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Cost-Benefit Analysis of Conventional and Integrated Crop Management for Vegetable Production

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ABSTRACT

Smallholder vegetable farmers involved in agricultural production are confronted with numerous challenges which can adversely affect performance. Farmers would prefer to adopt the most profitable vegetable production systems. A cost-benefit analysis of integrated crop management (ICM) and conventional method (CM) systems for vegetable production was conducted. Primary data were solicited from 120 vegetable farmers using questionnaires. Descriptive statistics were used to describe levels of awareness and extent to which farmers understood use of the ICM system. A cash flow projection was done on a 0.4 ha size of land for 5 years. Net present value (NPV) and cost-benefit ratio (CBR) analyses were performed for farmers operating under the ICM and CM production systems. The NPV analysis indicated production of vegetables under both systems was viable. The incremental NPV for cabbage (*Brassica oleracea* var. *capitata* L.) and onion (*Allium cepa* L.) production, and the whole farm enterprise were all positive, indicating the ICM system was more financially viable than the CM system. The NPV increase was GHS 2563.58 (GHS is Ghanaian currency, 1$US = 3.5 GHS in January 2015 when data were collected) for cabbage and GHS 3949.43 for onion, and of the whole farm enterprise, i.e., combined cabbage and onion production, was GHS 6162.75. The CBR analysis indicated that vegetable production under the two systems was viable, confirming results of the NPV analyses. The CBR for cabbage production was 1.58 for the CM and 2.08 for the ICM systems; the CBR for onion production was 2.69 for the CM and 4.36 for the ICM systems. The CBR for whole farm enterprise was 2.42 for the CM and 3.93 for the ICM systems. Sensitivity analyses, under the assumption of a 5% reduction in yield and a 10% cost over-run, indicated positive NPVs for both production systems for cabbage and onion production, and the whole farm enterprise. The NPVs from use of the ICM system were higher than under the CM system. Overall, vegetable production is profitable under both the ICM and CM systems, and awareness is a factor influencing practice of the ICM system.

KEYWORDS
Crop production practices; Ghana; Manya Krobo District; profitability

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Smallholder farmers play a crucial role in developing and emerging economies (Panichvejsunti et al., 2018). However, smallholder farmers are confronted with numerous challenges which adversely affect performance. Cost of production is of great concern to vegetable farmers. Due to higher costs and reduced revenues, lower profit is generated from production of vegetables. Farmers would prefer to adopt the system of vegetable production, which is most profitable. Apart from the conventional system of vegetable production (conventional method (CM)), other systems of vegetable production such as the integrated crop management (ICM) are in place in other locations.

The CM of vegetable production involves practicing conventional tillage and application of commercial fertilizers and synthetic agricultural pesticides to crops to reduce pest infestation (Ferdous et al., 2018; Timprasert et al., 2014). Insect pests and diseases destroy most crops grown in Ghana and farmers apply high quantities of synthetic pesticides in attempts to gain control (Dinham, 2003; Timprasert et al., 2014). Unfortunately, these chemicals are not applied at the right dose resulting in pesticide residues in, and on, vegetables. Some farmers apply these chemicals near maturity, others apply some a few weeks prior to harvest and supply to the market before the recommended safety period for consumption is reached. Consumers perceive vegetables at the market as unsafe, unhealthy, and harmful for human consumption (Fianko et al., 2011; Obuobie et al., 2006). Most farmers experience side effects due to mishandling of chemicals (Ackerson and Awuah, 2010; Wu et al., 2001).

