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DEMONSTRATION ON THE USE OF URINE IN URBAN AGRICULTURE

FINAL REPORT

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Executive summary

This report is an output of the Sustainable Urban Water Management Improves Tomorrow's City's Health (SWITCH) demonstration project, which took place in Accra, Ghana. Accra is one of the ten (10) demonstration cities under the SWITCH project. The main objective of the demo project was to demonstrate (as pilot) the potential of using urine for crop production in Accra Metropolitan Area (AMA) and provide recommendations for scaling up.

Methodology

The study was organized into three main parts: I) socioeconomic, II) agronomic, and III) training. The socioeconomic component had two parts: the financial feasibility and the perception studies.

I) *Socioeconomic part*

The socioeconomic part has two components: a) financial feasibility analysis and b) perception studies. In both cases the study adopted a triangulation approach. First, the theoretical framework was determined, then the methods of data analysis of each specific objective were identified and finally the data collection procedure.

a) Financial feasibility analysis

The methods used include: Cost Benefit Analysis (CBA) for the financial feasibility of using urine, partial budgeting for assessing the savings to be made by farmers and Contingent Valuation Method (CVM) was used and for willingness to pay analysis. In estimating the savings made by farmers when they use urine instead of chemical fertilizer, data from IWMI on yield of cabbage under different fertilizer treatments were used. The design of the urine collection system and the logistic needs of the entrepreneur at the Valley View University (VVU) were observed to verify existing literature. Equipment suppliers like Dizengoff Ghana Limited, Agrimat, Poly tank Ghana Limited and local enterprises were contacted to ascertain the market prices of the logistics needed for the establishment and operation and maintenance of the urine collection system in Ghana Cedis (GH¢).

b) Perception studies

The perception assessment studies were in three parts: farmer's perception on the use of human urine for vegetable production, marketers' perception on the use of human urine for vegetable production and consumers' perception on the use of human urine for vegetable production. A total of about three hundred and fifteen (315) respondents were interviewed. A pool of six questions was used to quantify consumer's perception about the use of human urine for vegetable production. Data collection commenced by sensitizing the farmers after which face-to-face interviews were conducted with the aid of questionnaires.

II) *Agronomic part*

The purpose of this part of the study was to determine the effect of human urine (alone or in combination with other organic manure) on the growth/yield of cabbage, crop nutrient uptake and soil characteristics. The study was carried out in Accra, Ghana between September, 2009 and June 2010 using a field trial. A Randomised Complete Block Design (RCBD) was used and four different treatments (urine alone, urine + dewatered faecal sludge, urine + poultry droppings, NPK + poultry droppings and soil alone were applied. The chemical characteristics of the urine and the other fertilizer sources were determined using standard methods before application. Data on growth parameters were collected forth-nightly starting from the third day after transplanting. Yield parameters were determined at maturity.

III) *Training*

A series of training programmes were organized to demonstrate the potential of using urine as an alternative source of fertilizer for crop production in Accra Metropolitan Area (AMA). The main aim of the urine demonstration was to enhance the operational skills of farmers and Agricultural Extension Agents (AEA's) of the Ministry of Food and Agriculture (MoFA) and other key stakeholders. A total of about six separate training programmes/meetings were organized between September 2009 and January, 2011. Methods used include presentation (both pictorial and power point), field observations, demonstrations, discussions, role plays etc.

Main project findings

Financial feasibility study

The results of the study shows that there are many inbound, operations and outbound logistics that need to be budgeted for each year. The least cost (May 2010 prices) item is the mob stick and the greatest variable cost item is vehicle maintenance fees. Apart from organizing logistics for construction, procuring the dislodging vehicle is the greatest challenge. The operation of the urine collection and reuse system require administrative and managerial competence and these can all be found in the Central Business District (CBD) of the AMA. Urine generation in the CBD can be a reliable source of low-cost fertiliser for urban vegetable farming in the city of Accra as the volumes of urine generated by the urinals far exceed that which would be required for urban vegetable farming. About five thousand meter cube (5,000m^3) of urine is generated yearly by these urinals as against two thousand meter cube (2000m^3) which would be required for urban vegetable farming.

The profitability level of the operations depended on whether the ownership was fully private or public. It also depended on the urinal user charge and urine sale charges agreed upon by the Assembly and the farmers. At the current situation of GH¢0.05

urinal charge, the investment in urinal project will not be feasible for both a private and public sector entrepreneur. However, if the charge is increased by 100% and the sales price by 5 percent, then there will be profitability and the investment will be paid back in after 6 and 3 years for private and public owners, respectively. In one cropping season (usually 3 months), a cabbage farmer in Accra (of farm size 200 m^2 -0.02 ha with a planting distance of 0.45m × 0.60m) would make a savings of GH¢24.60 for using S+PD+U as an alternative fertiliser in lieu of S+PD+NPK. .

Perception

Farmers with positive perception about urine quality will adopt the technology. The probability that male farmers will be willing to adopt the urine technology will increase by 26% more than females. Young farmers will be more willing to adopt the technology than the elderly. Farmers who use organic fertilizers probability of using the urine technology are higher than those who do not use organic fertilizers by 0.06.

Marketers' willingness to buy u-vegetables was influenced by their perception, gender, norm and religious influence. A unit increase in a marketer's urine perception index increases the probability of willingness to buy u-vegetables by 0.03. Probability of willingness to buy u-vegetables was highest among marketer's whose religious beliefs is not against the use of human urine for vegetable production than those whose religious belief is against human urine use on vegetable production by 0.585. .

Fifty six percent (56%) of consumers do not want human urine to be disposed off as a municipal waste, although they (72%) could not tell what is in human urine that makes it a resource. Meanwhile, from the PCA results, about 44% of the consumers were willing to buy u-vegetables. These were people who perceive urine as a resource and their consumption of u-vegetables is independent of religious influence and norm in the society. Consumers mentioned a perceived health risk associated with the consumption of u-vegetables as a major concern that can influence their choice to consume u-vegetables.

Consumers with alternative source of buying vegetables willingness to buy u-vegetables will decrease by 35 percent relative to consumers with no alternative source. However, a positive consumer perception about urine will increase his/her willingness to consume u-vegetables by 2.4%. The study also observed some potential barriers that can impede the successful introduction of the use of human urine on vegetables. These include the health effects, socio-cultural perceptions, environmental effects, technical know-how and economic effects.

Agronomic study

The major lipophylic pharmaceutical residues expected to be present in the collected for the trial are chloroquine, amodiaquine and lumefantrine. The total nitrogen concentration (10.3 g L^{-1}) was close to the total N concentration for undiluted fresh

human urine. Phosphorus and potassium values of 0.20 to 0.21 g L^{-1}, respectively were also close to what has been reported in literature.

Between various treatments, there were no significant differences ($P < 0.05$) in the plant height, number leaves, canopy size, circumference of cabbage head, fresh and dry matter yield. However, cabbages treated with NPK + PD had the highest percentage (58.2%) of rotten cabbage heads. This was significantly higher than the other treatments. 'Urine + DFS' on the other hand had the lowest percentage (30%) of rotten cabbage heads. Soil residual nitrogen content for Urine + DFS and Urine + PD were significantly ($P< 0.05$) higher than that of NPK + PD. Even though urine could be an alternative source of nutrients for crop production applying it in combination with other organic fertilizer e.g. poultry droppings or dewatered faecal sludge produced better results.

Training Results and lessons learnt

Participants as well as Agricultural Extension Agents (AEAs) and other stakeholders are now aware of the potential of urine as a source of fertilizer for crop production and have understood how to apply urine, the potential health risks associated with the use and how to minimize these risks. Concerns raised by participants suggest that further research would be required to address them. These include:

- How users could receive regular supply of urine and how to obtain storage facilities.
- Application rates for various crops and how different would these rates be compared with that of cabbage
- The effect of urine on different soil types (especially sandy soil) as well as the effect on soil characteristics.
- How to reduce the bad odour of urine
- Health concerns related to potential pharmaceutical residues

For up-scaling the results of the demo project further training and awareness creation would be required to improve the knowledge and skills of all stakeholders

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List of abbreviations

AMA	Accra Metropolitan Assembly
BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CBD	Central Business District
CDF	Cumulative Distributive Function
CVM	Contingent Valuation Method
DFS	Dewatered Faecal Sludge
EPA	Environmental Protection Agency
FDB	Food and Drugs Board
GH¢	Ghana Cedis
GSB	Ghana Standard Board
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IRR	Internal Rate of Return
IWMI	International Water Management Institute
LR	Likelihood Ration
LSD	Least Significant Difference
MLE	Maximum Likelihood Estimate
MoFA	Ministry of Food and Agriculture
NPK	Nitrogen Phosphorus and Potassium
NPV	Net Present Value
PBP	Pay Back Period
PCA	Principal Component Analysis
SWITCH	Sustainable Urban Water Management Improves Tomorrows Citys Health
UDDT	Urine Diverted Dry Toilet
VVU	Valley View University
WHO	World Health Organization
WIAD	Women in Agricultural Development
WMD	Waste Management Department
WTP	Willingness To Pay
WTU	Willingness To Use

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CHAPTER ONE

1.0 INTRODUCTION

Ghana's capital city is Accra and like most cities in the developing world it is experiencing rapid population growth and urbanization. This rapid urbanization has brought about urban poverty, food insecurity and severe environmental degradation (Tetteh-Lowor, 2007). To reduce the impact of food security in the city several cities including those in the developed countries have given attention to urban agriculture which is considered as part of the urban ecological system.

Earlier studies in Accra observed that, up to 90 percent of the city's fresh vegetable consumption is from production within the city (Cencosad 1994, Drechsel *et al.,* 2006). Extensive urban agriculture takes place on seven main sites and there are about one thousand (1,000) vegetable farmers as well as other farmers who are engaged in some seasonal crops such as maize and cassava. In addition to this, a considerable number of households are engaged in backyard gardening. As at 2004, it was estimated that about 17 hectares of land was under cultivation for maize, 20 ha under cultivation for pepper, 104 ha under cultivation for okro and 14 ha under cultivation of tomatoes (Obuobie *et al.,* 2006, Cofie *et al.,* 2006). With the growing use of agrarian land for residential and office buildings, the area under cultivation is bound to reduce over the years. What will grow as a result of this phenomenon is the intensification of agriculture which requires the use of fertilizers to maintain soil fertility.

Currently farmers in Accra, particularly operating commercial irrigated vegetable production use poultry manure and chemical fertilizers. The high cost of mineral fertilizers is a constraint to farming activities in the city (see figure 1). Hence availability of alternative sources of nutrient will enhance the productivity of urban agriculture. Alternatives such as urine have been suggested by several researchers and tested and accepted in economies like Finland, South Africa, Israel and China (Mang *et al*., 2007, Jönsson, 2003). Can the success story be replicated in Accra? May be yes; however the government of Ghana represented by the Ministry of Food and Agriculture (MoFA) is yet to start experiments to demonstrate the feasibility of urine based farming system. The International Water Management Institute (IWMI), Ghana in collaboration with both local and international organizations initiated this project to address this issue.

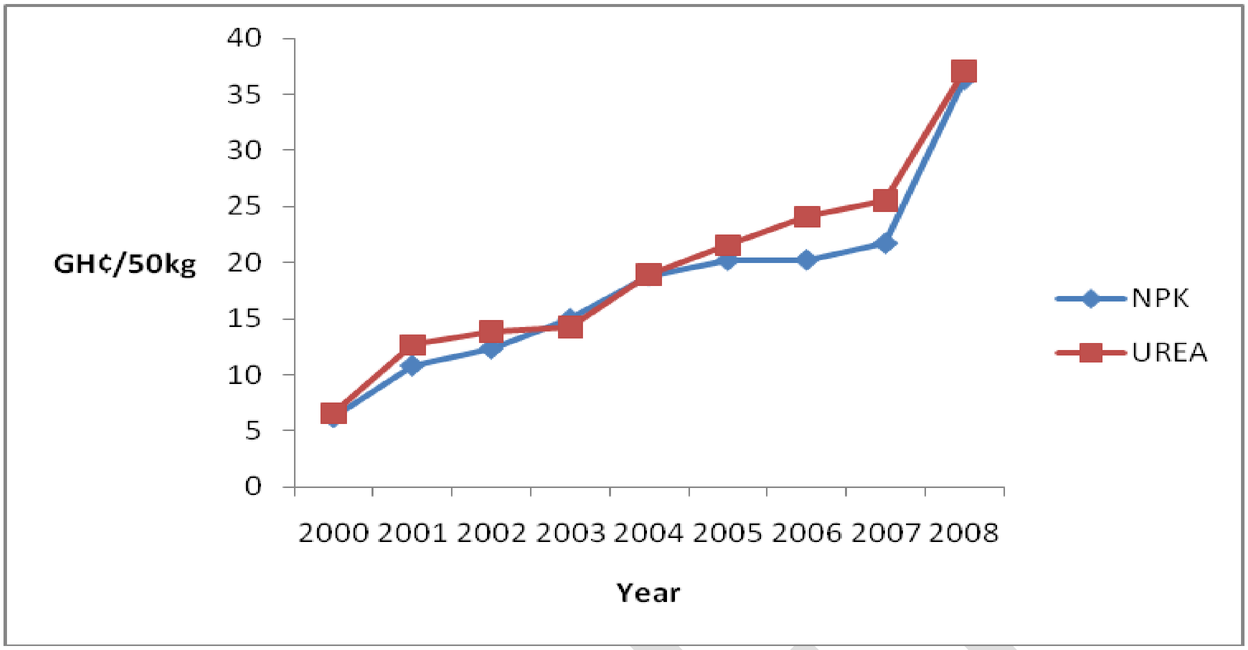


Figure 1: Trends in fertiliser prices in Ghana, 2000-2008

Accra is one of the ten (10) demonstration cities under one of its projects, Sustainable Urban Water Management Improves Tomorrow's City's Health (SWITCH) with work package 5.2 which focuses on urban and peri-urban agriculture. The project aims at developing possible interventions to effect significant improvements in agricultural production, and other livelihood activities using freshwater, storm and wastewater among others. As part of the project objectives, urine use as an alternative fertilizer in urban and peri-urban agriculture is being considered.

Results of a rapid appraisal study in 2007, showed that, in Accra 95% of the city's populace uses on site sanitation facilities (public toilet, bucket latrines, septic tanks) as the main means of sanitation (Cofie *et al.,* 2007). This makes these places a potential source of nutrients and organic matter production for urban agriculture in Accra in the form of human excreta and urine. Public toilets are common, especially in the highly densely populated marginalized areas. Close to a third of the city's households have no toilets in their homes and they therefore rely on public places of convenience. Furthermore, there are public urinals which are located within some of the densely populated residential areas and public places such as bus stations, markets and restaurants. Most of the urinals and public toilets that are located within and around the city centre are privately owned and are pay to use.

Further results of the study carried out on 14 of the urinals which are located within the Central Business District (CBD) of Accra, revealed that 7.3 m^3 of urine is generated per day. This is approximately 2.2 thousand m^3 of urine per year. In terms of nitrogen content this volume represents 6.6 tonnes of plant available nitrogen. According to Wolgast (1993), the annual amount of human excreta of one person corresponds to the amount of fertiliser needed to produce 250 kg of cereal which is also the amount of

cereal that one person needs to consume per year. The value of human urine as nutrient can thus not be over emphasized. All that is needed is proper liquid waste collection and management technologies. Unfortunately these are generally absent in most public urinal facilities.

It is speculated that there has been agreements between the Waste Management Department of the Accra metropolitan Assembly (AMA) and an entrepreneur; the latter was given a franchise to operate public urinals and properly disposed off the urine generated from these urinals at the waste disposal sites of AMA. Unfortunately this agreement has not been adhered to. Consequently all the urine that comes from these urinals are discharged directly into the drains and consequently into the Korle lagoon untreated thereby seriously polluting the water body. The environmental consequence of this practice is any bodies guess. In 2005, the GTZ documented the "Ecosan approach" to solving the sanitation problems of cities. It suggested that sanitation problems could be solved more sustainably and efficiently if the resources contained in excreta and wastewater are recovered and used rather than discharged into the water bodies and the surrounding environment (GTZ, 2005). Earlier in 2004, it was also reported that, an international group of planners, architects, engineers, ecologists, biologists, agronomists and social scientists had developed an approach to sanitation that saved water, does not pollute and returns the nutrients in human excreta (human faeces and human urine) to the soil (Winblad and Simpson-Hébert, 2004). It means that the current linear[1] flow of plant nutrients in cities can be reversed. By harvesting and using urine for urban agriculture, a win-win situation can be achieved. It can reduce the pollution burden from current urine discharge into drains. It will serve as another fertilizer source for urban farmers.

1.1 Description of SWITCH project

The International Water Management Institute's (IWMI'S) SWITCH project proposed that "in collaboration with the private sector, an entrepreneur will adopt existing urinals within the Central Business District of Accra and adapt them to make urine collection possible. The entrepreneur will handle the transport of urine from the urinals to the farm. This approach will make it easier for the technology to be exploited by urinal operators within the city thereby contributing to a healthy environment and a reduction of the level of pollution in the Korle lagoon.

The urine so collected will be used for demonstration purposes as an alternative fertilizer on one of the urban farming sites in Dzorwulu. The demonstration project will run for a period of two years. It will demonstrate to the farmers the right use of urine application and also a comparative analysis in the increase in yield of crops fertilized with urine as compared to chemical fertilizer, poultry manure and crops not fertilized at all. The innovation in this demonstration project lies in the integration of two sectors, the

[1] This means that plant nutrients are taken up from the soil by the plant, transported to the market as crop, consumed in the form of food, excreted and discharged in the form of urine and faeces

recycling of a material that is considered as waste and the consequent reduction of pollution. The use of urine in urban agriculture will provide an alternative fertilizer and lead to a higher crop yield. The use as a fertilizer will create incentives to store and use the urine instead of discharging it into the drains provides an option to reduce the level of pollution in the Korle lagoon".

1.1.1 Objectives of SWITCH project:

The main objective of the demo project was to demonstrate (as pilot) the potential of using urine for crop production in Accra Metropolitan Area (AMA) and provide recommendations for scaling up.

The following were the specific objectives of the study:

- Assessment of the feasibility (logistics, financial and economic) of urine use for agriculture

  a. Identify the logistic needs of the entrepreneur who will invest in urine-based fertiliser.
  b. Determine the profitability of the urine-based fertiliser production system.
  c. Estimate the savings made by farmers when they use urine as an alternative fertiliser.

- Assessment of farmers, marketers and consumers perception of and demand for urine :
  a. Farmers perception as well as demand for/willingness to buy urine
  b. Marketers' perception and willingness to buy urine cultivated produce.
  c. Consumers perception and willingness to buy/eat urine cultivated produce

- Evaluation of urine quality especially with respect to the impact of pharmaceuticals in urine use for agriculture

- Assessment of the agronomic feasibility of urine use at the demo site

  a. Collection/treatment of urine before use
  b. Effect of urine on yield and growth characteristics of crops fertilized with urine

- Training of farmers, extension workers and other stakeholders to enhance their operational skill in urine use for agriculture

1.1.2 Potential impact of SWITCH project

If the demonstration project is successful and accepted by stakeholders and upscaled to the city level, it has the potential to impact various aspects of the society

Environmental impact

The nutrient load particularly on the Korle lagoon (which receives most of the municipal wastewater from the city) will be reduced drastically. Currently most of the municipal wastewater from Accra enters this water body untreated through the Odaw River. Several studies have shown that up to 80% of the total N load, and around 45% of the total P load in municipal wastewater originates from urine. A separation of urine therefore will improve the quality of this water body and reduce eutrophication.

Socio-Economic impact

Farmers, private entrepreneurs and municipal authorities would benefit from the intervention. The approach will cater for a new type of fertilizer. Urine application may increase crop yield between 2 to 6 times more than crops not fertilized at all. This will improve the crop yield of the farmers and increase their income, hence improve livelihood. Furthermore, the project will also provide employment for those who will be engaged in transporting the urine.

Health impact

There would also be positive impact on the public health from reduction in pollution and odour as nuisance from indiscriminate disposal of urine. Beyond Accra, the success of this intervention can be taken up across sub-Saharan Africa and other developing nations.

1.2 Organization of the Report

The study is organized into three main parts, I, II and III. Part I is the socio economic component described in chapter 2 and 3. Chapter 2 describes the financial feasibility of producing a urine-based fertiliser for vegetable farming in Accra, Ghana whiles chapter 3 describes the perception and willingness of market actors on the use of human urine as a source of fertilizer. Part II which is on agronomy is describes the effect of urine on cabbage growth, yield, nutrient uptake and soil characteristics in chapter four of the report. Part III is on training of farmers and other stakeholders on the use of urine for crop production. This is described in chapter five. Chapter 6 is on general conclusions and recommendations for further studies.

CHAPTER TWO

2.0 Financial feasibility of producing a urine-based fertiliser for vegetable farming in Accra [2]

This chapter presents the financial feasibility/profitability of the urine-based production system. It identifies the logistic needs of the entrepreneur who will invest in urine-based fertilizer production and estimate the savings that will be made by farmers when they use urine as an alternative source of fertilizer for crop production.

2.1 Methodology

The methodology of the study adopted a triangulation approach. First, the theoretical framework was determined, then the methods of data analysis of each specific objective were determined and finally the data collection procedure.

2.1.1 Theoretical framework

Human urine and vegetables produced from their use (here referred to as u-vegetables) are basically non-market goods (they are not sold on the market) in Ghana. In order to study its feasibility in terms of financial viability analysis and estimation of market actor's willingness to process, distribute and pay for human urine and u-vegetables, several economic methodologies including hedonic pricing, cost-benefit analysis, travel cost and cost-effectiveness have been used.

2.1.2 Financial feasibility analysis

For financial feasibility analysis, it is assumed that the project is an investment activity where capital resources will be expended to create a producing asset from which we can expect to realize benefits over an extended period of time (Gittinger, 1982). Hence, the profitability of a project can be appraised by both qualitative and quantitative analysis. Nevertheless, the most common appraisal method based on efficiency criteria is a general Cost Benefit Analysis (CBA) framework. Cost Benefit Analysis takes into account both financial and socio-economic costs and benefits to assess the comparative advantage of different options in monetary terms. A decision on the profitability of a project can be arrived by the estimation of the Net Present Value (NPV), Internal Rate of Return (IRR), the Benefit Cost Ratio (BCR) and the Pay Back Period (PBP) using equations (3.1), (3.2),(3.3) and (3.4) respectively(Gittinger, 1982 and Berry et al, 1979).

i. *Net Present Value (NPV)*

[2] This chapter is a extract from an MSc theses by Mark Ofei (University of Ghana-Legon, Ghana)

Net present value is computed by finding the difference between the present worth of benefit stream less the present worth of cost stream.

$$NPV = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+r)^t} \qquad (3.1)$$

A project is profitable or feasible if the calculated NVP is positive when discounted at the opportunity cost of capital. This would reflect a project where the present value of net benefits exceeds the present value of all capital and operating costs. The final result is a numerical value in Ghana cedis (GH¢).

