

CLOSING THE LOOP BETWEEN SANITATION AND AGRICULTURE IN ACCRA, GHANA.

(Improving yields in urban agriculture by using urine as a fertilizer and drivers & barriers for scaling-up)



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Preface

This thesis report on closing the loop between sanitation and agriculture in the city of Accra is the final part of my study programme of M.Sc in Urban Environmental Management at the Wageningen University. I was first drawn to this issue when I heard people talking about this alternative sanitation technology and proclaiming it to be the panacea for all the sanitary and food security needs of people in the developing countries who lack access to these two basic needs of humanity. So for five months I spent time at the Shimo la Tewa prisons in Mombasa, Kenya familiarising myself on how the system will work in a typical situation in Africa. Some of the facts that I stumbled upon made me to realise that the subject have not been fully researched into. I was therefore happy when I was approached by SWITCH to research into the drivers & barriers for scaling-up that urine faces as an alternative fertilizer in urban agriculture in Accra. This thesis is therefore meant to contribute to SWITCH theme 4.1 which among other things seek to develop and demonstrate pollution prevention-based approaches to wastewater handling in urban areas in which concentrated waste flows are separately collected and treated.

Ecological sanitation has been promoted as offering a new philosophy of dealing with what is presently regarded as municipal waste. It therefore presents a paradigm shift from the present conventional system which sees municipal waste as a health hazard. But in the selection of a system for a given situation, four main factors are normally taken into consideration. These are the technical performance of the artifact, the social acceptability; the environmental impact expected from the said artefact as well its economic performance. For a very long time so much attention has been focused on the technical, social and environmental performance of Ecosan products without touching on the economic aspect. But most business men go into business first and foremost to make profit. So I believe that, if Ecosan is to attract the interest of the business community then equal attention should be given to the economic performance as well. This thesis is therefore meant to touch this area and stimulate more research into it.

In the course of this research, a large amount and diversity of sources were accessed in order to come to a balanced picture of the drivers and barriers towards the up scaling of the technology. This does not preclude the possibility that generalisations or simplifications are sometimes made amiss. In the case of comparing the cost between the three types of fertilizer used in urban agriculture in Accra for instance, I must admit that environmental cost was not taken into consideration. If such a cost was taken into consideration, then perhaps the real cost of urine harvesting would be much cheaper than what was provided for.

I would like to thank my supervisors at Wageningen University Dr. Adriaan Mels and Claudia Agudelo who stimulated my interest in the area. Ing. Ruud Kampf and Mr. Sjef Ernes of Aqua for All who sustained my interest in the subject, Dr. Pay Drechsel, Mr. Larbi and Dr. Cofie of IWMI (Ghana Office), SWITCH team members Ms. Dartey and Prof. Esi Awuah who assisted me immensely in my work and finally Ms. Bendera and Mr Mwanguni of CDA, Kenya who offered me the opportunity to use their office and gave me some very useful insights when I was in Mombasa, Kenya.

Summary

Accra like most cities in the developing world is experiencing rapid population growth and urbanization. This rapid urbanization has brought about urban poverty, food insecurity and severe environmental degradation. Urban agriculture is now a predominate feature within the urban ecological system but it is confronted with many challenges key amongst them is the high cost of mineral fertilizers which has led to the search for alternative fertilizers. Meanwhile the majority of the city's populace uses the public toilet as their main means of sanitation making these places a potential source of nutrients production for urban agriculture in Accra in the form of human excreta and urine. The value of human urine as nutrient is well known amongst some of the farmers and its application has been advocated on many platforms on sustainable sanitation worldwide but its implementation on a wide scale virtually remains unknown.

This thesis project was therefore aimed at addressing this problem by analysing whether there is a market and market acceptance for urine as a fertilizer and investigating how a demonstration for this approach could be up scaled. The thesis was therefore divided into two parts. The first part was a technical study and was aimed at finding out if the financial benefits of the system achieved by the increase in crop yield by urine fertilization will be able to finance the cost of operating the system. Whilst the second part which was a social study was aimed at addressing how the technology could be up scaled from a demonstration phase to a larger scale using the theories of transitional management. During the technical study, the research tools that were used included the review of literature and field visits from where the infrastructure was designed and estimates prepared. This led to the health and economic implications of urine usage. Similarly in the social study, literature was also reviewed and the existing policies with regard to the usage of municipal waste was also analysed. In addition to this a stakeholder analysis was also conducted to determine those who really matter in urban agriculture. Structured and unstructured interviews were conducted with these stakeholders to determine their perception about urine usage and application in urban agriculture.

Urine is by far the highest nutrient contributor to the household waste. It accounts for 87% of the nitrogen, 50% of the phosphorous and 54% of the potassium in the household waste water stream. Every year an average individual excretes about 500 litres of urine. Taking the population that uses the public toilet in Accra this means that every year 1064 tons of nitrogen, 70.93 tons of phosphorous and 294.4 tons of potassium could be obtained yearly from these toilets. This is far in excess of the urban agricultural demand in Accra. Meanwhile urine is a safe and effective fertilizer as all the nutrients that exist in it are in forms that are readily available to the plants. Plant yield with crops fertilize with urine is between 2 to 6 times higher than plants not fertilized at all and very comparable with plants fertilized with mineral fertilizer. Storage is a simple and effective way for sanitizing urine as almost all the pathogen dies off within that period. The storage period should be between one to six month under a high temperature depending on where the urine was harvested and also for what crops it will be used for.

Comparative cost analysis conducted on the field based on the current economic prices (without considering the other factors such as environmental and other related costs) indicated that urine harvesting is the most expensive among all the other known fertilizers such as mineral fertilizers and poultry manure. On the social level, there is virtually no law against the use of urine or indeed municipal waste in general for

agriculture except an AMA bye-law which prohibits the use of drain water for irrigation. Additionally almost all the stakeholders who were interviewed were favourably disposed towards the use of urine in urban agriculture except the fertilizer companies and an exporter who feared that all the issues relating to its usage has not fully been researched into. In spite of this, urine application remains at the beginning of the pre-development stage as it is not even on the agenda of even the innovative thinkers although it is being practiced on a pilot basis at the Valley View University.

