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ECONOMIC ANALYSIS OF CEREAL, VEGETABLE AND GRAPE PRODUCTION SYSTEMS IN URBAN AND PERI-URBAN AGRICULTURE OF KABUL, AFGHANISTAN

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SUMMARY

Little is known about the economics of urban and peri-urban agriculture in Kabul, Afghanistan. This study therefore aimed to investigate the profitability of 15 mixed cropping farms with a total of 42 farm plots that were selected from a survey of 100 households (HHs). The sample represented the three dominant farm types: cereal producers (15 plots), vegetable farmers (15 plots) and grape producers (12 plots). A cost-revenue analysis of all inputs and outputs (costs of tillage, seed where applicable, weeding, harvesting, casual labour, machinery use, pruning, pesticides and of revenue from produce sold) over two years showed major differences in net HH income. Differences were largely due to production type and crops grown and reflected differences in market prices for produce. Cereal production yielded a total bi-annual revenue of 9630 US$ ha^{-1}, and a gross margin and a net profit of 8770 US$ ha^{-1}. Vegetable farming gave an average bi-annual revenue of 27 900 US$ ha^{-1}, a gross margin of 26 330 US$ ha^{-1} and a net profit of 25 530 US$ ha^{-1}. Surprisingly, vineyards generated the lowest returns with a revenue of 5400 US$ ha^{-1}, and a gross margin and a net profit of 4480 US$ ha^{-1}. The results suggest that among the production systems studied vegetable cultivation was most profitable given its direct linkage to city market demands, rather stable prices and much shorter growing season than for cereals and grapes. In addition, the inflow of wheat and grapes from rural areas into the city negatively affects local producer revenues. If vineyards are to be maintained in the city surroundings, incentives such as subsidized credit may need to be made available to producers.

INTRODUCTION

In recent years urban and peri-urban agriculture (UPA) has been widely recognized as a means to contribute to the livelihoods of local livestock and vegetable producers, small traders and consumers in many cities of the developing world. While UPA is part of the legal economy, its existence is often only tolerated rather than supported, given that most UPA producers operate on land to which they have no legal entitlement (Gerstl *et al.*, 2002). As poor urban households can spend 60–80% of their income on food, UPA may also significantly contribute to their subsistence needs and thus to poverty alleviation (Avila and van Veenhuizen, 2002; Nguni and Mwila, 2007; van Veenhuizen and Danso, 2007). On the other hand the often intensive use of sewage water for irrigation and urban waste as a soil amendment in UPA has been reported

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to cause microbial and heavy metal contamination of agricultural soils and produce (Abdu *et al.*, 2011; Amoah *et al.*, 2005; Keraita and Drechsel, 2002; Keraita *et al.*, 2007). In view of such pros and cons of UPA, urban planners and policy makers are increasingly seeking effective solutions to integrate these activities into inner city areas (FAO, no date; Nugent, 1999).

Given the scarcity of data on the profitability of different types of UPA production systems and the role that such activities play for the household (HH) income of its practitioners, the objective of this study was to compare costs and benefits of UPA for the Afghan city of Kabul where rapid city development and economic growth strongly determine its spatial extension and income potential.

MATERIALS AND METHODS

Site conditions and UPA activities

Kabul, the capital city of Afghanistan, is located at 1750–1770 m asl. It is characterized by an average annual precipitation of 300–330 mm, distributed between November and May, and a long-term annual average temperature of 10–13 °C with a relative humidity of 54% (Grieser *et al.*, 2006). Kabul province comprises 14 rural and 22 urban districts, and about 81% of its population lives in the city. The average farm size in the province is about 0.4 ha, and even large landowners rarely have more than 1 ha. Sharecropping, whereby the landlord rents out his land typically in return for 50% of the harvest, is common practice among small farmers. While in the countryside cereals such as wheat (*Triticum aestivum*), maize (*Zea mays*) and barley (*Hordeum vulgare*) dominate, in the city the majority of crops grown are vegetables rotated with some cereals and grapes.

