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Urban Vegetable Production in Ghana: Investigating the Financial Viability and Key Drivers of Irrigation Techniques

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Abstract
Irrigation is an integral part of vegetable production in the cities of Ghana. Urban vegetable farmers therefore have to make a choice with regards their livelihood and the interests of consumers in their decision to adopt an irrigation technique. This study investigates the factors that influence vegetable farmers' decision to use various irrigation techniques for production in the Kumasi Metropolis of Ghana. A total of 150 vegetable farmers were selected using the simple random approach from three purposively selected sub-metros in the Kumasi Metropolis. The most common irrigation technique used for vegetable production in Kumasi was watering can irrigation (relatively less expensive). The revenue of vegetable farmers who use pump for irrigation was 18.23% more than those who use watering can for irrigation. Farm size, source of water, annual production cycles, seasonal revenue, household size, lettuce production and method of land acquisition influenced vegetable farmers' decision to use an irrigation technique. The labour intensive nature of watering can irrigation was identified as the key constraint associated with its use, whilst that of pump irrigation was the high cost involved. The study concludes that pump irrigation is cost-effective, less laborious and encourages relatively large-scale production. Therefore, the adoption of pump for irrigation is recommended.

Keywords: *Adoption decision, Farmers, Financial viability, Irrigation, Urban agriculture, Vegetable production*

Introduction

Urban agriculture entails all agricultural activities that are undertaken in the urban centres or cities. Mougeot (2000) broadly defines urban agriculture as the production, processing and distribution of foodstuff from crop and animal production, ornamental plants and flowers within and around urban areas. According to GSS (2013), 26.5% of the agriculture households in Ghana are located in urban areas and contributes significantly to the agricultural output.

The initiation of urban agriculture in Ghana started way back in the sixteenth century. In the sixteenth century, vegetables were grown in gardens around the castle and forts in the then Gold Coast. Vegetables produced under urban agriculture (Keraita et al. 2007) account for 50% to 90% of vegetables consumed in urban centres (Coffie et al., 2003). Although carried out informally, urban vegetable production has been an important means of attaining balanced diets and urban food security in Ghana (Obuobie *et al.* 2006). In general, urban agriculture comprises of livestock rearing, crop production, tree planting and aquaculture. Urban areas accounts for 26.5% of the agriculture households in Ghana [Ghana Statistical Service (GSS), 2013] and have contributed significantly to agricultural output.

Most agricultural producers involved in crop production in the urban areas have focused on the production of perishable produce such as vegetables, which have shorter shelf life, to meet the demand of urban consumers. More than 200,000 urban dwellers in Ghana consume vegetables daily from streets vegetable vendors and in canteens and restaurants (Obuobie et al., 2006), of which 50% to 90% of the quantity consumed are produced within or close to urban areas (Coffie et al., 2003). The high demand for vegetables in urban centres has necessitated the need to increase production. However, farmers are usually constrained with the resources, particularly water for vegetable production (Danso et al., 2002). According to Cornish and Lawrence (2001), vegetable production in Kumasi recorded more than 10,000 ha under seasonal vegetable farming. Vegetable production in the Metropolis is done all year round and mostly done on lands where construction is yet to begin, usually belonging to governmental institutions and departments or private developers. The Kumasi Metropolis is a city rich in water bodies such as the Wiwi, Owabi and Subin river. The inland valley areas surrounding the stream/rivers, especially where groundwater levels are low, are of high value for urban vegetable production.

According to Drechsel et al., (2013), vegetable production in the urban areas are predominant in the dry season where prices are high. This does not imply that irrigation is only done in the dry seasons. Irrigation is also needed in the rainy season on days without rain as exotic vegetables respond quickly to water shortage. Over the past, wastewater in urban areas serve as source of water for irrigating crops due to erratic rainfall pattern in the country. Wastewater irrigation has been the centre of many controversies surrounding urban agriculture. The use of

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wastewater for irrigating in urban vegetable production is recognized as an effective source of water supply throughout the year [Food and Agriculture Organization (FAO), 2012] and also reduces the pressure on portable drinking water. However, the source of water can influence the irrigation technique used for vegetable production in the urban centres (Drechsel et al., 2011; Drechsel et al., 2010).

As compared to traditional crops, vegetables, especially leafy vegetables, have higher and more regular crop water requirement. Erratic rainfall conditions in Ghana have been one of the hindrances to urban vegetable production and mostly lead to a deficit in the crop water requirements of vegetables. The issue escalates in the dry seasons where, urban vegetable production is predominant due to the increase in price of vegetables. Most vegetables grown in Ghana, depending on the climatic conditions and crop species, have an irrigation water requirement between 300 and 700 mm (Agodzo *et al.*, 2003; Danso et al., 2002). As compared to more traditional crops, vegetables, especially leafy vegetables, have higher and more regular crop water requirement (Danso & Drechsel, 2003; Drechsel et al., 2010).

This means that most vegetables, especially exotic vegetables, are likely to wither and die off in the dry season where rainfall is insufficient to meet the water requirement of the crops. This comes as a cost to the farmer since money is spent on inputs but yields low output to generate returns to cater for the costs incurred. Also, this affects the supply of vegetables which causes an increase in its prices. Moreover, this causes a reduction in the consumption of vegetables and further leads to the non-attainment of the nutrient requirement of consumers.

Due to this, farmers have adopted various irrigation methods in order to improve production and increase productivity throughout the year. However, depending on the irrigation technique used, irrigation can take between 40% and 70% of the farmer’s time throughout the season (Tallaki, 2005). Decisions made on factors such as investment of labour and irrigation technique employed can cause a variation in the income of farmers (Danso & Drechsel, 2003). However, these irrigation techniques adopted by farmers to cater for the water deficit comes with different cost and benefit. Irrigation takes between 40 and 70% of farmers’ time and may be required in all seasons (Danso et al., 2002; Tallaki, 2005) and also contributes significantly to production cost. According to Drechsel et al., (2013), there is a variation in the income of farmers depending on factors such as investment of labour and irrigation technique employed. According to Castle et al. (2016), increasing production efficiency is aimed at the use of agricultural technologies being developed. A study by Muzari et al. (2012) also revealed that the adoption of technology by smallholder farmers in Sub-Saharan Africa is affected by factors such as the assets, income, labour and innovativeness of the farmer.

The main thrust of this study is to investigate the financial viability and key drivers of irrigation techniques for urban vegetable production so as to provide useful information to guide decision making on alternative irrigation methods used for urban vegetable production. We ask the following questions; 1) What are the common irrigation methods used for urban vegetable production? 2) What are the costs and benefits of the alternative irrigation methods employed for urban vegetable production? 3) Are the returns associated with various irrigation techniques different? 4) What factors determine the use of a particular irrigation method? 5) What are the constraints associated with each irrigation technique?