The harvesting and consequent application of urine on the field will produce a win-win situation for both the city managers and the urban farmer. The city managers will benefit as there will be a reduction in the volume of nutrients entering the water bodies whilst the urban farmer will also benefit by getting a readily available alternative fertilizer. But the technology is expensive as substantial initial capital is needed for the provision of infrastructure for the storage. Furthermore, a reliable transportation system is required to transport urine from the storage to the farm site. Comparatively urine is the least attractive alternative fertilizer to the farmer as the cost of bringing it to site is far more expensive than the cost of the existing fertilizers such as mineral fertilizers and poultry manure.

This notwithstanding however, the socio-technical regime is warm as those in the urban agricultural sector are looking for an alternative fertilizer as a result of the high cost of the mineral fertilizers. On the other hand, the regime of urban sanitation is also looking for a logical means of waste disposal and they see the agricultural sector as the most likely candidates. There are several niches on the ground still experimenting with the idea of alternative fertilizers but none of them is as yet strong enough to break into the socio-technical regime where the mineral fertilizer still dominates. The Valley View University which currently practices urine application on a pilot level cannot be considered as a transitional arena as it is far removed from the urban agricultural setting. The lack of a transitional arena as well as issues relating to contaminants in urine and its rightful application and the high cost of the product constitutes a barrier to up scaling although the search for a cheaper fertilizer and a logical way of waste disposal still continues to be the drivers.

It is therefore been recommended that having identified urine as the major cause of eutrophication among the household wastewater, a policy should be formulated and enforced against the discharge of such large volumes of urine (particularly those coming from the public toilets and public urinals) into the urban wastewater stream. This policy should compel the urinal and toilet operators to collect and dispose of their urine separately. Where there is already a kind of agreement existing such as the case between the WMD and the urinal operator at the Central Business District this should be enforced to the letter. In addition to this policy, those operators who collect their urine separately and dispose it as such should be motivated by providing incentives such as tax rebate and a reduction in the commission they pay to the assembly.

Again, the collection of the urine to the farm should not be left into the hands of the suction trucks operated by the septic tank operators. Instead an entrepreneur should be found to invest into the purchase of a truck which will deal exclusively in the transportation of urine. An ordinary pickup truck mounted with a tank could be alright at the initial stages.

In view of the fact that the cost of transportation of the urine is too high, farmers should be encouraged to store the urine on the farm site. In this case, the urinal entrepreneur delivers the urine when it is needed on the farm site and dispose of it when it is not required. In this situation, the operational cost to the farmer is then erased as the urine entrepreneur will now consider these farms as an extension of his disposal site.

Furthermore, research should be intensive into the concentration of urine without the urine losing any of its nutrients. For instance, if urine could be concentrated by a factor of 5, then the nitrogen level will rise to 15 grams per litre. This means that for the same volume of 7500 litres of urine, the farmer gets an equivalent of 5 bags of urea which will currently cost GH ¢220 or 5 tons of poultry manure which will cost GH¢82.50. This will really make urine competitive provided the cost of concentration does not rise abnormally.

Additionally, transitional arena should be built around the technology. Such a transitional arena should include members from the government agencies such as the Department of Food and Agriculture, the AMA Waste Management Department, the AMA Planning & Coordinating Department, Metropolitan Environmental Health Unit, the Town & Country Planning, the Ministry of Trade and Industry, the Ghana Standard Board, the Environmental Protection Agency, the Food and Drugs Board. From the research institutions organisations such as IWMI and CSIR – STEPRI would be helpful. Other local organizations such as the various farmers association, the Vegetable Producers and Exporters association and the Market Women would be handy. Other organizations such as the FAO, GTZ, CRS, ADRA, Action AID and People's Dialogue would also be needed. The media would also come in handy and last but not the least the urinal and toilet entrepreneurs. The Valley View University farm can still serve as an experimental base for future development but more importantly a demonstration farm should be cited in one of the urban farms.

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List of Abbreviations

ADRA	Adventist Development and Relief Agency
AMA	Accra Metropolitan Assembly
CBD	Central Business District
CRS	Catholic Relief Services
CSIR-STEPRI	Council for Scientific & Industrial Research Science and Technology Policy Research Institute
DESAR	Decentralised Sanitation
Ecosan	Ecological Sanitation
FAO	Food and Agricultural Organization
GEPC	Ghana Export Promotion Council
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IWMI	International Water and Management Institute
KVIP	Kumasi Ventilated Improved Latrine
MOFA	Ministry of Food and Agriculture
NGO	Non Governmental Organisation
SWITCH	Sustainable Water management Improving Tomorrow's Cities' Health
UA	Urban Agriculture
UASB	Up-flow Anaerobic Sludge Blanket
VVU	Valley View University
WHO	World Health Organisation
WMD	Waste Management Department

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1. INTRODUCTION

1.1. *Background of the Study*

Accra like most cities in the developing world is experiencing rapid population growth and urbanization. According to the 2000 Population and Housing census the population the city is about 1.6 million with the functional population that comes into the city daily ranging between 3.0-3.4 million people. The population growth rate within the city centre is about 3.4% per annum extending up to 9.2% within its peri-urban settings. Currently, the population density of the city is 82.9 persons per hectare. With such a growth rate, Accra is today one of the most populated and fastest growing metropolis in Africa. (GSS, 2002, De Silva, 2007, Obuobie et.al, 2006 & AMA, 2006). This rapid population growth rate is mainly due to migration which accounts for 35% of the said growth. The migration pattern is also due to concentration of industries and businesses in the city at the expense of other locations in the country. As a result of this, the city attracts many rural dwellers that come to the city in search of formal employment within these businesses and industries.