The cereal farming area under study is mainly situated in the southern part of the city (34°28′45.96″N, 69°12′54.94″E; 1767 asl; Figure 1) and for a few months each year obtains irrigation water from the Charasyab district to complement precipitation for a single crop. A few vegetables such as potato (*Solanum tuberosum*), onion (*Allium cepa*), turnip (*Brassica rapa* var. *rapa*) and forages such as alfalfa (*Medicago sativa*) and clover (*Trifolium* spp.) are also occasionally grown. In this area, no regular runoff exists but occasional rainfall in spring and sometimes in summer can lead to flash floods that rush through the low laying areas. The total area under cultivation per household ranged from 6025 to 39 490 m^2 and plot sizes from 100 to 2000 m^2. While vegetable production is largely for sale, cereals are for both subsistence and to earn cash. Major constraints of this landuse system are the timely availability of water and mineral fertilizers.

The vegetable farming area is located in the centre of the city (34°29′59.76″N, 69°09′22.06″E; 1765 m asl; Figure 1) stretching from East to West along the Kabul River. This area has an old irrigation infrastructure including sewage channels from local residential areas. The total area under cultivation per household ranged from 4020 to 9925 m^2. Plots sizes ranged from 54 to 1000 m^2 and are typically cropped from April to November with an intensive rotation of vegetables such as radish (*Raphanus*

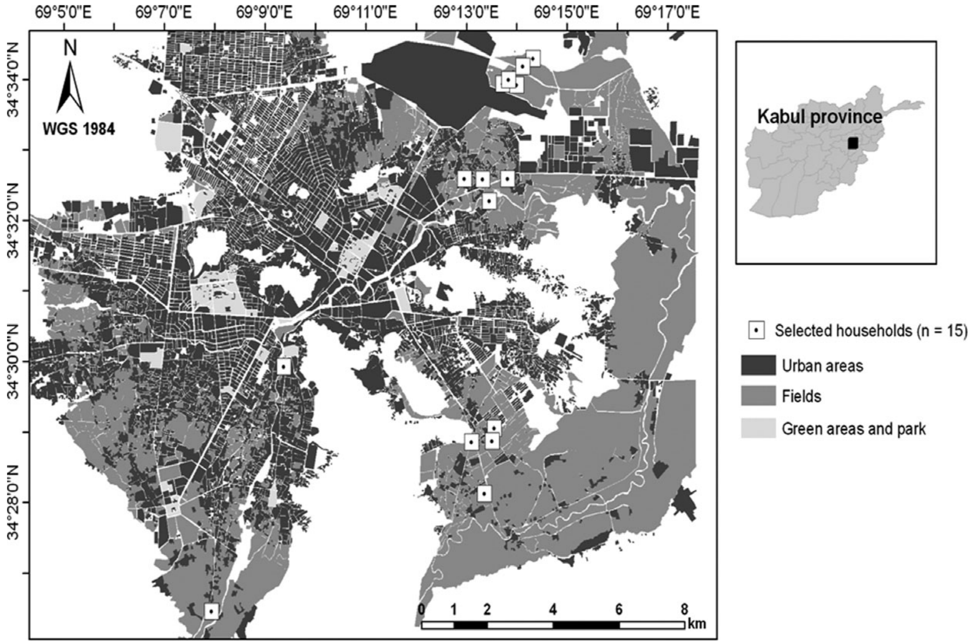

Figure 1. Map indicating the location of the studied urban and peri-urban farming households in Kabul, Afghanistan. White areas indicate barren wasteland.

sativus), coriander (*Coriandrum sativum*), leek (*Allium ampeloprasum* var. *porrum*), onion, carrot (*Daucus carota*), turnip (*Brassica compestris* var. *rapa*), eggplant (*Solanum melongena*), spinach (*Spinacia oleracea*), pepper (*Capsicum annuum*), lettuce (*Lactuca sativa*), mint (*Mentha arvensis*), garlic (*Allium sativum*), cabbage (*Brassica oleracea*), pumpkin (*Cucurbita moschata*), tomato (*Lycopersicon esculentum*) and wheat. Forages such as alfalfa and clover are also grown sporadically. Major opportunities in this system are the easy market access for produce while water availability, the amount of arable land and competition from other parts of Afghanistan with cheaper labour costs are important constraints.