Where:
$B - C$ = net cash flow in n_{th} year of the project
B = Benefit in each year of the project
C = Cost in each year of the project
r = Interest (discount) rate
t = 1, 2…20 (time of the project life in years)
n = Number of years in the project, in this case 20 years

ii. Internal Rate of Return (IRR)

Internal Rate of Return (IRR) is that discount rate which just makes the net present value (NVP) of the cash flow equal zero. It represents the average earning power of the money used in the project over the project life. It is also sometimes called yield of the investment. A project is profitable or feasible for investment when the internal rate of return is higher than the opportunity cost of capital.

$$IRR = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+r)^t} = 0 \qquad (3.2)$$

iii. Benefit Cost Ratio (BCR)

It is the ratio of present worth of benefit stream to present worth of cost stream.

$$BCR = \sum_{t=1}^{t=n} \frac{B_t}{(1+r)^t} \Big/ \sum_{t=1}^{t=n} \frac{C_t}{(1+r)^t} \qquad (3.3)$$

The investment is said to be profitable when the BCR is one or greater than 1.

iv. Pay Back Period (PBP)

The Payback period is the length of time required for an investment is able to pay itself out.

$$PBP = I \Big/ \sum_{t=1}^{n} E_{n=1} \qquad (3.4)$$

Where:

I = initial investment of the project
E = the projected net cash flows per year from the investment.

The Pay Back Period is expressed in number of years and a project with a shorter PBP is normally good for an investor especially when the initial investment cost is higher.

v. Sensitivity Analysis

A sensitivity analysis is conducted to systematically test what would happen to the earning capacity of a project, here, the urine collection system if events change from that used in the initial planning of the project. This is done as a means of dealing with uncertainty about future events and values (Gittinger, 1982). The sensitivity analysis is carried out by varying the cost and benefits of the urine collection system and the effect on the outcome of the project worth is determined.

2.1.3 Analysis of savings to be made by farmers

Partial budgeting is suggested for assessing the savings made due to a small change on a firm's operations. It is considered as a managerial analysis technique as it looks at the changes in cost and receipts (benefit), that is net farm income, likely to result from marginal change in farming system (Johnson, 1982). The layout and valuations include new costs, costs saved, new revenue and lost revenue/income (Table 2.1).

Table 2.1: Standard layout for partial budgeting

LOSSES		**GAINS**
Income lost:		New income:
New cost:		Cost saved:
Net gains	or	Net loss

Source: Johnson, 1982

2.1.4 Willingness to pay analyses

Much of the current willingness to pay (WTP) analysis is based on Contingent Valuation Method (CVM) which elicits directly what individuals (here, farmers, marketers, consumers) would be willing to pay for a particular product or good (Misra *et al*., 1991; Huang *et al*., 1999; Boccaletti and Nardella, 2000; Batte *et al*., 2007; Posri *et al.*, 2007). Individuals simply indicate their willingness to use and how much they would be willing to pay (WTP) without purchasing the (nonmarket) hypothetical product (in this study, human urine). A major drawback to CVM is that market actors may have little information about the risks involved and therefore they may give a wrong monetary evaluation of the benefit from risk avoidance. In order to go round this, researchers suggest a thorough description of the product (including risks and benefits involved) during the interview (Buzby *et al*., 1995; Fox *et al*., 1995).

The decisions individuals face are assumed to be dichotomous; a farmer can decide to use human urine for vegetable production or not; a marketer/consumer will buy u-vegetables or not. These binary (yes/no) decisions require a binary response model during estimation (Greene, 2003). If there is an assumption of a cumulative distributive function (CDF) then the logit and probit models can be applied (Gujarati, 2004). In most applications, the choice between these two models seems not to make much difference. Several empirical studies have tried to capture the influence of socio-economic variables on farmer's adoption decision (Rahm and Huffman, 1984; Hailu, 1990; Kebede *et al*., 1990; Adesina, 1996). In the current study, the requirement is to produce predictions consistent with the underlying theories of input demand (farmers and marketers) and consumer demand (consumers). The probit model was selected.

The probit model is associated with the normal cumulative density function[3]. The probit model is based on the premise that an individual decision [farmers to use human urine on vegetables or not; marketers and consumers' willingness to buy u-vegetables or not] depends on a vector of X_i influential factors and unknown parameters, β. It assumes a theoretically continuous index, Z_i which is determined by the explanatory variables. i.e. $Z_i = X_i^{'}\beta$ (Gujarati, 2004). A positive decision takes place only when the combined effect of the influential and unknown parameters ($X_i\,\beta$) reach a certain unobservable critical value, Z_i^*. The decision variable, Y_i (the dichotomous dependent variable) takes the value of 1 if a positive decision is made and 0 otherwise; for example the dichotomous willingness to use human urine on vegetables for the i^{th} farmer could be specified as:

$$Y_i = \begin{cases} 1 \text{ if } X_i^{'}\beta \geq Z_i^* \\ 0 \text{ if } X_i^{'}\beta < Z_i^* \end{cases} \qquad (3.5)$$

where $i = 1, 2, \ldots, N$

[3] If a variable X follows the normal distribution with mean μ and variance σ^2, its probability density function (PDF) is

$$f(X) = \frac{1}{\sqrt{2\sigma^2\pi}} e^{-(X-\mu)^2/2\sigma^2}$$

In the model the probability that

$$X_i^{'}\beta \geq Z_i^{*}(Y_i = 1) \text{ is given by } P_i = \text{Prob}(Y_i = 1) = F(X_i^{'}\beta) \text{ and} \quad (3.6)$$
$$X_i^{'}\beta < Z_i^{*}(Y_i = 0) \text{ is given by } 1 - P_i = \text{Prob}(Y_i = 0) = 1 - F(X_i^{'}\beta)$$

Where $F(X_i^{'}\beta)$ represents the cumulative distribution function.

Also, given the assumption of normality of the combined effect ($X_i\ \beta$), the estimated values of the dependent variable, represent the probability that an individual (farmer; marketer or consumer) will use human urine for vegetable production or buy u - vegetables given the values of *X*. The probability that an individual will use human urine for vegetable production or buy u-vegetables can be defined as;

$$E[Y|X] = P_i = 0.[1 - F(X^{'}\beta)] + 1.[F(X^{'}\beta)] = F(X^{'}\beta) \quad (3.7)$$

The parameter estimates in the model are estimated by the Maximum Likelihood Methods. This is because the maximum likelihood estimates (MLE) of the coefficients in large samples are approximately normally distributed and the significance of the individual coefficients can be tested by the ratio of the estimated coefficient and its corresponding standard error (asymptotic t-value).

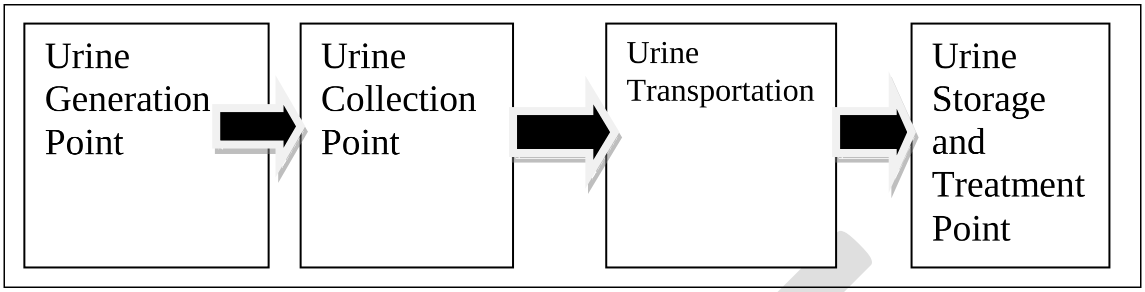
For qualitative choice models, the estimated coefficients should be interpreted in the sense that they affect the probability that a certain event would occur. This interpretation can be obtained by computing the probability derivatives or marginal probabilities (marginal effects) from the estimated model. The STATA 10.0 statistical package generates these. The likelihood ratio (LR) statistic and the Pseudo R^2 were used to assess how good the probit model is. The LR statistic (equivalent of the F test in the linear regression model) tests the joint null hypothesis that all slope coefficients except the constant are zero. The Pseudo R^2 is the likelihood ratio index expected to be between 0.2 – 0.6 (Gujarati, 2004).

2.2 Methods of data analyses

2.2.1 Identifying the logistics needs of the entrepreneur

Logistics involves the planning and control of the flow of goods and materials through an organization or manufacturing process. Logistics include collection, storage, management of processing, distribution, information & services flow and related management from source to end users. In this study what is needed was classified into four stages, viz., urine generation, collection, transportation and storage and treatment points (figure 2.1). All the materials, buildings, vehicles, tools, equipment and the organism (urine) were identified and valued.

Figure 2.1: Schematic diagram of the stages involved in the urine collection and distribution



It was assumed that 519 litres of urine can be collected in a day, and a person (male or female) spends 3 minutes in a cubicle. With the 3.4% population growth rate of the city the number of urinal cubicles required to collect urine after 10 years were increased.

2.2.2 Determining the profitability of the urine-based fertiliser production system

In order to ascertain the profitability of the urine collection system, the total costs and total benefits were identified and valued based on the technological design.
The total cost of the urine collection system was then estimated from the equation (3.8) below.

$$TC_{UCS} = TFC_{UCS} + TVC_{UCS} \qquad (3.8)$$

Where:
$TC_{UCS} =$ The total cost of the urine collection system.
$TFC_{UCS} =$ The total fixed cost of the urine collection system
$TVC_{UCS} =$ The total variable cost of the urine collection system

The total fixed cost (TFC_{UCS})or investment cost is the money required at the beginning of the project to finance or purchase materials, labour and any other costs related to construction and implementation of the urine collection system. Equation (3.9) was used to estimate the total fixed cost of the urine collection system.

$$TFC_{UCS} = C_{f1} + C_{f2} + \ldots + C_{f12} \qquad (3.9)$$

Where:
$C_{f1} =$ Construction of platform for the installation of male and female urinal
$C_{f2} =$ Construction and installation of underground storage tanks at source
$C_{f3} =$ Construction and installation of storage tanks at destination

C_{f4}= Installation of urinals on platform
C_{f5} = Poly kiosk for attendants
C_{f6} = Dislodging vehicle (used 6000 litre suction truck)
C_{f7} = Dustbin
C_{f8}= Change of the suction truck tires every 5years
C_{f9}= Waterless stand-alone urinals (for male)
C_{f10} = Waterless stand-alone urinals (for male)
C_{f11} = Bidet (waterless urinal for female)
C_{f12} = Sink

The total variable cost (TVC_{UCS}) or operational and maintenance cost of the urine collection system is the money that is required to sustain the system once it has begun operation. Equation (3.9) was used to estimate the total variable cost of the urine collection system.

$$TVC_{UCS} = C_{v1} + C_{v2} + \cdots + C_{v14} \tag{3.9}$$

Where:
C_{v1} = Mob stick
C_{v2}= Mob bucket
C_{v3}= Gloves
C_{v4}= Detergent (allow GH¢ 20.00 per month for detergent)
C_{v5} = Ground rent (30% of total revenue as mandated by AMA)
C_{v6} = Registration fee (Business Operating Permit)
C_{v7} = Director(salaries increases by 5% of previous every 2 years)
C_{v8} = Supervisors (salaries increases by 5% of previous every 2 years)
C_{v9}= Secretary (salaries increases by 5% of previous every 2 years)
C_{v10}= Driver for dislodging truck (salaries increases by 5% of previous every 2 years)
C_{v11}= Attendants (2) (salaries increases by 5% of previous every 2 years)
C_{v12} = Labourers for dislodging vehicle (2) (salaries increases by 5% of previous every 2 years)
C_{v13} = Fuel
C_{v14} = Change of oil, filters and workmanship

2.2.3 Estimating the savings made by farmers when they use urine instead of chemical fertilizer

In the urban vegetable farming system in Accra poultry manure is usually mixed with chemical fertilizers during soil fertility management. Hence the budgeting here included evaluation of the following:

- New costs that arose for using poultry manure + Urine

- Explicit costs saved for not using Poultry manure + Chemical fertiliser
- Explicit income lost when Poultry manure + chemical fertilizer was not used
- New income obtained when Poultry manure + Urine was used

In terms of fertiliser usage, the main types of fertilisers that are used by the urban farmers are: NPK15-15-15, Ammonia Sulphate, Urea and Muriate of Potash.

The net gain/loss was calculated as an arithmetic difference. Then the significance of the difference between the value and zero was tested using the chi-square. The mean values of costs and returns, obtained from which were the result of a demonstration project conducted by IWMI on the use of urine for cultivating cabbage on Dzorwulu farmers' site. It was validated with survey data.

2.3 Sources and methods of data collection

2.3.1 Sources of data

The study used data obtained from the following sources:

- International Water Management Institute (IWMI), provided data on yield of cabbage (in kilogrammes) under different fertiliser treatments from a demonstration project which took place at Dzorwulu, on the use of urine and poultry manure to grow cabbage as compared to cabbage grown with NPK and poultry manure, data on volume and urine generation rate by some urinals in the Central Business District (CBD) in Accra in litres and project reports and existing studies on ecological sanitation systems relevant to this study were also obtained.

- The design of the urine collection system and the logistic needs of the entrepreneur were observed at the Valley View University to verify existing literature. Also a local consultant and engineer of Safi Sana Company Limited was contacted to provide estimates in Ghana Cedis (GH¢) of the construction of platform for the installation of male and female urinal, construction and installation of underground storage tanks near the urine generation point and construction and installation of storage tanks at the storage and treatment point.

- Equipment suppliers like Dizengoff Ghana Limited, Agrimat, Poly tank Ghana Limited and local enterprises were contacted to ascertain the market prices of the logistics needed in the establishment and operation and maintenance of the urine collection system in GH¢.

- Questionnaires were issued to six hundred and fifteen (615) vegetable farmers, marketers and consumers several farming sites and markets in Accra to obtain data on awareness, perception and willingness to use and pay for human urine as an alternative liquid fertilizer. Other data included fertiliser and pesticide

utilisation, land size and ownership, harvesting and marketing of cabbage and common farmer practices.

- Management of Big 2 Company Limited (a urinal operator), One Touch Waste Management (human excreta dislodging suction truck operator) and the Waste Management Department (WMD) of Accra Metropolitan Assembly (AMA) of Ashiedu Keteke Sub-metro were interviewed to obtain information on urinal and dislodging truck operation and maintenance including urinal user charges, labour, administrative and managerial charges and policies regarding the operation of urinal and excreta management in the Central Business District (CBD) of Accra.

2.4 Results and discussion

The key findings of the financial feasibility study are presented and discussed according to the three specific objectives:

1. Identify the logistic needs of the entrepreneur who will invest in urine-based fertiliser.

2. Determine the profitability of the urine-based fertiliser production system.

3. Estimate the savings made by farmers when they use urine as an alternative fertiliser.

2.4.1 The logistic needs of the entrepreneur who will invest in urine-based fertilizer

Inventory of logistics and valuation

There are two types of urine process technologies, the simple and the hi-tech (see Plate 2.1 and 2.2). This study assumed that an investor with profit maximization goal would need large volumes to ensure economies of scale and will opt for a modern and hi-tech operation. Hence the logistics identified refers to the hi-tech operation.

The results of the study shows that there are many inbound, operations and outbound logistics that need to be budgeted for each year. There are those related to construction (one time), those that will be changed mid-stream (after a decade), and those that will be changed at regular intervals, say 5 years) and those that will be changed yearly (Table 2.2 and Table 2.3). The least cost (May 2010 prices) item is the mob stick and the greatest variable cost item is vehicle maintenance fees. Apart from organizing logistics for construction, procuring the dislodging vehicle is the greatest challenge.

Considering the logistic needs of the urine collection and reuse system, it can be concluded that it is a capital intensive project that would need financial support in its operation and sustenance. Technical expertise is also required to ensure efficiency of operation.

Plate 2.1: Small scale urine collection system

Plate 2.2: **Large scale urine collection system**

Table 2.2: Fixed cost logistic items for the urine collection system

Item	Quantity	Unit cost (GH¢)	Rank of cost	Lifespan (Years)
Construction of platform for the installation of male and female urinal				***
Construction and installation of underground storage tanks at source				***
Construction and installation of storage tanks at destination				***
Urinal cubicles	12	1200	3	20
Waterless stand-alone urinals (for male)	6	35	7	10
Bidet (waterless urinal for female)	6	135	6	10
Sink				
Dustbin	12	7	8	10
Poly kiosk for attendants	2	920	4	20
Poly tank(Rambo 850)	5	1265	2	20
Dislodging vehicle (used 6000 litre suction truck)	1	45000	1	20
Change of the suction truck tires every 5years	6	550	5	5

Source: Survey results (May 2010) ***See tables in Offei, 2010) for details

Table 2.3: Variable cost logistic items for the urine collection system

Item	Quantity	Unit cost (GH¢))	Rank of cost	Lifespan (Years)
Mob stick	2	4	13	1
Mob bucket	2	5	12	1
Gloves	6	7.5	11	1
Detergent (allow GH¢ 20.00 per month for detergent)		20	10	**
Ground rent (30% of total revenue as charged by AMA)	***	***		***
Registration fee (Business Operating Permit)		140	9	1
Director(salaries increases by 5% of previous every 2 years)	1	1000	2	**
Supervisors (salaries increases by 5% of previous every 2 years)	1	800	3	**
Secretary (salaries increases by 5% of previous every 2 years)	1	700	5	**
Driver for dislodging truck (salaries increases by 5% of previous every 2 years)	1	300	6	**
Attendants (2) (salaries increases by 5% of previous every 2 years)	2	200	7	**
Labourer for dislodging vehicle (2) (salaries increases by 5% of previous every 2 years)	2	200	7	**
Fuel	***	720	4	1
Change of oil, filters and workmanship	***	1080	1	1

Source: Survey results (May 2010) **Monthly salaries

2.4.2 Justification for inventory of logistics

Urine generation point

At the urine generation level (the case of the large scale urine collection system), urinal cubicles are fitted on a platform which serves as an enclosed compartment that houses the urinal and give users privacy from the public. Inside these cubicles are waterless urinals made of ceramic for the collection of pure undiluted urine; usually standalone urinals for male and bidets for female (see pictures in Offei, 2010).

Plastic tubes are connected from the urinal level which re-routes the urine generated to an underground storage tank near the urine generation point.

Poly kiosks are also important to provide shade for the attendants who are responsible for the cleaning of the urinal and collection of urinal user charges and sale of urine to farmers. Other logistics at the urine generation point include dustbin, mob stick and basket and gloves.

Urine collection stage

The urine collection point consists of a suitably constructed underground structure with plastic holding tanks (see plate 2.2B which shows an underground holding tank at the Valley View University for urine collection). Due to the chemical composition of urine, the tanks are made airtight and kept at a minimum ventilation to retain plant available nutrients in the form of ammonia and also to minimise odour. These tanks are fitted with adapters to make suction possible. Also an overflow is connected to the tanks so that in cases of emergency, the urine will flow into the drain. The system is covered with precast slaps so that tanks are not visible to the public and also prevent rain water and the influx of unwanted materials. When the underground holding tanks are full, a suction truck is made available to empty their content and transported to a storage and treatment point close to a farm site or at one of the disposal sites of the Waste Management Department (WMD) of the Accra Metropolitan Assembly.

Transportation

The Central Business District of Accra in the Ashiedu Keteke sub-metro, where large volumes of urine is expected to be collected (as a result of the concentration of businesses) is generally far from most farming sites in Accra where the storage and treatment point is expected to be located. The use of suction truck by the septic tank operators would lead to faecal contamination of the urine and therefore the introduction of pathogens in the urine. This means that the operator of the urine collection and reuse system need to acquire its own suction truck solely for the transport of the urine.

Storage and treatment

The storage and treatment point of the urine collection and reuse system is very important; because at this point the urine could be kept for a minimum of one month and a maximum of six months (WHO, 2006) prior to usage on the farm.

The storage process allows the formation and accumulation of bottom sludge (see *equation 2.4*) which contains urease, the enzyme active for the decomposition of urea to ammonium, thereby increasing the pH of the urine from 6 to about 9. This allows any existing pathogenic-microorganism no matter its source and calibre to die-off making the urine thoroughly sanitized and suitable for application on the farm.

Usually, the storage and treatment tanks are arranged in such a way that while some tanks are being filled other tanks are being stored so that at a certain point in time while fresh urine is being filled some would be ready for use on the field.

2.4.3 Profitability of the urine-based fertiliser production system

The results of the study showed that the profitability level of the operations depended on whether the ownership was fully private or public. A public corporate may overlook some costs due to ownership of some rights in land and other services which may not be paid for. It also depended on the urinal user charge and urine sale charges agreed upon by the Metro Assembly and the farmers respectively.

Scenario A: Private ownership

This is under the assumption that the urine-based fertiliser production system (all operations, from the point of urine generation through to the point of urine storage and treatment) is under the confines of a private profit oriented entrepreneur**,** who invests into the establishment of the system and its sustenance and benefited from the urinal user charges and sale of urine to farmers.

It is important to note that currently the Accra Metropolitan Assembly (AMA) holds the sole responsibility to operate a urinal in the Metropolis. However, in-line with its privatization policy, private entrepreneurs are invited to operate the urinals on condition that 30% of the earnings (Total revenue) made by the entrepreneurs goes to AMA (AMA, 2006).

At the current situation of GH¢0.05 urinal charge the investment in urinal project will not be feasible for a private entrepreneur. It would cost GH¢ 78,502.58 to establish the urine collection system and an average annual operating cost of GH¢ 55,900.32. The average annual benefit is GH¢ 46,601.74. The NPV of GH¢ -89,372.15 is less than zero (NPV < 0); it implies that the present value of incremental benefit is less than the present value of all investment and operating costs. The BCR of 0.59 is less than one

(BCR: 0.59:1). This means that for each GH¢ 1.00 invested at a discount rate of 25% would yield a return of GH¢ 0.59. The IRR is the rate at which the discounted benefit equals discounted costs and suggests the entrepreneur can still breakeven. However, in this scenario, the IRR is invalid suggesting that there is no any real discount rate that would make the NPV greater or equal to zero. It can be concluded under this scenario, investment into the urine-based fertiliser production system is not feasible and there would be no payback when the lifespan is 20 years and the discount rate is 25%.

However, if the urinal user charge is increased by 100 percent and the sale price by 5 percent, then there will be profitability and after 6 years the investment will be paid back (Table 2.4) (see appendices 4.1 and 4.2 for details of the discounted cash flow of the financial analysis).

Table 2.4; Financial analysis of the investment into urine-based fertiliser production system under private ownership

Base situation (Urinal user fee = GH¢0.05)	
Investment cost (GH¢)	78,502.60
Total operating cost (GH¢)	1,062,106.04
Total benefit (GH¢)	885,433.00
NPV (25%) (GH¢)	(89372.15)
BCR (25%)	0.59:1
IRR	-
Sensitivity situation (Urinal user fee=GH¢0.10)	
Investment cost (GH¢)	78502.60
Total operating cost (GH¢)	1,062,106.04
Total benefit (GH¢)	1,770,866.00
NPV (20%) (GH¢)	8,147.79
BCR (20%)	1.03
IRR (%)	22.65
PBP (years)	5.44

Scenario B: Public Ownership

This is under the assumption that; the AMA is the operator of the urine-based fertiliser production system and pays neither ground rent nor any annual Business Operating Permit which accounts for 33.8% of total operating cost (that is: saves an average operating cost of GH¢ 14,120.32 annually), it however makes all other investment and operating costs that the private operator would have made and benefited from the urinal user charges and sale of urine to farmer. In this scenario B, it is shown that it would cost GH¢78,502.58 to establish the urine-based fertiliser production system with an average annual operating cost of GH¢ 41,780.00. The average annual benefit would be GH¢ 46.601.74.

At the current situation of GH¢0.05 urinal charge the investment in urinal project will not be feasible for a public sector entrepreneur. The NPV of GH¢ -50,699.01 is less than zero (NPV < 0), this means that the present value of incremental benefit is less than the present value of all investment and operating costs. The BCR of 0.71:1 is less than one (BCR: 0.71:1), this means that for each GH¢ 1.00 invested at a discount rate of 25% would yield a return of GH¢ 0.71 which is unable to recover the total investment and operating costs. Also IRR of 1.37% is far less than the discount rate of 25%. It can be concluded under this scenario that, investment into urine-based fertiliser production system would not be feasible and would not yield a payback within the 20 years of the project lifespan.