This rapid population growth rate has brought about urban poverty and food insecurity. Additionally, severe environmental degradation and hygienic problems are also now rampant in the city as a result of the lack of adequate infrastructure to cater for this alarming population increase.

It is estimated that by 2020, about 40-45% of the poor in Africa and Asia will be concentrated in towns and cities. Most cities in the developing world have great difficulties coping with this development as they are unable to create sufficient formal employment opportunities for the poor. These cities also have increasing problems with the disposal of urban waste and waste water and maintaining air and river water quality (RUAF, 2006). These developments are serious challenges that are confronting these cities as they will bring about the increase in the number of slum dwellers as well as the further deterioration in their livelihoods. This will ultimately lead to severe hunger and malnutrition among these people.

Already, the demand for food and other agricultural products in the city of Accra is high. This is because the rural population (which hitherto where the bread basket of the city) is unable to supply the city's food demand. This is due to the migration of the would-be farmers to the city in search of other forms of employment. This gap in food shortage and the resulting high prices has therefore led to an increasing number of city dwellers resorting to urban agriculture. It is estimated that up to 90% of fresh vegetable consumed within the city comes from within its own boundaries (Cencosad 1994). Urban agriculture is therefore contributing greatly to food supply; employment creation and livelihood support in the city and has now become a part of the urban ecological system as it is playing an important role within the urban environmental management system.

Unfortunately many urban farmers as a result of the high cost of synthetic agricultural inputs have resorted to unorthodox farming practices. Key among this is the irrigation of crops particularly vegetables with urban run-offs from drains (Obirih-Opareh & Otchere-Larbi, 2007). This development is unfortunate as the application of untreated or inadequately treated wastewater and excreta on crops have been associated with the transmission and elevated prevalence of intestinal helminth infections (Fewtrell and Bartram 2001).

The choice between an expensive synthetic fertilizer on one hand and a free but polluted and potentially disease causing irrigated water stream is one of the challenges facing urban agriculture in Accra today. Ecological sanitation which seeks to solve sanitation problems more sustainably and efficiently could form an answer here. This approach seeks to close the loop between sanitation and agriculture by producing a win-win situation for the city authorities who are burdened with the unpleasant sanitary situation and the urban farmers who is in search of alternative fertilizer.

An assessment of the sanitary situation in the city of Accra indicates that up to 32.7% of households use public toilets as their main means of sanitation (GSS, 2002). Although such toilets were initially meant for the commuter population and its construction was mostly encouraged in places such as bus stops and markets it has become a predominate feature in most of the densely populated informal settlements within the city. Even though public toilets do not count for improved sanitation in the Millennium Development Goal no. 7 (WHO/UNICEF, 2005) the reality is that it is serving and will continue to serve the sanitary needs of a considerable number of people, more so as the population in the city continues to rise.

Instead of seeing these public toilets as a nuisance, they could also be turned into centres of nutrient production. This would result in reducing the pollution and the degradation of the environment which is so pervasive today. This line of thought in the management of public toilets is in line with the aim of the SWITCH project. Theme 4.1 of this EU funded research and demonstration project seeks to achieve a paradigm shift in urban water management in order to get sustainable, effective and safe urban water systems.

SWITCH (Sustainable Water management Improving Tomorrow's Cities' Health) has recognised that one of the challenges facing technical innovations is the up scaling of technologies. Many of the success stories that have been recorded in the sector remains as islands of isolation. This is principally due to the fact that such innovations have not been institutionalized. Learning Alliances are believed to help address this problem and facilitate the uptake of innovations. Smits et al 2007 define learning alliance as "a series of connected multi-stakeholder platforms at institutional level involved in innovations in an area of common interest and it's scaling up". Scaling up is achieved in two dimensions. There is a vertical scaling up as well as a horizontal scaling up. Vertical scaling up occurs when an innovation is adopted from a community level, through an intermediate or regional level to national level whilst horizontal scaling up occurs when there is a geographical spread to more communities and people (Gundel et al 2001).

This approach has brought together multiple stakeholders in areas such as implementation, policy, regulation, research and learning as well as dissemination and documentation in order to upscale technologies. Worldwide SWITCH is implemented by a consortium of 32 organisations including two organisations from Ghana. The findings of this MSc. work will therefore form part of the lessons to be learnt within the SWITCH learning alliances of Accra and other cities within the consortium.

1.2. Problem Statement

Urban agriculture is one of the key employment sectors in Accra. However, one of the factors threatening this sector is the high costs of mineral fertilisers. Human urine has been identified as having a comparable fertilizing value compared to synthetic

fertilizers. Its application has however remained at the pilot scale and its performance in the field particularly in Accra remains virtually unknown. This thesis project aims to address this problem by analysing whether there is a market and market acceptance for urine as a fertilizer and investigating how a demonstration for this approach could be up scaled.

1.3. Justification of the Study

Urbanization coupled with rapid population growth has resulted in the creation of public toilets within the Accra Metropolitan Assembly. Many of the households within the metropolis have no access to their own means of sanitation. They have therefore resorted to the use of public toilets. The public toilets in Accra therefore constitute one of the greatest points of human waste discharge. Unfortunately, most of the wastewater and waste flows from these toilets go, mostly untreated, into the cities' drains and environment thereby polluting ground and surface water sources.