Vineyards for table grape production are located at the northern corner of the city (34°34′12.27″N, 69°14′13.15″E; 1758 m asl) and are at least 40 years old. The moderately fertile vineyards are situated in a large flat area with a poor drainage system. During spring the area's major water source is the Kabul River which is increasingly complemented by sewage water from residential areas as the year progresses. Total area under cultivation per household ranged from 1720 to 9586 m^2 with plot sizes from 200 to 6500 m^2. Some of the farmers also grow wheat, vegetables and forages in association with grapes or in separate plots, but grapes are always dominant. Apricot (*Prunus armeniaca*), mulberry (*Morus*) and other deciduous fruit trees grown for non-commercial purposes are also present as garden borders. The major constraints to this system are water availability, poor drainage conditions and seasonal sensitivity of the grapes to frost events.

Table 1. Basic household (HH) characteristics in the three management systems of urban peri-urban agriculture (UPA) in Kabul, Afghanistan (2008–2009)[†].

HH	Total cultivated land area (m^2)	Land use mode	Indigenous/ immigrant	Cropping history (years)	Income from cropping (%)[‡]	Labour availability		Fertilizer application	
						Full-time (family)	Casual (hired)	Organic (%)	Inorganic (%)
1	10 685	Open	Indigenous	>40	50	1	1	58	42
2	9600	Open	Indigenous	>40	50	2	3	38	62
3	39 490	Open	Indigenous	>40	100	1	1	23	37
4	6025	Open	Indigenous	>40	80[a]	1	2	51	49
5	10 800	Open	Indigenous	>40	80	1	1	58	42
6	6651	Open	Indigenous	40	100	2	1	80	20
7	9924	Open	Immigrant	5	100	2	1	84	16
8	4020	Open	Indigenous	40	50	2	–	70	30
9	1380	Open	Indigenous	5	80[a]	1	1	65	35
10	3427	Open	Indigenous	>40	100	2	–	49	51
11	2220	Wall fenced	Indigenous	>40	30[a]	1	2	0	100
12	1720	Wall fenced	indigenous	>40	50	1	1	46	54
13	9586	Wall fenced	Indigenous	>40	20	–	2	82	18
14	6326	Wall fenced	Indigenous	>40	80	1	1	79	21
15	4530	Wall fenced	Indigenous	>40	80[a]	2	2	65	35

[†]Labour payment rates for agricultural labour are $4 per day (10 hours) regardless of whether the labour was skilled or unskilled.
[‡]Household in which animal husbandry contributed to total income.

Data collection and calculations

For this study we used data obtained from a detailed farm and HH survey conducted from 14 April 2008 to 25 October 2009 (Safi *et al.*, 2011). The data included all quantitative plus monetary values of crop inputs, such as seeds, organic and inorganic fertilizers, pesticides, irrigation water, land leasing, hired labour charges, fuel, machinery needed for all field operations and harvested crop yields from all fields of each of the 15 representatively selected farm HHs. All of these were headed by full-time farmers who may, however, still have had some secondary, yet unquantified income from Afghanistan's sprawling informal economy or from small ruminants kept at home (Table 1). Each of the three existing UPA production types were represented by 5 HHs and a total of 42 plots were used for this study. All input prices and the farm gate price of each type of produce sold were recorded. Costs of manure and irrigation water were calculated based on current prices at the farm gate. All expenses and revenues were computed on a hectare basis and converted from the local currency Afghani to US$ at a rate of 50:1. Depreciation of irrigation equipment as well as interest on capital for the variable expenses incurred by the farmers during the crop season was not taken into account in our calculations of production costs. Furthermore the establishment costs of the vineyard plantations were considered amortized over their past 40 years' life span. Therefore, no further amortization costs were considered.

Based on crop yields, product prices and costs, we evaluated relative farm profitability using the average gross margin and average net profit per hectare and year. The gross margin was computed by subtracting variable costs from the value of total production as follows:

$$TGM = \sum(Yi \times Pi) - \sum(VCi) \quad (1)$$

where, $Yi =$ is the yield of crop i; $Pi =$ the farm gate price for crop i; $VCi =$ the total variable costs for crop i.