However, if the urinal user charge is increased by 100 percent and the sale price by 5 percent, then there will be profitability and after 3 years the investment will be paid back (Table 2.5) (see appendix 4.3 and 4.4 in Ofei, 2010 for details of the discounted cash flow of the financial analysis).

Table 2.5: Financial analysis of the investment into urine-based fertiliser production system of public ownership

Base situation (Urinal user fee=GH¢0.05)	
Investment cost (GH¢)	**78,502.60**
Total operating cost (GH¢)	793,820.04
Total benefit (GH¢)	885,433.00
NPV (25%) (GH¢)	(50699.01)
BCR (25%)	0.71:1
IRR (%)	1.37
Sensitivity situation (Urinal user fee=GH¢0.10)	
Investment cost (GH¢)	78,502.60
Total operating cost (GH¢)	793,820.04
Total benefit (GH¢)	1,770,866.00
NPV (25%) (GH¢)	68089.61
BCR (25%)	1.38:1
IRR (%)	51.45
PBP (years)	2.48

It can be concluded that investment into the urine-based fertiliser production system can be made feasible for operation by both a private entrepreneur and the Accra Metropolitan Assembly (public ownership). The right pricing system needs to be determined all the time. What is not determined yet is whether there is opportunity for increase in sale volumes which can also alter the benefit stream in favour of the entrepreneur. Whether new spaces will be made available for new farmers or additional fields acquired by old farmers cannot be determined.

2.4.4 Savings made by farmers when they use urine as an alternative fertiliser

Socio-demographic characteristics

The farmers whose views inform the results of the partial budgeting have somewhat variable socio-demographic characteristics. Majority (94%) are men, many (42%) have not received formal education (Table 2.6), majority (70%) are married, many (68%) are

of the Islamic faith (Figure 2.2) and majority (82%) work as full time farmers (Table 2.7). Many of the farmers are energetic; their ages are 50 years or below.

Table 2.6: Cross tabulation between educational level and gender of respondents

	Gender (n=300)		Total
Educational level of respondent	Female	Male	
None	2	56	58
Primary	3	37	40
JSS/Middle school	11	75	86
SSS	0	23	23
Post secondary	0	12	12
Tertiary	2	10	12
Non-formal	1	68	69
Total	19	281	300

Pearson Chi-Square Value (14.252), DF (6), Probability (0.027)

Source: Survey data (May, 2010)

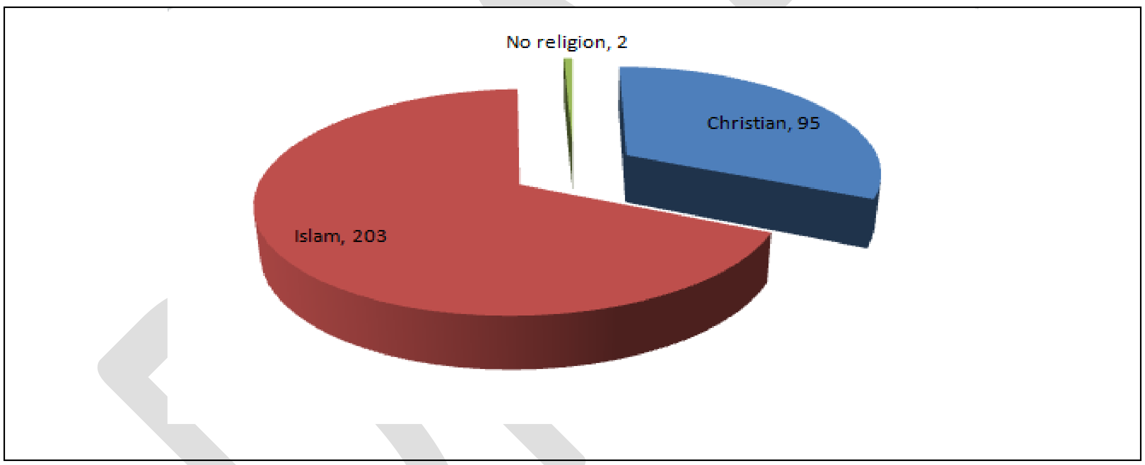


Figure 2.2: Distribution of respondents according to religion (Source: Survey data (May, 2010)

Table 2.7: Distribution of respondents according to full time occupation

Occupation	Frequency	Percent
Vegetable farming	246	82.00
Aluminium Fabricator	1	0.33
Carpentry	1	0.33
Cashier	1	0.33
Cleaner	4	1.33
Construction Works	1	0.33
Croupier	1	0.33
Electronic Technician	1	0.33
Embroidery Designer	1	0.33
Fabric Designer	1	0.33
Gardener	4	1.33
Graphic Designer	1	0.33
Health Care Assistant	1	0.33
Hotel Attendant	1	0.33
Labourer	1	0.33
Mason	1	0.33
Mechanic Technician	2	0.67
Pavement/block Layer	1	0.33
Pensioner	1	0.33
Plumber	1	0.33
Poultry Farming	1	0.33
Security	18	6.00
Student	2	0.67
Tailor	2	0.67
Trader	2	0.67
Truck pushers	3	1.00
Total	300	100

Source: Survey data (May, 2010)

From Tables 2.8 – 2.12), it is shown that, majority of the farmers are squatting on the lands cropped; many have been in business for more than 5 years and operating on up to 300 beds. Majority (72%) operate less than 0.01 hectares and apply both organic and inorganic fertilisers and pesticides. Some (35%) farmers were already aware of urine use, some had experimented; many who were sensitised at time of interviewing were willing to give portions of plots free for further experimentation. Many said they will be willing to pay for the use of the urine if the experiments were successful. All the farmers used irrigation; about 55% of farmers cultivate cabbage once a year.

Table 2.8: Respondents land ownership and acquisition

Farming Site	Do you own the land you are operating on?		Total
	No	Yes	
Dzorwulu	54	1	55
Roman ridge	25	0	25
Plant pool	22	0	22
Korle-bu	75	0	75
Osu-cantoment	30	0	30
La	35	6	41
Airport residential	52	0	52
Total	293	7	300

If no, how did you acquire it?	Frequency	Percent
Rented/leased	1	0.3
Acquired from a friend/relative for free	28	9.6
From AMA or government at a fee	4	1.4
Sharecropping	5	1.7
Squatting on a private land	36	12.3
Squatting on a public land	209	71.3
Family land/traditional council	10	3.4
Total	293	100

Source: Survey data (May, 2010)

Table 2.9: Distribution of respondents according to farming experience

Experience(years)	Frequency	Percent	Mean
1- 2	44	14.7	
3 – 5	34	11.3	
6 – 8	30	10.0	
9 – 11	32	10.7	
12 – 14	21	7.0	
15 – 17	31	10.3	5.6 years
18 – 20	36	12.0	
21 – 23	7	2.3	
24 – 26	12	4.0	
27 – 29	6	2.0	
30 – 32	17	5.7	
33 – 35	8	2.7	
36 & >	22	7.3	
Total	300	100.0	

Source: Survey data (May, 2010)

Table 2.10: Distribution of respondents according to farm size

Number of beds	Mean number of beds	Frequency	Percent	Farm size /ha
6-8	7	5	1.7	0.01
10-20	15	54	18.0	0.02
21-30	26	44	14.7	0.04
31-40	36	51	17.0	0.05
41-50	46	35	11.7	0.06
51-60	56	19	6.3	0.08
61-70	66	9	3.0	0.09
71-100	86	25	8.3	0.12
101-120	111	5	1.7	0.15
121-130	126	4	1.3	0.17
131-140	136	1	0.3	0.19
141-150	146	4	1.3	0.20
151-300	226	10	3.3	0.31
> 300* **	---	34	11.3	----
Total		300	100	

Source: Survey data (May, 2010) *** Farm size: > 1 acre (> 0.4048 ha)

Table 2.11: Fertiliser and pesticides usage by respondents

	Do you use fertilizer?			Do you use pesticides in production?	
Farm site	No	Yes	Total	Yes	Total
Dzorwulu	0	55	55	55	55
Roman ridge	0	25	25	25	25
Plant pool	0	22	22	22	22
Korle-bu	2	73	75	75	75
Osu-cantonment	0	30	30	30	30
La	3	38	41	41	41
Airport residential	1	51	52	52	52
Total	6	294	300	300	300

Source: Survey data (May, 2010)

Table 2.12: Awareness of human urine as an alternative fertiliser

	Are you aware human urine has fertilizing potential as chemical fertilizer?		Total number of respondents
Farm site	No	Yes	
Dzorwulu	36	19	55
Roman ridge	7	18	25
Plant pool	8	14	22
Korle-bu	61	14	75
Osu-cantonment	22	8	30
La	25	16	41
Airport residential	36	16	52
Total	195	105	300
Pearson Chi-Square (33.391), DF (6), Probability (0.000)			

Source: Survey data (May, 2010)

Table 2.13: Willingness to pay for the use of urine as an alternative fertiliser

	Frequency	Percent
No	1	0.40
Yes	260	99.6
Total	261	100.0

Source: Survey data (May, 2010)

2.4.5 Results of partial budgeting

The results of the partial budgeting analysis (effect of substituting Soil + Poultry Droppings + urine, S+PD+Ufor Soil +Poultry Droppings + NPK, S+PD+NPK) on a 200 metre square cabbage farm shows a net gain of approximately GH¢ 25.00 (see Table 2.1.4).

When cabbage was fertilized with S+PD+U fertiliser (82.9g PD + 158.5cm^3U), it increased the mean yield from 775.67g (of the no fertiliser application) to a mean yield of 1,080.07g (of S+PD+U application). There is an additional 304.4g when urine is applied together with other organic manures. The cost incurred is GH¢ 0.84. On the other hand, cabbage which was fertilized with S+PD+NPK fertiliser (82.9g PD + 10.9g NPK) gave a mean yield of 1,041.70g (that is 266.03g over the no fertilizer case); the cost incurred was GH¢ 1.46.

In one cropping season (usually 3 months), a cabbage farmer in Accra (of farm size 200 m^2 $^{-}$0.02 ha with a planting distance of 0.45m × 0.60m) would make a savings of GH¢24.60 for using S+PD+U as an alternative fertiliser in lieu of S+PD+NPK. The revenue accrued to the farmer who uses urine is GH¢135.60 when the mean price of

cabbage is GH¢ 0.60 per kilogramme. On the other hand, revenue accruing to the farmer who does not use urine is GH¢118.20.

Table 2.14: Partial budget to estimate the effect of substituting (S+PD+U) for (S+PD+NPK) as fertiliser on a 200m^2 cabbage farm

LOSSES		**GAINS**	
Income lost	GH¢	New income	GH¢
0.197 tonnes mean extra yield of cabbage at GH¢ 0.60/kg	118.20	0.226 tonnes mean extra yield of cabbage at GH¢ 0.60/kg	135.60
New costs Fertiliser (S+PD+U):		Costs saved Fertiliser (S+PD+NPK):	
(61.4kg PD + 117.4L U)	3.70	(61.4kg PD +8.1kg NPK)	10.89
Net gain	24.59		
	GH¢146.49		GH¢146.49

Source: Survey data (May, 2010).

2.4.6 Experiment on the use of S+PD+U and S+PD+NPK (*see details in chapter 4*)

The results of the demonstration project in Dzorwulu showed that with the exception of the first replication (R1), cabbage fertilized with poultry manure and urine (S+PD+U) gave higher yields in R2 and R3, than cabbage fertilized with poultry manure and chemical fertiliser (S+PD+NPK) (Figure 2.4). That is; in R1, yield of cabbage fertilized with S+PD+U gave a mean of 762.5g whilst yield of cabbage fertilized with S+PD+NPK gave a mean of 1089.0g. In R2, cabbage fertilized with S+PD+U gave a mean of 1260.7g whilst S+PD+NPK gave a mean of 1172.0g. Also in R3, mean yield of cabbage was 1217.0g and 864.1g for S+PD+U and S+PD+NPK, respectively.

However, when the statistical significance was tested between yields of cabbage fertilized with S+PD+U and S+PD+NPK, the t-calculated gave a value of (0.26), but t-critical at 5% significant level gives a value of (2.13). Since t-cal. (0.26) > t-crit. (2.13), we do not reject the null hypothesis and conclude that there was no statistically significant difference in the yield between cabbages fertilized with S+PD+NPK and S+PD+U. This would mean that *ceteris paribus*, vegetable farmers in Accra have an alternative fertilising material.

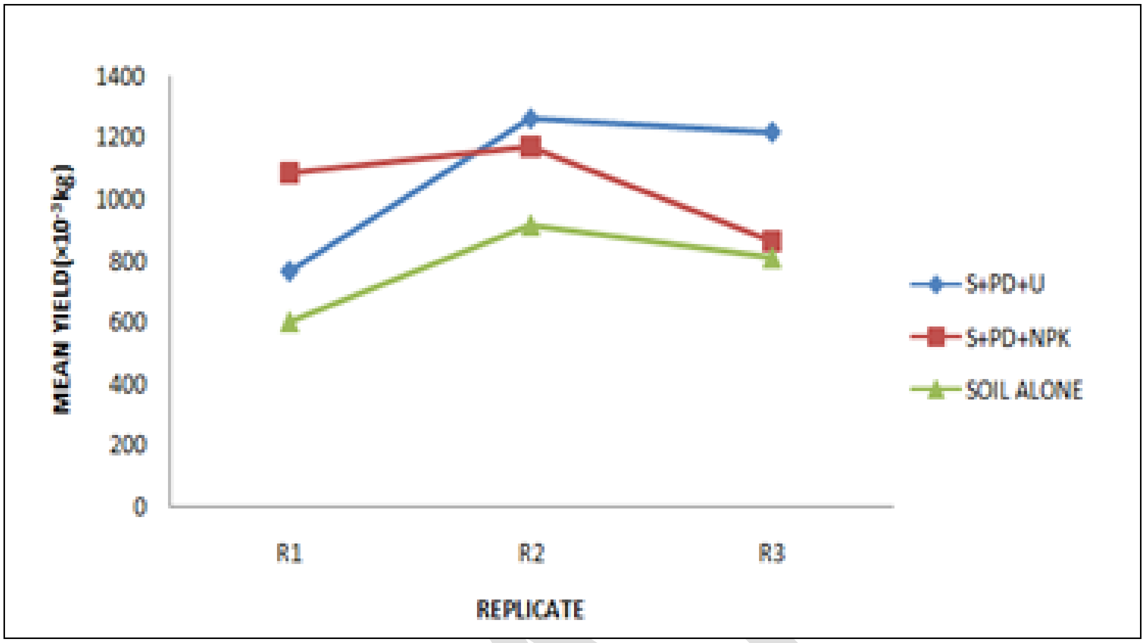


Figure 2.4: Yield response of cabbage to different fertiliser application
Source: Adamptey, May 2010 (drawn from Appendix 12)

The results of the urine-use perception analysis suggest that if farmers are well sensitised and shown the usefulness of urine as an alternative fertiliser, they will give it a try and adopt it in the long run. Again the result of the experiment on yield also shows that there was a mathematical difference between use of urine and chemical fertiliser; the farmer is slightly better-off with the urine. The partial budget is carried out to ascertain the extent of cost saving, if any.

However, when the statistical significance was tested between yields of cabbage fertilized with S+PD+U and S+PD+NPK, the t-calculated gave a value of (0.26), but t-critical at 5% significant level gives a value of (2.13). Since t-cal. (0.26) < t-crit. (2.13), we do not reject the null hypothesis and conclude that; there was no statistically significant difference in the yield between cabbages fertilized with S+PD+NPK and S+PD+U. This would mean that *ceteris paribus*, vegetable farmers in Accra have an alternative fertilising material.

2.5 Conclusion

The study revealed that the urine collection system is a capital intensive project considering the logistics that are involved. The system should have four (4) main features that would enable the collection of pure undiluted urine:

- a urine generation point which comprises of a urinal with urinal attendant who clean the facility and takes user charges,

- a urine collection point comprises of a well-constructed underground storage tanks connected to the urinal at the urine generation point with plastic tubes to allow urine to be collected and temporally stored,

- a medium of transporting the collected urine; this involves a suction truck which is devoted solely for the transport of urine from the urine collection point near the urinal to the storage and treatment point,

- storage and treatment point involves the installation of poly tanks for filling and storing urine to make the urine sanitised for application on the field.

The operation of the urine collection and reuse system require administrative and managerial competence and these can all be found in the Central Business District of the AMA.

Urine generation in the CBD can be a reliable source of low-cost fertiliser for urban vegetable farming in the city of Accra as the volumes of urine generated by the urinals far exceed that which would be required for urban vegetable farming. That is, 5.2 thousand m^3 of urine is generated yearly by these urinals as against 2 thousand m^3 which would be required for urban vegetable farming.

The cost-benefit analysis study (including sensitivity analysis) showed that both a profit-oriented entrepreneur and the Accra Metropolitan Assembly (AMA) who would wish to enter into such a business would not be successful if it is considered that the operation will last 20 years and the discount rate is 25% with a urine user fee of GH¢ 0.05 and sale of urine to farmers at GH¢0.30 per jerry-can (20 litres) as it gave negative NPVs (NPVs: GH¢ -89372.15 and GH¢ -50699.01), BCRs of less than one (BCRs: 0.59:1and 0.71:1) and IRRs of less than 25% (IRRs: - and 1.37%) respectively. However it is feasible for operation by both a private entrepreneur and the Accra Metropolitan Assembly (Public ownership), only if they charge a urine user fee of GH¢ 0.10 as it gave positive NPVs (NPVs: GH¢ GH¢ 8147.79 and GH¢ GH¢ 104901.34), BCRs of less than one (BCRs: 1.03 and 1.49) and IRRs of less than 25% (IRRs: 22.65% and 51.45%) and payback periods of 5.44 and 2.91 years respectively.

The partial budgeting study showed that, in one cropping cycle (normally 3 month), a cabbage farmer with an average farm size of 0.02ha (200 m^2) would make a savings of GH¢24.59 when they pay for and use sanitized urine as an alternative to the chemical fertiliser NPK. The farmer perception study revealed that many farmers (82%) perceive human urine to contain plant nutrients and that it should not be disposed off as municipal waste. About 89% of the farmers were willing to handle human urine as an alternative fertilizer. The socioeconomic characteristics of 'likely users of human urine' for vegetable production were similar to 'non-likely users'. The PCA revealed that 90% of the farmers were more willing to embrace the urine technology to help improve their

yield. Farmers' religion and norm in the society would not be an impediment to their use of the urine technology. However, the farmers expressed their willingness to discontinue the use of the human urine if u-vegetables were not patronized by consumers and marketers.

The marketers' perception study showed that some marketers (54%) do not want human urine to come close to any farm activity. They believe it has no nutrient value to be used for vegetable production. They also cited a perceived health risk factor on consumers and that many consumers would not patronize their produce. They said their religion would not be a stumbling block in their choice to buy u-vegetables however it would be influenced by the customary situation (as suggested by 60% of them) existing in the society (norms). Some marketers identified the reduction in cost (making vegetables cheaper on the market), the medicinal value inherent in human urine and the long lifespan of organic produce as the main reasons they would encourage farmers to use human urine as an alternative fertilizer on vegetables.

Some marketers (48%) indicated they will look for alternative places other than Accra to buy vegetables if the ones produced in Accra are fertilized with human urine although most of the marketers (76%) were not aware of the use of human urine for vegetable production in the city of Accra. Marketers (77%) were not willing to buy u-vegetables at a higher price than the conventional ones. There was no distinct difference between the socio-economic characteristics of marketers who will likely buy u-vegetables and those who will not. The study concludes that marketers do not view human urine as a resource and their decision to buy u-vegetables or not is not backed by religion but rather norms in the society and possible health risk associated with the use of human urine for vegetable production on consumers. This can lead to customers not satisfied with their produce leading to a negative effect on their sales.

CHAPTER THREE

3.0 Perception and willingness of market actors on the use of human urine as a source of fertilizer for vegetables production[4]

This chapter presents the results of the assessment of farmer's perception on the use of human urine for vegetable production, examines the factors that will influence marketer's willingness to buy urine fertilized-vegetables (u-vegetables) from farmers, and assesses marketers and consumers perception on the use of human urine for vegetable production. It also examines the factors that will influence consumer's willingness to buy u-vegetables from marketers.

3.1 Methodology

3.1.1 Assessing perception

The assessment studies were in three parts: farmer's perception on the use of human urine for vegetable production, marketers' perception on the use of human urine for vegetable production and consumers' perception on the use of human urine for vegetable production.

A pool of six questions was used to quantify consumer's perception about the use of human urine for vegetable production. In terms of item scores, "Strongly Agree" received 5 points, "Agree" received 4 points, "Neither Agree nor Disagree/Don't know" received 3 points, "Disagree" received 2 points and "Strongly Disagree" received 1 point. To construct the perception variable, the 6 item scores for each respondent were first summed to obtain a total score. The total perception scores were then expressed as an index of relative urine perception index ranging from 0 to 100. An index value of 100 corresponds to the highest possible total score of 30 points.

3.1.2. Assessing factors that influence willingness to use urine and u-vegetables

It was assumed that willingness to use a product will be affected by an individual's perception about the product (urine/u-vegetable), level of school attainment, age, gender, location of farmer, religious influence, norm, knowledge of production, access to alternative source of the product, mode of soil conservation, farmers' soil condition and urine availability. The dependent variable is whether an individual will use the product or not. If the farmer/marketer/consumer will use it takes the value of 1 and 0 otherwise. The expectations of the effect of selected variables on willingness to use are shown in

[4] This chapter is a extract from the MSc thesis of Patrick Koomson (University of Ghana-Legon, Ghana)

Tables 3.1, 3.2 and 3.3 for farmers, marketer and consumers respectively. The justifications of expectations are discussed in Koomson, 2010 pp 36-48).

Table 3.1: Explanatory variables used in the probit model for farmers' willingness to use urine as an alternative fertilizer

Variables	Description of variables	Expected sign
Perception	Perception of urine quality (positive =1, negative = 0)	+
Education	Level of school attainment (above primary education =1, otherwise =0)	+
Age	Age of the farmer in years	+/-
Gender	Gender of farmer (male = 1, female = 0)	+
Location	Location of farmer (Dzorwulo =1, otherwise = 0)	+
Religious influence	Religion against use of urine for vegetable production (yes = 1, no = 0)	-
Norm	Customary situation against urine use (yes = 1, no = 0)	-
Mode of soil conservation	Mode of soil conservation (organic = 1, otherwise = 0)	+
Soil condition	Soil condition (good = 1, otherwise = 0)	-
Urine availability	Urine availability (yes =1, no = 0)	+

Table 3.2: Explanatory variables used in the probit model for marketers' willingness to use urine as an alternative fertilizer

Variables	Description of variables	Expected sign
Gender	Gender of marketer (male = 1, female = 0)	+
Age	Age of the marketer in years	-
Education	Level of school attainment (above basic education =1, otherwise =0)	+
Marital status	Marital status (married = 1, single = 0)	-
Religious influence	Religion against purchase of u-vegetables (yes = 1, no = 0)	-
Norm	Customary situation against u-vegetables (yes = 1, no = 0)	-
Knowledge of production	Knowledge of vegetable production (yes = 1, no = 0)	+
Perception index	Perception about human urine for vegetable production index (100 is highest, 0 least)	+

Table 3.3: Explanatory variables used in the probit model for consumers' willingness to buy u-vegetables

Variables	Description of variables	Expected sign
Gender	Gender of consumer (male = 1, female = 0)	+
Age	Age of the consumers in years	-
Education	Number of years spent in formal education	-/+
Marital status	Marital status (Married = 1, Single = 0)	-
Income	Monthly income (in natural logarithm)	-
Religious influence	Religion against u-vegetables (Yes = 1, No = 0)	-
Norm	Customary situation against u-vegetables (Yes = 1, No = 0)	-
Access to alternative source	Access to other source of vegetables than u-vegetables (Yes = 1, No = 0)	-
Urine perception index	Perception about human urine for vegetable production index (100 is highest, 0 least)	+

3.1.3 Sampling procedure

The loss of land to estate developers and widening of drains has led farming to be concentrated in some few areas in AMA, hence the purposive clustered sampling technique was employed in selecting the farm sites. With the exception of farmers in Dzorwulu (IWMI demonstration site), the other six farming sites were chosen for the fact that the urine technology for vegetable production is relatively unknown among these farmers allowing comparison on perception and attitudes of farmers to be made between them and farmers in Dzorwulu farm sites. In the case of the marketers, the market selected were major marketing centres in AMA. Also majority of the farmers sell their produce to market women from these market centres. Households in East Legon/Legon, Osu, La/Cantoments, and Dansoman were selected for their diversity in terms of cultural, social and economic characteristics which income, education, occupation and food shopping groupings. Nima/Maamobi was selected for the fact that Muslims are predominant in the area in order to compare the perceptions and attitudes of Muslims towards urine technology for vegetable production with non-Muslims.