Materials And Methods

Study area

The study area for this research is the Kumasi Metropolis. The Kumasi Metropolis is one of the 30 administrative districts in the Ashanti region. It is located between latitude 6.35˚N and 6.40˚S and longitude 1.30˚W and 1.35˚E and also elevated to 250 to 300 meters above sea level. The Metropolis happens to be the second largest most populous city in the country, next to the national capital (Accra), with a population of 1,730,249 which represent 36.2% of the total population of Ashanti Region (GSS, 2014). It lies in the transitional forest zone, specifically the moist semi-deciduous South-East ecological zone. The Metropolis has 37,456 households (representing 8.5% of the households) involved in agricultural activities (GSS, 2014) and are usually located around their dwelling units often along the wetlands in the Metropolis. About 41 hectares of urban land in Kumasi are under vegetable production whiles more than 12,000 hectares of peri-urban lands are under irrigated vegetable production (Cornish & Lawrence, 2001).

Population

The population for this study includes vegetable farmers in the Kumasi Metropolis. This implies that any individual involved in the production of vegetables in the study area, with no regards to the farm size, age or location, qualified to be a respondent to the questionnaire in this study. As done by Abdulai et al, (2017), the population of the selected sub-metros in the Metropolis was used to represent the population. The population of vegetable farmers in the selected sub-metros of the study area was one hundred and fifty (150) (Table 1).

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Table 1. Population of selected sub-metros in the Kumasi Metropolis

Sub-metros	Towns	Number of farmers	Sample
Oforikrom	Boadi	43	30
	Kentinkrono	40	26
	Ayeduase (Engineering)	26	10
	Poku Sika	28	15
	Behind Brunei	19	8
Asawasi	Asokore Mampong	6	2
	Sawaba (New Site)	25	21
Asokwa	Kyirepatare	5	4
	Ahensan	11	8
	Gyinyase	38	26
Total		241	150

Source: Field Survey

Sampling technique

For the purpose of this study, multistage sampling technique was used to obtain the primary data. At the first stage of sampling, the Kumasi Metropolis was selected because it happens to be one of the urban centers noted for agricultural activities in Ghana. According to GSS (2014), 8.5% of the household in the Metropolis are involved in agricultural activities, specifically vegetable production. At the next sampling stage, the purposive sampling technique was used to select three sub-metros (Asawasi, Oforikrom and Asokwa sub-metro). Vegetable production in the Metropolis is mainly undertaken areas within six sub-metros, which are the Kwadaso, Nhyiaso, Manhyia, Asawasi, Oforikrom and Asokwa sub-metro (Fig. 1). However, vegetable production in the Kumasi Metropolis is predominant in these selected sub-metros. Lastly, simple random sampling technique was used to select respondents from the population for the study.

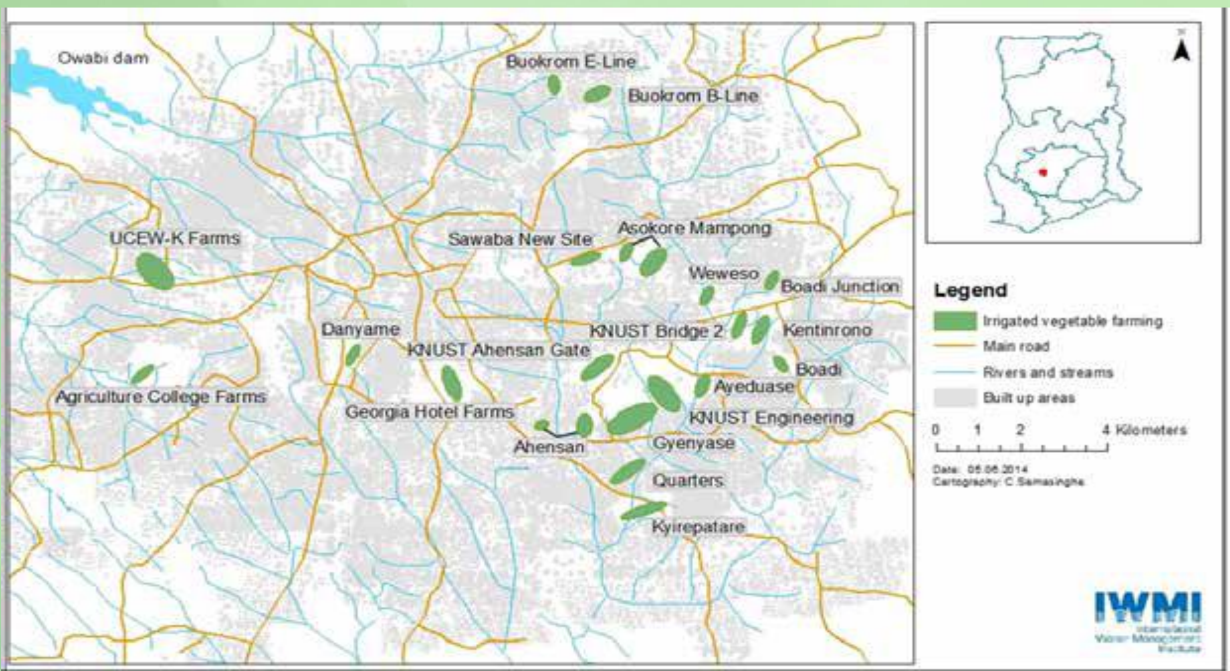

Fig. 1: Map of vegetable growing areas in the Kumasi Metropolis
Source: International Water Management Institute (IWMI), 2014

Sample size

A sample size of 150 was obtained with the use of the Slovin formulae, which is a scientific approach of finding a representative sample size. It is mathematically presented as:

Sample size= $\frac{N}{1+N(\alpha)^2}$

Where: N= Population (241)

α = Margin of error (5% or 0.05)

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Data collection, sources and type of data

Questionnaires were administered in local dialect and English in order to make communication easy and enhance the quality of the data. Field visit was adopted to obtain information from respondents through face to face interview. For the purpose of this study both primary and secondary sources of data was used for the research. Primary data was collected through structured questionnaire consisting of closed and open-ended questions, through structured interviews. Specific questions were asked to obtain personal information about the farmers, the characteristics of vegetable production, the cost and revenue involved in vegetable production and the constraints associated with the use of each irrigation method. The data obtained from these questions were analyzed to achieve the objectives of the study.