Though vegetables can be produced using the CM, another set of agronomic practices, known as ICM, can be practiced by farmers, which could affect productivity and the sustainability of the environment (Ferdous et al., 2017, 2018; Kletnikoski et al., 2013; Parra-Lopez et al., 2007). ICM is defined as a holistic system of crop production that conserves, and enhances, natural resources while producing food in an economically viable and environmentally sound manner. It integrates existing farmer practices (local knowledge) with new technologies. The ICM system, if properly practiced, will allow farmers to produce quality products, which could increase income (Parra-Lopez et al., 2007). The ICM system is different from the CM because it involves management practices such as minimum tillage, nutrient balancing, integrated pest management, intensification of intercropping, crop rotation, and application of manure. Vegetable farmers practicing integrated pest management, crop rotation, intercropping, and manure application reduce use of pesticides, reduce input cost, and increase income (Theocharopoulos, 2009). Organic agriculture is different from ICM as it includes management practices such as no-till and cover cropping to minimize erosion, reduction of pests through rotation, use of manure and natural fertilizers, and biological methods of pest control (Brumfield et al., 2000). Organic agriculture prohibits the use of any synthetic materials into the production systems. The ICM system is receiving attention to address issues of pesticide residues in vegetables (Kletnikoski et al., 2013; Parra-Lopez et al., 2007; Theocharopoulos, 2009).

Food supply chains have been transformed from production-oriented chains to consumer-oriented chains. Farmers must be market-oriented in their operations and farming practices to meet consumer demand (Kuwornu et al., 2004, 2005, 2009). However, farmers find it difficult to practice new technologies as their decision is normally based on benefits derived from the new technology.

The objectives of the study were to (1) describe the level of awareness of ICM among vegetable farmers, (2) assess the extent to which vegetable farmers understand the importance of using ICM, (3) perform a comparative cost-benefit analysis of using ICM and CM systems among vegetable farmers, and (4) determine factors influencing practice of ICM among vegetable farmers.

Materials and methods

The study was conducted at Kpong in the Lower Manya Krobo District, in the Eastern Region of Ghana. A multi-stage sampling technique was used. First, Kpong was selected since a project on introduction of ICM was implemented in the area. Second, a combination of simple random sampling and purposive sampling was employed to select 120 vegetable farmers using CM and ICM production systems. A total of 89 farmers practicing CM for vegetable production were randomly sampled from among 150 farmers. Among the 89 conventional vegetable farmers sampled, 40 produced cabbage (*Brassica oleracea* var. *capitata* L.) and 49 produced onion (*Allium cepa* L.). Third, all 31 vegetable farmers practicing ICM were interviewed. The 31 vegetable farmers sampled consisted of 17 cabbage and 14 onion farmers. Primary data collected included age, educational qualification, gender, household size, years of farming experience, average annual income from vegetable production, production of other crops, quantities of vegetables harvested within the cropping season, and prices at which vegetables were sold. Descriptive statistics (percent) was used to present levels of awareness of, and use of, ICM. A Likert scale of 1, 2, or 3 that denoted no understanding, slight understanding, and complete understanding, respectively, was used to solicit information regarding vegetable farmer understanding of aspects of the ICM system.

Cost-benefit analysis describes the worth of an investment by comparing costs involved to benefits received. It is used for financial analysis of projects to estimate financial viability of the project. The financial ratios used for cost-benefit analysis included net present value (NPV) and cost-benefit ratio (CBR). The CBR is defined as the value of all benefits divided by the value today of all costs. The NPV is the difference between value of all present, and future, benefits and value of all present, and future, costs (Gittinger, 1982; Kuwornu et al., 2013).

The costs and benefits of the CM to the ICM using the NPV and CBR as indicators were determined. The underlying assumptions were specified; a cash flow projection for the CM and ICM systems was estimated; CBRs and NPVs were employed using discounted cash flows, and a sensitivity analysis for both methods was calculated to determine whether NPVs will still be positive if there is a percent reduction in yield and a percent increase in cost. Before doing cash flow projections for both methods, costs and returns must be estimated. Costs of items used for both methods included watering cans, boots, hoes, machetes, wheel barrows, and a tape measure. The investment included expenditure on polyvinyl chloride pipes, a pumping machine, and a knapsack sprayer. Returns were estimated by taking into consideration yields of cabbage and onion as numbers of bags harvested from a 0.4 ha plot of land under cultivation.

Assumptions for comparing costs and benefits of using the CM or ICM system included the following: (1) a 5% contingency was assigned for the items because they are not affected when there are changes in prices compared with seed and fertilizer, (2) a 10% contingency was estimated for variable inputs such as seed and fertilizer because vegetable farmers will buy these inputs for every cropping season and given the likelihood prices of these inputs will increase, and (3) for repairs and maintenance in year one, an 1% of the total cost item was assumed and increased by 1% each year over the life of the investment. Items reaching their useful life will have zero salvage value (Okoh et al., 2010).