It is known that such uncontrolled dumping of wastewater into the environment, particularly into water bodies, ends up in eutrophication of these water bodies. Eutrophication is normally the result of nutrient pollution caused by factors such as the release of sewage effluent into natural waters. It generally promotes algae growth and causes severe reduction in water quality. In aquatic environments, enhanced growth of these algae disrupts normal functioning of the ecosystem, causing a variety of problems such as a lack of oxygen in the water needed for fishes to survive. Eutrophication also decreases the resource value of rivers, lakes, and estuaries because their recreational, fishing, hunting and aesthetic enjoyment are hindered. Health-related problems can also occur where eutrophic conditions interfere with drinking water extraction. This is exactly the case in Accra where most of the wastewater is released untreated into the Korle Lagoon which is an outlet of the Odaw River. The Odaw River passes through most of the urbanised part of Accra and serves as a cesspool for many households. These households release their waste and wastewater into this water body, resulting in the lagoon becoming one of the most polluted water bodies on the planet. This pollution has seriously disrupted the natural ecology of the lagoon (Boadi and Kuitunen, 2002). Meanwhile, instead of addressing the root cause of this pollution (which is mainly the waste and wastewater from households and industries); millions of dollars are being spent on an end of pipe solution in a restoration project for this lagoon.

Urine is by far the greatest contributor of nutrients into the household water stream. Several studies have also shown that up to 87% of the total Nitrogen, 50% of the total Phosphorous and 54% of potassium load in municipal wastewater originates from urine (Larsen & Gujer, 1996; Hanaeus et al 1997 and Wilsenach & Loosdrecht, 2000). It therefore stands to reason that by merely separating urine from the wastewater stream, eutrophication will be reduced. The separated urine could then be used as fertilizer in urban agriculture which is a major source of employment for many of the urban unemployed.

Urban agriculture in the city faces many challenges. Like many other countries in Africa, the fertility of the soil in the city is low. This now constitutes a fundamental impediment to increasing agricultural output as most of these farmers work on soils which are poor, degraded and nutrient depleted. These soils lack available nutrients such as nitrogen, phosphorus, sulphur, magnesium and zinc additionally they have inadequate organic matter and poor physical structure. As a way out of this predicament, many experts have advocated for the increase in the use of mineral

fertilizer arguing that the usage of this mineral fertilizers will not have any significant major repercussion as the usage is so low in Africa. The per capital usage of fertilizer in Africa is estimated at 10,000 tonnes per 1,000,000 people (UN Millennium Project, 2005a). However recent trends over the last 5 years have shown an increase in concentration of nitrate and phosphate at river mouths in some African countries and this is believed to be as a result of the use of mineral fertilizers (UNEP, 2006). Not to be forgotten also is the high cost of this fertilizers which are astronomical and way beyond the means of many of the urban poor who are engaged in farming.

The UN Millennium Project (2005b) recommends the use of environmentally friendly nitrogen-fixing plants and agro forestry as alternative fertilizers. Also mentioned are bio-fertilizers such as animal waste and mulch. However the availability of such fertilizers in a city such as Accra is difficult.

Public toilets can serve as centres for the production of valuable nutrients and organic resource in the form of human waste. These centres can therefore be turned to places of alternative fertilizer production with the harvesting of excreta as a soil conditioner and urine as liquid fertilizer. This will provide a solution in three dimensions. First and foremost is a solution in terms of the disposal of human waste which is fast becoming a problem in the city. Secondly, the production of a cheaper fertilizer source which would improve urban agriculture by creating higher crop yields. Lastly, employment will be generated for those who will be engaged in that sector of production as well as an increase in revenue for the public toilet operators.

1.4. Theoretical Framework

Persistent societal problems as being faced in the area of inadequate sanitation and urban agriculture are complex, unstructured and involve many stakeholders. It is also surrounded by fundamental uncertainties that are deeply rooted in societal structures and institutions. Their resolution according to Loorbach and Rotmans (2006) demands a fundamental revision of both developmental processes and the institutions that have been built to handle them. In order to resolve these societal problems, structural transformations or transitions are necessary.

These societal transformations are guided by technological transitions. Technological transitions are major technological transformations in the way societal functions are fulfilled. This change does not only involve technological changes, but also changes in elements such as the user practices, regulations, industrial networks, infrastructure and symbolic meanings (Geels, 2002).

1.5. Objective of the Study

To investigate the financial feasibility of the introduction of urine harvesting for use as an alternative fertilizer source so as to improve urban agriculture in Accra and to design a strategy on how this approach can be scaled up.

1.6. Hypothesis:

The use of urine as an alternative fertilizer source will improve urban agriculture in Accra by introducing a low-cost fertilizer. At the same time this approach will reduce the nutrient loads to city drains and the ocean. The financial benefits of such a system

(savings of chemical fertilizer and / or higher crop yields) could finance infrastructure modifications (toilets) and the collection and transportation of urine.

1.7. Research Questions

Research Question 1:

Can the financial benefits achieved by the increase in crop yield by urine fertilization finance the cost of operating the system?

Specific Research Questions

Where are the urinals located in the city?

Which farmers will be interested?

What is the potential urine that can be harvested from public urinals?

What is the cost of infrastructural modifications in order to harvest the urine?

What is the cost of operating the system?

What is the nutrient value of urine in Accra?

What is the economical value when compared to mineral fertilizer?

What is the economical value when compared with poultry manure?

What is the increase in crop yield?

What is approximately the financial revenue of this increased crop yield?

What are the health implications in the use of urine?

How would the health implications be addressed?

Research Question 2:

How can the described approach be up scaled to a higher level?

Specific Research Questions

Who are the stakeholders in the current socio-technical regimes?

What are norms, interests, rules and belief systems that underlie their activities?

What is their attitude towards the new agenda?

What kind of niches are there on the ground?

What is the state of the niches?

What is the state of urine adoption in the framework of the niches?

What kind of transitional arena is the urine adoption fitted?

Does the membership of the arena reflect the diversity of the task at hand?

What are the drivers for up scaling of the adoption of urine?

What are the impediments hindering the up scaling of the adoption of urine?

How can the impediments be overcome?

1.8. Scope of the Study

The study will be limited to the city of Accra with a focus on urban agriculture and sanitation. Sanitation will also be limited to excreta management and to the possibility of extracting urine (yellow water) from the public toilets in the city for use in urban agriculture. Urban agriculture also on the other hand will be limited to the growing of crops and not the raising of live stocks and fisheries.