Empirical framework

Benefit-cost analysis: The most comprehensive economic and financial evaluation is benefit-cost analysis. In the use of benefit-cost ratio, the monetary value of benefits (revenue) and costs are quantified and compared to determine the viability of a project or the best option, technique or approach to be employed regarding a project. This helps to identify the worthiness of an investment, project or an adopted technique. In calculating the benefit-cost ratio over a given number of periods, the benefit and cost streams expected to be realized over the years are needed for the calculation. Since all the costs and benefits are of different years, the amounts should be discounted to obtain the present value of these future amounts before they can be used to calculate for the cost-benefit ratio for the given number of years. Benefit-cost ratio is obtained from the ratio of discounted revenues to discounted costs. In this study, the value of summation of the discounted revenues obtained from production was divided by the summation of the discounted costs. This is represented mathematically as:

$$BCR=\frac{\sum\frac{Bt}{(1+r)^n}}{\sum\frac{Ct}{(1+r)^n}}$$

The value for total cost include both variable and fixed cost of production. The variable cost was obtained by multiplying the quantity of the input used by its unit prices. Also, fixed assets were accounted for in the year of their purchase. The costs incurred in the operation as well as maintenance of some fixed assets also contributed to the value of total cost. When a benefit-cost ratio greater than unity (1) is realised, the project is deemed viable. On the other hand, a project with benefit-cost ratio less than one is deem unprofitable whereas a benefit-cost ratio of one represents a breakeven. The irrigation technique with the highest ratio was considered most viable.

Net present value (NPV): It is defined as the difference between the summation of the present value of the cash inflows (benefits) of an investment and the summation of the present value of its cash outflows (costs). This is given by:

$$NPV=\sum\frac{Bt}{(1+r)^n}-\sum\frac{Ct}{(1+r)^n}$$

The computation of NPV as the same as that of the BCR and the irrigation technique with the highest value was considered most viable.

Internal rate of return (IRR): Internal rate of return is a capital budgeting procedure used to measure and compare the profitability of an investment. It is referred to as the discounted cash flow rate of return (DCFROR). It is the rate of return at which the net present value of an investment or project becomes zero. That is, the discount rate that equates the present value of the stream of benefits to the present value of the stream of costs.

$$IRR= LDR + (HDR-LDR) *\frac{NPV@LDR}{NPV@LDR-NPV@HDR}$$

Where,
IRR = Internal rate of return
LDR = Lower discount rate
HDR = Higher discount rate

Empirical specification of probit model

The probit model is a type of regression where the dependent variable is dichotomous and can take only two values, for example YES or NO. The probit model was used in this study to identify the factors that influence the use of a particular irrigation method for vegetable production in urban Kumasi. In other to achieve this, the choice of the predominantly used irrigation techniques (pump and watering can irrigation) was the dependent variable which

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was assumed to be influenced by certain socio-economic characteristics of the farmer as well as factors associated with vegetable production. These socioeconomic characteristics of farmers in addition to the factors affecting vegetable production were the independent variables as shown in Table 2.

The empirical specification underlying the probit model was specified as:

$Y_{ij} = \beta_0 + \beta_1 Age_i + \beta_2 Gen_i + \beta_3 Edu\_yrs_i + \beta_4 wat\_sor._i + \beta_5 Loc_i + \beta_6 Crop\_typ_i + \beta_7 Farm\_size_i + \beta_8 Yrs\_farm_i + \beta_9 Land\_acq_i + \beta_{10} Prod\_cycle_i + \beta_{11} Add\_lab_i + \beta_{12} Ext\_rec_i + \beta_{13} Inc\_veg_i + \mu_i$

Where: Y_{ij} = Irrigation techniques (1= Pump irrigation; 0= Watering can irrigation)

β_0 = Constant

β_1-β_8 = The coefficient of the various factors

μ_i = error term

Table 2. Description of variables

Variables	Measurement	Apriori sign
Age of respondents (Age*i*)	Age in years	+
Gender (Gen*i*)	1 if male and 0 if otherwise	+/-
Formal education yrs (Edu_yrs*i*)	Number of years in formal education	+
Source of water (Wat_sor.*i*)	1 if stream/river and 0 if otherwise	+/-
Location of respondent (Loc*i*)	1 if Oforikrom and 0 if otherwise 1 if Asokwa and 0 if otherwise	+/-
Major crop produced (Crop_typ*i*)	1 if Lettuce and 0 if otherwise 1 if Spring onion and 0 if otherwise	+/-
Farm size (Farm_size*i*)	Acres	+
Vegetable farming experience (Yrs_farm*i*)	Years	+
Land acquisition (Land_acq*i*)	1 if Non-payment and 0 if otherwise	+
Production cycle (Prod_cycle*i*)	Number of production cycle in a year	+
Additional labour (Add_lab*i*)	1 if Friends/ Family and 0 if otherwise 1 if Hired and 0 if otherwise	+/-
Extension received (Ext_rec*i*)	1 if Yes and 0 if otherwise	+
Income (Inc_veg*i*)	Amount generated from vegetable production	+

Analytical tools

Descriptive statistics such as percentages, graph, tables and charts, was employed to analyze the data to summarise the socioeconomic characteristics of the respondents and also to know the major sources of water for irrigation. The net margin and return on investment (ROI) analyses were used to help achieve objective two of the study. In order to obtain the net margin, the income statement was used. With the ROI, the ratio of the net margin and the initial investment was used which is mathematically represented as:

$$ROI = \frac{Net\ margin}{Initial\ investment} * 100$$

This viability of the irrigation techniques was achieved with the use of the discounted method of project appraisal such as BCR, NPV and IRR.

In order to achieve our third objective, factors influencing the use of an irrigation technique, the binary probit model was employed. This aided to determine the effect certain factors have on the use of the various irrigation methods.

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To find out the constraints associated with the major irrigation techniques employed by vegetable producers in the Kumasi Metropolis, the Garrett Ranking Technique was adopted. The farmers were asked to rank the constraints given on the questionnaire in the order of severity to their business. Where one (1) means most severe, two (2) means more severe, three (3) means severe in a descending manner. The order of merit assigned by the farmers was converted into ranks using the following formula:

$$\textit{Percent position of each rank} = \frac{100(Rij-0.5)}{Nj}$$

where;
Rij denotes the rank given for the ith factor by jth individual
Nj denotes the number of factors ranked by the jth individual

The data collected was then analyzed by dividing the total scores of each constraint by the total number of respondent (150) in order to get their respective mean scores. The resulting mean scores were ranked in a descending order, with the first (1st) position being the most limiting factor or severe constraint which affects the use of a particular irrigation technique.