Random sampling is where sample selection of the population is entirely done at random. The random sampling technique was employed because of unavailability of suitable sampling frame for market actors and hence farmers, marketers and consumers were identified at random when they are available on the field, market and households respectively and were willing to participate in the research. In November 2009, a total of 315 respondents were selected and this included farmers, marketers and consumers. Table 3.5 presents the number of respondents selected from the various sub-metropolitan areas. In May 2010, the farmer survey was repeated to validate the earlier study and track new issues in partial budgeting (Table 3.6). Some of the farmers in the old survey were interviewed in the second survey. Since the sample is large enough, no grave consequences were expected in the analysis.

3.1.4 Data collection

Data collection commenced by sensitising the farmers after which face-to-face interviews were conducted with the aid of questionnaires. A description of the product was given to the respondents (see Appendix 3.1 section B of willingness to pay farmer questionnaire in Koomson, 2010) at the selected urban agricultural sites (Fig. 3.1).

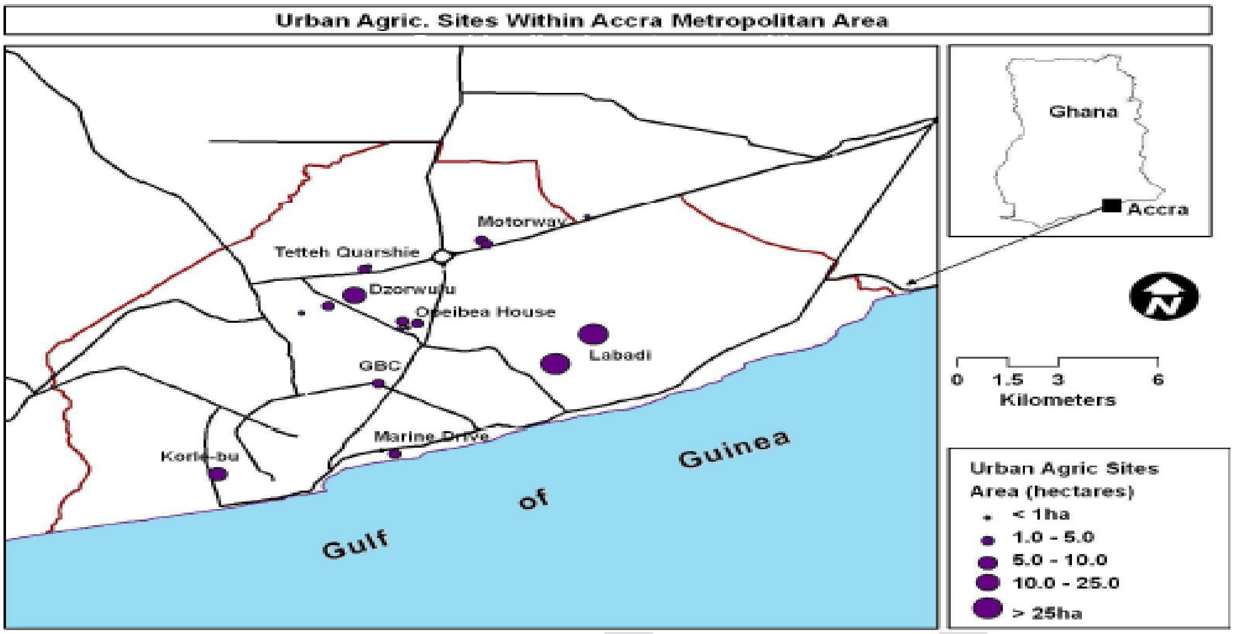


Figure 3.1: Urban agricultural sites within Accra Metropolitan Area

Table 3.4: Sample of market actors from selected AMA sub-metropolitan areas

Areas	**Sub-metropolitan area**	**Number**
Farmers		
Cantonments/La	La	18
Dworwulo/Plant pool	Ayawaso West-Wuogon	32
Airpot	Ayawaso West-Wuogon	13
Korle Bu	Ablekuma South	13
Marine Drive	Osu-klottey	14
Total		**90**
Marketers		
Agbobloshie	Ashiedu-Keteke	13
Malata	Ayawaso Central	16
Makola	Osu-Klottey	12
Kaneshie	Okaikoi Soutth	31
Dansoman	Ablekuma South	11
Total		**83**
Consumers		
Nima/Maamobi	Ayawaso East	15
East Legon/Legon	Ayawaso West-Wuogon	38
Osu	Osu-Klottey	17
La/Cantoments	La	29
Dansoman	Ablekuma South	43
Total		**142**
Grand Total		**315**

Source: Koomson's survey data (November, 2010)

Table 3.5: Distribution of farmer respondents according to farming sites in Accra

Farm site	Frequency	Percentages
Dworwulu	55	18.3
Roman ridge	25	8.3
Plant pool	22	7.3
Korle-bu	75	25.0
Osu-cantoment	30	10.0
La	41	13.7
Airport residential	52	17.3
Total	300	100.0

Source: Offei's survey data (May 2010)

3.2 Results and discussion

The key findings of the study are presented and discussed according to the six specific objectives:

- Assess farmers' perception on the use of human urine for vegetable production
- Assess marketers' perception on the use of human urine for vegetable production
- Assess consumers' perception on the use of human urine for vegetable production
- Examine the factors that will influence farmer's willingness to use sanitized human urine for vegetable production.
- Examine the factors that will influence marketer's willingness to buy u-vegetables from farmers.
- Examine the factors that will influence consumer's willingness to buy u-vegetables from marketers.

3.2.1 Socio-Demographic Characteristics of Respondents

The respondents whose views informed the results of the perception and probit analyses have somewhat variable socio-demographic characteristics.

Farmers

Majority (94%) are men and youthful, many (76%) have received formal education (Table 3.6), majority (60%) are married, many (54%) are of the Islamic faith and many (64%) have family sizes of five or less (Table 3.7).

Marketers

Majority (94%) are women and youthful, many (83%) have received formal education (Table 3.6), majority (70%) are married, many (85%) are of the Christian faith and many (54%) have family sizes of five or less (Table 3.7). Many marketers are concerned about the quality characteristics of the vegetables they purchase. (Table 3.8).

Consumers

The consumers interviewed are men and women of youthful ages, majority of them single and living with family, of mixed ethnicity and faith; many are literate (Table 3.9). They are of diverse income groups (Table 3.10). Many consumers are concerned about the quality characteristics of the vegetables they purchase (Table 3.11).

Table 3.6: Socio-demographic characteristics of respondents

Characteristics	Location of farm (n=90)					Total
	Dzorwulo	Airport	La	Korle-Bu	Marine Drive	
Gender						
Female	12.5	0.0	22.2	0.0	7.1	10.0
Male	87.5	100.0	77.8	100.0	92.9	90.0
Marital status						
Married	46.9	61.5	72.2	61.5	71.4	60.0
Single	53.1	38.5	27.8	38.5	28.6	40.0
Age						
Less than 20	6.3	0.0	0.0	0.0	7.1	3.3
20-29	28.1	46.2	11.1	0.0	14.3	21.1
30-39	18.8	15.4	5.6	46.2	14.3	18.9
More than 40	46.9	38.5	83.3	53.8	64.3	56.7
Household size						
1 person	21.9	38.5	16.7	0.0	42.9	23.3
2-5 persons	37.5	23.1	50.0	61.5	35.7	41.1
6-10 persons	31.3	38.5	33.3	30.8	21.4	31.1
Above 10 persons	9.4	0.0	0.0	7.7	0.0	4.4
Ethnicity						
Busanga	53.1	84.6	0.0	76.9	0.0	42.2
Ga/Adangme	9.4	0.0	77.8	0.0	71.4	30.0
Akan	6.3	7.7	11.1	0.0	14.3	7.8
Ewe	12.5	0.0	0.0	7.7	0.0	5.6
Mossi	6.3	7.7	0.0	0.0	0.0	3.3
Others	12.5	0.0	11.1	15.4	14.3	11.1
Religion						
Christian	34.4	0.0	100.0	7.7	64.3	43.3
Muslims	65.6	100.0	0.0	92.3	21.4	54.4
No religion	0.0	0.0	0.0	0.0	14.3	2.2
Education						
Illiterate	28.1	38.5	11.1	46.2	0.0	24.4
Basic	50.0	53.8	55.6	38.5	50.0	50.0
Secondary	18.8	7.7	22.2	15.4	21.4	17.8
Tertiary	3.1	0.0	11.1	0.0	28.6	7.8

Source: Survey data, November, 2009.

Table 3.7: Socio-economic background of marketers

Characteristics	Location of market (n=83)					Total
	Agbogbloshie	Malata	Makola	Kaneshie	Dansoman	
Gender						
Female	92.3	100.0	83.3	96.8	90.9	94.0
Male	7.7	0.0	16.7	3.2	9.1	6.0
Marital status						
Married	53.8	81.3	83.3	58.1	90.9	69.9
Single	46.2	18.8	16.7	41.9	9.1	30.1
Age						
Less than 20	0.0	0.0	0.0	3.2	0.0	1.2
20-29	23.1	25.0	8.3	25.8	18.2	21.7
30-39	23.1	25.0	41.7	38.7	36.4	33.7
More than 40	53.8	50.0	50.0	32.3	45.5	43.4
Household size						
1 person	23.1	6.3	8.3	9.7	0.0	9.6
2-5 persons	30.8	31.3	75.0	45.2	45.5	44.6
6-10 persons	46.2	56.3	16.7	41.9	36.4	41.0
Above 10 persons	0.0	6.3	0.0	3.2	18.2	4.8
Ethnicity						
Akan	100.0	31.3	41.7	51.6	45.5	53.0
Ewe	0.0	31.3	33.3	6.5	18.2	15.7
Ga/Adangme	0.0	18.8	25.0	25.8	27.3	20.5
Mossi/Grusi/Busanga	0.0	0.0	0.0	6.5	9.1	3.6
Dagarti	0.0	0.0	0.0	3.2	0.0	1.2
Dagomba	0.0	18.8	0.0	3.2	0.0	4.8
Other	0.0	0.0	0.0	3.2	0.0	1.2
Religion						
Christian	92.3	81.3	83.3	87.1	81.8	85.5
Moslems	7.7	18.8	16.7	12.9	9.1	13.3
Traditional	0.0	0.0	0.0	0.0	9.1	1.2
Education						
Illiterate	15.4	18.8	16.7	9.7	36.4	16.9
Basic	69.2	75.0	75.0	77.4	54.5	72.3
Secondary	15.4	6.3	8.3	12.9	9.1	10.8

Source: Survey data, November, 2009.

Table 3.8: Marketers' criteria for assessing vegetable quality

S/N	Quality statements	Agree		Undecided		Disagree		Mean
		N	%	N	%	N	%	
A13	I look out for the size of the vegetables that I purchase	81	97.6	1	1.2	1	1.2	1.04
A14	I look out for the freshness of the vegetables that I purchase	83	100.0	0	0.0	0	0.0	1.00
A15	I look out for the colour of the vegetables that I purchase	83	100.0	0	0.0	0	0.0	1.00
A16	I look out for the firmness of the vegetables that I purchase	82	98.8	0	0.0	1	1.2	1.02
A17	I look out for absence of spots on the vegetables that I purchase	82	98.8	0	0.0	1	1.2	1.02
A18	I look out for dirt on the vegetables that I purchase	27	32.5	7	8.4	49	59.0	2.27

Source: Survey data, November, 2009.

Table 3.9: Socio-demographic background of consumers

Characteristics	Location of consumer (n=142)					Total
	Nima / Maamobi	East Legon / Legon	Osu	La/ Cantoments	Dansoman	
Gender						
Female	46.7	42.1	64.7	65.5	30.2	46.5
Male	53.3	57.9	35.3	34.5	69.8	53.5
Marital status						
Married	40.0	21.1	29.4	51.7	25.6	31.7
Single	60.0	78.9	70.6	48.3	74.4	68.3
Age						
Less than 20	6.7	2.6	11.8	13.8	9.3	8.5
20-29	26.7	60.5	23.5	48.3	60.5	50.0
30-39	33.3	18.4	29.4	24.1	14.0	21.1
More than 40	33.3	18.4	35.3	13.8	16.3	20.4
Household size						
1 person	20.0	65.8	47.1	41.4	34.9	44.4
2-5 persons	40.0	28.9	35.3	44.8	30.2	34.5
6-10 persons	33.3	2.6	17.6	10.3	30.2	17.6
Above 10 persons	6.7	2.6	0.0	3.4	4.7	3.5
Ethinicity						
Akan	33.3	76.3	35.3	48.3	55.8	54.9
Ewe	6.7	5.3	5.9	17.2	16.3	11.3
Ga/Adangme	13.3	10.5	52.9	20.7	25.6	22.5
Mossi/Grusi/Busanga	20.0	0.0	0.0	6.9	0.0	3.5
Guan	6.7	5.3	0.0	6.9	2.3	4.2
Sissala/Wala	6.7	0.0	5.9	0.0	0.0	1.4
Other	13.3	2.6	0.0	0.0	0.0	2.1
Religion						
Christian	53.3	94.7	88.2	86.2	88.4	85.9
Moslems	46.7	2.6	5.9	13.8	2.3	9.9
Traditional	0.0	2.6	0.0	0.0	7.0	2.8
No religion	0.0	0.0	5.9	0.0	2.3	1.4
Illiterate	13.3	5.3	5.9	0.0	7.0	5.6
Basic	53.3	10.5	52.9	44.8	18.6	29.6
Secondary	20.0	31.6	29.4	37.9	44.2	35.2
Tertiary	13.3	52.6	11.8	17.2	30.2	29.6
Illiterate	13.3	5.3	5.9	0.0	7.0	5.6

Table 3.10: Income distribution of respondents

Income	Location of consumer (%) (n=142)					Total
	Nima / Maamobi	East Legon / Legon	Osu	La/ Cantonments	Dansoman	
Less than GH¢100	60.0	63.2	88.2	72.4	60.5	66.9
GH¢100-GH¢500	40.0	23.7	11.8	27.6	34.9	28.2
More than GH¢500	0.0	13.2	0.0	0.0	4.7	4.9

Table 2.11: Consumers' criteria for assessing vegetable quality

S/N	Quality statements	Agree		Undecided		Disagree		Mean
		N	%	N	%	N	%	
A11	I look out for the size of the vegetable that I purchase	132	93.0	0	0.0	10	7.0	1.14
A12	I look out for the freshness of the vegetable that I purchase	141	99.3	0	0.0	1	0.7	1.01
A13	I look out for the colour of the vegetable that I purchase	123	86.6	0	0.0	19	13.4	1.27
A14	I look out for the firmness of the vegetable that I purchase	131	92.3	0	0.0	11	7.7	1.15
A15	I look out for absence of spots on the vegetable that I purchase	128	90.1	0	0.0	14	9.9	1.20
A16	I look out for dirt on the vegetable that I purchase	111	78.2	5	3.5	26	18.3	1.40
A17	I look out for holes on the vegetable that I purchase	140	98.6	0	0.0	2	1.4	1.03

Source: Survey data, November, 2009.

3.2.2 Farmers' perception of the use of human urine for vegetable production

The perception of farmers on the use of human urine for vegetable production is presented in Table 3.12. Most of the farmers (82%) disagreed with the disposal of human urine as municipal waste. They strongly believe that there are plant nutrients in human urine that can be used for vegetable production. Only 11 farmers (12 %) said human urine is of no use and should be disposed off as municipal waste. Of the 11

farmers who said human urine should be disposed off as municipal waste 73% were Muslims while the remaining 27% were Christians.

Additionally, the Principal Component Analysis (PCA) was applied to identify the main dimensions of farmers on the use of human urine for vegetable production. Results on farmers' perception statements after the PCA have been applied are presented in Table 5.8. The PCA applied to the farmers' perception statements gave two factors which accounted for about 74% of the total variance. All the seven variables were used because their communalities were high (more than 0.5) (see also appendix D1 of Koomson, 2010).

The first factor labeled 'resource' explains 45% of the total variance and is associated with non-disposal of urine as a municipal waste, farmers' willingness to handle urine as an alternative fertilizer, use of urine for vegetable production, positive influence of urine on vegetables and willingness to cope with the smell of human urine. The second factor accounts for 29% of total variance and is associated with the influence of religion and norm on farmers' willingness to use human urine for vegetable production.

Table 3.12: Perception of farmers on the use of human urine for vegetable production

S/N	Perception Statements	Agree		Undecided		Disagree		Mean
		N	%	N	%	N	%	
P1	Urine should be disposed off as a municipal waste	11	12.2	5	5.6	74	82.2	2.70
P2	Will you be willing to handle urine as an alternative fertilizer	80	88.9	4	4.4	6	6.7	1.18
P3	Religion will have an influence on your choice to use human urine as an alternative fertilizer	12	13.3	5	5.6	73	81.1	2.68
P4	Norm will have an influence on your choice to use human urine as an alternative fertilizer	10	11.1	5	5.6	75	83.3	2.72
P5	Urine is a waste and should not be used for vegetable production	13	14.4	4	4.4	73	81.1	2.67
P6	I think urine has a positive influence on vegetable production	72	80.0	13	14.4	5	5.6	1.26
P7	I will be willing to cope with the smell of urine	79	87.8	1	1.1	10	11.1	1.23

Source: Survey data, November, 2009. Sample size = 90

Table 3.13: Correlation among farmers' perception statements and factors from PCA

S/N	Perception statements	Farmers *Factor 1* Resource	Farmers *Factor 2* Religion and Norm
P1	Urine should be disposed off as a municipal waste	**-0.669**	0.327
P2	Will you be willing to handle urine as an alternative fertilizer	**0.850**	-0.218
P3	Religion will have an influence on choice to use human urine for vegetable production	-0.282	**0.923**
P4	Culture will have an influence on choice to use human urine for vegetable production	-0.183	**0.941**
P5	Urine is a waste and should not be used for vegetable production	**-0.754**	0.279
P6	I think urine has a positive influence on vegetable production	**0.807**	-0.043
P7	I will be willing to cope with the smell of urine	**0.818**	-0.256
	% of Total variance	45.30%	29.11%

Bold values indicate the highest correlations between sentences and factors

Further analysis of qualitative data showed that there are a lot of concerns in relation to the use of human urine for vegetable production. These included:

- The nutrient effect of human urine on their vegetables
- The efficiency of storage of human urine in soil
- The availability of the sanitized human urine for all the farmers in urban Accra should in case they all adopt urine fertilization for their vegetables
- The possibility of rodents attacking their vegetable farm since urine has been used as bait to attract rodents
- The fertilization rate and application techniques for different vegetables when using the sanitized human urine
- Suspect fertilization rate and application techniques will be labour intensive than the conventional mineral fertilizer and poultry manure
- The effectiveness of the urine fertilization on vegetables under different climatic conditions
- How easier will it be to handle relative to the conventional mineral fertilizer and poultry manure during fertilization

These technical concerns raised by the farmers suggest the need for demonstration farms (see chapter 4).

This is how one farmer puts it:

“if the sanitised human urine proves to be better than the conventional method, I will buy and use it no matter the price after all the mineral fertilizers and poultry manure are also sold (Male, age 25, La)”.

There were suggestions that any entrepreneur who wants to go into the business of supplying sanitized human urine to farmers should consider ways of improving his/her sanitized urine to be better (for example conversion into struvite (powder) for easy handling and other plant nutrients) than the one generated in the household by the farmers to induce them to buy his/her own.

3.2.3 Marketers perception on the use of human urine for vegetable production

Table 3.14 presents a summary of perception of marketers on the use of human urine for vegetable production. Opinions of respondents were sought (agree or disagree with certain statements). Of the 83 responses, 54 (65.1%) indicated that human urine should be disposed off as a municipal waste. Another 29% of the marketers said human urine should not be disposed off as municipal waste and the rest of the respondents were not sure. Respondents were also asked to express their opinion concerning the use of human urine as a resource. About 57% indicated that human urine can be used as a resource. Only 20% of the respondents suggested that religious influence will have an effect on their choice to buy u-vegetables for marketing. Majority of the respondents (72%) said religious influence will not have an influence on their choice to buy u-vegetables for marketing. About 60% of the respondents suggested that the norms (customary situation or circumstances) in their society will not have any influence on their choice to market u-vegetables.

Table 3.14: Perception of marketers on the use of human urine for vegetable production

S/N	Perception statements	Agree		Undecided		Disagree		Mean
		N	%	N	%	N	%	
A1	Urine should be disposed off as a municipal waste	54	65.1	5	6.0	24	28.9	1.64
A2	Urine can be used as a resource	47	56.6	1	1.2	35	42.2	1.86
A3	Religion will have an influence on choice to buy U-vegetables	17	20.5	6	7.2	60	72.3	2.52
A4	Norms will have an influence on choice to buy U-vegetables	27	32.5	6	7.2	50	60.2	2.28
A5	Urine is a waste and should not be used for vegetable production	45	54.2	0	0.0	38	45.8	1.92
A6	I will be willing to sell my urine	16	19.3	2	2.4	65	78.3	2.59
A7	I will buy vegetable if I know that it is cultivated with urine	47	56.6	0	0.0	36	43.4	1.87
A8	I will not buy U-vegetables from Accra if I know that it is cultivated with urine	40	48.2	0	0.0	43	51.8	2.04
A9	I will like toilet system which separates urine from human excreta	35	42.2	5	6.0	43	51.8	2.10
A10	I will wash U-vegetables very well before retailing if it is cultivated with human urine	30	36.1	8	9.6	45	54.2	2.18
A11	I am aware of the use of urine for vegetable production	20	24.1	0	0.0	63	75.9	2.52
A12	I will pay higher price for u-vegetables	12	14.5	7	8.4	64	77.1	2.63

Source: Survey data, November, 2009. Sample size = 83

About 54% of the respondents said urine is a waste and should not be used for vegetable production whiles the remaining 46% said human urine is not a waste and can be used for vegetable production. Respondents that disagree with the use of human urine for vegetable production gave the following reasons:

- They believe there is a health risk factor associated with the use of human urine for vegetable production.
- Customers (consumers) will no longer patronize their vegetables.
- They believe that human urine is a waste and there is nothing good it can be used for.

The marketers that said human urine can be used for vegetable production gave the following reasons:

- Chemical fertilizer vegetables' lifespan is very short and therefore they want something organic.
- Urine is from the human body and therefore they do not see what is wrong if it is used as a resource.