1.9. Limitation of the Study

The study was mainly limited by time. As the unavailability of time on the part of the researcher limited the depth into which the research could have been carried

2. RESEARCH STRATEGY AND LAYOUT OF STUDY

2.1. *Research Strategy and Methods*

The study is divided into a technical and a social scientific study. The technical study analysed the financial benefits of urine separation and the use of it as a fertilizer in agriculture in order to evaluate whether the financial benefits generated will be able to cater for the cost of the infrastructural modifications and / or operation of the system. The social scientific study also dealt with how this technology can be up scaled to a higher level by identifying the drivers and barriers towards full implementation. A number of research methods such as observations, structured and unstructured interviews with the major stakeholders, literature review and analysis of policy documents were employed to generate data which was used to arrive at conclusions and recommendations.

2.2. *Data Generation*

During the preparatory phase, I reviewed various theories that could serve as a framework to the empirical study. Literature was reviewed to understand the concept of transitional management and how it could serve the purpose of the research conducted. Furthermore, interviews were conducted with some experts including Dr. Adriaan Mels my supervisor from WUR, Dr. Pay Drechsel and Dr. Cofie of IWMI as well as Ms. Dartey of SWITCH. These interviews gave me a good insight into the concept of decentralised sanitation (DESAR), urban agriculture in Accra and also some works that have already been done in relation to the potential of urine harvesting in Accra.

2.2.1. Technical Study

The purpose of this part of the study was to analyse the financial benefits of urine usage for urban agriculture. Some preliminary works have already been done by O.O Cofie and Mainoo on the potential of urine harvesting from the Central Business District in Accra. A follow up study was carried out on the urinals to assess their locations, the state in which they are, and the availability of space around the urinals for creating storage capacity. In addition to this some public toilets were also examined to analysis their potential for urine harvesting. This led to the design of the holding tanks and consequently a cost estimate. An interview was also conducted with the urinal operator to determine some of the challenges he is facing.

From this point, the transportation route was traced from the urinals and the toilets to the farms. Cost estimates were obtained from notable operators of suction trucks to determine how much they would charge for their services in conveying the urine from the CBD and other locations to the farm site. Thereafter the Dzorwulu farm site and the GBC farm site were also visited. The purpose of this was to get a first impression of the nature of urban agriculture and the practices within the city as well as the modifications required for the urine application.

At the end of the technical study, the economic implication of the design was determined vis-à-vis the current input practices.

2.2.2. Social Study

The social study was mainly carried out to determine the relation among the main actors as well as the perception of the existing regime towards the new technology of urine harvesting. Literature sources were reviewed to determine already existing

secondary data. Face to face interviews - through semi-structured and open ended questionnaires were administered to selected stakeholders involved in urban agriculture and in urban sanitation. The main purpose of these interviews was to determine their roles and interests within the regime and their attitudes towards an innovation of urine harvesting and use.

In addition to the interviews, an analysis of policy documents and existing literature was made and current practices were observed to also analyse the reaction of the existing regime towards the new innovation. The niche itself was also assessed to determine if it has all the potential and the right members to break into the current socio-technical regime.

2.3. *Sampling Strategy*

Purposive sampling technique as well as the snowball technique of non-random sampling was throughout the study. This strategy was so chosen because I believe that the information so required is in the hands of some few selected people who should be sought.

2.4. *Layout of Report*

Chapter 3: Technological Transitions theories including elements such as Technology development, changing technologies, technological transitions, transitional framework and transitional Management

Chapter 4: Profile of the study area including: country and city profile, housing, sanitation and water situation and urban agricultural practices within the city

Chapter 5: Alternative Sanitation Systems including elements such as: Background of ecological sanitation, constituent of household wastewater, urine harvesting, fertilizing value of urine and health implications of urine usage.

Chapter 6: Required infrastructure, logistics and financial implications of urine harvesting and use including aspects such as: Potential for urine harvesting in Accra, design for Source Separation of Urine in Accra, infrastructure required and comparative cost analysis with other fertilizer types

Chapter 7: Networks, Co-operation and Translations: Actors involved in urban agriculture, actors involved in urban sanitation, perception among members of the socio-technical regime as well as Networking and co-operation

Chapter 8: Discussions: Interpretation of the results using the theoretical framework

Chapter 9: Conclusions and Recommendations

3. UPSCALING OF INNOVATIONS AND TECHNOLOGICAL TRANSITIONS

3.1. *Defining Technology and Technological Systems*

The high cost of imported mineral fertilizers is beyond the economic means of many resources-poor urban farmers in Accra. This has therefore given rise to a situation where many of the farmers resort to continuous cropping without adequate fertilizer. Organic nutrients such as cow dung and poultry manure exist and have been receiving some promotion from many local and foreign partners but they are scarce in urban centres and information about their use is scanty. The high cost of mineral fertilizer and the absence of sufficient amount of organic matter in many urban centres in Ghana therefore create a situation in which recycling of human excreta could be greatly advantageous (Cofie and Mainoo, unpublished). But changing from a known practice such as cropping with synthetic fertilizers to an unknown practice such as the one been advocated requires a lot of careful consideration and planning. The current farming practice is a complete technological system on its own and to change this practice one needs to understand how technological changes are achieved.

Ayres (1994) regard technology as knowledge combined with appropriate means which transform materials, carriers of energy or other types of information from a less desirable state to more a desirable form. Technology therefore consists of two components. These are the hardware and the software of technology. In the urban agricultural sector for instance, the hardware consists of the physical and tangible technological artifacts such as the cutlasses, the hoes, the fertilizers, the spraying and watering equipments as well as the pesticides among others. Technology is however more than these tangible products. The hardware will only work when combined with knowledge, know-how, practices and organisational skills. These are the software of technology. The importance of these softwares cannot be underestimated as they directly influence the inception, development and diffusion process of a technology (Weaver et. al 2000).

