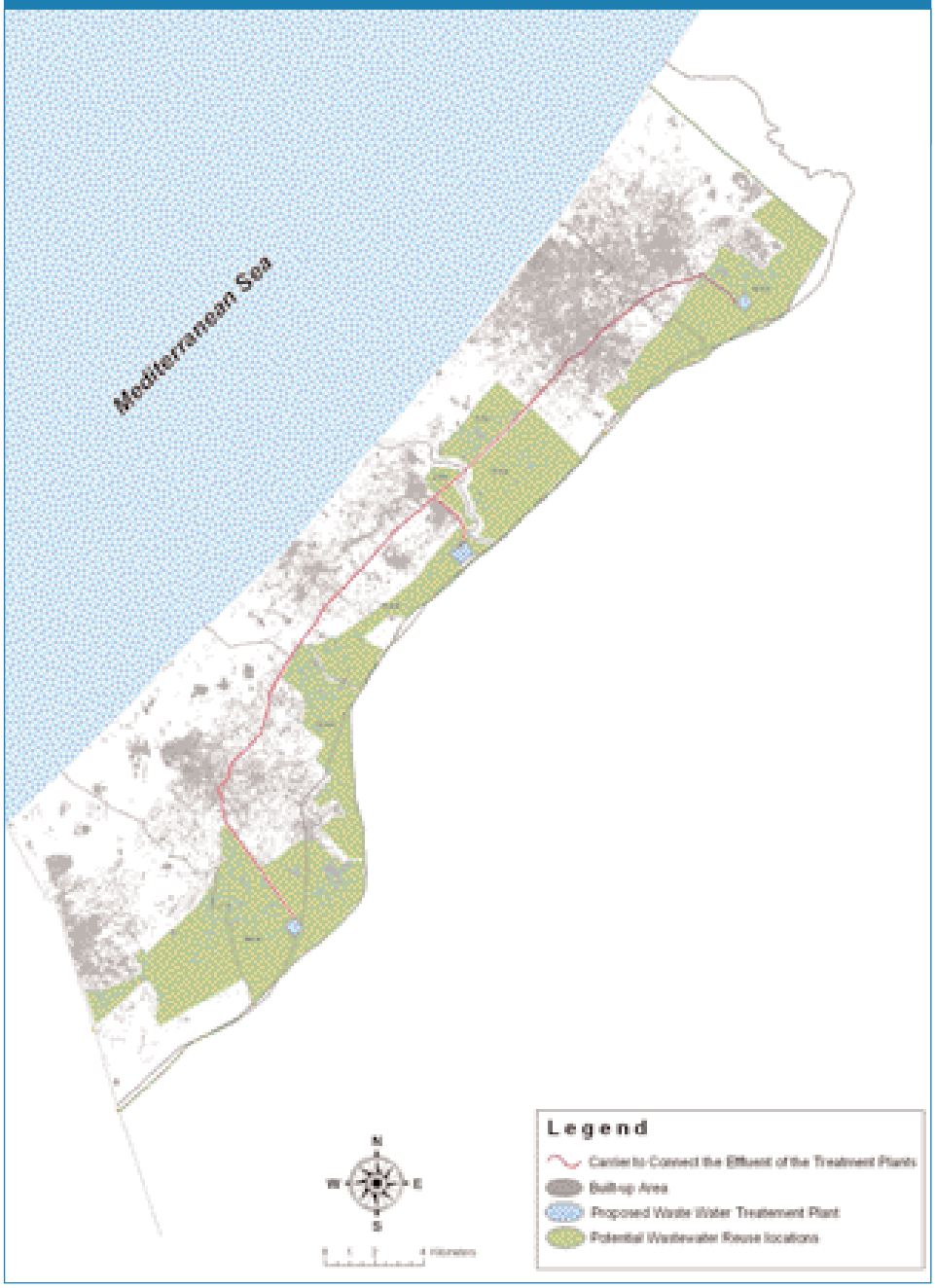
Composting of municipal organic wastes

The insufficient collection and inappropriate disposal of solid wastes are a source of water, land and air pollution, and pose risks to human health and the environment. Over the next several decades, rapid urbanization in the developing world could further deteriorate this situation. Solid waste management usually accounts for 30-50 percent of municipal operational budgets (El-Hawi, 2004). The amount of solid waste generated daily in the Gaza Strip is estimated to be 1000-1200 tonnes, 65% of which is organic. The composting of the organic fraction could be the best disposal and reuse approach (Agro-Vision/EU 1998). Through the composting process half of the volume will be reduced. Therefore, the expected amount of produced compost calculated to be 142,000 ton/year. The amount of produced compost will be enough for 178 km^2, considering the amount of 0.8 ton will provide 100 kg/dunam of total nitrogen (Al-Najar et al. 2003). The produced amount of compost is more than enough to fertilize the total used agricultural land which is 155 km^2 (Table 1).

It is worth mentioning that, the compost for Gaza's agriculture is imported and constitutes a high percent of the agricultural sector's total costs. Gaza's organic waste disposal also causes serious environmental problems. More than 75% of Gaza soil is sandy or sandy loam soil, which is characterised by low organic and mineral content. Farmers compensate the lack of soil fertility by using huge amounts of chemical fertilizers, which pollute the groundwater with nitrates.