Net profit (NP) was calculated by subtracting the total fixed costs from the gross margin:

$$\text{NP} = \text{TGM}i - \text{TFC}i \quad (2)$$

where, NP is the net profit, TGMi is total gross margin of crop I and TFCi is the total fixed cost for crop i.

Statistical analysis

A multivariate analysis of variance (MANOVA) using the GLM procedure of SPSS version 18 (SPSS Inc. Chicago, IL, USA) was performed to assess differences between farms and between production systems.

RESULTS

Cereal production

Cereal farms were mainly subsistence- and only partly market-oriented. At the end of the growing season, some of the farmland was used by landless families to graze their flocks. Most farmers had pre-paid contracts with retailers which allowed the latter to purchase the produce at less than half the market price prevailing at harvest. Given the distance to the city, manure costs were 0.44 US$ per wheelbarrow (including handling). Malathion® (organophosphate parasympathomimetic) was applied to control aphids and leaf hoppers. Across farms machinery was often used for land preparation.

Vegetable production

Despite the availability of snow-melt water in the spring season and year-round availability of sewage water for irrigation, two out of the five vegetable farms had invested in a water pump to convey river and sewage water onto the plots which carried a wide variety of species (Table 2). Manure price per wheelbarrow was 0.08 US$ plus additional handling cost of 0.08 US$. Manure had 97% dry matter and contained 70% sand and 30% of organic and non-organic municipal solid wastes. Night soil was sometimes collected for free from local toilets and applied to the field after a few months of composting. Mineral fertilizers such as urea and di-ammoniumphosphate (DAP) were also used. The produce market was very close to the production area, but most clients and retailers came to the farm to make their purchases. Rent paid in kind for leased land was 350 kg wheat for 0.2 ha yr^{-1}. As on cereal farms, malathion was used to control aphids and leaf hoppers in the gardens.

Table 2. Crop rotation and marketable yields in 15 urban and peri-urban farming systems in Kabul from April, 2008 to October, 2009.