The cash flow projection was estimated for 5 years because by the end of year 5 it is assumed that the life span of the items used for the vegetable production would have ended. Costs and benefits of cabbage and onion using the CM or ICM system were discounted at 28%, the bank lending rate. The CBR can be expressed using the equation of Gittinger (1982). The decision rule for CBR is that if CBR > 1 for the CM or ICM system it means vegetables produced under both methods are financially viable; CBR < 1 for the CM or ICM system means the vegetable produced under both methods are not financially viable; CBR = 1 for the CM or ICM system means that there is a breakeven (i.e., benefits are equal to costs). The NPV can be expressed using the equation of Gittinger (1982). The decision rule for NPV is that if NPV > 0 for the CM or ICM system it means vegetables produced under both methods are financially viable; NPV < 0 for the CM or ICM system means vegetables produced under both methods are not financially viable. A sensitivity analysis was conducted with an assumption of a 5% reduction in yield and 10% cost over-run.

The logit regression model normally used in describing a relationship between a binary response variable and one or more explanatory variables (which may be either discrete or continuous) was used for analysis of factors influencing farmers' decision (willingness) to use the ICM system. Dependent variables in the regression equation are the logarithm of odds that an end user will willingly use the ICM system. For this model, the coefficients do not show the extent to which explanatory variables affect a dependent variable, but the marginal effect does.

Results and discussion

Responses to the questions varied (Table 1). Most respondents had no idea to what ICM referred. Of the 45 farmers who were aware of the ICM, the majority were using the system. The remaining farmers were using the CM in the same way as farmers that were not aware of ICM.

Respondents indicated their extent of understanding of the importance of using ICM through use of crop rotation, intercropping, application of manure, and application of crop residues (Table 1). Most respondents had a complete understanding of crop rotation because most cultivated other crops when the vegetable crop season was over. A minority of respondents had a complete understanding of intercropping.

Most respondents were using synthetic fertilizer, i.e., 15N:15P:15K, and a large minority of respondents applied manure to their vegetable crops to improve yields (Table 1). For respondents who were incorporating more of the crop residue, a large minority indicated they had a complete understanding of the practice. Most respondents practiced manual weeding rather than applying herbicides. Most respondents used irrigation for growing cabbage and onions. A large minority of respondents had a complete understanding of use of mulching early in the growing cycle to enhance crop growth by conserving water and reducing weed competition.

All cost items were the same for methods of production, except the knapsack sprayer was not used for ICM, resulting in a lower total cost for ICM (Table 2). Initial costs for CM and ICM systems had a 5% contingency

Table 1. Extent to which farmers understood use of the integrated crop management system.

Integrated crop management system	No understanding	Slight understanding	Complete understanding	Total
Crop rotation				
Frequency	17	22	81	120
Percent	14.17	18.33	67.50	100
Intercropping				
Frequency	49	32	39	120
Percent	40.83	26.67	32.50	100
Manure application				
Frequency	33	1	56	120
Percent	27.50	25.83	46.67	100
Application of crop residue				
Frequency	38	23	59	120
Percent	31.67	19.17	49.17	100
Weeding				
Frequency	5	31	84	120
Percent	4.17	25.83	70.00	100
Irrigation				
Frequency	6	43	71	120
Percent	5.00	35.83	59.17	100
Mulching				
Frequency	52	21	47	120
Percent	43.33	17.50	39.17	100

Table 2. Estimated costs of vegetable production under the conventional method (CM) and the integrated crop management (ICM) systems.