Results And Discussion

Socioeconomic characteristics of vegetable farmers

Table 3. Socioeconomic characteristics of vegetable farmers

Variables	Category	Watering Can Frequency	Watering Can Percentage (%)	Pump Irrigation Frequency	Pump Irrigation Percentage (%)	Pooled Sample Frequency	Pooled Sample Percentage (%)
Gender	Male	97	96	47	96	144	96
	Female	4	4	2	4	6	4
Marital Status	Single	22	21.8	16	32.7	38	25.3
	Married	76	75.2	33	67.3	109	72.7
	Divorced	3	3	0	0	3	2
Religion	Christianity	62	61.4	25	51	87	58
	Islamic	37	36.6	25	49	61	40.7
	Traditional	2	2	0	0	2	1.3
Ethnic Group	Akan	38	37.6	11	22.4	49	32.7
	Ewe	2	2	2	4.1	4	2.7
	Northners	61	60.4	36	73.5	97	64.7
Location	Oforikrom	70	69.3	19	38.8	89	59.3
	Asokwa	28	27.7	9	18.4	37	24.7
	Asawasi	3	3	21	42.9	24	16.0
Major veg.	Cabbage	7	6.9	3	6.1	10	6.7
	Lettuce	71	70.3	17	34.7	88	58.7
	Spring onion	23	22.8	29	59.2	52	34.6
Extension service	Yes	78	77.2	44	89.8	122	81.3
	No	23	22.8	5	10.2	28	18.7
Land acquisition	Temporal	82	81.2	35	71.4	117	78
	Leasehold	17	16.8	14	28.6	31	20.6
	Inheritance	2	2	0	0	2	1.4
Payment for land	Yes	17	16.8	14	28.6	31	20.6
	No	84	83.2	35	71.4	119	79.4
Additional labour	None	23	22.8	15	30.6	38	22.9
	Hire	43	42.6	29	59.2	72	43.4
	Family	31	30.7	4	8.2	35	21.1
	Friends	4	4	1	2	5	3.0

Continuous variables	Min.	Max.	Mean	S.D	Min.	Max.	Mean	S.D	Min.	Max.	Mean	S.D
Age	17	67	37.2	12.6	19	75	34.4	13.9	17	75	13.1	36.3
Household size	1	11	4	2.21	1	10	4	2.57	1	11	4	2.33
Farming experience	1	44	8.16	7.47	1	35	8.00	7.63	1	44	8.11	7.45
Education in years	0	20	6.11	5.27	0	14	4.78	4.32	0	20	5.67	5.01
Revenue	1641	2386	2117	551.3	1502	3006	2503	497.7	1502	3006	2254	518.6
Farm size	0.25	1.2	0.5	0.52	0.25	1.5	0.75	0.64	0.25	1.5	0.68	0.61

Source: Field Survey

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Table 3 presents the results of the socioeconomic characteristics of the vegetable farmers in the Kumasi Metropolis based on the irrigation method employed. As indicated in Table 3, vegetable production in the Kumasi Metropolis is dominated by men. A majority of 96% of the total sample are male. The percentage is the same for farmers who use watering can irrigation as well as farmers who use pump irrigation. These findings agree with that of Abdulai et al. (2017), who identified that vegetable farming is dominated by males whiles its marketing is mainly done by female. From the study, it was realized that a greater percentage (72.7%) of the respondents were married and was same among both watering can (75.2%) and pump irrigation (67.3%) farmers.

Vegetable production in the Kumasi Metropolis was found to be dominated by people from the three Northern regions of Ghana. This agrees with an observation made by Danso et al., (2002) that majority of vegetable farmers in the urban centres are immigrants who mainly come to the city in search of jobs. Majority (58%) of the total respondents were identified to be Christians. The predominance of vegetable production in the Oforikrom sub-metro of the Kumasi Metropolis can be attributed to the availability and accessibility of unused government land, especially lands around KNUST. Moreover, majority (69.3%) of the vegetable farmers who use watering can for irrigation were located in the Oforikrom sub-metro whiles majority (42.9%) of farmer's using pump irrigation were located in the Asawasi sub-metro. It was observed that most vegetable farmers in the Oforikrom sub-metro had dug well on their farms making them closer to their source of water hence, influencing their decision.

The major vegetable produced by the farmers in the Metropolis was lettuce (58.7%). This may not always be the case since the type of vegetable produced is usually dependent on the market demand. Notwithstanding, most farmers prefer the production of lettuce because it is easier to produce as compared to other vegetables such as cabbage and this is consistent with Gyiele (2002). The study identified that pump irrigation was not preferred in the production of lettuce, mainly because it can cause physical injury or damage to the crop, especially at its initial growth stage, due to its delicate nature of lettuce.

Vegetable production in the Kumasi Metropolis was mainly done on temporally acquired lands which are usually owned by the government/government institutions or individuals and estate developers who are yet to put the land into use. About 78% of vegetable farmers were found to be operating on temporary lands, greater percentages were also recorded for farmers using watering can (81.2%) as well as farmers using pump (71.4%) for irrigation.

The labour intensiveness of the activities involved in the production of the vegetables has led to a majority (43.4%) of vegetable farmers hire additional labour to assist them in undertaking certain farm activities. Some farmers (21.1%) also were using their family members as a source of additional labour where as others (22.9%), mainly farmers operating on a smaller farm size, were not using any form of additional labour.

Majority (81.3%) of the vegetable farmers do receive various forms of extension service mainly from the agricultural extension agents in the Metropolis. Some farmers also stated that representatives from the Food and Drugs Authority (FDA) do come around to also provide some extension services and also monitor their operation. This was mainly due to the concerns raised by some consumers and researchers relating to the contamination of vegetable produce from urban centres usually due to the source of water for irrigation.

The mean age of farmers using watering can irrigation was found to be thirty-seven (37) years whiles that of farmers who use pump irrigation was thirty-four (34) years. The average age of the sampled population was thirty-six (36) years; this shows that majority of vegetable farmers in the Kumasi metropolis are in the working-class category.

On the average, a vegetable farmer's household size was found to be four (4) and this was the same for both farmers using watering can and farmers using pump for irrigation. The household size was usually made up of the vegetable farmer and his nuclear family but some vegetable farmers also expressed the need to stay with their permanent labour in order to facilitate their activities hence, adding up to their household size. The average number of years in vegetable production for the pooled sample was approximately eight years. However, with a maximum of 44 years in vegetable production, this means that most farmers start vegetable production in their youthful age which continues to become their lifetime occupation.