- They are aware of the medicinal value inherent in human urine.

- They believe that the use of human urine will cut down on cost of production making vegetables cheaper on the market.

Marketers' perception communalities after conducting PCA (Appendix D2, Koomson 2010) revealed that only 11 variables could be used for the PCA since the twelfth variable communality was less than 0.5. The results are shown in Table 3.15. Information obtained was reduced into three principal components accounting for 70% of the total variance. The first factor, "Resource" explains 38% of the total variance and refers to non-disposal of urine as a municipal waste, urine as a resource, use of urine for vegetable production, willingness to sell urine, willingness to buy u-vegetables with information about source, access to alternative source of vegetables if farmers in Accra produce u-vegetables and likeness for UDDTs.

The second factor accounts for 16% of total variance and is associated with the influence of religion and norm on marketer's willingness to buy u-vegetables. The third factor was called 'awareness'. It contributes 15% of the total variance and was associated with washing u-vegetables very well before retailing and awareness of u-vegetables on the market.

Table 3.15: Correlation among marketers' perception statements and factors from PCA

S/N	Perception statements	Marketers		
		Factor 1 Resource	*Factor 2* Religion and Norm	*Factor 3* Awareness
A1	Urine should be disposed off as a municipal waste	**-0.800**	-0.011	-0.142
A2	Urine can be used as a resource	**0.815**	-0.115	0.027
A3	Religion will have an influence on choice to buy U-vegetables	-0.155	**0.909**	-0.029
A4	Norms will have an influence on choice to buy U-vegetables	-0.027	**0.893**	-0.124
A5	Urine is a waste and should not be used for vegetable production	**-0.855**	-0.084	0.166
A6	I will be willing to sell my urine	**0.696**	-0.170	-0.247
A7	I will buy vegetable if I know that it is cultivated with urine	**0.798**	-0.109	-0.327
A8	I will not buy U-vegetables from farmers if I know that it is cultivated with urine	**-0.761**	0.213	0.299
A9	I will like toilet system which separates urine from human excreta	**0.585**	0.117	0.567
A10	I will wash U-vegetables very well before retailing if it is cultivated with human urine	-0.348	-0.011	**0.724**
A11	I am aware of the use of urine for vegetable production	0.084	0.196	**-0.691**
	% of Total variance	38.45%	16.20%	14.95%

Bold values indicate the highest correlations between sentences and factors

3.2.4 Consumer's perception of the use of human urine for vegetable production

Perception statements about the use of human urine for vegetable production were presented to the consumers and the results tabulated in Table 3.16. About 56% of the consumers disagree that urine should be disposed off as a municipal waste. They strongly believed that there is something (which they could not tell) in urine which can be put into good use rather than letting it go waste. Another 42% said they do not see anything good in urine and that it should be disposed off as a municipal waste. When asked if urine can be used as resource about 72% (102 consumers) of the consumers said they agree. About 25% said they do not agree with such a statement that urine can be used as a resource.

About 78 (54.9%) of the consumers were willing to provide their urine for a fee. They were willing to sell it for a maximum and average price of GH¢500 and GH¢44 per 200 litres of human urine respectively. Only one person was willing to give her urine for free.

Table 3.16: Perception of consumers on the use of human urine for vegetable production

S/N	Perception statements	Agree		Undecided		Disagree		Mean
		N	%	N	%	N	%	
A1	Urine should be disposed off as a municipal waste	59	41.5	3	2.1	80	56.3	2.15
A2	Urine can be used as a resource	102	71.8	4	2.8	36	25.4	1.54
A3	Religion will have an influence on choice to consume U-vegetables	24	16.9	5	3.5	113	79.6	2.63
A4	Culture will have an influence on choice to consume U-vegetables	31	21.8	6	4.2	105	73.9	2.52
A5	Urine is a waste and should not be used for vegetable production	61	43.0	3	2.1	78	54.9	2.12
A6	I will be willing to sell my urine	78	54.9	2	1.4	62	43.7	1.89
A7	I will buy vegetable if I know that it is cultivated with urine	77	54.2	4	2.8	61	43.0	1.89
A8	I will not consume vegetables from Accra if I know it is u-vegetables	71	50.0	1	0.7	70	49.3	1.99
A9	I will like toilet system which separates urine from human excreta	81	57.0	12	8.5	49	34.5	1.77
A10	I will wash U-vegetables very well before consumption	125	88.0	6	4.2	11	7.7	1.20
A18	Think more research should be done about health impact of U-vegetables	134	94.4	2	1.4	6	4.2	1.10

Source: Survey data, November, 2009. Sample size = 142

Those who did not want to sell their urine formed about 44% of the respondents. These people were wary of the use of their urine for ritual purposes “sakawa” and entirely against the use of human urine for vegetable production. Consumers were asked if they will buy u-vegetables, 77 (54.2%) said they will buy them. These consumers explained that they cannot guarantee the safety of the current vegetables found in the market. Some even concluded that the vegetables they consume are consuming now are “u-vegetables” because the farmers use waste water for irrigation which contains human urine. Some too said u-vegetables should even be priced higher because they believe it is better than chemically produce vegetables in terms of health and lifespan. About 43% of the consumers also said they will not buy u-vegetables because they belief that it is not healthy to consume u-vegetables.

Table 3.17 describes the correlation among consumer perception statements and components from the PCA.

Table 3.17: Correlation among consumers' perception statements and factors from PCA

S/N	Perception statements	Consumers		
		Factor 1 Resource	*Factor 2* Religion and Norm	*Factor 3* Access
A1	Urine should be disposed off as a municipal waste	**-0.713**	0.244	0.198
A2	Urine can be used as a resource	**0.687**	-0.406	-0.249
A3	Religion will have an influence on choice to consume U-vegetables	-0.108	**0.928**	0.033
A4	Culture will have an influence on choice to consume U-vegetables	-0.132	**0.922**	-0.009
A5	Urine is a waste and should not be used for vegetable production	**-0.830**	-0.011	0.050
A6	I will be willing to sell my urine	**0.722**	-0.053	0.379
A7	I will buy vegetable if I know that it is cultivated with urine	**0.783**	0.038	-0.269
A8	I will not consume vegetables from Accra if I know it is u-vegetables	-0.169	0.030	**0.909**
A9	I will like toilet system which separates urine from human excreta	**0.646**	-0.284	-0.043
	% of Total variance	36.44%	22.46%	12.78%

Bold values indicate the highest correlations between sentences and factors

Only 9 variables were used for the PCA because the tenth variable communality was very low (A10, 0.341; See Appendix D3, Koomson, 2010). Consumers perception were summarized into three factors that accounted for 72% of the total variance. The first one, 'Resource', explains 36% of variance and is linked to the non-disposal of urine as municipal waste, urine as a resource, use of urine for vegetable production, willingness to sell urine, willingness to buy u-vegetables and likeness of the UDDTs. The second factor, 'Religion and Norm influence', explains 22% of the total variance and refers to the influence of consumers religion and current circumstances surrounding the society in which he/she lives on the consumers consumption of u-vegetables. Finally, the third factor contributes 13% of the total variance. It is called 'Access' and shows consumers desire to consume vegetables outside Accra if vegetables within Accra are u-vegetables.

3.2.5 *Factors that influence farmers' willingness to use sanitized human urine for vegetable production*

Level of willingness to use

Out of the 90 farmers, 81 (90%) were willing to use (WTU), indicating a very high willingness to use the urine technology. Interestingly, this high rate of willingness to use human urine was translated into high willingness to pay. About 96% of the farmers who were willing to use were willing to pay. As Figure 3.2 shows, 97% of the respondents who were willing to pay for the urine technology were willing to pay the first bid, which was GH¢1.5 per 200 liters of sanitized urine. In the follow up questions, farmers (100%) who were willing to pay the first bid were also willing to pay the second higher bid (GH¢2.0) and 100% of the respondents who were not willing to pay the first bid were willing to pay the second lower bid (GH¢1.0).

Results of probit analysis

A probit model was estimated to examine the various factors that affect farmer's willingness to use (WTU) human urine for vegetable production. The dependent variable of willingness to use human urine was regressed on perception, education, age, gender, location, religious influence, norm, mode of soil conservation, soil condition and urine availability. The results are presented in Table 3.18. The Wald statistics reveal that the variables included in the model are jointly statistically significant in explaining the WTU human urine decision of the farmers. The Pseudo R^2 value of 0.5681 means that about 56.8% of the variation in the dependent variable is explained by variation in the independent variables.

Figure 3.2: Summary Statistics to double-bounded dichotomous choice questions

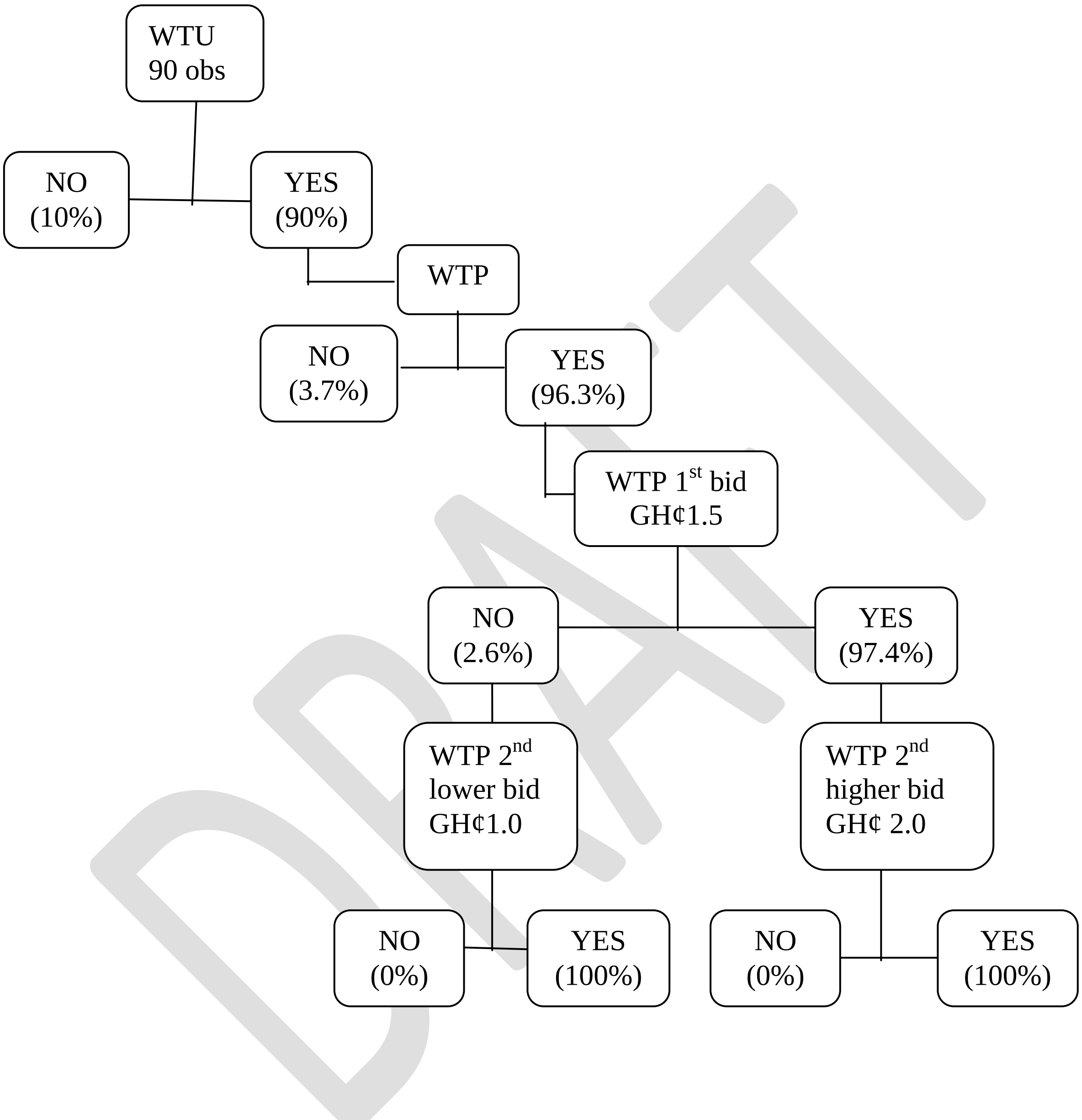


Table 3.18: Regression results of farmers' willingness to use urine as an alternative fertilizer (probit model)

Variables	Coefficient	Robust Std. Error	z.	P>z	Marginal Effects
Constant	1.739	2.874	0.610	0.545	0.000
Perception	6.923***	1.603	4.320	0.000	0.999
Education	0.773	0.524	1.480	0.140	0.010
Age	-0.597***	0.183	-3.260	0.001	-0.005
Age square	0.007***	0.002	3.490	0.000	0.000
Gender	2.365***	0.676	3.500	0.000	0.260
Location	1.262*	0.678	1.860	0.063	0.010
Religious influence	-0.576	1.200	-0.480	0.631	-0.009
Norm	-0.229	1.046	-0.220	0.827	-0.002
Mode of soil conservation	1.823***	0.561	3.250	0.001	0.060
Soil condition	1.897**	0.958	1.980	0.048	0.139
Urine availability	0.871	0.565	1.540	0.123	0.017

Number of obs = 90 Log pseudo likelihood = -12.63659
Wald $chi^2(11)$ = 49.63 Pseudo R^2 = 0.5681
Prob > chi^2 = 0.0000

*** significant at 1%, ** significant at 5%, * significant at 10%

The second column shows the coefficient of various variables that affect the decision of farmers to use human urine for vegetable production. With the exception religious influence, norm, education and urine availability, all the explanatory variables are statistically significant. This means that although religious influence, norm, education of the farmer and urine availability bears the a priori sign they do not play a role in determining whether a farmer will adopt the urine technology for fertilization or not. Perception about human urine, age, gender, and mode of soil conservation were statistically significant at 1 percent while soil condition and location of the farmer are statistically significant at 5 and 10% respectively.

The results show that the young farmers are more likely to adopt the urine fertilization technology than the elderly as shown by the negative and positive coefficients of the age and the age square variables. The perception variable indicates that farmers with positive perception. Additionally, males will be more likely to use the urine technology than females. Farmers who use organic means of conserving the soil and those who perceive their soil conditions to be good are more likely to use the human urine for vegetable production. This result was not surprising because farmers will always want to increase their productivity and those who use organic (poultry manure, cow dung, compost) means to conserve soil nutrients will be more willing to welcome the urine fertilization technology. Farmers in Dzorwulu farm site are more likely to use the urine

technology. This is because farmers here have received a demonstration of the urine technology.

The marginal effects of the perception variable shows that farmers with positive perception about urine quality have about 100% chance of using the urine for vegetable production than those who have negative perception about urine quality, ceteris paribus. The probability that male farmers will adopt the urine technology will be 26% more than female farmers. The elderly will be 0.005 less likely to adopt the urine technology for fertilization. Dzorwulu farmers will have 1 percent more chance to adopt the urine technology than farmers at other farm sites. Farmers with perceived good soil conditions will still adopt the urine fertilization of vegetables and this will be higher than farmers with perceived bad soil conditions of their land by about 14%. Farmers familiar with organic fertilization of soils probability of using human urine for fertilization will be 0.06 more than those who use chemical fertilizers for fertilization.

3.2.6 Factors that influence marketers' willingness to buy U-vegetables

Results of probit analysis

The Wald statistic reported was 44.55 with a p-value of 0.0000 suggesting that the whole model is statistically significant at 1 percent (Table 3.19). The Pseudo R^2 value of 0.4361 implies about 43% of the variation in the dependent variable is explained by variation in the explanatory variables.

Table 3.19 Regression results of marketer's willingness to buy u-vegetables from farmers (probit model)

Variables	Coefficient	Robust Std. Error	z.	P>z	Marginal Effects
Constant	-5.653**	2.238	-2.530	0.012	0.000
Gender	-1.321**	0.573	-2.300	0.021	-0.478
Age	0.150	0.112	1.340	0.179	0.057
Age square	-0.002	0.001	-1.470	0.141	-0.001
Education	-0.063	0.528	-0.120	0.906	-0.024
Marital status	-0.888	0.547	-1.620	0.104	-0.304
Religious influence	-1.633***	0.515	-3.170	0.002	-0.585
Norm	0.829*	0.498	1.670	0.096	0.296
Knowledge of production	0.075	0.405	0.190	0.852	0.029
Urine perception index	0.074***	0.014	5.330	0.000	0.028

Number of obs = 83 Log pseudo likelihood = -32.030683
Wald $chi^2(9)$ = 44.55 Pseudo R^2 = 0.4361
Prob > chi^2 = 0.0000

*** significant at 1%, ** significant at 5%, * significant at 10%

All the estimated coefficients had the expected sign with the exception of gender, education and norm. Moreover, gender and norm were statistically significant at 5 and 10% significant levels respectively. This result appears plausible because Obuobie *et al*. (2006) observed that market women (vegetable marketing business is female dominated) support the growing of vegetables within the city. It provides them with employment, reduced cost and time for transporting vegetables from peri-urban and rural areas. It will also give the women easy access to fresh vegetables and will also lower prices on the vegetable produce since transportation cost will be less. This also support the argument that norm will not be a hindrance to their purchasing of u-vegetables within the city. For instance, market women continue to buy produce from farmers despite media reports about farmer's within the city usage of waste water for irrigation.

Both religious influence and urine perception index were statistically significant at 1%. The negative sign for the religious influence variable supports the hypothesis that the probability that a marketer would be willing to buy u-vegetables for the market would decrease if his/her religion is against the use of human urine for vegetable production. The positive sign for urine perception index variable supports the hypothesis that the probability that a marketer will be willing to pay for u-vegetables increases as his/her perception about human urine use for vegetable production increases.

The marginal effect for the religious influence variable suggest that for marketers whose religion is against the use of human urine for vegetable production, the probability that they will buy u-vegetables will decrease by 0.585 compared with marketers whose religion is not against the use of human urine for vegetable production. Similarly, a unit increase in marketers' urine perception index increases the probability of willingness to buy u-vegetables by 0.03. The probability of willingness to buy u-vegetables is higher for female marketers than male marketers by 0.478.

3.2.7 Factors that influence consumers' willingness to buy U-vegetables

Results of probit analysis

The estimated results from the probit model for consumer's willingness to buy u-vegetables were presented in Table 3.20. The Wald chi^2 value of 79.27 was significant at 0.01 level which means that the overall model is significant. The Pseudo R^2 value of 0.4474 implies about 45% of the variation in the dependent variable is explained by variation in the explanatory variables.

Except for income, access to alternative source of vegetables and perception index, none of the estimated coefficients is statistically different from zero at the 10% significance level. This means that religious influence, norm, age, sex, education and marital status do not have an effect on consumers' willingness to buy u-vegetables. Huang *et al.* (1999) used ordered probit to reveal that socioeconomic characteristics do

not have an influence on consumers' willingness to pay for hydroponically grown vegetables.

The results rather confirmed that, willingness to buy u-vegetables decreases as consumer's income increases. Huang *et al.* (1999) observed similar results in their joint estimation probit model for consumers' willingness to pay for food safety in Taiwan. A one percent increase in consumer's income is likely to decrease willingness to buy u-vegetables by 11%. The impact that access to alternative source of vegetables will have on willingness to buy u-vegetables is also shown. Most consumers complained about the source of water for irrigation in the urban area by farmers but they consume the vegetables produced by them because they do not have alternative source. The results show that consumers with alternative source of buying vegetables other than u-vegetables will be less willing to buy u-vegetables. The marginal effect of -0.348 means that **if consumers are to have alternative sources of buying vegetables, their willingness to buy u-vegetables will decrease by about 35%**. Individuals with positive perception about the use of human urine for vegetable production will be more willing to buy u-vegetables. The chances are that consumers with positive perception about the use of human urine for vegetable production willingness to buy u-vegetables will be higher than those with negative perception by 2.4%.

Table 3.20: Regression results of consumers' willingness to buy u-vegetables from marketers (probit model)

Variables	Coefficient	Robust Std. Error	z.	P>z	Marginal Effects
Constant	-3.862**	1.649	-2.340	0.019	0.000
Sex	0.402	0.298	1.350	0.177	0.159
Age	0.040	0.073	0.550	0.583	0.016
Age square	0.000	0.001	-0.290	0.774	0.000
Education	0.011	0.040	0.290	0.775	0.005
Marital status	0.238	0.426	0.560	0.576	0.094
Income (natural log)	-0.286*	0.170	-1.680	0.092	-0.114
Religious influence	-0.653	0.564	-1.160	0.247	-0.254
Norm	0.713	0.516	1.380	0.167	0.272
Access to alternative source	-0.904***	0.307	-2.940	0.003	-0.348
Urine perception index	0.060***	0.010	6.110	0.000	0.024

Number of obs = 128 Log pseudo likelihood = -48.946702
Wald $chi^2(11)$ = 79.27 Pseudo R^2 = 0.4474
Prob > chi^2 = 0.0000

*** significant at 1%, ** significant at 5%, * significant at 10%
Note: Sample size = 128 (Respondents with no income were ignored because of the natural log)

3.3 Conclusion

The consumers' perception study showed that some consumers (56%) do not want human urine to be disposed off as a municipal waste, although they (72%) could not tell what is in human urine that makes it a resource. Meanwhile, about 44% of the consumers were willing to buy u-vegetables as obtained from the PCA. These were people who perceive urine as a resource and their consumption of u-vegetables is independent of religious influence and norm in the society. The reasons they gave included lack of alternative source of vegetables and their inability to guarantee the safety of the conventional vegetables on the market because the market women would not disclose the source of the produce to them. However, consumers mentioned a perceived health risk associated with the consumption of u-vegetables as a major concern that can influence their choice to consume u-vegetables. None of the consumers was able to mention a specific disease associated with consumption of u-vegetables. Socio-economic characteristics of consumers who were willing to consume u-vegetables was however not different from those who would not consume. The main conclusion drawn is that consumers were willing to buy u-vegetables but more concerned about the possible health effects of u-vegetables consumption.

The farmer probit estimation showed that perception about urine quality, gender, mode of soil conservation, location and soil condition positively affected farmers' willingness to adopt the urine technology. The study concludes that farmers with positive perception about urine quality will adopt the technology. The probability that male farmers will be willing to adopt the urine technology will increase by 26% more than females. Young farmers will be more willing to adopt the technology than the elderly. Farmers who use organic fertilizers probability of using the urine technology are higher than those who do not use organic fertilizers by 0.06. Indeed, farmers with perceived good soil conditions will increase their adoption of the urine technology by 14% relative to their colleagues with perceived poor soil conditions.

The marketer probit model estimation found that marketers' willingness to buy u-vegetables was influenced by their perception, gender, norm and religious influence. A unit increase in a marketer's urine perception index increases the probability of willingness to buy u-vegetables by 0.03. Probability of willingness to buy u-vegetables was highest among marketer's whose religious beliefs is not against the use of human urine for vegetable production than those whose religious belief is against human urine use on vegetable production by 0.585. Female marketers' willingness to buy u-vegetables is higher than male marketers by 48% even if the cultural situation surrounding their communities is against the use of human urine for vegetable production.

The consumer probit estimation also revealed that a 1% increase in consumer's income will lead to 11% decrease in consumer's willingness to buy u-vegetables. Consumers with alternative source of buying vegetables willingness to buy u-vegetables will decrease by 35 percent relative to consumers with no alternative source. However, a

positive consumer perception about urine will increase his/her willingness to consume u-vegetables by 2.4%.