Equipment	Quantity		Unit price (GHS)[a]	Value (GHS)		Useful life (years)
	CM	ICM		CM	ICM	
Knapsack	1	–[b]	45.00	45.00	–	3
Watering can	1	1	25.00	25.00	25.00	2
Wellington boot	1	1	20.00	20.00	20.00	2
Pipes	11	11	26.00	286.00	286.00	5
Hoes	2	2	18.00	36.00	36.00	2
Machete	2	2	17.00	34.00	34.00	2
Wheelbarrow	1	1	80.00	80.00	80.00	5
Tape measure	2	2	35.00	70.00	70.00	3
Shovel/Spade	2	2	17.00	34.00	34.00	2
Pumping machine	1	1	65.00	65.00	65.00	5
Subtotal				695.00	650.00	
Contingency (5%)				34.75	32.50	
Total				729.75	682.50	

[a]Exchange rate in 2015: $1US = approx. 3.5 GHS (Ghanaian Cedi).
[b]Knapsack spraying machine for production of vegetables was not used under the ICM system.

to account for additional costs due to unstable prices. Some items such as watering can, wellington boots, machete, and hoe with a useful life of 2 years were replaced in the third year. For the third year, cost was GHS 156.45 including items/inputs whose life span did not exceed 2 years. The tape measure and knapsack sprayer, with a useful life of 3 years, were replaced in the fourth year. An amount of GHS 120.75 was spent on items, including those whose useful life exceeded 3 years, but for the ICM system an amount of GHS 73.5 was spent because the cost of the knapsack sprayer was not added due to non-application of chemicals.

Five-year cash flow projections under the CM and ICM systems varied (Tables 3 and 4). For CM, costs for nursery management and bed preparation were constant throughout the years as laborers usually charge a specific amount for nursery management and bed preparation, irrespective of revenue generated by the farmer. Costs for repairs and maintenance increased yearly since items depreciate over time. The cost for seed and fertilizer increased through the fifth year. Total operating cost increased from year 1 to year 5. The total cash outflow increased from year 1, but decreased in year 2 because no item was replaced in that year. However, there was an increase in year 3 to year 5.

For the ICM system, cost of materials included seed and fertilizer (manure) because this method of production discourages use of synthetic chemicals, but does not completely rule out their use. Costs of materials and other labor activities varied with respect to revenue and services that included administrative and marketing cost. Cost for nursery management and bed preparation were constant and there was no variation with proportion to revenue. Costs for repairs and maintenance increased yearly since the items depreciated over time. A 10% contingency was estimated to account for additional costs since

Table 3. Discounted cash flow for cabbage using the conventional method and the integrated crop management systems.

Conventional method (n = 40)						Integrated crop management system (n = 17)				
Cash flows (GHS)[a]	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
Cash inflow	1,384.96	2,086.64	2,788.32	3,125.36	3,575.20	1,384.96	2,086.64	2,788.32	3,125.36	3,575.20
Cash outflow	1,534.96	1103.44	1,554.95	1,672.47	1,718.53	1,340.40	800.02	1119.14	1,140.62	1,173.32
Net cash flow	−150.00	983.20	1233.37	1452.89	1856.67	44.56	1,286.62	1,669.18	1,984.74	2,401.88
Discount factor @ 28%	0.7813	0.6104	0.4768	0.3725	0.2910	0.7813	0.6104	0.4768	0.3725	0.2910
Discounted cash flow	−117.19	600.10	588.12	541.24	540.36	34.8125	785.2905	795.927	739.3733	699.0391
Net present value @ 28% = GHS 2152.63 per 0.4 ha						Net present value @ 28% = GHS 3054.44 per 0.4 ha				
Cost-benefit ratio @ 28% = 1.58						Cost-benefit ratio @ 28% = 2.08				

[a]Exchange rate in 2015: $1US = approx. 3.5 GHS (Ghanaian Cedi).

Table 4. Discounted cash flow for onion using the conventional method and the integrated crop management systems.

Conventional method (n = 49)						Integrated crop management system (n = 14)				
Cash flows (GHS)[a]	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
Cash inflow	900.09	2,576.97	4,253.85	5,127.23	6,113.40	3,600.36	3,927.11	4,253.85	5,877.30	7,598.55
Cash outflow	1086.64	753.81	1303.89	1506.32	1650.88	1329.44	702.75	910.67	1072.57	1260.69
Net cash flow	−186.55	1,823.16	2,949.96	3,620.91	4,462.52	2,270.92	3,224.36	3,343.18	4,804.73	6,337.86
Discount factor @ 28%	0.7813	0.6104	0.4768	0.3725	0.2910	0.7813	0.6104	0.4768	0.3725	0.2910
Discounted cash flow	−145.742	1112.769	1406.651	1348.894	1298.764	1774.156	1967.993	1594.152	1789.901	1844.56
Net present value @ 28% = GHS 5021.34 per 0.4 ha						Net present value @ 28% = GHS 8970.76 per 0.4 ha				
Cost-benefit ratio @ 28% = 2.69						Cost-benefit ratio @ 28% = 4.36				