Household type/No.	Marketable yield (t ha^{-1})	Farming type	Cropping sequence[†]
Cereals			
1	[4.8/14][‡]; [5.4]	Commercial & subsistence	Wheat (grain/straw)[‡]; onion (bulb)
	[4.9]; [2.5/22.5]		Onion; wheat
	[2.9/8.7]; [2.5/22.5]		Wheat; wheat
2	[4.1/10.0]; [4.5, 4,5, 5.6]	Commercial & subsistence	Wheat; clover, clover, clover
	[3.7, 4.5, 5.5]; [5.5/20.6]		Alfalfa[§], alfalfa, alfalfa; wheat
	[3.9]; [4.8/21.4]		Onion; wheat
3	[2.4, 5.0, 5.0, 10.0, 6.8, 12.0, 4.6]	Commercial & subsistence	Alfalfa, alfalfa, alfalfa, alfalfa, alfalfa, alfalfa, alfalfa
	[4.1/10.0]; [5.6]; [1.9]; [0.36/25.4]; [4.7]		Wheat; clover; corn; wheat; onion
	[3.8]; [4.5/21.2]; [14.5]		Onion; wheat; corn
4	[4.9]; [5.6/19.9]; [7.4]	Commercial & subsistence	Onion; wheat; turnip
	[4.1/10.0]; [5.4]; [6.5];		Wheat; corn; onion
	[5.9]; [3.9]; [5.6/19.9]; [37.2]		Potato; tomato; wheat; millet
5	[4.9/20.0]; [10.7];[5.4]	Commercial & subsistence	Wheat; barley; onion
	[7.9]; [5.4/16.1]; [3.2]		Potato; wheat; barley
	[5.7]; [5.4/16.1]; [3.2]		Onion; wheat; barley
Vegetables			
6	[3.4]; [3.2]; [2.7]; [2.2]; [3.1]; [1.9]; [3.0]	Commercial	Garden cress; coriander; spinach; coriander; radish (shoot and bulb); radish; spinach
	[1.3]; [0.54]; [1.8]; [0.55]; [1.3]; [1.8]; [2.7]; [3.4]		Spinach; eggplant; eggplant; radish; spinach; radish; coriander; garden cress
	[1.6, 1.1, 0.93, 0.56, 2.3, 4.2, 5.2, 2.1, 2.6]		Leek, leek, leek, leek, leek, leek, leek, leek, leek
7	[2.0]; [4.2]; [0.18]; [0.66]; [1.2]; [4.0]; [2.09, [3.0]	Commercial	Radish; lettuce; eggplant; eggplant; spinach; lettuce; radish; onion
	[2.3]; [6.4]; [2.0]; [4.0]; [4.0]; [5.1]; [2.7]; [7.3]		Radish; lettuce; radish; onion; onion; lettuce; radish; garden cress
	[5.4, 6.6, 5.1, 1.3, 1.3]; [1.9]; [1.8]; [2.1]		Mint, mint, mint, mint, mint; radish; lettuce; radish
8	[2.0]; [2.3]; [2.0]; [0.94]; [2.8]; [5.5/31.0]; [7.4]	Commercial	Radish; coriander; radish; coriander; spinach; wheat; turnip
	[2.1]; [2.2]; [2.7]; [2.7]; [4.1]; [4.6/31]; [2.0]		Spinach; coriander; radish; radish; coriander; wheat; spinach
	[4.9/24.2]; [2.7]; [4.2]; [1.3]; [1.1]; [0.59]; [1.3]		Wheat; coriander; radish; spinach; onion; radish; spinach
9	[6.0, 5.8, 6.3, 15.9, 13.6, 6.8, 6.8]	Commercial	Alfalfa, alfalfa, alfalfa, alfalfa, alfalfa, alfalfa, alfalfa
	[6.2, 6.2, 7.0, 15.9, 11.4, 6.6, 3.3]		Alfalfa, alfalfa, alfalfa, alfalfa, alfalfa, alfalfa, spinach
	[3.5, 3.3, 4.3, 9.1, 9.8, 6.8, 12.3]		Alfalfa, alfalfa, alfalfa, alfalfa, alfalfa, alfalfa, corn

Table 2. (Continued)

Household type/No.	Marketable yield (t ha^{-1})	Farming type	Cropping sequence†
10	[4.1]; [2.3]; [3.4]; [2.7]; [3.4]; [2.7]; [5.9]	Commercial	Radish; onion; radish; coriander; radish; coriander; spinach
	[4.1]; [2.9]; [3.4]; [2.7]; [2.8]; [5.9]		Radish; coriander; radish; coriander; spinach; spinach
	[4.6, 7.4, 5.3]; [0.79]; [3.2, 6.8, 4.1]		Mint, mint, mint ; radish ; mint, mint, mint
Vineyards			
11	[0.37], [0.37], [0.42]; [5.4], [1.5], [0.35], [4.1]¶	Commercial	Grape (fruits, leaves, sprouts); grape (fruit, leaves, sprouts, sticks)¶
12	[0.36], [0.39], [0.42]; [4.7], [1.5], [0.42], [3.8]	Commercial	Grape; grape
	[0.0], [0.39], [0.43]; [0.0], [0.87], [0.42], [3.8]		Grape; grape
	[0.37], [0.39], [0.43]; [4.7], [1.5], [0.42], [3.8]		Grape; grape
13	[1.8, 2.2, 2.0, 9.9, 16.5, 9.9]	Commercial & subsistence	Alfalfa, alfalfa, alfalfa, alfalfa, alfalfa, alfalfa
	[2.3, 4.0, 5.0]; [9.8, 9.9, 14.8]		Clover, clover, clover; alfalfa, alfalfa, alfalfa
	[0.36], [0.38], [0.42]; [4.6], [1.3], [0.89], [3.1]		Grape; grape
14	[0.38], [0.389], [0.45]; [5.9], [2.2], [0.82], [3.7]	Commercial & subsistence	Grape; grape
	[4.1]; [6.1]; [0.88], [0.82], [0.81]		Pumpkin; onion; grape (intercropping)
	[5.1]; [3.6/19.0]		Tomato; wheat
15	[0.37, [0.39], [0.43]; [5.3], [4.6], [0.87], [3.8]	Commercial	Grape; grape
	[0.37], [0.39], [0.43]; [5.3], [4.6], [0.87], [3.8]		Grape; grape