The study also observed some potential barriers that can impede the successful introduction of the use of human urine on vegetables. These include (no order): The health effects (the perceived health risk of urine use and effect of misapplication by farmers), socio-cultural perceptions (opposition from the religious groups, traditional councils and media), environmental effects (perceived effect of continuous use of the human urine on plants and the soil), technical know-how (lack of knowledge on application rate and mode of application, urine availability, rodent attack, urine effect on different climatic conditions, and so on) and economic effects (would it be profitable - the price that the urine would be sold).

CHAPTER FOUR

4.0 Use of Human Urine in Urban and Peri-urban Agriculture: Effect on cabbage growth, yield, nutrient uptake and soil characteristics

This chapter describes a field study carried out to determine the effect of human urine (and other fertilizers including poultry droppings, NPK and human excreta) on cabbage growth, yield, nutrient uptake and soil characteristics. It describes the existing infrastructure (urinals), the process of urine collection from the Central Business District (CBD) of Accra, transportation to the experimental site and its subsequent application either as the only source of fertilizer or in combination with other forms of fertilizer. The chapter also touches on potential pharmaceutical residues in the urine collected for the trial. The field study was carried out at Dzorwulu in Accra, Ghana between September to December 2009 and March to June 2010. The field demonstration was carried out in collaboration with a private company (SAFISANA HOLDING) who was responsible for collection and transportation of urine to the farm site.

4.1 The existing infrastructure

The urinal from which urine was collected for this study at the Central Business District (CBD) is the property of Big 2 B Limited. This company was set up to provide urinals for the teaming masses of people who come to the city daily for business and other related activities.

The urinals are made of plastics and are lockable both from the inside and outside. It therefore provides some kind of privacy for the users (Plate 4.1). These urinals have been constructed in such a way that there is a storage receptacle underneath (Plate 4.2). This storage receptacle could be used to store the urine for later collection but the urine is released into the drainage system that runs through the Novotel Park in Accra. The urinals have been modified into male and female units. The male unit uses a standard standing urinal (Plate 4.3) whilst the Female unit uses a bidet (Plate 4.4).

Plate 4.1: Big 2 B Ltd Urinals

Plate 4.2: Storage container underneath the urinal

Users of the urinal pay an amount of ten Ghana pesewas (10p approximately 0.65 USD) to use the facility. Operators have been employed to collect the user fees and also clean the facility every morning and evening and a thorough cleaning on Sundays when there is virtually little or no patronage. The main cleaning agents used are detergents.

Plate 4.3: A standing Urinal used the Male Clients

Plate 4.4: Bidets used by the female

4.2 Collection of urine for field trial

A survey was conducted in the market adjacent the Novotel Hotel in Accra to identify the potential lipohpylic pharmaceutical residues likely to be present in urine samples to be collected from a public urinary located within the market premises. Questionnaires were designed to collect information on the major sicknesses/diseases and the drugs used in the treatment of these sicknesses/diseases from respondents within the market premises.

Prior to the actual collection of the urine it was decided that there is the need to eliminate the use of chemical detergents and to use only biodegradable ones. Vinegar and Citronella were therefore chosen to wash and to control the scent emanating from the urinal during this period. Two of the units (one female and one male) were chosen for this exercise. The operators were instructed to stop the use of the chemical detergents and were asked to use vinegar instead. The operators were provided with overcoats, wellington boots, gloves and nose masks for protection.

Special plastic stop cocks were used to regulate the flow of urine from the urinal into the drain. Since the urine was located very close to the drain, a wooden platform was constructed about 450mm from the bottom of the drain (see plate 4.5). The purpose of this platform was to act as a kind of support for the containers during the collection process. Every morning, the stop cock was closed to ensure that the urine stays within the collection receptacle. In the evening the stop cock was opened and the urine was then collected into 25L containers placed on special platforms mounted in the drain.

Plate 4.5: Outlet connection from the urinal showing the stop cock *(Photo credit: Frederick Iowor-Tettey)*

The average daily collection was three 75L (25L containers). The containers were stacked close to the urinal for subsequent transportation to the field. After collection the urine was taken to the urban agricultural site at Dzorwulu where the urine was stored in a 450L poly tank container (plate 4.6) for about one month to sanitize it before use.

Plate 4.6: Urine storage in poly tank container *(Photo credit: Philip Amoah)*

4.3 Methodology of field trial

4.3.1 Experimental site

The project was carried out at Dzorwulu (Figure 4.1) in Accra, Ghana between September, 2009 and June 2010.

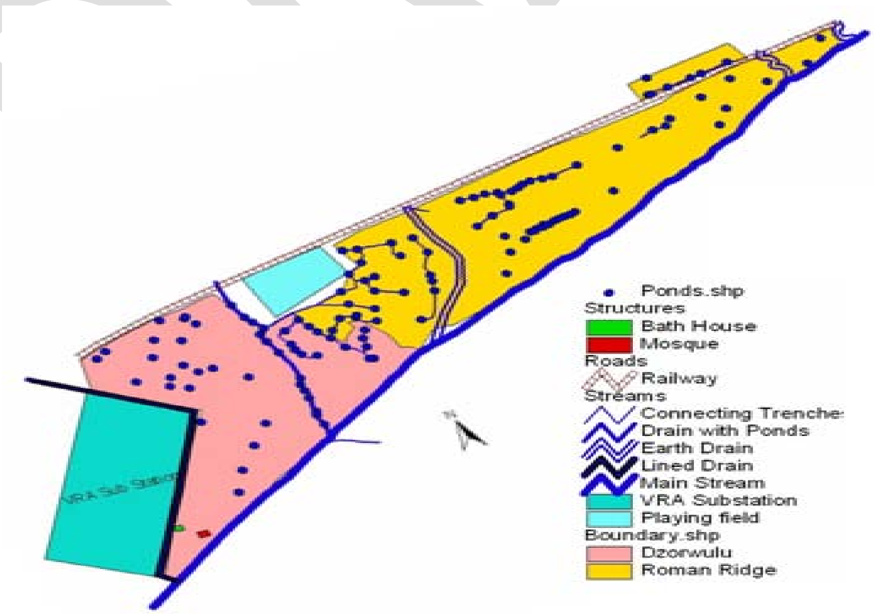
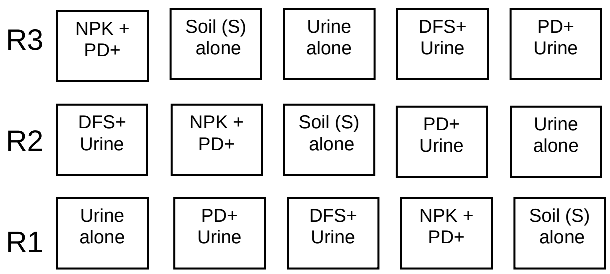


Figure 4.1

4.3.2 Experimental design

A Randomised Complete Block Design (RCBD) was used (Figure 4.2 and 4.3).Each experimental plot was replicated three times. The total plot size was 11.4 m x 20.4 m and each experimental unit was 3.8 m x 3.4 m consisting of four rows of 28 plants (Figure 4.3) and the planting distance was 60 cm x 45 cm.



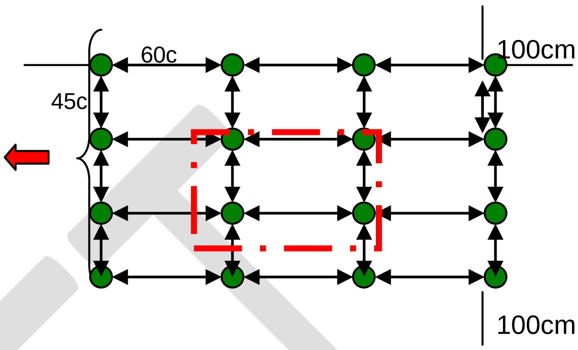


Figure.4.2: Experimental design of the trial- A Randomised Complete Block Design

Figure: 4.3: Experimental unit showing plants for data collection in a rectangle earmarked red

4.3.3 Treatments and mode of application

The treatments applied included urine alone (U), urine + dewatered faecal sludge (U + DFS), urine + poultry droppings (U + PD), NPK + poultry droppings (NPK + PD) and soil alone (S). With the exception of soil alone, each treatment was applied at the rate of 121 kg N ha^{-1} according to Adamtey (2006). The combined treatments were applied such that each treatment contributed to 50% of the total N applied. All the treatments were buried at the surface of the soil. Three days after transplanting about 60.5 kg N ha^{-1} of urine was applied to seedlings that received urine alone whiles 60.5 kg N ha^{-1} each of DFS and PD was applied to seedlings that were labelled to receive urine + DFS Urine + PD and PD + inorganic fertilizer (NPK). A month after transplanting the manure applications were repeated at the same rate described above. The 1 month old stored urine was well shaken before application with a well calibrated container. Urine application was done through holes dug 20 cm away from the plants (Plate 4.7 and 4.8) and 1–4 cm deep.

Plate 4.7A: Photo showing the distance between plant and a hole in which urine is applied
(Photo credit: Noah Adamptey)

Plate 4.8: A farmer applying urine in a hole dug near the plants
(Photo credit: Noah Adamptey)

The holes were covered immediately with soil as described by Heinonen-Tanski and Wijk-Sijbesma (2005). This simple practice mimics the successful injection technique used by Richert Stintzing *et al.* (2002) to avoid ammonia losses. The soil was slightly watered before the urine was applied late in the evening to avoid volatilisation.

The chemical characteristics of the urine and the other fertilizer sources were determined before application. The pH and EC were determined in DFS- or PD-water slurry with a ratio of 1:5, v/v (TMECC, 2002) and soil- water slurry with a ratio 1:1 v/v (Black *et al*., 1965). Total nitrogen in urine was determined according to the method described by Folin and Farmer (2009). The resultant digest was used to determine phosphorus (P) and potassium (K). Phosphorus was determined calorimetrically using spectrophotometer (model Perkin Elmer Lambda 45). Total K was determined using flame photometer (model Jenway PFP7). The nitrogen content of DFS, PD and soil were determined according to the Kjeldahl method described by Okalebo et al. (2002). Inorganic nitrogen (NH_4^+-N, NO_3^- -N) was determined from 40-ml aliquots of 2M KCl extracts by steam distillation (Okalebo *et al*., 2002). Total carbon content of DFS, PD and soil was determined by dry combustion using Carbon and Surphur Analyser Eltra CS 500. Total P and K of DFS, PD and soil were determined as described above after digestion with ternary mixture (20 ml $HClO_4$: 500 ml HNO_3: 50 ml H_2SO_4).

4.3.4 Field operations

Cabbage seeds *cv. Oxolus* were nursed in September 2009 and transplanted onto permanent field in the third week of September, 2009. A second cropping was also carried out between March and June 2010. At transplanting seedlings height and number of leaves were noted and recorded; this was to ensure that there were some levels of uniformity among the transplanted seedlings. Watering, weeding, pest and disease control were done as and when necessary.

Data on growth parameters (no. of leaves, leaf area, canopy, and plant height) were collected forth-nightly starting from the third day after transplanting. Cabbage canopy was measured using meter rule across the longest diameter. Unlike the other parameters, cabbage canopy was taken two weeks after transplanting. This is because, before week 2 after transplanting, the plant canopy was not uniform. Yield parameters (fresh weight, circumference of head, no of leaves of head, height of head and dry matter yield) were determined at maturity (see plate 4.9). Circumference was measured using tape measure. Cabbage heads that got damaged (rotten) were counted per treatment and expressed over total number of heads per bed as a percentage. This data was taken once at the later stage of the experiment to determine the level of damage or rottenness in each of the treatments.

Plate 4.9: Farmers weighing lettuce heads after the trial
(Photo credit: Philip Amoah)

4.34 Plant and soil analysis

Soil samples were collected before and immediately after harvest, air dried, sieved and analysed for pH, EC, N, P, K as described above. Harvested plants were oven dried at 70°C for two weeks, milled before analysed as described above.

4.3.5 Statistical analysis

Data collected were subjected to statistical analysis using ANOVA and means separated by the Least Significant Difference (LSD).

4.4 Results and discussion

4.4.1 Chemical characteristics of treatments

The chemical characteristics of the different fertilizer sources used for the first trial are shown in (Table 4.1a).

Table 4.1a: Chemical characteristics of soil and other fertilizer sources

Sample	pH	EC µScm-1	Carbon %	Nitrogen %	NH_4^+-N mg/kg	NO_3^- -N mg/kg	Phosphorus %	Potassium %
Soil	7.0	275	13.60	0.05	38.00	9.14	0.05	0.02
Urine	8.5	>3000	NA	1.03	NA	NA	0.10	0.75
DFS	5.4	>3000	1.06	2.26	489.216	83.72	2.82	0.50
PD	6.8	1650	15.41	1.96	740.376	26.404	1.95	1.23

The pH of dewatered faecal sludge (DFS) and poultry droppings (PD) was slightly acidic whereas that of urine was basic. The main nitrogen source in stored urine is ammoniacal nitrogen, with bicarbonate as the main anion (Kirchmann and Pettersson, 1995). Urea and urate decompose during storage and may account for the high pH value that was measured for stored urine (Kirchmann and Pettersson, 1995). The nitrogen and phosphorus content of DFS was higher than that of urine and PD. Potassium content of PD was about twice the number of leaves in andd Urine. The pH (8.5) of the 1 month old stored urine was close to the value (8.9) reported by Kirrchmann and Petterson (1995) for stored human urine. The total nitrogen concentration (10.3 g L^{-1}) was also close to the total N concentration for undiluted fresh human urine (7-9 g L^{-1}) reported by Guyton (1986). The phosphorus and potassium values were similarly close to 0.20 to 0.21 g L^{-1}, and 0.9 to 1.1 g L^{-1} reported by Kirrchmann and Pettersson (1995).

Table 4.1b shows the chemical characteristics of the soil and urine used for the second trial. The total nitrogen and phosphorus content of urine reduced after six month of storage whereas the potassium content fairly remained the same.

Table 4.1b: Chemical characteristics of soil and urine for second cropping

Sample	pH	EC µScm-1	Carbon %	Nitrogen %	NH_4^+-N mg/kg	NO_3^- -N mg/kg	Phosphorus %	Potassium %
Soil	7.4	416.67	NA	0.03	25.1	6.7	0.06	0.05
Urine	7.9	NA	NA	0.91	NA	NA	0.03	0.81

4.4.2 Effect of various treatments on plant growth parameters

Plant height

Plant height measured every two weeks after transplanting is shown in (Figure.4.4a). At week 0 (after transplanting), all the plants had virtually the same height, ranging from 5.9 cm to 6.3 cm. This was taken to ensure that significant differences observed in plant height at the end of the experiment will not be by chance but related to the specific treatments applied. Plant height increased progressively and at week 6, there was no significant difference between the different treatments in plant heights ($P < 0.05$).

From week 2 to week 4 after transplanting, the cabbage height almost doubled for each of the treatments. At the end of first trial, cabbages treated with urine alone had the lowest plant height with the average height of 20.9 cm whiles those treated with "NPK+PD" was at 23.3 cm. However, there were no significant differences between various treatments (Figure. 4.4a).

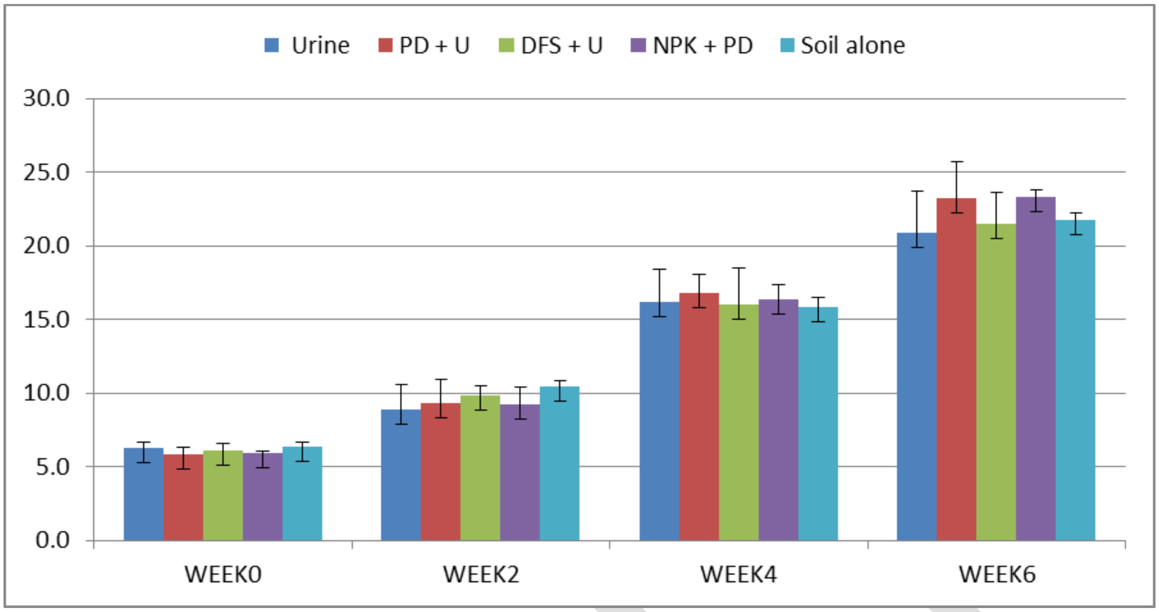


Figure: 4.4a Effect of urine and its related treatments on cabbage plant height after first trial

In the second trial, plant height, number of leaves and canopy of cabbage plant were taken only at maturity. This was because most of the initial transplanted seedlings died and were replaced later. This resulted in unequal growth among the plants. The plant height at maturity at the end of second trial is shown in (Figure. 4.4b).

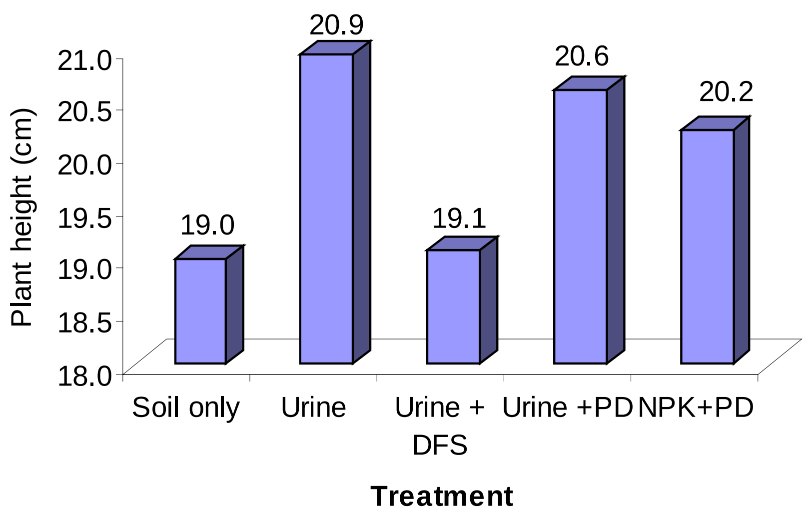


Figure 4.4b: Effect of urine and its related treatments on cabbage plant height at maturity after second trial

Number of leaves

The number of leaves at various weeks after transplanting is shown in (Figure 4.5a). There was no significant difference (*P* < 0.05) in the number of leaves between the various treatments at the end of the experiment. However, there was a significant difference (*P* < 0.05) in the number of cabbage leaves between 'week 0' and 'week 2' after transplanting for all treatments. The average minimum number of leaves per plant was 17. The number of leaves per plant did not really change from the fourth week to the sixth week.

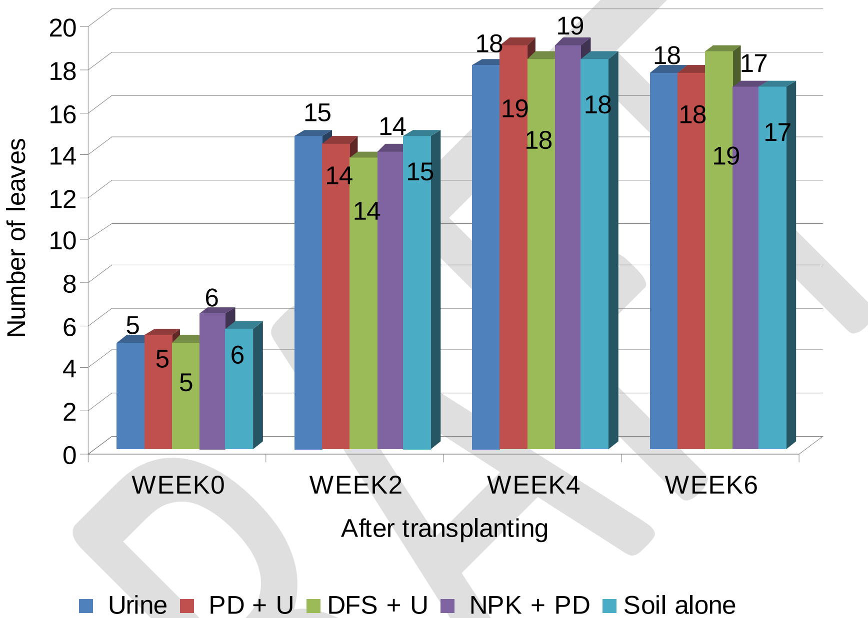


Figure 4.5a: Effect of urine and its related treatments on number of cabbage leaves after first trial

For 'PD+U', 'NPK+PD' and 'Soil alone', the number of leaves decreased by 1 to 2. This was due to the drying of the lower leaves which were therefore not counted. There were no significant differences in the number of leaves between the various treatments in the first trail. Similar observation was made at the end second trial (Figure 4.5b). The results of the plant height and number of leaves confirm a study carried out by Pradhan *et al.* (2007). The authors reported that the total growth rate of urine-fertilized cabbages was slightly higher than that of the mineral-fertilized plants, but the difference was not significant.

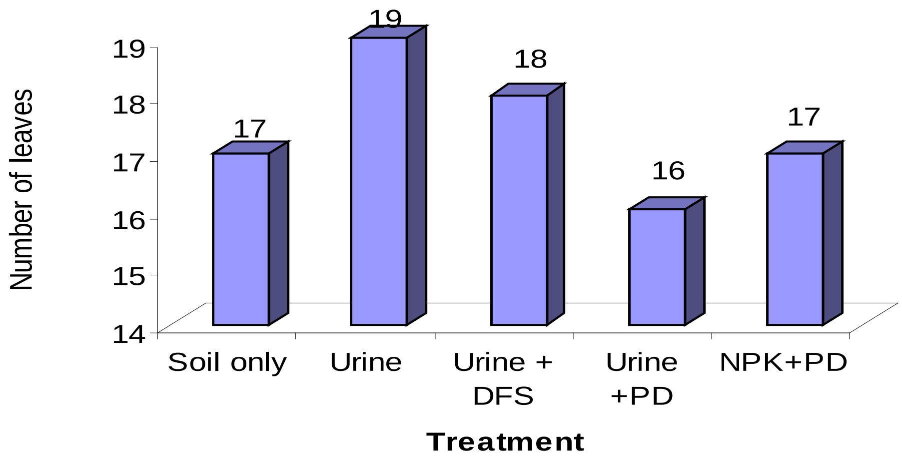


Figure 4.5b: Effect of urine and its related treatments on number of cabbage leaves after second trail

Canopy of cabbage

The canopy of cabbage at various weeks after transplanting is shown in (Figure 4.6). There was no significant difference (P<0.05) in canopy size between various treatments at the end of the experiment. The canopy size for all treatments increased significantly from week 2 to week 6 after transplanting. The canopy size at week 4 was higher than that of week 6. Similar observations were observed during the second trial. This indicates a decrease in canopy size, though not significant. This might be attributed to dried outer leaves which affected the canopy size.