[a]Exchange rate in 2015: $1US = approx. 3.5 GHS (Ghanaian Cedi).

variable items (seed and fertilizer) increase with respect to changes in prices. The 10% contingency estimated amounted in the first year and increased through the fifth year. Total operating cost increased from year 1 to year 5. Total cash outflow decreased in the second year because there was no item replaced in that year. It then increased from year 3 to year 5.

Net cash flow is the difference between cash outflow (costs) and cash inflow (returns) (Tables 3 and 4). For cabbage production using CM, total cash outflow was higher in the first year compared with revenue producing a negative net cash flow. This indicates that initial cost of production was higher compared with revenue obtained from sale of the product at a particular price. In the second year, there was a decrease in total cash outflow since no item was replaced in that year. The value of the net cash flow was positive from year 2 through year 5 indicating revenues in those years were greater than costs. Cabbage cultivated under ICM had a positive net cash flow for the 5 years, costs were lower than revenues. The net cash flows increased from year 1 to year 5. Lower costs could be attributed to non-application of synthetic pesticides to crops under ICM. Inter-cropping onion with cabbage reduced pest infestation resulting in improved quality of cabbage and consequently market value of cabbage increased compared with those under CM.

Onion produced under CM had a negative net cash flow in year 1 due to high initial cost invested in year 1 with a lower revenue obtained in that same year (Table 4). The net cash flow was positive from year 2 through year 5. Compared with onion produced under ICM, net cash flows were positive throughout the 5 years and increased from year 1 to year 5 since total cash outflows were lower than revenues.

The discounted cash flow for cabbage, or onion, produced under CM and ICM systems varied (Tables 3 and 4), as did the CBRs. The discounted cash flow for combination of the enterprises, cabbage and onion (whole farm), varied (Table 5). The NPVs for farmers producing both vegetables were lower under the CM than ICM systems. The CBRs for producing both vegetables were lower for the CM than ICM systems.

Cabbage and onion output under both methods varied. Incremental discounted cash flows for cabbage, onion, and whole farm varied (Table 6). The incremental NPV indicated that cabbage produced under the ICM system was more viable compared with cabbage production under the CM. The incremental NPV indicated that onion produced under the ICM system was more viable than that of the CM. The incremental NPV for the whole farm enterprise indicated the ICM system was more viable than the CM.

Sensitivity analysis for the whole farm enterprise (combination of cabbage and onion production) for both ICM and CM, under the assumption of a 5% reduction in yield and a 10% cost over-run, varied (Table 7). The NPV for the whole farm vegetable production under the ICM was higher compared

Table 5. Discounted cash flow for the whole farm using the conventional method and the integrated crop management systems.

Conventional method (n = 89)						Integrated crop management system (n = 31)				
Cash flows (GHS)[a]	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
Cash inflow	2,285.05	4,663.61	7,042.17	8,252.59	9,575.80	5,764.36	6,677.28	7,590.20	9,579.20	11,666.87
Cash outflow	1,762.27	1735.15	2,615.15	2,949.13	3,236.06	2,017.16	1508.24	1833.25	2,115.57	2,450.71
Net cash flow	522.78	2,928.46	4,427.02	5,303.46	6,339.74	3,747.20	5,169.04	5,756.95	7,463.63	9,216.16
Discount factor @ 28%	0.7813	0.6104	0.4768	0.3725	0.2910	0.7813	0.6104	0.4768	0.3725	0.2910
Discounted cash flow	408.42	1787.39	2110.97	1975.69	1845.11	2927.50	3154.93	2745.13	2780.42	2682.26
Net present value @ 28% = GHS 8127.58 per 0.4 ha						Net present value @ 28% = GHS 14290.23 per 0.4 ha				
Cost-benefit ratio @ 28% = 2.42						Cost-benefit ratio @ 28% = 3.93				

[a]Exchange rate in 2015: $1US = approx. 3.5 GHS (Ghanaian Cedi).