The maximum years of formal education attained by vegetable farmers who use watering can for irrigation was recorded to be twenty (20) years and a minimum of zero (0), resulting in a mean of six (6) years of formal education. On the other hand, farmers involved in pump irrigation have a maximum year of formal education to be fourteen (14) years and a minimum of zero (0) as well as a mean of four (4) years. This implies that, vegetable farmers who are into watering can (dug well) irrigation had spent many years in obtaining formal education as compared to those who use pump for irrigation. The average years of formal education for the pooled sample was five (5).

The average farm size for vegetable production in urban Kumasi was 0.68 acre (Table 3). However, vegetable farmers who use pump for irrigation recorded an average farm size of 0.75 acre whiles the average farm size of vegetable who use watering can for irrigation was half an acre (0.5 acre). This shows that vegetable production with the use of pump irrigation is usually done large farm size as compared to the use of watering can.

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The average revenue obtained from vegetable farmers in urban Kumasi was approximately GH₵ 2254.00 (US$ 391.61) per season. However, the use of watering can for irrigation yields approximately GH₵ 2117.00 (US$ 367.80) per season whiles vegetable production under pump irrigation generates revenue which amounts to GH₵ 2503.00 (434.87) per season. This indicates that vegetable farmers who opt to use pump irrigation over watering can are likely to experience 18.23% (GH₵ 386.00/ US$ 67.06) increase in their revenue. This shows that the use of pump for irrigation generates higher revenue than the use of watering can on seasonal basis.

Major irrigation technique/Reasons for choice of irrigation technique

Table 4. Major irrigation technique/Reasons for choice of irrigation technique

Types	Frequency	Percentage
Pump irrigation	49	32.6%
Watering can	101	67.3%
Total	150	100.0%
Reasons for Using Watering can		
Less Expensive	46	48%
Nearness to water source	27	28%
Prevent crop destruction	9	9.4%
Lack of water	6	6.3%
Small farm size	5	5.2%
Easy to use	3	3.1%
Reasons for Using Pump irrigation		
Longer distance to water source	20	41%
Faster and saves time	16	33%
Provision of enough water	7	14%
Large farm size	6	12%

Source: Field Survey

As presented in Table 4, 67.3% of vegetable farmers were found using watering can as their major irrigation outlet whereas 32.6% of vegetable farmers used pump as their major irrigation. This indicates that a significant majority of vegetable farmers (67.3%) prefer the use of a watering can for irrigation. The watering can is a manual irrigation tool that typically involves pouring water directly onto the plants or soil. It is a simple and low-cost method commonly used by farmers, especially in smaller-scale or backyard vegetable production. On the other hand, a smaller proportion of farmers (32.6%) utilize a pump as their major irrigation method. A pump-based irrigation system involves using mechanical or electric pumps to draw water from a water source and distribute it to the crops. Pump-based irrigation systems are generally more automated and can provide water to a larger area or larger-scale agricultural operations. The presented data suggests that among the surveyed vegetable farmers, the use of watering cans for irrigation is more prevalent compared to pump-based irrigation systems. This information provides insights into the irrigation practices and preferences of vegetable farmers in the context of the surveyed area. Most vegetable farmers in urban Kumasi use watering can for irrigation relative to that of pump, making watering can the common irrigation technique. This is in line with a study by Keraita et al. (2007) that states that the watering can is the most common irrigation technique used in all urban vegetable production study and it is easy to use and less expensive (Amoah et al., 2011).

Majority (48%) of vegetable farmers use watering can for irrigation because it is less expensive whereas 28% attributed it to the nearness of source of water for irrigation to farmland. This suggests that the affordability and cost-effectiveness of the watering can make it an attractive choice for farmers with limited financial resources. For those who mentioned the nearness of source of water, it suggests that the convenience of having a water source in close proximity to the agricultural plots makes the watering can a practical and accessible irrigation method.

On the other hand, about 41% of farmers who use pump for irrigation gave their reason to be the longer distance to water source, with another 33% also ascribing their reason of use to it as being faster and helping to save time. This suggests that when the water source is located far from the agricultural plots, a pump-based irrigation system becomes a more efficient and practical option. For those who cited speed and time-saving benefits as their reason for choosing this irrigation method, it implies that the ability of a pump-based system to deliver water quickly and efficiently allows farmers to save time and potentially irrigate larger areas within a shorter timeframe.

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Sources of water for irrigation

Table 5. Main source of water for irrigation

Irrigation Technique	Stream		Dug Well	
	Frequency	Percentage	Frequency	Percentage
Watering can	26	25.7%	75	74.3%
Pump Irrigation	40	81.6%	9	18.4%
Pooled Sample	66	44%	84	56%

Source: Field Survey

Farmers can source their water for irrigation from dug wells, stream/river, pipe, drains and reservoirs (Cornish *et al*. 1999; Obuobie *et al.* 2006). The study revealed that most of the farmers (56%) had their main source of water from dug wells. With farmers who use watering can for irrigation, a majority (74.3%) sourced their water from dug wells as presented in Table 5. This information suggests that dug wells play a crucial role as a primary water source for irrigation among farmers using the watering can. Dug wells are typically manually constructed wells that are dug into the ground to access groundwater sources. They can provide a relatively accessible and affordable water supply for agricultural purposes. The high percentage (74.3%) of farmers using dug wells for watering can irrigation highlights the importance of these wells as a reliable and readily available source of water. This finding indicates that farmers who rely on the watering can as their primary irrigation method primarily depend on dug wells to meet their irrigation water needs. Understanding the predominant use of dug wells as the main water source for the watering can irrigation technique can be valuable for policymakers, researchers, and agricultural practitioners. It emphasizes the significance of maintaining and ensuring the sustainability of dug wells as an important water resource for agricultural activities in the studied area

On the contrary, 81.6% of farmers who use pump for irrigation had their main source of water from streams. This finding implies that streams serve as the primary water source for farmers utilizing pump-based irrigation methods. Streams are natural sources of water that can provide a consistent and reliable supply for agricultural purposes. The high percentage (81.6%) of farmers relying on streams for irrigation using a pump highlights the significance of stream water availability and accessibility for this particular irrigation technique. This suggests that farmers using pump irrigation systems primarily depend on stream water to fulfill their irrigation water requirements. Understanding the predominant use of stream water for pump irrigation can help inform water resource management strategies, particularly in areas where streams are the primary water source. It emphasizes the importance of preserving stream ecosystems, ensuring sustainable water extraction practices, and addressing potential challenges related to water availability and quality.