†The scientific (and local) names of the listed crops are: garden cress: *Lepidium sativum* (taratezak); coriander: *Coriandrum sativam* (gashneez); spinach: *Spinacia oleracea* (palak); radish: *Raphanus sativus* (mulisurkhak); eggplant: *Solanum melongena* (*badenjan*); leek: *Allium ampeloprasum* (gandana); onion: *Allium cepa* (piaz); tomato: *Lycopersicum esculentum* (romibadenjan); lettuce: *Lactuca sativa* (*kaho*); Mint: *Mentha arvensis* (nana); pumpkin: *Cucurbita moschata*, (kadu); turnip: *Brassica compestris* var.rapa (*shalgham*); wheat: *Triticum aestivum* (gandum); barley: *Hordeum vulgare* (jau); maize: *Zea mays* (jawari); potato: *Solanum tuberosum* (kachalu); alfalfa: *Medicago sativa* (rishqa); and clover: *Trifolium resupinatum* (shabdar).

‡ For wheat, values represent the yield for grain and straw separately.

§Alfalfa is largely sold and only in some cases partly used as a feed supplement for a few small ruminants destined to home consumption.

¶For grape, values represent yield of fruits, leaves, sprouts, and where available, fruits, leaves, sprouts, sticks separately.

Grape production in vineyards

Grape producers in the city had only infrequent access to municipal solid wastes as Kabul International Airport cuts the grape growing area off from the city, but sewage water and stream sediments were used abundantly. Most farmers used sulfur to control powdery mildew, but during our study no such disease outbreak occurred. Farmers pruned their vines and vine sprouts in early and late spring, respectively. Weeding and soil loosening was done once in the spring season by spading of the furrows. While the latter operation is traditionally performed under the Afghan *ashar* labour-sharing system, this practice was not observed during the time of our study. This likely was a consequence of the recent war history and the still insecure current political situation. Most grapes were sold at the farm to retailers who transported them to the market. Surpluses of product are traditionally dried under the open sun or in a well-aerated shed to produce *sayagee* (sun-dried raisins) and *aftabee* (shed-dried raisins).

Price fluctuations during the study period

During the two-year study period labour wage rates were constant at 4 US$ / 8 hr day for an unskilled labourer while input costs fluctuated widely. In 2008, the first year of study, prices of urea and DAP (18:46:0) were 24 US$ 50 kg^{-1} and 44 US$ 50 kg^{-1} respectively, while in 2009 they were 16 US$ 50 kg^{-1} and 24 US$ 50 kg^{-1}. Fuel prices were 1.3 US$ l^{-1} in the first year and declined to 0.9 US$ l^{-1} in the second year. The wheat price was 0.52 US$ kg^{-1} in 2008 and 0.36 US$ kg^{-1} in 2009. Vegetables prices remained fairly constant, although they are affected by imports from other parts of Afghanistan and neighbouring Pakistan, China and Iran (MAAHF, 2005).

Farm-based analyses of key economic parameters

Total cost of production. Total production cost varied from 640 to 1100 US$ ha^{-1} yr^{-1} in cereal production farms (Table 3), whereas in the five vegetable farms it ranged from 1460 to 3110 US$ with a maximum in one farm growing forage with the vegetables. Production costs in vineyards ranged from 700 to 1130 US$ ha^{-1} yr^{-1} and were two-fold higher in farms growing grapes only compared to those growing grapes in association with vegetables and forages. Differences in production costs between farms of the three production systems were highly significant ($p < 0.001$).