Table 6. Incremental discounted cash flow for cabbage and onion production in the study area.

	Cabbage (n = 57)					Onion (n = 63)					Whole Farm (n = 120)				
Year	With project net cash flow (GHS)[a]	Without project net cash flow (GHS)	Incremental net cash flow (GHS)	Discount factor @ 28%	Discounted Incremental net cash flow (GHS)	With project net cash flow (GHS)	Without project net cash flow (GHS)	Incremental net cash flow (GHS)	Discount factor @ 28%	Discounted Incremental net cash flow (GHS)	With project net cash flow (GHS)	Without project net cash flow (GHS)	Incremental net cash flow (GHS)	Discount factor @ 28%	Discounted Incremental net cash flow (GHS)
2015	823.60	−149.89	973.49	0.7813	760.54	2270.92	−186.55	2,457.47	0.7813	1919.90	3747.20	522.78	3224.42	0.7813	2519.1
2016	1950.15	983.20	966.95	0.6104	590.18	3224.35	1823.16	1,401.19	0.6104	855.22	5169.20	2928.46	2240.74	0.6104	1367.6
2017	2217.21	1,233.37	983.84	0.4768	469.13	3343.19	2949.96	393.23	0.4768	187.51	5756.95	4427.02	1329.93	0.4768	634.16
2018	2561.72	1452.89	1108.83	0.3725	413.07	4804.73	3620.91	1,183.82	0.3725	441.01	7463.63	5303.46	2160.17	0.3725	804.73
2019	2992.80	1856.67	1136.13	0.2910	330.66	6337.86	4462.52	1,875.34	0.2910	545.80	9216.16	6339.74	2876.42	0.2910	837.15
Incremental net present value = GHS 2563.58 per 0.4 ha						Incremental net present value = GHS 3949.43 per 0.4 ha					Incremental net present value = GHS 6162.75 per 0.4 ha				

[a]Exchange rate in 2015: $1US = approx. 3.5 GHS (Ghanaian Cedi).

Table 7. Sensitivity analysis for the whole farm using the conventional method and the integrated crop management systems.

Conventional method (n = 89)						Integrated crop management system (n = 31)				
Cash flow	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
Cash inflow	2,285.05	4,663.61	7,042.17	8,252.59	9,575.80	5,764.36	6,677.28	7,590.20	9,579.20	11,666.87
Reduction (5%)	2170.80	4430.43	6690.06	7839.96	9097.01	5476.14	6343.42	7210.69	9100.24	11083.53
Discount factor @ 28%	0.7813	0.6104	0.4768	0.3725	0.2910	0.7813	0.6104	0.4768	0.3725	0.2910
Discounted cash inflow	1695.94	2704.12	3190.07	2920.61	2647.58	4278.24	3871.71	3438.32	3390.10	3225.73
Cash outflow	1,762.27	1735.15	2,615.15	2,949.13	3,236.06	2,017.16	1508.24	1833.25	2,115.57	2,450.71
Cost over-run (10%)	1938.50	1908.67	2876.67	3244.04	3559.67	2218.88	1659.06	2016.58	2327.13	2695.78
Discount factor @ 28%	0.7813	0.6104	0.4768	0.3725	0.2910	0.7813	0.6104	0.4768	0.3725	0.2910
Discounted cash outflow	1514.451	1164.957	1371.701	1208.50	1035.999	1733.50	1012.61	961.58	866.92	784.58
Net present value @ 28% = GHS [a] 6862.71 per 0.4 ha						Net present value @ 28% = GHS 12844.92 per 0.4 ha				

[a]Exchange rate in 2015: $1US = approx. 3.5 GHS (Ghanaian Cedi).

Table 8. Logit regression model estimates[a] of the factors influencing farmers' practice of integrated crop management system (n = 120).