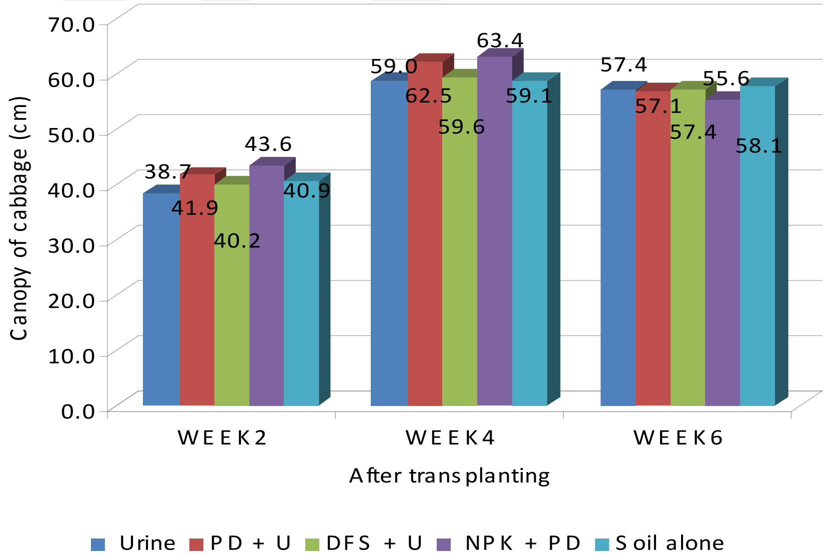


Figure 4.6: Effect of urine and its related treatments on canopy of cabbage

after first trail

Rotten cabbage head

Figures 4.7a and b show the percentage of rotten cabbage heads for the various treatments in the first and second trials. At the end of first trial cabbages treated with NPK + PD had the highest percentage (58.2%) of rotten cabbage heads. This was significantly higher than the other treatments. 'Urine + DFS' on the other hand had the lowest percentage (30%) of rotten cabbage heads. With exception of 'NPK + PD' treatments, there were no significant differences ($P < 0.05$) between the various treatments. Similar observation was made in the second trial (Figure 4.7b). The high percentage of rotten cabbage heads in 'NPK + PD' and ´Urine + PD´ treated cabbages may be attributed to the high nitrogen uptake. The high N uptake might have promoted vegetative growth as well as succulent plant parts making such plants more susceptible to various forms of damage.

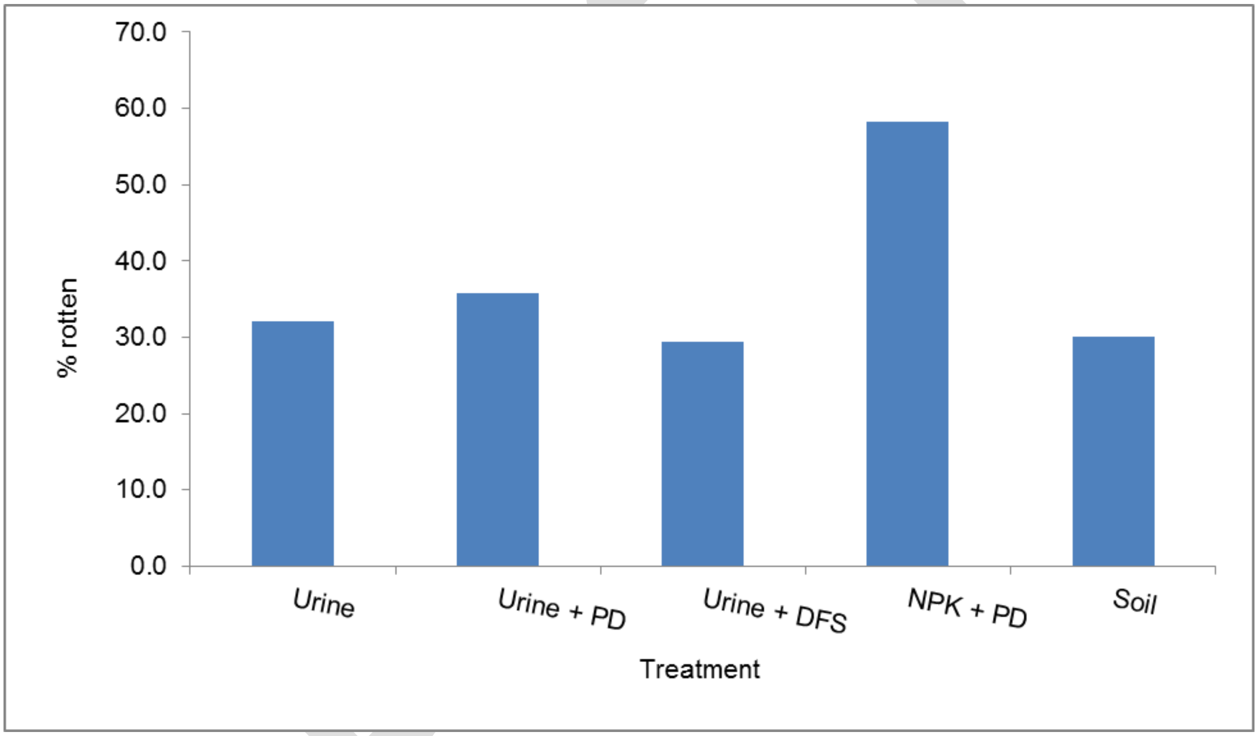


Figure: 4.7a: Effect of urine and its related treatments on rotten of cabbage heads after firs cropping

Pradhan *et al.* (2007) reported that the nitrogen content of cabbage plants could affect the performance of special insect pest of *Brassica* plants and that there was a good correlation between the extent of insect damage and the cabbage growth rate. The authors also reported that insect damage was more severe in the mineral-fertilized cabbages, which had a faster initial growth than the urine-fertilized cabbages. This probably reflects the preference of many insects, for example, the diamondback moth (*Plutella xylostella*), flea beetle (*Phyllotreta striolata*), and mustard beetle (*Phaedon*

cochleariae), to feed and reproduce on industrial NPK-fertilized cabbage plants. This should however be further investigated. Rotten of cabbage head should be investigated into details since it will help in making a better recommendation for intended users of the outcome of the research.

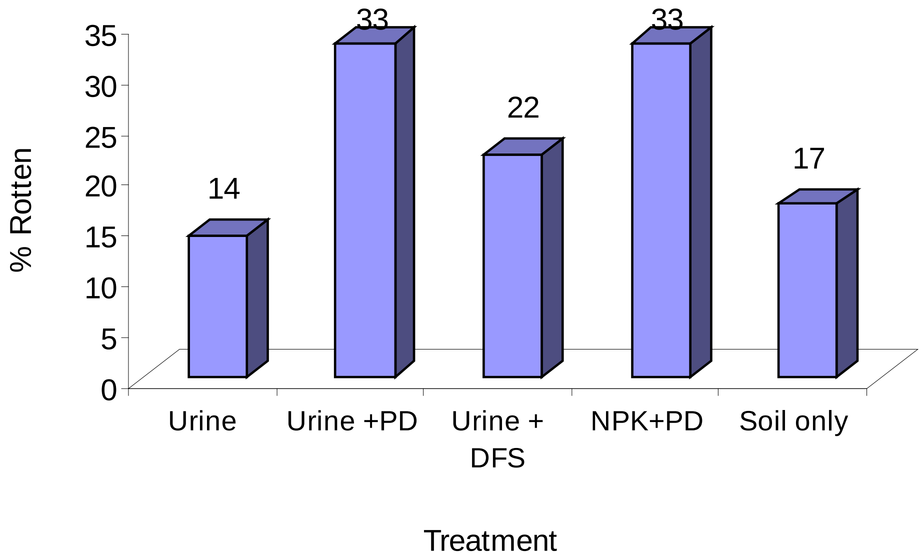


Figure 4.7b: Effect of urine and its related treatments on rotten of cabbage heads after second trial

Circumference of cabbage head

The effect of the various treatments on the circumference of cabbage heads at the end of first trial is shown in (Figure 4.8). Cabbage from soil without any fertilizer treatment had the smallest head as it is reflected in the lowest head circumference of 44.5 cm. This could be due to the relatively low N uptake (see Table 4.2a) which may delay maturity. NPK + PD treated soil produced cabbages with the biggest head with a head circumference of 48.4 cm. Urine-fertilized cabbage plants achieved their maximum growth earlier than other cabbages; that is, the cultivation time was shorter in urine-fertilized cabbages. This might be due to the relatively high N uptake. However, there were no significant differences ($P < 0.05$) in the circumference of cabbage heads for the various treatments. The result again agrees with a similar study by Pradhan *et al*. (2007) who reported earlier growth and the circumference of cabbage head from urine-fertilized plots to be slightly higher (though not significant) than those from mineral-fertilized cabbage plots and non-fertilized plots. No data was collected on the circumference of cabbage head after second trial.

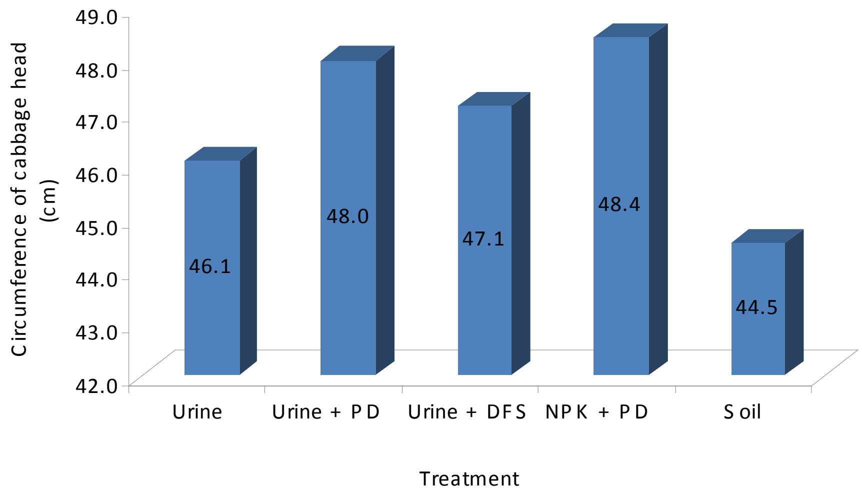


Figure 4.8: Effect of urine and its related treatments on circumference of cabbage heads after first trail

Fresh weight and dry matter yield

After the end of first trial, there were no significant differences (P<0.05) in the fresh weight of cabbage head among the treatments (see Table 4.2a). The fresh weight of cabbage head from Urine + PD treated soil was the highest and was 3.6% higher than NPK + PD treated ones. On the other hand NPK + PD treated cabbage was 14.2% and 10% higher than that treated alone urine alone and Urine + DFS, respectively (see Table 4.2a). Also, the fresh weight of Urine + DFS and Urine + PD treated cabbage was 6.6% and 7.8 % higher than those treated with urine alone and 14.2% higher than soil alone, respectively. There was no significant difference between Urine + PD, NPK + PD and Urine + DFS treated cabbages after the end of second trial (Table 4.2b). The fresh weight of cabbage treated with Urine + PD was 3.9% higher than those treated with NPK + DFS.

Table 4.2a: Effect of urine and its related treatments on fresh weight, dry weight and nutrient uptake of cabbage after first trial

Treatment	Fresh weight g $head^{-1}$	Dry matter g $head^{-1}$	N uptake mg kg^{-1}	P uptake mg kg^{-1}	K uptake mg kg^{-1}
Soil alone	861.0	85.3	194.0	45.8	230.9
Urine	913.0	89.7	222.0	46.8	241.5
Urine+DFS	965.0	90.6	212.0	46.8	294.6
Urine+PD	1080.0	102.9	277.0	61.0	229.5
NPK+PD	1042.0	96.8	261.0	52.0	274.9
LSD(P<0.05)	357.5	18.94	73.5	13.7	94.0

Table 4.2b: Effect of urine and its related treatments on fresh weight, dry weight and nutrient uptake of cabbage after second trial

Treatment	Fresh weight g head^{-1}	Dry matter g head^{-1}	N uptake mg kg^{-1}	P uptake mg kg^{-1}	K uptake mg kg^{-1}
Soil alone	269.7	15.8	31.7	11.3	58.8
Urine	375.5	17.3	40.5	15.3	78.7
Urine+DFS	434.6	17.6	42.1	16.0	68.6
Urine+PD	529.7	24.8	65.8	20.2	107.9
NPK+PD	510.0	18.5	37.0	15.9	78.9
LSD(P<0.05)	104.9	NS	20.4	5.80	30.4

Significant differences were observed in the second trial between fresh weight of cabbages treated with Urine + PD, Urine + NPK and Urine or soil alone. In general, the fresh weight of cabbage for all the treatments during the first trail was lower than those from the second trail. This can be attributed to poor plant growth and development as a result of prolong drought (2 weeks) and heavy downpour which led to flooding during the growing period.

Plate 4.10: Farmers weighing cabbages from different treatment plots
(Photo credit: Philip Amoah)

There were no significant differences in the Dry Matter Yield (DMY) between the treatments at the end of first trial (p<0.05), (Table 4.2a). Cabbages treated with Urine +

PD gave the highest DMY followed by NPK + PD with soil alone having the least. The DMY at the end of second trial (Table 4.2b) followed similar pattern as observed in the first trial. The relatively low DMY of cabbage treatment with NPK + PD indicated that the cabbage from such treatment was more succulent and might also account for the high percentage of rottenness observed (Figures4.7a and b). The above results agree with that of Pradhan *et al.* (2007) who reported total biomass (dry matter yield) and commercial biomass (fresh weight of head) of urine-fertilized cabbage to be slightly higher than those from mineral -fertilizer treated plots but this was not significantly different from non-fertilized cabbage plots (soil alone).

Nutrient uptake

At the end of first trial the nitrogen uptake from NPK + PD treatment cabbage was 6.1% lower than those treated with Urine + PD but 17.6% to 23.1% higher than those treated with urine alone and Urine + DFS, respectively (Table 4.2a). With the exception of treatments with urine + PD and soil than received no treatment (soil alone), there were no significant differences ($P<0.05$) in the nitrogen uptake among the treatments. Phosphorus uptake followed similar pattern as in nitrogen uptake (Table 4.2a). Potassium uptake from cabbages treated with Urine + DFS was three times higher than those treated with NPK + PD. At the end of second trial, the nitrogen, phosphorus and potassium uptake (Table 4.2b) followed similar pattern as observed in the first trial.

4.4.3 Effect on soil characteristics

The addition of urine related treatments did not lead to any significant changed in the pH of soil (Tables 4.3a and b). However, urine related treated soils showed a decrease in soil pH by 0.1. The decrease in pH was probably a result of nitrification of the ammonia, producing H^+ ions, from the urine (Mekeni *et al*., 2008). Soil electrical conductivity (EC) for urine treated plots showed higher electrical conductivity compared to soil alone. This agrees with Mekeni *et al*. (2008) who reported urine to increase soil electrical conductivity to 4.64 and 13.35 mS cm^{-1} as rate of N application increased. The soil residual nitrogen content for Urine + DFS and Urine + PD were significantly ($P< 0.05$) higher than that of NPK + PD at the end of first trial (Table 4.3a). On the other hand no significant differences were observed in the soil residual nitrogen after second cropping among treatments Urine + DFS, Urine + PD, NPK + PD and Urine alone (Table 4.3b). At the end of first and second cropping the soil residual P and K for Urine + PD and NPK + PD related treatments were higher than Urine alone, or soil alone (Tables 4.3a and b). The high soil residual nitrogen content for treatment Urine + DFS at the end of first cropping can be attributed to low nitrogen uptake. Whereas the insignificant differences in the residual nitrogen among urine related treatments at the end of second trial (Table 4.3b) may be attributed to the flooding effect that occurred during crop growth.

Table 4.3a: Effect of urine and its related treatments on soil characteristics after first trial

Treatment	pH	EC μScm^{-1}	NH_4^+-N mg kg^{-1}	NO_3^- -N mg kg^{-1}	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}
Soil alone	7.4	416.7	25.1	6.7	266.0	593.0	535.5
Urine alone	7.3	883.33	21.8	5.7	359.0	645.0	808.3
Urine + DFS	7.3	1090.0	21.8	5.0	494.0	711.0	1208.3
Urine + PD	7.3	1283.3	28.4	5.3	449.0	754.0	916. 7
NPK + PD	7.3	1293.3	26.9	7.0	380.0	732.0	1187.5
LSD (P<0.05)					0.007	134.6	

Table 4.3b: Effect of urine and its related treatments on soil characteristics after second trial

Treatment	pH	EC μScm^{-1}	NH_4^+-N mg kg^{-1}	NO_3^- -N mg kg^{-1}	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}
Soil alone	7.8	895.0	28.4	6.6	866.0	720.0	1062.0
Urine alone	7.8	1156.0	28.4	6.8	1001.0	622.0	1232.0
Urine + DFS	7.7	1227.0	25.5	6.1	1057.0	819.0	1194.0
Urine + PD	7.6	1109.0	28.8	10.4	1097.0	838.0	1271.0
NPK + PD	7.7	1002.0	26.2	5.9	1052.0	948.0	1150.0
LSD (P<0.05)	NS	NS	NS	2.54	201	NS	NS

4.5 Conclusion

The results suggest that urine with poultry droppings (PD) or dewatered faecal sludge (DFS) could be used as a good substitute for NPK + PD (farmer practice) for cabbage cultivation. Although the amounts of applied N were similar for all the fertilizer treatments, the cabbage yield and above ground dry matter yield were highest in the Urine + PD treatment possibly due to high nutrient uptake. Urine treated plots had reduced percentage rottenness of cabbage between 20% and 28% compared to 58% farmer practice (NPK + PD) in the first trial. Soil residual nitrogen content for Urine + DFS and Urine + PD were significantly (P< 0.05) higher than that of NPK + PD. Even though urine could be an alternative source of nutrients for crop production applying it in combination with other organic fertilizer e.g. poultry drippings or dewatered faecal sludge produce better results confirming the fertilizer value of Urine + DFS, and Urine + PD.

The findings from this study have important implications. They may contribute to the development of positive attitudes about the use of Urine + PD or Urine + DFS as fertilizer - a way to increase crop yield and reduce water pollution. In addition, results may contribute to optimize the use of Urine + PD or Urine + DFS to fertilize crops, which will help to maintain cabbage quality, improve soil characteristics, and to control N emission from the waste materials as well as reducing the demand for industrial fertilizer to some extent, thus reducing the environmental pollution released during fertilizer

manufacturing and transportation. However, the authors recommend that the research should be repeated on different soils in different locations to confirm the conclusions made. Detail research should also be conducted on the effect of the treatments on rottenness of cabbage head, leaching of nitrate, and soil electrical conductivity.

CHAPTER FIVE

5.0 Training on the use of urine as an alternative source of nutrient for crop production: *Risks and benefits, method of application, impact on crop yield and soil characteristics.*

This chapter focuses on a series of training programmes organized to demonstrate the potential of using urine as an alternative source of fertilizer for crop production in Accra Metropolitan Area (AMA) and provide recommendations for scaling up. The main aim of the urine demonstration project was to enhance the operational skills of farmers and Agricultural Extension Agents (AEA's) of the Ministry of Food and Agriculture (MoFA) and other key stakeholders in the use of urine for agriculture. In these programmes the participants were trained about the possibility, benefits and risk of the use of human urine for crop production and on how urine (with or without other soil ameliorants) is applied and the effect on crop yield. A total of six separate training programmes were organized between September 2009 and January, 2011.

5.1 Introductory meeting with farmers, Agricultural Extension Officers and other stakeholders

Preparations

Prior to the meeting preparations were made by developing a session plan (*see appendix 1*) and presentations to be made including photos to be used carefully selected and printed for distribution to participants. Other materials including flip charts, markers were gathered.

The learning objectives were:

- to make the participants aware of the benefits of urine as a source of nutrient for crop production (*Message: urine is a good source of nutrients for crop production*)
- for the participants to know the risk associated with the use of urine for crop production (*Message*: *urine is safe for crop production if handled well*)

What happened

At two separate meetings held on the 13th and 16th of October 2009, the first training program in the series was conducted to create awareness among participants on benefits and risks of the use of urine for crop production.

At the farmers meeting held on the 13th of October, 2009 on the demo site (farm), two short presentations on 1) benefits and 2) risks of using for crop production were presented to the farmers. This was after a brief introduction of the resource person(s) and the agenda for the day which were clearly displayed on a flip chart. For easy understanding of the information presented to farmers, coloured pictures showing farmers from other parts of the world using urine, crops fertilized with urine or without urine, crops treated with urine and other forms of fertilizer etc. (*see examples of photos in plate 5.1 below*) were shown to participants during each of the two presentations. After that participants were allowed to ask questions (*see box 5.1 for questions asked by farmers*) and answers were provided. Finally farmers were led as a group by the training team to visit the trial site which was also used during the subsequent training programme. A total of about 45 farmers participated in the training.

Plate 5.1: Photos showing lettuce fertilized with urine (a) and others produced with other form of fertilizer *(Photo credit: CREPA, Ouagadougou)*

Plate 5.2: Meeting with farmers on the benefits and risks of using urine as alternative source of fertilizer for crop production at Dzorwulu
(Photo credit: Philip Amoah and Noah Adamptey)

Box 5.1 Questions from farmers and MoFA staff and other key stakeholder

Farmers

1. Will any chemical be added to the urine before it is used?
2. Can the urine of other farm animal (sheep, goat, pigs) be used or only human urine?
3. Will farmers be willing to purchase urine?
4. Land has different soil characteristics, how will the experiment here cater for different soil characteristics on different land?
5. Inorganic fertilizer has different application rates and mode of application. What about urine fertilizer?
6. What are the possible problems to be encountered when urine is applied to soil with high salinity?

MoFA staff and other key stakeholders

1. How will the urine be collected?
2. Are there urine-diverted toilets in the country?
3. Is the project working with the Ministry of Health to look at their views concerning the use of urine fertilizer on public health?
4. Are the urine-diverted toilets designed to take care of both males and females?
5. What are the mode of application and the application rates of the urine fertilizer?
6. Are there guidelines for the use of urine as a source of fertilizer?
7. What can be done about the bad odour of urine on the farm?
8. Can urine used on the field as fertilizer drive away insects or attract them?
9. Urine in the villages have been used to trap rodents especially grasscutter. Will the urine fertilizer when applied attract these rodents to the farmer's crops or not?
10. What is the perception of farmers, marketers and consumers concerning the use of urine as fertilizer?

A similar training was organized for 25 Agricultural Extension Agents (AEAs) of the Ministry of Food and Agriculture (MoFA) and other key stakeholders on the 16th October, 2010(see plate 5.3). However, unlike the farmers two power point presentations on the benefits and risks of using urine as fertilizer were made. Each presentation was followed by a question and answer section.

Plate 5.2: Meeting with the extension staff of the Ministry of Food and Agriculture (MoFA), Accra on the benefits and risks of using urine in crop production
(Photo credit: Philip Amoah and Noah Adamptey)

5.2 The second training

A second training for only farmers was held on the 14th of December, 2009.. This was organized to demonstrate to farmers how urine (with or without other soil ameliorants) is applied, the effect on crop yield and on soil characteristics. A total of 35 farmers participated in this training.
The following were gathered prior to the training:

- Stored urine
- Other soil ameliorants e.g. poultry manure (PM), dewatered faecal sludge (DFS), inorganic fertilizer(NPK)
- Weighing scale
- Flip charts and sheets of paper for recording

The learning objectives were as follows:

- participants to know the correct method andrate of application of urine for crop production.

- participants to appreciate the effect of urine (with or without other soil ameliorants) on crop (yield, quality etc.).

- to register farmers to take part in a field demonstration on urine use on farmers own field.

At the start of the meeting participants were welcomed by the trainer after which they were registered. Participants were then given an overview of the day's agenda. The days training was introduced by recapping the issues discussed during the previous training (*see the first training*) and participants were allowed to ask questions for further clarification.