Irrigation hours per day

Table 6. Irrigation hours per day

Irrigation Techniques	Duration of a single irrigation (Hours)	No. of irrigation per day (Times)	Total irrigation hours
Watering can	3	2	6
Pump irrigation	4	1	4

Source: Field Survey

On the average, a farmer who uses watering can for irrigation irrigates twice daily and they spend approximately three (3) hours on every single irrigation. This indicates that a farmer who uses watering can for irrigation requires six (6) hours to undertake a daily irrigation for an acre of land (Table 6). With the use of watering pump for irrigation, farmers usually irrigate once daily and it takes an average duration of four (4) hours to complete an acre of land. It must be noted that, the duration for irrigation may differ depending on the various seasons or weather conditions. It is consistent with Danso *et al.* (2002) and Tallaki (2005) who stated that between 40% and 70% of a vegetable farmer's time spent on the field is used for irrigation.

Factors influencing the use of an irrigation technique

The empirical probit results on factors that influence the use of an irrigation technique showed a Pseudo R^2 value of 0.6987 (69.87%) indicating that the results explain 69.87% of the variation in the dependent variable. The results in Table 6 shows that the household size of farmers is significant at 10% and has a negative effect on the irrigation technique used. This means that an increase in the household size of farmers by a person will decrease the probability of using pump for irrigation by 5.34%, hence, the higher the household size the lesser the probability of the farmer using pump for irrigation. Vegetable farmers with large household sizes have a greater likelihood to use watering can for irrigation as compared to pump. This is because the household of a vegetable farmer can be a source of additional labour to help the farmer in performing certain production activities such manual irrigation.

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Table 7. Determinants of the use of an irrigation technique

Variables	Coeff.	Std. Err.	Z	Marginal effect (dy/dx)	P>z
Age	0.0275	0.0296	0.93	0.0052	0.354
Gender	-2.599	1.310	-1.98	-0.8060	0.147
Formal education in years	-0.0316	0.0502	-0.63	-0.0060	0.529
Vegetable farming experience	0.0403	0.0421	0.96	0.0076	0.339
Household size	-0.2831*	0.1640	-1.73	-0.0534	0.085
Farm size	1.086**	0.4721	2.30	0.2049	0.021
Source of water	2.120***	0.6406	3.31	0.4653	0.001
Asokwa	-0.5995	0.9101	-0.66	-0.0974	0.510
Oforikrom	-0.7132	0.7555	-0.94	-0.1413	0.345
Lettuce	-1.775*	0.9524	-1.86	-0.3992	0.062
Spring onion	0.0064	0.8906	0.01	0.0012	0.994
Land acquisition	-2.043**	1.032	-1.98	-0.6537	0.048
Production cycle	0.5671**	0.2296	2.47	0.1069	0.014
Family and friends labour	-0.7092	0.7244	-0.98	-0.1095	0.328
Hired labour	0.7724	0.7102	1.09	0.1501	0.277
Extension received	-1.21	0.7804	-1.55	-0.2283	0.121
Revenue	0.0011***	0.0003	3.48	0.0002	0.000
_cons	-3.625	2.795	-1.30		0.195
Number of obs. = 150; LR chi^2 (11) = 131.32; Prob > chi^2 = 0.000; Log likelihood = -28.312; Pseudo R^2 = 0.698					

***significant at 1%, **significant at 5% and *significant at 10%; Source: Field Survey

At a 5% significant level, an increase in farm size is likely to cause 20.49% increase in the likelihood of a vegetable farmer using pump for irrigation relative to watering can. Vegetable farmers with larger farm sizes have a greater tendency of using pump to irrigate their crops. This agrees with a study by Drechsel et al., (2013) which identified that farmers with larger farm size will have to use a pump or hire labour due to high labour requirement.

The probability of a vegetable farmer to use pump for irrigation relative to watering can increases by 46.53% if the farmer's main source of irrigation is from stream/river, and had a 1% significance level. This implies that farmers who have water bodies around their farm site and as their main source of water for irrigation are more probable to use pump for irrigation.

The production of lettuce by a vegetable farmer has a negatively correlation on the use of an irrigation technique. The probability of a lettuce producing farmer to use pump relative to watering can for irrigation decreases by 39.92%. This implies that vegetable farmers who produce lettuce are more likely to use watering can for irrigation due to its delicate nature and the potential injury or destruction associated with pump irrigation since it is usually done under high pressure.

A unit increase in the number of production cycles undertaken in a year increases the probability of a vegetable farmer using pump for irrigation relative to watering can by 10.69%. Therefore, vegetable farmers who undertake many production cycles in a year are more likely to use pump for irrigation as compared to watering can.

The results also show that the method of land acquisition by vegetable farmers significantly affects the irrigation technique used. Non-payment of land has a negative correlation with the decision to use pump irrigation. The result interprets that, the less a vegetable farmer pays for a land, the more likely it is to use watering can for irrigation and the higher the amount paid the likelihood of using pump increases. This explains that a farmer who does not pay for the land used for cultivation has a greater likelihood of using watering can for irrigation rather than pump. This is because, farmers who pay some amount in order to use the land for cultivation have security over the land for a given period of time and are willing to invest in long-term fixed assets in order to improve their operations over a given period.

Lastly, at a significant level of 1%, the revenue generated by farmers from vegetable production has a positive effect on the irrigation technique used. This implies that a cedi increase in the revenue of farmers causes a 0.02% increase in the likelihood of a farmer using pump for irrigation. This means that as the farmer's income from vegetable production increases, the farmer is more likely to use pump for irrigation.

Returns on each irrigation technique

In order to obtain the returns associated with each irrigation technique, it was vital to first obtain the cost and revenue of vegetable production under each irrigation technique. Since most farmers are into the production of more than one crop, the proportion of each vegetable on a given acre of land was estimated in order to find the portion each vegetable produced contributes to farmer's income and cost of production. It was found that proportionately a farmer who use watering can for irrigation has 16%, 47% and 37% of an acre land for the production of cabbage, lettuce and spring onion respectively. Also, for farmers who use pump for irrigation, cabbage, lettuce and spring onion accounted for 20%, 33% and 47% of vegetable production on an acre of land. This helped to ascertain the proportion of cost and revenue of each crop on seasonal basis.

In the computation of the annual cost and returns, the resultant proportion of each crop was multiplied by the number of production cycles in a year. In a given year, farmers may produce cabbage, lettuce and spring onion for three (3), six (6) and five (5) times respectively. In multiplying the proportionate cost and revenue of each crop by the number of production cycle in a year, the amount obtained was a representation of the annual cost and revenue of each crop. The summation of the results of the three crops provided the value for the annual cost and return of each irrigation technique.
All fixed assets were depreciated on the straight-line basis where the costs were divided by its useful life (Table 8). This helped to know the annual cost of each of the fixed assets.