Variables	Marginal effect	Standard error	*P*-value
Gender	0.058*	0.035	0.099
Household size	−0.005	0.011	0.673
Age	0.004	0.003	0.147
Education	−0.003	0.024	0.909
Average annual income from vegetable production	−0.000	0.000	0.106
Farming experience	−0.009	0.000	0.183
Production of other crops	−0.099	0.084	0.235
Awareness	0.363***	0.117	0.002

*, ***significant at 10% and 1% levels, respectively.
[a]Pseudo R^2 = 0.6141; Wald chi-square statistic = 38.18; Prob > chi-square = 0.000.

with the CM system. Cost-benefit analysis results were consistent with other reports that the ICM system is more profitable than the CM system for vegetable production (Kletnikoski et al., 2013; Parra-Lopez et al., 2007; Theocharopoulos, 2009) in different locations under different conditions providing additional information, especially for an emerging economy.

The pseudo R^2 of the model (Table 8) indicated that most variation in farmer use of ICM is influenced by independent variables. The Wald chi-square indicated the independent variables explained farmer use of the ICM system. Empirical results indicated that gender and awareness were significant. Both variables indicated a positive relationship with respect to use of the ICM system by vegetable farmers. Being aware of the technology and being a male farmer positively influenced farmer use of the ICM system. The gender distribution of vegetable farmers indicated that the majority were male. The females were more involved in sorting, packaging, and marketing of the vegetables. Most farmers used the CM system in vegetable production. The marginal effect of gender indicates that being a male vegetable farmer slightly increases the likelihood of using the ICM system. This is consistent with Doss and Morris (2001) that males use or practice new technology compared with females. Awareness had a positive influence on use of the ICM system. The marginal effect of awareness indicates that being aware of ICM as a production technology substantially increases the likelihood of using the ICM system. This is consistent with Asrat et al. (2004), Corner-Thomas et al. (2015), and Udoh et al. (2008) on socioeconomic factors influencing adoption of new technology. Improved dissemination of information about use of the ICM system could improve acceptance. Farmers using the ICM system may reduce cost of operation.

The ICM system compares favorably with the CM system for cabbage and onion production. However, producers might be reluctant to switch from the CM system to the ICM system as it requires more intensive management. Nevertheless, the ICM system has less negative impact on the environment.

References

Ackerson, N.O., and E. Awuah. 2010. Urban agriculture practices and health problems among farmers operating on a University Campus in Kumasi, Ghana. Field Actions Sci. Rep (Online). Special Issue 1:1–8.http://factsreports.revues.org/index451.html

Asrat, P., K. Belay, and D. Hamito. 2004. Determinants of farmers' willingness to pay for soil conservation practices in the southeastern highlands of Ethiopia. Land Degrad. Dev. 15:423–438. doi: 10.1002/ldr.623.

Brumfield, R.G., A. Rimal, and S. Reiners. 2000. Comparative cost analyses of conventional, integrated crop management, and organic methods. Hort. Technol. 10:785–793.

Corner-Thomas, R.A., P.R. Kenyon, S.T. Morris, A.L. Ridler, R.E. Hickson, A.W. Greer, C.M. Logan, and H.T. Blair. 2015. Influence of demographic factors on the use of farm management tools by New Zealand farmers. New Zealand J. Agric. Res. 58:412–422. doi: 10.1080/00288233.2015.1063513.

Dinham, B. 2003. Growing vegetables in developing countries for local urban populations and export markets: Problems confronting small-scale producers. Pest Manag. Sci. 59:575–582. doi: 10.1002/(ISSN)1526-4998.

Doss, C.R., and M.L. Morris. 2001. How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. Agric. Econ. 25:27–39. doi: 10.1016/S0169-5150(00)00096-7.

Ferdous, Z.F., A. Datta, and M. Anwar. 2017. Plastic mulch and indigenous microorganism effects on yield and yield components of cauliflower and tomato in inland and coastal regions of Bangladesh. J. Crop Improv. 31:261–279. doi: 10.1080/15427528.2017.1293578.

Ferdous, Z.F., A. Datta, and M. Anwar. 2018. Synthetic pheromone lure and apical clipping affects productivity and profitability of eggplant and cucumber. Int. J. Veg. Sci. 24:180–192. doi: 10.1080/19315260.2017.1407858.