Hughes et.al (1987) sees technology as a system. This system according to him contains messy, complex and problem solving components. They comprise of artefacts such as the physical artefacts, the organisation, the incorporated components, legislative materials as well as the natural resources. Geels (2002) also emphasises the heterogeneous nature of a technology by explaining that societal functions are fulfilled by socio-technical configurations. According to him, things and skills are part of routines, patterns, and organisational behaviour. They work only because they are embedded in the organization.

Figure 3.1 shows the modern socio-technical configuration for land-based personal transportation. Although a transportation system such as a vehicle is a unit on its own it cannot function independently. For the vehicle to function, it must be supported by road infrastructure and traffic systems. Without this no vehicle can function rightly. The vehicle itself is also made from components such as the drive train, the suspensions, the body and the control systems. These parts are normally manufactured by different actors. Still within the system are the fuel infrastructure and maintenance system which also sustain the personal transportation system. Further down the system again are others such as the finance and the insurance sectors. All these different and isolated units function as one to support the system. It is therefore logical to reason that these isolated artefacts work only because they are heterogeneous and are governed by some unique rules and organisational practices. If

an artefact is suddenly removed from this system or its characteristics are changed, the other artefacts will have no choice but to alter accordingly. Because these components interact with each other, their characteristics are derived from within the system.

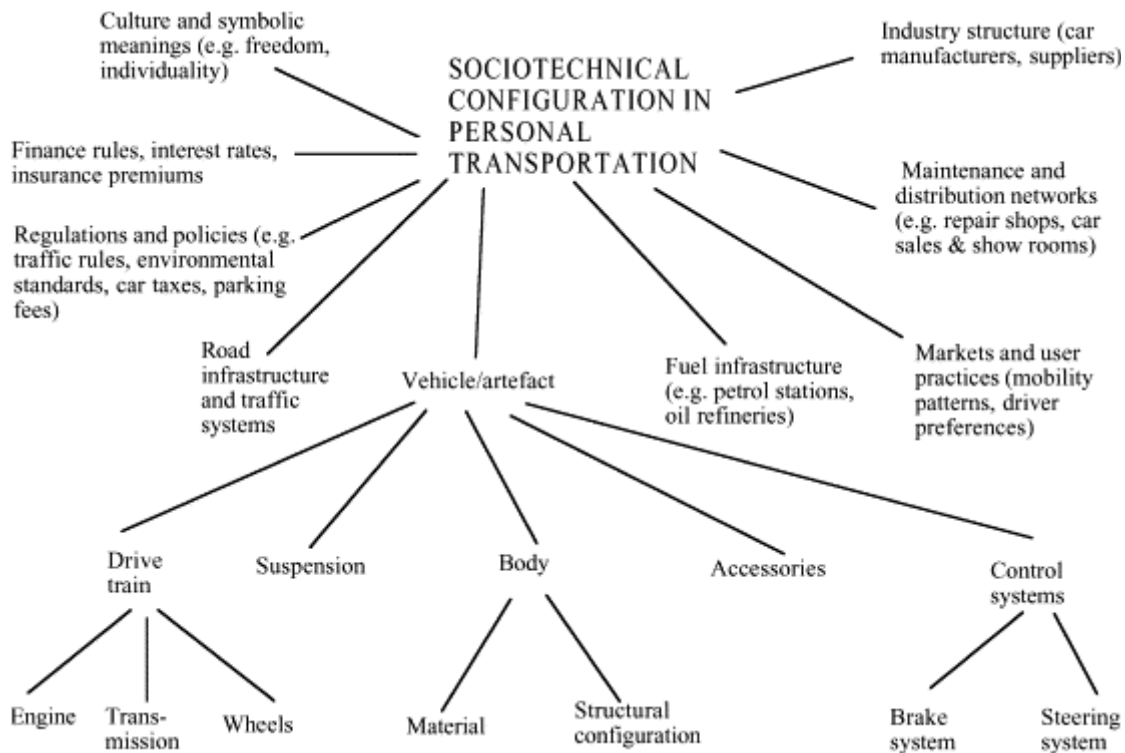


Figure 3-1 Socio-Technical Configuration in Personal Transportation (Source: Geels, 2002)

3.2. Technology Development

The fact that technology is a system and the artefacts within are heterogeneous and interacting regularly does not mean the system should be static. Like every other system, technology also develops. This development is cyclical. Belt (2001) refers to technology development as the development of new processes and products in the spheres of material production, consumption and recreation. This development is irrespective of the level of scientific sophistication involved. The development can therefore be tangible or non tangible in nature. Weaver et al (2000) list three stages of technological development. The first phase is the invention phase at which level a new technological solution is found. The next is the innovation stage during which process the technology is improved. The improvement might be radically or gradual and incremental. The final phase is the diffusion process. This is the process and pattern of the adoption and spread of a technology over time, space and across new user groups

Different views exist on how technologies develop and go through the process of invention, innovation, diffusion and use. The view one chooses depends on the discipline being studied. These views range from a determinist point of view where technology is seen to have an imminent strength and determines its own path of

development, to a neo-classical approach where technology is seen as been controlled by the market pull forces of demand and supply. The others are the social-construction view of technology which sees technology as an interactive process between the inventors and their paymasters and the Actor Network Theory which advocated the building of networks and the dissolution of all kinds of distinctions.

3.2.1. Technology Determinism

The earliest view of technology was one that seeks to portray technology as independent from society. The proponents of this concept argue that technology develops autonomously and in conformity with an imminent logic. This development according to them is self-generating and feeds on itself. Society and culture are seen as external effects and their only option is to adapt and adjust to the dictates of technology (Belt, 2001).