Information on urine application (*application rate with or without other fertilizer sources, application distance, time of application etc.*) was explained to participants. After that they were allowed to observe the urine and other forms of fertilizer used. The information used in this meeting was based on a field trial set out earlier by the research team (*see chapter four of this report for details*). The field trial (*See a short description in box 5.2)* was carried was carried out with one local farmer fully in charge of the day to day activities. Other farmers occasionally visited the site to observe what was happening.

Box 5.2: The field trial

Cabbages were grown on raised beds of size of approximately 3m^2. Each bed had a total number of 30 cabbages planted at approximately 0.25m intervals. For the trial the plot was divided into 3 blocks. Each block contained five beds making a total of 15. Using a randomized complete block design (RCBD), each of the five beds in a block was randomly allocated to one of five treatments. The five different treatments (including control) consisted of application of urine alone, urine + dewatered faecal sludge (DFS), urine + PM (poultry manure), PM + NPK, and soil alone (control). These treatments were applied to the beds two weeks after transplanting following farmers' usual practices. Before transplanting soil samples were collected from the beds for chemical analysis. The crops on a bed were irrigated once daily with approximately 30 litres of water every morning excluding rainy days.

Cabbages growing on beds at the trial plots *(See detailed results on this trial with appropriate scientific analysis in chapter four)*

After the explanation (followed by questions and answers), the farmers were taken to the urine experimental plot to observe the effect of the various treatments on the mature cabbage. This session was very practical because after physical observation of the various plots, they were allowed to harvest four randomly selected cabbage heads and weigh (see plate 5.3 below) the marketable portion to assist them make a choice of the treatment they prefer to use. After the session, the harvested vegetables were carried to the laboratory for further analysis (including nutrient uptake assessment, fresh and dry weight determination, counting the number of leaves per cabbage head per treatment etc.) to see how the laboratory results compare with the farmers choice (*results on this*

was used during the third and last training). After that the trainer summarized the main points discussed and farmers willing to use urine and/or other soil ameliorants were registered.

Plate 5.3 farmers measuring harvested cabbage heads during the training
(Photo credit: Philip Amoah)

5.3 The third training

The third training workshop which targeted a bigger audience to train and further disseminate the trial results was carried out in two days: a day each for farmers and Agricultural Extension Agents (AEAs) and other stakeholders.

Farmer training (Day 1)

A total of about 60 farmers consisting of 5 representatives each from selected vegetable growing sites in Accra plus 20 farmers from the Dzorwulu farming site (the urine demonstration site) participated in this training.

Agricultural Extension Agents (AEAs) and other stakeholders (Day II)

A total of about 40 people from selected organizations took part in this meeting. This include a representative each from the following organizations:

- The Environmental Protection Agency (EPA),
- Women in Agricultural Development (WIAD),
- Food and Drugs Board (FDB),
- Ghana Standard Board (GSB),
- The Metropolitan Health Directorate and
- The Ministry of Food and Agriculture (MoFA),

The rest were 23 Agricultural Extension Agents (AEAs) from Accra Metropolitan Assembly (AMA) plus 4 AESs from each of the nearby districts assemblies and 3 IWMI Researchers.

The learning objectives

On both occasions the learning objectives included the following:

- Participants will be aware of the potential of urine as a source of fertilizer for crop production (*Message 1: urine is a potential source of fertilizer*)
- Participants will understand how to minimize the health risk during the use of urine for crop production (*Message 2: potential health risk are manageable*)
- Participants will know rate of application of urine (to be applied alone on in combination with other sources of fertilizer) and methods of application for effective crop yield. (*Message 3: urine could be applied alone or combined with other forms of fertilizer*)
- Participants (especially farmers) will know how to modify of on-farm ponds could minimize risks associated with the use of wastewater for crop production.

What happened

The training sections were held separately on the 26th and 27th January, 2011 for farmers and other stakeholders, respectively (See plate 5.4 below). The methodology used included power point presentations, demonstrations and role plays. The presentations were on methods of application of urine and how to minimize potential risks associated with the urine, results from the on farm demonstrations carried out at Dzorwulu. After each of these presentations, participants were allowed to ask questions (see some questions below) for clarification. The questions asked opened up very fruitful discussion and gave more insight to the participants. The resource persons addressed all questions/issues raised and took note of suggestions from participants for consideration. At the end of the training participants were asked to give their remarks or generation impression about the entire training programme.

Plate 5.4 Photo showing AEAs from MoFA and other stakeholders and farmers during the training ***(Photo credit: Philip Amoah)***

Box 5.2 Questions asked

Farmers

- The waste management Department has septic tank operators who dump faecal sludge and urine indiscriminately into the environment. How best can we put the mixed toilet and urine into good use?
- What should be the planting distance(in this case cabbage) when using undiluted urine?
- If crops are cultivated using the broadcasting method (not row planting) which is very common among farmers, how can the urine be applied?
- Is urine applied only to vegetables?
- How does the use of urine help reduce carbon emission?
- Urine may have different chemical composition depending on the source. Has the project taken into consideration the health implications on the consumers of urine fertilized vegetables?
- Does the farmer need to know the moisture level of the soil before fertilization with either diluted or undiluted urine?
- After storage for 1 month, will the nutrients in the urine be available for the crops?
- Is it proven that after storage for 1 month there will be no health implications to the consumer?
- Has the pharmaceutical contents of the urine been considered? If no will it be advisable to encourage farmers to start urine fertilization?
- The chemical composition of urine shown suggests that there is low level of phosphorus. Do farmers need to supplement the soil with phosphorus fertilizers?
- Did the project consider different ratios (urine-water ratio) to benefit other plants?

AEAs and other stakeholders

- What mechanisms do you have in place such that detergents and disinfectants are not found in the urine?
- What is the best form of storage material since polytanks have hydrocarbons which can easily be dissolved into the urine?
- What goes into pretreatment of urine?
- Can urine be applied during land preparation phase?

5.4 Results and lessons learnt

5.4.1 The introductory meeting

The level of participation in the first training programme was very high. The participants were very happy to receive this training. This was evident from the enthusiasm with which the participants from both groups asked questions. During the first training farmers and the Agricultural Extension Agents (AESs) from the Ministry of Food and Agriculture showed different concerns on the use of urine in crop production. Farmers wanted to know more about how they can receive a regular supply of urine, how to obtain storage facilities, the mode and the different application rates for the various crops and different soil types (especially sandy soil) as well as the effect on soil characteristics[5]. These questions were directly related to their farming activities and how the urine can be used effectively. Concerns were also raised about the use of using urine and the fear of being ridiculed for using urine as fertilizer, since it is perceived to be unhygienic. Religion was also an issue among the Moslem farmers who saw urine as unclean.

The extension staff on the other hand was more concerned about the possibility of collecting urine in substantial quantities. They expected that high volumes of urine will be required for production. Other concerns raised were safety issues related to the use of urine for farmers and consumers, guidelines on the use of urine, willingness of the farmers to use urine, the societal readiness to market and consume urine products. There are always varied fears and concerns surrounding handling of human excreta and urine. This was evident from the questions and comments made by most of the participants which pre supposes that more awareness campaigns would be required erase the negative perception some farmers and non-farmers have.

Most of the questions asked were answered by the resource persons. However, some few questions were deferred to a later date when appropriate answers are expected to be ready. For example, on the rate of application of urine, farmers were referred to the experimental set up on the field which was designed to address this and other relevant issues. The two groups expressed interests to see the outcome of the field trial.

5.4.2 second training

Like the previous training the level of enthusiasm of the participants was very high. The participatory approach used made is easier for the farmers to identify which of the treatments had a better impact on the yield and growth characteristics of cabbage. this made it easier for them to choose which type of fertilizer had the best impact on the crops and what will be applied on tried on their own farms. Questions from the previous training (e.g. the rate of application of urine) which were deferred pending results from the field trial were answered.

[5] This was addressed in subsequent training

Most (about 60%) of the farmers who were prepared to use urine for crop production chose Urine + Poultry Dropping which gave a relatively high yield and low number of rotten cabbage heads. None of them said that they will use NPK and poultry droppings (PD) Even though that was the normal farmer practice. This combination (NPK and PD) recorded the highest number of rotten cabbage heads.

Table 5.1 shows simplified results (see *detailed results presented in chapter 4 above*) of the observation and weighing exercise carried out by farmers during the training.

Table 5.1: Fresh weight of cabbage and the number of rotten cabbage heads

Treatment	No of cabbage per bed	No of rotten cabbage head	Weight of cabbage head (g)
Urine alone	28	4	900
Urine + PD	28	5	1000
Urine + DFS	29	7	900
NPK + PD	23	16	1040
Soil alone	17	6	700

From the discussions after the presentations it was obvious that participants were happy but would need more training and awareness creation to

5.4.3 Third training

Farmers who participated in the training were happy to be trained on the use of urine as a source of fertilizer for crop production. This was more evident from the participants who joined the training for the first time. Similar observations were made in the agricultural extension agents and other stakeholder. The questions asked by both groups indicated that they were prepared to know more about urine and its use for crop production. It was evident from the questions asked that a lot more work needs to be done to ensure that enough information on urine use is made available for potential users. For example there is the need to conduct these trials on different soils and in different regions and also on different crops since some conclusions drawn from the trials conducted cannot be generalized. A simplified user manual on the methods and use of urine was suggested since this is new to many farmers especially those who were not part of the previous training. This will also make it easier for more Agricultural extension staff to be trained and scale up the use of urine by farmers in other areas.
Concerns raised about the pharmaceutical residues in urine and the potential impact on consumer and this needs to be investigated. Detailed research and laboratory analysis of urine would be required to confirm or other the presence and quantities of the pharmaceutical residues. Other concerns raised which would need further and research is the bad odour of urine and how to reduce it. Suggestions were also made to look at the possibility of converting urine and other sources (PD, DFS etc) into of pellets for easy application

Chapter 6

General conclusions and recommendations

Socioeconomic part

The demo project has revealed that:

- Considering the logistic needs which include collection, storage and treatment, transportation of urine and also labour requirements etc. it is concluded that investment in urine to be used for fertilization purposes is capital intensive and would require a high initial capital for any potential investor. The required administrative and managerial competence for the operation of the urine collection and reuse system can all be found in the Central Business District of the Accra Metropolitan Assembly

- The volumes of urine generated by the urinals in the Central Business District of Accra far exceed what would be required for urban vegetable farming. It is estimated that about 5,000m^3 of urine is generated yearly from these urinals as against 2,000m^3 which would be required for urban vegetable farming.

- The cost-benefit analysis study showed that both a profit-oriented entrepreneur and the Accra Metropolitan Assembly (AMA) (Public ownership) who would wish to enter into such a business would not be successful if it is considered that the operation will last 20 years and the discount rate is 25% with a urine user fee of GH¢ 0.05 and sale of urine to farmers at GH¢0.30 per jerry-can (20 litres). However it is feasible for operation by both a private entrepreneur and for public ownership if they charge a urine user fee of GH¢ 0.10. The payback periods of 5 and 3 years were calculated for the private entrepreneur and the public ownership, respectively if they charge a user fee of GH¢ 0.10.

- In one cropping cycle which is normally 3 month, a cabbage farmer with an average farm size of 0.02ha would make a savings of about GH¢ 25 when they purchase and use sanitized urine as an alternative to the chemical fertiliser (NPK).

- Many farmers (>80%) perceive human urine to contain plant nutrients and that it should not be disposed off as municipal waste and about 80% of them were willing to handle human urine as an alternative fertilizer. About 90% of the farmers were more willing to embrace the urine technology to help improve their yield and that religion and norm in the society would not be an impediment to their use of the urine technology. However, the continuous use of urine by farmers would depend on the patronage of u-vegetables by consumers and marketers.

- The study concludes that marketers do not view human urine as a resource and their decision to buy u-vegetables or not is not backed by religion but rather norms in the society and possible health risk associated with the use of human urine for

vegetable production on consumers. Most marketers do not want human urine to come close to any farm activity. They, unlike the farmers believe that urine has no nutrient value to be used for vegetable production. The perceived health risks on consumers were also cited and that many consumers would not patronize their produce. Some of them will look for alternative places other than Accra to buy vegetables if the ones produced in Accra are fertilized with human urine. Marketers were not willing to buy u-vegetables at a higher price than the conventional ones.

- Some marketers however identified 1) the potential reduction in cost of vegetables if urine, instead of inorganic fertilizer, is used in for production as why they are in favour of the use of urine, 2) the perceived medicinal value inherent in human urine and 3) the long lifespan of organic produce were cited as the main reasons why they would encourage farmers to use human urine as an alternative fertilizer on vegetables.

- The consumers' perception study showed that some consumers (56%) do not want human urine to be disposed off as a municipal waste, although they (72%) could not tell what is in human urine that makes it a resource. Meanwhile, about 44% of the consumers were willing to buy u-vegetables as obtained from the PCA. These were people who perceive urine as a resource and their consumption of u-vegetables is independent of religious influence and norm in the society. The reasons they gave included lack of alternative source of vegetables and their inability to guarantee the safety of the conventional vegetables on the market because the market women would not disclose the source of the produce to them. However, consumers mentioned a perceived health risk associated with the consumption of u-vegetables as a major concern that can influence their choice to consume u-vegetables. None of the consumers was able to mention a specific disease associated with consumption of u-vegetables. Socio-economic characteristics of consumers who were willing to consume u-vegetables was however not different from those who would not consume. The main conclusion drawn is that consumers were willing to buy u-vegetables but more concerned about the possible health effects of u-vegetables consumption.

- The farmer probit estimation showed that perception about urine quality, gender, mode of soil conservation, location and soil condition positively affected farmers' willingness to adopt the urine technology. The study concludes that farmers with positive perception about urine quality will adopt the technology. The probability that male farmers will be willing to adopt the urine technology will increase by 26% more than females. Young farmers will be more willing to adopt the technology than the elderly. Farmers who use organic fertilizers probability of using the urine technology are higher than those who do not use organic fertilizers by 0.06. Indeed, farmers with perceived good soil conditions will increase their adoption of the urine technology by 14% relative to their colleagues with perceived poor soil conditions.

- The marketer probit model estimation found that marketers' willingness to buy u-vegetables was influenced by their perception, gender, norm and religious influence.

A unit increase in a marketer's urine perception index increases the probability of willingness to buy u-vegetables by 0.03. Probability of willingness to buy u-vegetables was highest among marketer's whose religious beliefs is not against the use of human urine for vegetable production than those whose religious belief is against human urine use on vegetable production by 0.585. Female marketers' willingness to buy u-vegetables is higher than male marketers by 48% even if the cultural situation surrounding their communities is against the use of human urine for vegetable production.

- The consumer probit estimation also revealed that a 1% increase in consumer's income will lead to 11% decrease in consumer's willingness to buy u-vegetables. Consumers with alternative source of buying vegetables willingness to buy u-vegetables will decrease by 35 percent relative to consumers with no alternative source. However, a positive consumer perception about urine will increase his/her willingness to consume u-vegetables by 2.4%.

- The study also observed some potential barriers that can impede the successful introduction of the use of human urine on vegetables. These include (no order): The health effects (the perceived health risk of urine use and effect of misapplication by farmers), socio-cultural perceptions (opposition from the religious groups, traditional councils and media), environmental effects (perceived effect of continuous use of the human urine on plants and the soil), technical know-how (lack of knowledge on application rate and mode of application, urine availability, rodent attack, urine effect on different climatic conditions, and so on) and economic effects (would it be profitable - the price that the urine would be sold).

Agronomic part

- The results suggest that urine with poultry droppings (PD) or dewatered faecal sludge (DFS) could be used as a good substitute for NPK + PD (farmer practice) for cabbage cultivation. Although the amounts of applied N were similar for all the fertilizer treatments, the cabbage yield and above ground dry matter yield were highest in the Urine + PD treatment possibly due to high nutrient uptake. Urine treated plots had reduced percentage rottenness of cabbage between 20% and 28% compared to 58% farmer practice (NPK + PD) in the first trial. Soil residual nitrogen content for Urine + DFS and Urine + PD were significantly ($P < 0.05$) higher than that of NPK + PD. Even though urine could be an alternative source of nutrients for crop production applying it in combination with other organic fertilizer e.g. poultry drippings or dewatered faecal sludge produce better results confirming the fertilizer value of Urine + DFS, and Urine + PD.

- The findings from this study have important implications. They may contribute to the development of positive attitudes about the use of Urine + PD or Urine + DFS as fertilizer - a way to increase crop yield and reduce water pollution. In addition, results may contribute to optimize the use of Urine + PD or Urine + DFS to fertilize crops,

which will help to maintain cabbage quality, improve soil characteristics, and to control N emission from the waste materials as well as reducing the demand for industrial fertilizer to some extent, thus reducing the environmental pollution released during fertilizer manufacturing and transportation. However, the authors recommend that the research should be repeated on different soils in different locations to confirm the conclusions made. Detail research should also be conducted on the effect of the treatments on rottenness of cabbage head, leaching of nitrate, and soil electrical conductivity.

Recommendations

Based on the findings from the study and questions asked by participants during the training exercise it can be recommended that further studies should be conducted in the following areas

- The research should be repeated on different soils in different locations to confirm the conclusions made.
- More research on the levels of pharmaceuticals and hormones in urine and its transformation through the soil and to plants
- Detail research should also be conducted on the effect of the treatments on rottenness of cabbage head, possible leaching of nitrate, and soil electrical conductivity
- The effect of urine on soil characteristics over a successive cropping season will be require further research since urine, for example has a relatively high amount of salt.
- More research on how to reduce the scent associated with urine and how to concentrate the nutrients will be required.
- More work on the logistical requirements for a successful business in the use of urine will be useful for potential entrepreneur.
- Further training and awareness creation would be required to improve the knowledge and skills of all stakeholders and to upscale the use of urine as a source of fertilizer in agriculture.

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Appendices

Appendix 1

SESSION PLAN

Name (main topic) of the session: Introducing urine as a source of nutrient for crop production

Planned date(s): 13th and 14th October, 2009
Planned location(s): Dzorwulu/Roman Ridge Vegetable Farms
Facilitator: Philip Amoah
Resource person: Noah Adamtey

Learning objectives of this meeting:

1. Participants to be aware of the benefits of urine as a source of nutrient for crop production (***Message: urine is a good source of nutrients and safe to be used for crop production***)
2. Participants to know the risk associated with the use of urine for crop production (urine could be harmful but safe for crop production if handled well)

Timing	**Topics/main learning points**	**Trainer activities**	**Participants activities**	**Materials needed**
9:00 – 9:15	Start of the meeting	Trainer welcomes participants Registration of participants Provides overview of agenda	Participants do self registration or assisted by training team	Flip charts Markers
9:15 – 10:00	Background information about the urine demonstration	Trainers present the background information about the demo and expected output. *(N.B. trainers to make this session as practical as possible through the use of pictures etc)*	Participants discussions through Q and A	Flip charts Markers (Beamer for ppt presentation. MoFA and other stakeholders training)
10:00–10:45	Participants to know the benefits of urine as a source of nutrient for crop production *(Message: urine is a good source of nutrients and safe to be used for crop production)*	Trainer presents benefits of the use of urine for crop production. *(N.B. trainers to make this session as practical as possible through the use of pictures etc)*	Participants discussions through Q and A	Flip charts Markers
10:45–	Participants to			

11:30	know the risk associated with the use of urine for crop production (***Message:*** *urine could be harmful but safe for crop production if handled well*	Trainer presents risks of the use of urine for crop production. *(N.B. trainers to make this session as practical as possible through the use of pictures etc)*	Participants discussions through Q and A	Flip charts Markers (Beamer for ppt presentation. MoFA and other stakeholders training)
11:30–12:15	Summary	Trainers summarizes the main points discussed.		Flip charts Markers

Appendix 2

SESSION PLANNING

Name (main topic) of the session: Urine application and its effect on crop yield

Planned date(s): 10th December, 2009

Planned location(s): Dzorwulu/Roman Ridge Vegetable Farms

Resource person: Noah Adamtey

Learning objectives of this meeting:

1. Participants to know the correct method of application of urine for crop production
2. Participants to appreciate the effect of urine (with or without other soil ameliorants) on crop (yield, quality etc)
3. Register farmers to take part in urine demonstration

Timing	Topics/main learning points	Trainer activities	Participants activities	Materials needed
9:00 – 9:15	Start of the meeting	Trainer welcomes participants Registration of participants Provides overview of agenda	Participants do self registration or assisted by training team	Flip charts Markers
9:00 – 9:30	Previous lessons recapped	Trainer introduces the days training by recapping the issues raised during the previous training	Participants to ask questions for better understanding	Flip charts Markers
9:30–10:15	Information on rate of urine application etc (*to be based on quantities of urine applied, application distance from crop, application with or without manure etc during the demo*)	Trainers present the background information about the demo and expected output. *(N.B. trainers to demonstrate these activities with the farmers on the field)*	Participants discussions through Q and A	Flip charts Markers Urine and other manure (poultry manure, comlizer)
10:15– 11:00	Participants to deepen their knowledge by asking question for further clarification	Trainer addresses related questions and further clarifies issues raised. *(N.B. trainers to make this session as practical as possible through the use of pictures etc)*	Participants discussions through Q and A	Flip charts Markers

11:00– 11:45	Participants to know the impact of urine use on crop yield	Trainer guides the participant to make direct observation of treated crops and explain the various treatments and their effect on crops to the farmers. *(N.B. trainers to make this session as practical as possible through the use of pictures etc)*	Participants discussions through Q and A Participants allowed to take some measurements (height, weight circumference of head etc) and compare various treatments to appreciate the impact on the yield	Flip charts Measuring devices (weighing scale, measuring tape/ruler) Markers
11:45– 12:15	Summary	Trainer summarizes the main points discussed.		Flip charts Markers

Appendix 3

SESSION PLAN

Name (main topic) of the session: Urine application and its effect on crop yield (2)

Planned date(s): 23rd March, 2010

Planned location(s): Dzorwulu/Roman Ridge Vegetable Farms

Facilitator: Philip Amoah

Resource person: Noah Adamtey

Learning objectives of this meeting:

- Participants to appreciate the effect of urine (with or without other soil ameliorants) on crop (yield, quality etc)
- Registered farmers to know the correct methods of application through practice
- Registration of new farmers

Timing	Topics/main learning points	Trainer activities	Participants activities	Materials needed
9:00 – 9:15	Start of the meeting	Trainer welcomes participants Registration of participants Provides overview of agenda	Participants do self registration or assisted by training team	Flip charts Markers
9:00 – 9:30	Previous lessons recapped	Trainer introduces the days training by recapping the issues raised during the previous training	Participants to ask questions for better understanding	Flip charts Markers
9:30–10:15	Results of the urine trial and farmers selection as against lab results	Trainer presents the results of the previous training. He compares farmers selection and results from the lab - *which includes numbers of leaves countered from each treatment*) *(Trainers explains how the lab results were obtained before comparing the two)*	Participants discussions through Q and A	Flip charts Markers Urine and other manure (poultry manure, comlizer)
10:15– 12:00	Correct application of urine and other	Trainer demonstrates the various application rates to the group After that he guides **each** of	Participants discussions through Q and A	Flip charts Markers Urine and other manure (poultry

	inputs	the registered farmers to apply the selected input on their own farms and also addresses related questions and further clarifies issues raised on individual basis. (*this section may be extended to the following day if all registered farmers are not covered*)	Farmers do the application on their own farms and asks question for clarification	manure, comlizer)
12:00– 12:15	Summary	Group reconvenes (*if all registered farmers are guided to apply the input(s) in time*) and trainer summarizes the main points discussed.		Flip charts Markers