Table 8. Depreciation of fixed assets

Fixed assets	Useful life	Cost	Annual depreciation	Quantity	Total annual depreciation (Watering can)	Total annual depreciation (Pump)
Cutlass	2	20.00	10.00	1	10.00	10.00
Hoe	1	15.00	15.00	2	30.00	30.00
Spade/ shovel	2	35.00	17.50	1	17.50	17.50
Knapsack sprayer	1	60.00	60.00	1	60.00	60.00
Hand fork	2	9.00	4.50	2	9.00	9.00
Watering can	2	45.00	22.50	4	90.00	-
Pump	5	1,200.00	240.00	1	-	240.00
Pump tubes (100 yards)	2	200.00	100.00	1	-	100.00
Total operating overhead					216.50	466.50

Source: Field Survey

Net margin: The income statement account was used in the calculation of the net margin of each irrigation technique (Table 8). The difference between the annual revenue and the annual variable cost was first calculated for to obtain the gross margin. After this, other operating overhead expenses such as the depreciation cost of fixed assets as well as the maintenance cost was deducted from the gross margin to obtain the net margin. The results show that on an annual basis, a farmer who cultivates an acre of land with the use of watering can for irrigation is likely to obtain a net margin of GH₵ 3,987.12 whilst a farmer who is into the pump irrigation may obtain a net margin of GH₵ 4,715.05. This shows a higher return on use of pump irrigation as compared to watering can irrigation. The difference in the net margin of farmers was a result of the differences in the revenue generated from vegetable production by farmers of each irrigation technique. It is evident that farmers that use pump for irrigation can undertake many production cycles in a year than those who use watering can for irrigation. In addition, since vegetable production under pump irrigation is done on large farm size compared to that of watering can, farmers enjoy economies of scale hence, increasing their revenue.

Table 9. Income statement for the irrigation techniques

Items	Watering can (Dug well)	Pump irrigation
	Amount (GH₵)	Amount (GH₵)
A. Annual revenue (Appendix I)	12,426.62	15274.1
B. Annual variable cost (Appendix I)	(7,333.00)	(9202.37)
C. Gross margin (A-B)	5,093.62	6,071.73
Annual operating expense		
Total operating overhead	216.50	466.50
Land	840.00	840.00
Well maintenance	50.00	-
Pump maintenance	-	50.00
D. Total operating expense	(1106.5)	(1365.50)
E. Net margin (C-D)	3,987.12	4,715.05

Source: Field Survey

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Return on investment (ROI): The net margin of the irrigation techniques was compared with their initial investment by finding the ratio of the net margin by the initial investment. With watering can (dug well) irrigation, the net margin (GH₵ 3,987.12) divided by the initial investment (GH₵ 5,218.00 in Appendix 1) was 76.40%. Under pump irrigation, the ratio of the net margin (GH₵ 4,715.05) to its initial investment (GH₵ 6,288.00 in Appendix I) was 75%. This means that vegetable production under watering can irrigation generates 76.4% of the initial investment as returns in a given year relative to pump irrigation which generates a return of 75%. This shows that there are variations in the returns to be realized for vegetable production under each of the irrigation technique. This shows that vegetable production with the use of watering can irrigation is profitable than the use of pump in the short-run.

T-test statistics

Table 10. T-test analysis

Variable	Watering can	Pump irrigation	Mean difference	t-value
Revenue	3562.91	4775.83	-1212.92	-7.134***

***significant at 1%; Source: Field Survey

A t-test analysis was performed in order to assess whether there is a difference between the returns of the two irrigation techniques. The result showed that there is variation between the returns of pump irrigation and watering can irrigation and it was significant at 1% (Table 4.7). In the short-run, the results show that it is better to use pump irrigation for vegetable production relative to watering can since it generates higher revenue.

Viability analysis of the irrigation techniques

Table 11. Projected cash flow for watering can irrigation and pump irrigation (per acre)

Projected cash flow for watering can irrigation (per acre)							
Years	Cash outflows GHC	Cash inflows GHC	Net cash flow GHC	Discount factor (30%)	Discounted cash outflow	Discounted cash inflow	Discounted net cash flow
0	5218.00	0.00	(5218.00)	1	5218.00	0.00	(5218.00)
1	7582.37	12426.62	4844.25	0.77	5832.59	9558.94	3726.35
2	8733.55	13718.99	4985.44	0.59	5167.78	8117.74	2949.97
3	9365.30	15145.76	5780.46	0.46	4262.77	6893.84	2631.07
4	10813.40	16720.92	5907.52	0.35	3786.07	5854.46	2068.39
5	11600.83	18459.90	6859.06	0.27	3124.44	4971.79	1847.35
Total					27391.65	35396.76	8005.11
Projected cash flow for pump irrigation (per acre)							
Years	Cash outflows GHC	Cash inflows GHC	Cash flow GHC	Discount factor (30%)	Discounted cash inflow	Discounted cash outflow	Discounted cash flow
0	6288.00	0.00	(6288.00)	1	6288.00	0.00	(6288.00)
1	9432.32	15274.10	5841.78	0.77	7255.63	11749.30	4493.67
2	10703.81	16862.60	6158.79	0.59	6333.61	9977.87	3644.26
3	11653.36	18616.31	6962.95	0.46	5304.22	8473.51	3169.30
4	12807.96	20552.41	7744.45	0.35	4484.42	7195.97	2711.55
5	14342.32	22689.86	8347.53	0.27	3862.80	6111.04	2248.23
Total					33528.69	43507.70	9979.01

Source: Field Survey

Unlike profitability, which usually measures short term performance, viability looks at the long-term performance and sustainability of a venture or investment. Therefore, in addition to the short-run profitability of vegetable production under each irrigation method, the study further assessed the viability of each irrigation technique with dug well and pump being the key fixed assets under watering can and pump irrigation respectively.

With the annual production cost and revenue already computed for under objective two, we anticipated that there will be an annual increase in the unit price of all inputs and outputs over the life of the project, hence, obtaining the annual percentage increase of each item. With inputs such as fertilizer, seed and weedicide, their cost for the past three years was obtained and we continued to find the average annual percentage increase. Also, certain inputs such as fuel and labour in addition to the output prices, the current inflation rate (10.4%) was to determine their

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annual increase. This helped to obtain the input cost and prices for each year which helped to compute the annual production cost and revenue for each irrigation technique.

In viability analysis, the cash flow statement was used to generate the cash inflows and cash outflows and it does not consider non-cash expenditure items like depreciation. Therefore, the exact cost incurred in obtaining the fixed assets was recorded in the year of their purchase. These were summed up for the various years and added to the respective annual production cost to obtain the total annual cash outflow for each year under each irrigation technique. The cash outflows and inflows were then discounted at the rate of 30% in order to obtain the discounted cash inflows and outflows for each irrigation technique to help in the computation of the BCR, NPV and IRR.