This view was to be challenged by the neo-classical who introduced their economic view of technology. The proponent of this view argues that technology development is a demand / market pull and not a technology pull as such. According to them, the extent and rate of technological development and also its character or direction is influenced by economic factors. Factors of production such as capital, labour, land are channelled in directions that minimize the exploitation of the most expensive factor of production. For instance, if labour suddenly becomes expensive, then technology will have no choice but to develop an alternative to labour. This view does not ascribe any role to the human players or society as a whole.

3.2.2. Technology as a Social Construct

The proponents of this view places the human actors at the core of technology development. They believe that technology, of itself, has no power and does nothing on its own. It is only in association with human agency, social structures and organisations that it could fulfil a function (Geels, 2002). Weaver et.al (2000) also commented that “contrary to what is tacitly assumed, technologies are not generally the products of a moment of inspired creativity on the part of the designer, inventor and engineer working in a remote laboratory set aside from the disturbance of everyday life”. On the contrary these technologies are social constructs. This is to say that social and economic values, opportunities and expectation, problems and incentive always influence the creative process.

Technology development from this perspective therefore, does not actually follow a fixed or rigidly prescribed course. The proponent of this concept believes that, at certain points in the developmental process, there are more than one alternative to choose from. The choice that is made depends on the economic and political relations of the wider society.

3.2.3. Actor Network Theory

This view seeks to reject all distinctions which exist between micro and macro, local and global, science and technology, nature and culture, nature and society, humans and non-humans. According to Latour (1999) there are no such given distinctions and that all this can be overcome by the hard works of the actors involved.

In this same sense, he sees no distinction between scientists and technologists, saying that they are one and the same. He calls them techno-scientists. Again he sees no difference between facts and artefacts claiming that in principle the fate of facts and

of artefacts is in the hands of later users. Once the users accept it without modifying or altering it, they are then recognised as real facts or successful artefacts.

In most cases however, later users will not adopt these things without further ado: each movement from one person or group to another is accompanied always accompanied by a 'translation'. To counteract this tendency, techno-scientists will try to give their products the character of black boxes, which may circulate without alteration. For this purpose they enrol 'allies' (both human and non-human) and build networks of larger or smaller size in which their products can circulate without being altered. In other words almost like the technological determinist proponents; the proponent of this theory believe that technological development has such pervasive effects that all existing relationships are turned upside down. Societal structures to them do not remain unaffected by technology development (van Vliet, 2006a).

3.3. *Up scaling Innovations*

A paradigm shift from a system which sees human waste as municipal waste and therefore a public health hazard to a system where the same waste is seen as a resource qualifies to be treated as a technological transition. For technology is a range of interconnected technological artefacts as well as social actors managing, using and regulating these systems. Such a change will not only require a change in infrastructure but also changes in relations, human behaviour, legislation and policies among others. This will call for realignment of relations and building up of new relations where there was none.

Learning alliances recently emerged in the Water and Sanitation and Hygiene (WASH) sector as a promising approach to problems of scaling up innovations. It is recognised as having great potentials for helping individuals and organisations to break through barriers of learning about innovations. It builds structures needed to bring people together to analyse and address problems as well as face the challenges of different expectations and interest and jointly learning how to find solutions. In this way innovations are quickly spread as the interest of all stakeholders have been taken into consideration.

The various aspects of technological transitions which will be discussed as part of this study will be based on three concepts based on the Dutch Knowledge Network on System Innovations and Transitions (Loorbach & Rotmans, 2006). These concepts are the transition itself, the transitional framework and transition management.

3.3.1. *Technological Transitions*

Technological transitions structurally change the way in which a societal function is performed in a society. These societal functions are normally performed by a system which is a coherent set of components that form a functional whole and influence each other in a particular direction. A sanitation system for instance is comprised of items such as the toilets, the storage facilities, the collection and transportation, infrastructure as well as the treatment and excreta use infrastructure together with the user practices, symbolic meanings, industrial structure; policies and knowledge all acting as a functional whole. The same also exist for the urban agricultural sector.

A transition will therefore mean a change from one socio-technical configuration to another. This involves the substitution not only of technology but also all the other aspects as it is a technological system. As the existing system is already a system, the

elements within are configured, linked and aligned to each other. A new technology will therefore have a hard time to break through, because regulations, infrastructure, user practices, maintenance networks are all aligned to the existing technology. But it is also true that no system remains close for good as previously achieved closure can be undone.

What is therefore required is a process of planning, steering and coordinating as some of these processes are autonomous and beyond the control of management. In many transitional processes, a cultural change for instance is required. For this reason, transitions cannot be managed in the traditional way of doing business but will rather require a careful manipulation of factors such as the market, the planning and also the institutional mechanisms.

Kemp and Rotmans (2004) opined that although each transition is unique in terms of content and context, generally there are two types of transitions. These are evolutionary transitions, in which the outcome is not planned in a significant way and goal-oriented transitions, in which goals or visions of the end state are guiding public actors and orienting the strategic decisions of private actors.

3.3.2. The Transitional Framework

The second, shared concept of technological transition is the transitional framework. There are two types of frameworks. These are the multi-phase (multi-stage) and the multi-level frameworks.

Multi Phase Framework

The multi-phase framework approaches transition from the viewpoint of the speed of change (Rotmans et.al.2000). The central assumption is that societal structures go through long periods of relative stability and optimization. This is then followed by a relatively short period of structural change (Loorbach, 2007).

Based on this framework, a transition then can be described in four stages. Figure 3.2 shows the various stages in this development. The first phase in the framework is the predevelopment stage. At this stage there is very little visible change and the status quo appears almost the same. But underneath the surface there is a lot of experimentation going on. The second phase is the take-off phase. At this stage, thresholds are reached and the state of the system begins to shift. The third phase is the acceleration phase where structural changes begins to take place through the accumulation of socio-cultural, economic, ecological and institutional changes that react to each other. It is during this process that there are collective learning processes, diffusion and embedding processes. The final phase is the stabilization phase where the speed of societal change decreases and a new dynamic equilibrium is reached.