In the proposed composting reuse approach, the specific needs of low-income areas would be considered; it would promote community participation and incorporate informal refuse collectors and scavengers into public-private partnerships, micro-enterprises, or scavenger cooperatives as a means of a surviving strategy to help them deal with the difficult economic situation prevailing in the area. The proposed approach could help solve the problem of disposing of solid waste in a socially desirable, economically viable and environmentally sound manner. With the growth in urban poverty associated with the current negative political atmosphere, and the growing amount of waste generation, waste recycling and composting could become an important source of income. Since the community has understood the need and importance of proper waste handling the community could be motivated to consider this as something valuable, and further utilize recycling opportunities in their private scheme.

Map 2 Potential agricultural locations for citrus and fruit trees to be irrigated by treated effluent (adopted from PWA, 2005).



4 Conclusions

Future urban and agricultural development

Land is one of the primary natural resources in the Gaza Strip. As a consequence of human activity, few areas remain in a pristine, natural state. The pressure on land is increasing rapidly in all sectors. Urban and Horticultural expansion is concentrated in the western coastal zones of Gaza. The expansion of buildings and other urban dwellings is estimated to be 1 to 1.5 km^2 per year. Ariel satellite images indicate that the urbanized area represented around 16% in the year of 1998 and 20% in the year of 2004. If the current trend of increase remains valid, it expected to represent 33% and 45% for the years of 2015 and 2025 respectively. The history of Gaza's rural population shows a rapid decrease in numbers, and representing 32%, 10% and 8% of the total population in 1948, 1967 and 2004 (MOP, 2005). Metcalf and Eddy (2000) suggested that, *the current land use will not expand in the future due to the fact that not much land in the Gaza Strip left is unused,* So, they claim that future expansion will be for residential use on the basis that agricultural land is already being used.

The demand in urban areas accounts for 57 and 120 km^2 of Gaza Strip's total area for the years 2005 and 2015 respectively, as shown in Table 4. Such urban expansion will occur on state owned land and agricultural areas.

It is clear that the process of urbanization is increasing at a rapid rate. The Strip was transformed from "mostly rural", to "mostly urban" within 40 years, which had several implications for agriculture and food security. Addressing the rural urban linkages is necessary because the phenomenon of urbanization in the Gaza Strip has been certain. People in both rural and urban areas are losing their control over, and connection to, the sources of their food. Gaza North Governorate registered the highest percentage of unemployment rates amongst the Gaza Strip Governorate which reached 40.6%, followed by Khanyounis Governorate 36.9%.

Demographic and urban growth is one of the major challenges of the next decade. In 1994, 45% of the world's population lived in cities, and this figure will have risen to 65% by 2025.

Table 4 Total build up, open and agricultural areas of Gaza Strip for years 2005 and 2015 (Khalaf et al. 2006).

Gaza Strip	Year 2005	Year 2015	Year 2005	Year 2015	Year 2005	Year 2015
	Total build up area*		Open area		Total available agricultural area	
			km^2			
365	57	120	101	67	207	176

*Buildup area, open area and agricultural areas are measured by using GIS tool of the existing satellite images (2005).

The most rapid change occurs in the developing world, where urban populations grow 3.5% annually. In 1988, about 25% of the urban population ranked among the world's most absolute poor. By 2000, this figure had risen to about 56%. Historically, cities were the driving force in the field of economic and social development. However, urbanization not only offers advantages, but poses environmental and social problems, including inadequate water supplies, poor environmental sanitation services and food insecurity. In environmental sanitation and urban agriculture, these problems should be addressed by using a holistic approach.

In conclusion, the current agricultural practices show that farmers are using the potable water to grow their crops and using the state owned water resources in unsustainable and unreasonable approaches. It is clear that the agricultural sector consumes more than 60% of water, and as such demand should be managed through the more efficient usage, such as adopting new crop patterns which have more profit per water consumption and the utilization of alternative water and organic waste resources, such as treated effluent and compost. Farmers show their understanding of the water crisis in the Gaza Strip and have accepted the use of the treated effluent is necessary. However, they are concerned that there will be difficulties in marketing their produce. Despite the fact that agriculture is considered to be the most prevalent sector is necessary the local economy by economists, the results of this and other current research indicates that water value has not been factored into their estimations and findings.

The eastern border of the Gaza Strip should be reserved for further agricultural expansion of permanent tress, and as potential land for the reuse of treated effluent. In addition the marketing of the products grown through the utilization of treated effluent, and the food industry should be the main concern of planning institutions. Development of agricultural infrastructure in the eastern boarder should be considered in order to attract the investors and farmers.

Urban areas and surrounding urban agriculture should be enhanced to ensure food security strategy, but high tech irrigation system should be considered to minimise the potable water consumption in urban areas.

A comprehensive plan and coordination between the various water-related institutions should be maintained to ensure the sustainability of water resources for various needs in the Gaza Strip.

Further technical studies and research are essential to ensure the monitoring and control of agricultural practices, particularly in terms of using environmentally sound measures and following up on the eco-sanitation approach.

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