Revenues, gross margins and net profits. Total revenues from crop cultivation ranged from 5690 to 13 790 US$ ha^{-1} yr^{-1} in cereal production, from 15 340 to 51 790 US$ ha^{-1} yr^{-1} in vegetable production and from 4580 to 5890 US$ ha^{-1} yr^{-1} in vineyards. These differences of revenues between farm types were highly significant ($p < 0001$). Similarly, gross margins were significantly different between farm types ($p < 0.001$; Table 4). They ranged from 4900 to 12 690 ha^{-1} US$ yr^{-1} in cereal production, from 14 670 to 49 470 US$ ha^{-1} yr^{-1} in vegetable production and from 3450 to 5200 US$ ha^{-1} yr^{-1} in vineyards.

Net profits were significantly ($p < 0.001$) higher in vegetable farms (13 880–48 680 US$ ha^{-1} yr^{-1}) than in cereal farms (4900–12 690 US$ ha^{-1} yr^{-1}), and in vineyards (3450–5200; US$ ha^{-1} yr^{-1}; Table 3).

Site-based key economic parameters

Costs of production: Cumulative costs of operation (total expenses) were 860 US$ ha^{-1} for cereal, 2365 US$ ha^{-1} for vegetable and 920 US$ ha^{-1} for grape production significantly ($p < 0.001$) different from each other

Table 3. Average variable and fixed costs of inputs for cereals, vegetable, and grape production in urban and peri-urban agriculture of Kabul, Afghanistan in 2008 and 2009.

			Costs (US$ ha^{-1} yr^{-1})											
Farming system	Farm No.	Area (ha)	Seed	Manure	Urea	DAP†	Pesticides	Land lease	Tractor	Tillage	Pruning	Weeding & harvest	Threshing	Irrigation
Cereals	1	0.03	52	62	100	85	20	–	67	69	–	324	74	62
	2	0.06	37	61	103	75	20	–	53	69	–	208	72	–
	3	0.04	94	61	88	85	20	–	100	69	–	347	73	102
	4	0.05	51	101	100	85	30	–	93	104	–	463	104	135
	5	0.07	78	60	113	85	30	–	93	69	–	324	80	48
Vegetables	6	0.07	93	131	163	102	–	935	–	347	–	625	–	561
	7	0.17	47	115	252	127	60	935	–	255	–	926	–	585
	8	0.07	115	103	180	67	20	935	53	278	–	880	112	–
	9	0.14	43	8	12	–	–	935	40	93	–	255	–	246
	10	0.07	70	53	178	104	120	935	–	208	–	625	–	–
Vineyards														
	11	0.22	–	–	200	340	–	–	–	–	208	278	–	–
	12	0.06	–	33	200	340	–	–	–	–	208	278	–	–
	13	0.28	–	26	93	340	–	–	40	69	208	231	–	198
	14	0.05	33	–	133	170	20	–	40	104	104	301	47	144
	15	0.23	–	–	200	340	–	–	–	–	208	278	–	–

† Diammonium phosphate.

Table 4. Mean (± one standard deviation) of the economic components of cereal, vegetable, and grape production in urban and peri-urban agriculture of Kabul, Afghanistan in 2008 and 2009. All values are in US$.

Farming system	Farm no.	Total cost	Revenue	Gross margin	Net profit
Cereals	1	789 (±184)	5687 (±2553)	4898 (±2437)	4898 (±2437)
	2	644 (±334)	7141 (±3670)	6498 (±3858)	6498 (±3858)
	3	902 (±385)	11615 (±3841)	10 713 (±3748)	10 713 (±3748)
	4	1103 (±347)	13 790 (±4465)	12 687 (±4520)	12 687 (±4520)
	5	864 (±190)	9902 (±5521)	9038 (±5397)	9038 (±5397)
Vegetables	6	2669 (±480)	24 025 (±19 227)	22 149 (±19 423)	21 356 (±19 575)
	7	3108 (±334)	51 787 (±27 031)	49 472 (±27 096)	48 679 (±27 231)
	8	2539 (±624)	18 564 (±7598)	16 818 (±7630)	16 025 (±7710)
	9	1462 (±372)	15 343 (±5977)	14 673 (±6068)	13 880 (±6193)
	10	2048 (±887)	29 770 (±13 375)	28 514 (±13 948)	27 721 (±14 090)
Vineyards	11	no data	no data	no data	no data
	12	1129 (±200)	4582 (±4337)	3454 (±4537)	3454 (±4537)
	13	695 (±390)	5892 (±2662)	5196 (±2948)	5196 (±2948)
	14	894 (±228)	5860 (±4054)	4966 (±4111)	4966 (±4111)
	15	1096 (±162)	4791 (±4550)	3695 (±4712)	3695 (±4712)