Table 12. Net present value (NPV)/ Benefit-cost ratio (BCR) and Internal rate of return (IRR) of each irrigation technique

Irrigation technique	Discounted cash outflows		Discounted cash inflow		NPV
Watering can (Dug well)	27391.65		35396.76		8005.11
Pump irrigation	33528.69		43507.70		9979.01
Irrigation technique	Discounted cash outflows		Discounted cash inflow		BCR
Watering can (Dug well)	27391.65		35396.76		1.29
Pump irrigation	33528.69		43507.70		1.30
Irrigation technique	LDR	NPV@LDR	HDR	NPV@HDR	IRR
Watering can (Dug well)	92%	89.44	97%	-48.18	95%
Pump irrigation	94%	84.43	98%	-46.19	97%

Source: Field Survey

Net present value (NPV): With a positive NPV for each irrigation technique, it can be said that vegetable production under both irrigation techniques is viable. However, pump irrigation is the most viable among the two techniques since it has an NPV of GH₵ 9,979.01 as compared to watering can's GH₵ 8,005.11.

Benefit cost ratio (BCR): The results show that the use of watering can for irrigation (dug well) generates a BCR of 1.29 whilst that of pump generates a BCR of 1.30. This means that a cedi invested in vegetable production under watering can (dug well) irrigation yields a return of 29 pesewas whiles that of pump irrigation provides a return of 30 pesewas. The decision rule with BCR is to accept all projects with a BCR greater than one. This shows that vegetable production under the two irrigation methods is viable but the project with the highest BCR is preferred. Therefore, the use of pump irrigation is more viable as compared to watering can (dug well) irrigation in the long-run.

Internal rate of return (IRR): With its computation, pump irrigation realized an IRR of 97% whilst that of watering can (dug well) irrigation was 95%. This means that vegetable production under watering can (dug well) irrigation has a breakeven interest rate or opportunity cost of capital of 95% whereas that of pump irrigation will also breakeven at a 97% interest rate. Therefore, any discount rate which is lower than the IRR will result in a positive NPV which makes the project viable. It is evidently clear that pump irrigation is more viable as compared to watering can (dug well) irrigation in the long-run, although they all have an IRR figure greater than the discount rate (30%).

Constraints of watering can and pump irrigation techniques

Table 13. Constraints of watering can and pump irrigations techniques

Watering can	1st*77	2nd*63	3rd*54	4th*46	5th*37	6th*23	Total Value	Average Score	Rank
Labour intensive	5159	1827	108	92	37	0	7223	71.51	1st
Time consuming	2079	3402	594	184	37	92	6388	63.25	2nd
Requires much maintenance	0	693	2754	1012	481	92	5032	49.82	3rd
High Cost involved	462	252	1080	2116	592	207	4709	46.62	4th
Difficulty in determining water adequacy	0	126	648	506	1295	943	3518	34.83	5th
Physical crop injuries	0	0	324	782	1295	989	3390	33.56	6th
Pump irrigation	1st*77	2nd*63	3rd*54	4th*46	5th*37	6th*23	Total Value	Average Score	Rank
High Cost involved	1925	882	270	138	37	23	3275	66.84	1st
Requires much maintenance	924	1071	702	322	0	0	3019	61.61	2nd
Time consuming	385	378	486	368	703	46	2366	48.29	3rd
Physical crop injuries	77	63	486	598	296	391	1911	39.00	4th
Labour intensive	154	441	756	184	222	138	1895	38.67	5th
Difficulty in determining water adequacy	77	0	0	184	555	667	1483	30.27	6th

Source: Field Survey

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The results for the constraints associated with the use of watering can for irrigation are presented in Table 13. The most severe problem recorded by farmers was the labour intensiveness of watering can irrigation with a mean score of 71.51. The labour intensiveness of the use of watering can for irrigation usually results in farmers experiencing body pains after irrigation. This was followed by the time-consuming nature of the use of watering can for irrigation, which was ranked second. The use of watering can require vegetable farmers to cover a distance from the source of water to the bed they want to irrigate. Vegetable farmers therefore consider the time involved in the use of watering can a constraint.

From the survey, the major ranked constraint with the use of pump irrigation was the high cost of pump. Much maintenance requirement of the pump was ranked in the second position, and it was followed by it being time consuming. This means that, although the use of pump is viable in the long-run than watering can, the cost of ownership is high as compared to watering can due to the initial cost and the cost of maintenance.

In comparison of the two irrigation techniques, it can be seen that each irrigation requires much time, hence, being ranked as the 2nd and 3rd constraint under watering can and pump irrigation respectively. In addition, farmers, irrespective of the irrigation technique used, find it of no difficulty in determining the adequacy of water provided for the crops. Some farmers stated that it was due to the experience acquired over the years, therefore, ranking them 5th and 6th under watering can and pump irrigation respectively.

Conclusion

The study revealed that the use of watering can for irrigation is the most common irrigation technique among vegetable producers in the Kumasi Metropolis. Comparatively, the use of pump irrigation generates a higher seasonal revenue than watering can; as vegetables farmers who use pump for irrigation enjoy an 18.23% (GH₵ 386.00) increase in their revenue. The probit regression model showed that factors that influence a farmer’s decision to use an irrigation technique include farm size, source of water for irrigation, household size, the production of lettuce, the method of land acquisition, the number of production cycle in a year and the revenue from vegetable production. Whilst the farm size, source of water, production cycles in a year and revenue from vegetable production affects the use of pump positively, household size, production of lettuce and the method of land acquisition had a negative effect on the use of pump irrigation. However, the use of each irrigation technique was associated with certain constraints. On the use of watering can for irrigation, it was realized that most farmers consider laborious nature as the main constraint which was followed by the time-consuming nature of the method of irrigation. On other hand, the key constraint associated with the use of pump for irrigation was the high cost involved and was followed by much maintenance requirement.

The study recommends that urban vegetable farmers, especially producers of vegetables such as cabbage and spring onion, should be encouraged to adopt pump irrigation in their production activities. This is because pump irrigation has been identified to provide greater returns for vegetable farmers. Also, the use of pump irrigation is less laborious, effective and encourages or supports production on relatively larger farm size. Farmers with insufficient income should pool resources to acquire pump for irrigation. A major constraint associated with the use of pump irrigation for vegetable was the high cost of pump. Therefore, pooling of resources to acquire the pump will reduce the financial burden involved and cause an increase in efficiency as well as returns.

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