Fianko, J.R., A. Donkor, S.T. Lowor, and P.O. Yeboah. 2011. Agrochemicals and the Ghanaian environment. J Environ Prot (Irvine, Calif). 2:221–230. doi: 10.4236/jep.2011.23026.

Gittinger, J.P. 1982. Economic analysis of agricultural projects. 2nd ed. Johns Hopkins University Press, Baltimore, MD.

Kletnikoski, P., E. Sofijanova, D. Jovanov, and V. Dimovska. 2013. Comparative cost analyses of pepper production under conventional and integrated crop management methods: The case of Strumica region in Republic of Macedonia. Food Sci. Eng. Technol. LX:18–19.

Kuwornu, J.K.M., W.E. Kuiper, and J.M.E. Pennings. 2004. Time series analysis of a principal-agent model to assess risk shifting in agricultural marketing channels: An application to the Dutch ware potato marketing channel, p. 255–271. In: Huylenbroeck G.V., Verbeke W., and Lauwers L. eds. Role of institutions in rural policies and agricultural markets. Elsevier, New York.

Kuwornu, J.K.M., W.E. Kuiper, and J.M.E. Pennings. 2005. Incentive provision and coordination costs in food marketing channels: A multi-stage channel agency theory perspective. J. Food Distribution Res. 36:95–100.

Kuwornu, J.K.M., W.E. Kuiper, and J.M.E. Pennings. 2009. Agency problem and hedging in agri-food chains: model and application. J. Marketing Channels. 16:265–289. doi: 10.1080/10466690902934557.

Kuwornu, J.K.M., A.A. Nafeo, and Y.B. Osei-Asare. 2013. Financial viability, value addition and constraint analyses of certified organic pineapple production and marketing in Ghana. Afr. J. Basic Appl. Sci. 5:12–24.

Obuobie, E., B. Keraita, G. Danso, P. Amoah, O.O. Cofie, L. Raschid-Sally, and P. Drechsel. 2006.Irrigated urban vegetable production in Ghana: characteristics, benefits and risks. International Water Management Institute - Global Partnership on sustainable Urban

Agriculture and Food Systems - International Development Research Centre - Consultative Group on International Agricultural Research- Challenge Program on Water and Food, International Water Management Institute Accra, Ghana.

Okoh, R.N., P.C. Ike, and E.C. Orji. 2010. Integrated farming system and its effect on farm cash income in Awka South Agricultural Zone of Anambra State, Nigeria. American-Eurasian J. Agric. Environ. Sci. 8:1–6.

Panichvejsunti, T., J.K.M. Kuwornu, G.P. Shivakotia, C. Grünbühel, and P. Soni. 2018. Smallholder farmers' crop combinations under different land tenure systems in Thailand. The Role of Flood and Government Policy, Land Use Policy. 72:129–137. doi: 10.1016/j.landusepol.2017.12.046.

Parra-Lopez, C., J. Calatrava-Requena, and T. de-Haro-Gimenez. 2007. A multi-criteria evaluation of environmental performances of conventional, organic and integrated olive-growing systems in the south Spain based on experts knowledge. Renewable Agric. Food Syst. 22:189–203. doi: 10.1017/S1742170507001731.

Theocharopoulos, A. 2009. Economic and environmental analysis of alternative forms of agriculture. Thessaloniki, Greece, School of Agriculture, Aristotle University of Thessaloniki, PhD Diss. (in Greek).

Timprasert, S., A. Datta, and S.L. Ranamukhaarachchi. 2014. Factors determining adoption of integrated pest management by vegetable growers in Nakhon Ratchasima Province, Thailand. Crop Prot. 62:32–39. doi: 10.1016/j.cropro.2014.04.008.

Udoh, A.J., A. Idio, E. Umoh, and U. Robson. 2008. Socioeconomic factors influencing adoption of Yam Minisett technology in South eastern Nigeria: **A** Probit analysis. Indian Res. J. Extension Educ. 8(2&3):1–5.

Wu, I., J. Lin, and E. Cheng. 2001. Acute poisoning with the neonicotinoid insecticide imidacloprid in N-methyl pyrrolidone. J. Toxicol. Clin. Toxicol. 39(6):617–621.