Revenue, gross margin and net profit: Revenue in the three production systems varied from 5400 to 27 900 US$ ha^{-1} yr^{-1} and were 2.8- and 5-fold higher in vegetable gardens than for cereals and grape production, respectively ($p < 0.001$). Cumulative gross margins ranged from 4480 to 26 330 US$ ha^{-1} yr^{-1}, with highest values in vegetable production followed by cereal and grape farms ($p < 0.001$). Net profits ranged from 4480 to 25 530 US$ ha^{-1} yr^{-1}. Similar to gross margins, they were significantly ($p <$ 0.001) higher in vegetable gardens than for cereal fields and vineyards.

DISCUSSION

Farm-based key economic parameters

Costs of operation. The recorded differences in costs of operation between cereal, vegetable and grape production systems were largely dependent on the inputs costs. Growing a commercial potato crop and vegetables such as onion led to much higher costs than the cultivation of extensive cereals. In vegetable gardens, the main costs of operation were for tillage and weeding, while in vineyards expenses for purchase and application of urea and DAP dominated (Table 3). Differences in variable costs between farmers operating the same system were considerable and seemed to be partly due to differences in farm location. Grape farmers cut off by the airport were unable to access city waste as a cheap organic fertilizer. They had to invest more than the vegetable and cereal farmers in mineral fertilizers, such as urea and DAP, that were applied at up to 500 kg ha^{-1}. Larger vineyard sizes also allowed the use of machinery and pesticides which reduced labour costs (Table 4).

Revenues. Similar scale effects in revenue from cereal farming as in our study were shown for wheat production in Pakistan (Hassan *et al.*, 2005). The low revenue from

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grape production may be due to effects of an unexpected frost in late 2007. Several years of dry and hot conditions left the farmers neglecting traditional frost protection techniques, such as coverage of vine roots with soil and organic material. In any case, the sensitivity of vineyards to climatic hazards makes grape production much more risky than vegetable and cereal farming.

Gross margins and net profits

The three cereal farmers with a particularly high revenue grew cash crops intensively in a well-irrigated double-cropping system that was closely connected to wholesalers and retailers who were able to provide cash advances to producers. Market-oriented vegetable farms yielded highest net profits. Net profits in vineyards were highest in those farms that were able to access local markets well or sell secondary farm products such as groundwater to water dealers or fresh fodder from parts of their land.

Site-specific differences in key economic factors

The poor economic performance of vineyards was likely due to the residual effects of a severe frost event in late 2007. The high profitability of subtropical vegetable production as compared to perennial tree crop cultivation was also shown by Al Said *et al.* (2007) for the Batinah coastal plain in Oman. Similar data were reported by Maiangwa and Okpukpara (2007) from a study in Nigeria, where gross margins per hectare were higher for double-cropping than for single- or triple-cropping systems. These findings contradict, however, reports by ICARDA (2003) which claimed that average gross incomes from vineyards are much higher than from cereal and vegetable production. This certainly does not hold for grape production in the surroundings of Kabul. The exact causes for the establishment of particular landuse systems at any particular site are unclear, but, beyond economic factors, may at least partly reflect differences in irrigation infrastructure, soil properties or socio-cultural preferences.

CONCLUSIONS

The 15 farms investigated showed a high variation in their costs of production, revenues, gross margins and net profits. Economic gains were highest in vegetable farms despite their high variable and fixed costs. Cereal cropping and grape production was much less profitable, particularly the latter that was hampered by high investment costs. While these data may need verification they provide evidence for the pivotal role of vegetable farming for income generation in the city of Kabul. Improved market access for small UPA farmers, enhanced access to credit and certification schemes specifying quality standards for produce may foster the existing opportunities for UPA farmers to escape poverty while contributing to food security in Afghanistan.

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