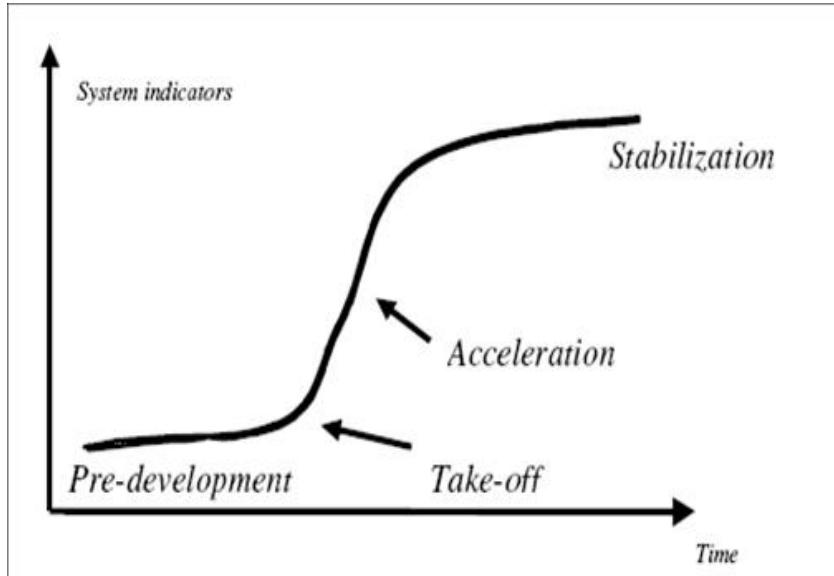


Figure 3-2 Multi Phase Framework (Source: Rotmans et al. 2001)

The Multi-Level Framework

This framework relates transition on different scale dynamics which are interrelated. There are three distinct levels namely the micro, the meso and the macro levels which are acting at interacting levels. Figure 3.3 shows the various scale levels and the activities that are taking place there.

At the first stage is the micro-level. Acting at this level are the niches. Niches are protected spaces for development and the space where promising technologies and approaches are nurtured. Like the pre-development stage in the multi-phase framework, a lot of experiments go on here. The aim of these experiments is to learn about the desirability of a new technology and also to enhance the further development and the application of the technology. Radically new technologies need such protection because they have relatively low technical performance, and are often cumbersome and expensive. Niches are important, because they provide locations and also provide space to build the social networks which support innovations.

The second stage is the meso-level. At this level is the socio-technical regime. Rip and Kemp (1998) define a social-technical regime as consisting of the rule set of a technology. These are embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons as well as ways of defining problems. All these are deeply fixed in institutions and infrastructures. Socio-technical regimes can be characterised along seven dimensions: namely technology; user practices and application domains; symbolic meanings of technology; infrastructures; industry structure; policy; and knowledge (Schot, 1998).

Finally at the macro-level is the socio-technical landscape. At the landscape level there are various background variables such as the material infrastructure, political culture and coalitions, social values, worldviews and paradigms, the macro economy, demography and the natural environment. These variables channel transition processes and change 'slowly in an autonomous way' (Kemp and Rotmans, 2001).

The structural character of the landscape means that changes at this level occur gradually and very slowly. In the case of the toilet for instance people are used to the concept of flush and forget and this is deeply imbedded in their practices. An attempt to change this to a system which will involves even a minimum of level of work is expected to bring about public criticism (van Vliet, 2006b)

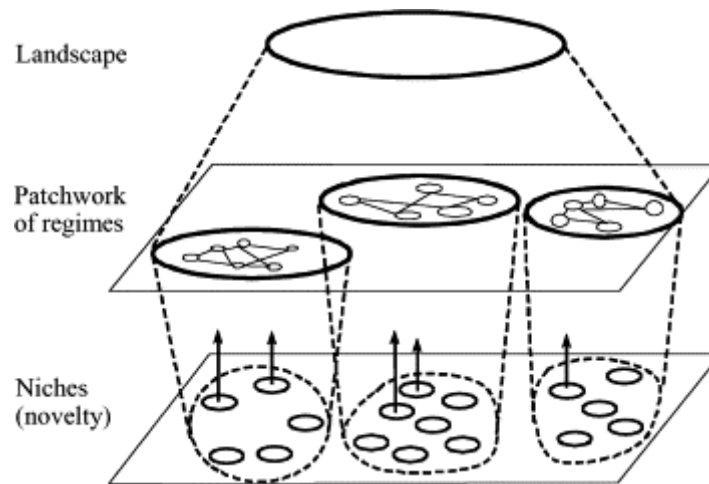


Figure 3-3 Multi-Level Framework (Source: Geels, 2002)

As to how transition occurs, Geels (2002) states that it is as a result of evolution involving ‘variation and selection’. The key characteristic of this framework is that regimes are embedded within landscapes and niches are equally embedded within regimes. Niches are crucial for technological transitions, because they provide the seeds for change. They are the place where radical variety is generated. Regimes on the other hand are the selection and retention platforms. Elements at the regime level are stable because they are linked together. These linkages are maintained and reproduced by the alignment and co-ordination of different actor groups. Under stable conditions, radical innovations, which are pioneered in niches, have a hard time to break out of the niche-level.

However, if the regime is confronted with problems and tensions emerge, the linkages in the configuration will loosen up. This creates an opportunity for radical innovations to escape the niche-level and be incorporated into the Socio-technical configuration. If new elements are introduced in the regime, they may trigger further changes if changes at the landscape level create pressure and new opportunities.

Another driver for further changes is the emergence of specialised actors directing their activities towards improving and expanding the new element. Reconfigurations thus occur when developments at multiple levels link up and reinforce each other.

3.3.3. Transition Management

Transition management consists of a deliberate attempt to bring about a transition, in stepwise and interactive manner, involving sequential and participatory decision making (Rotmans et al 2000). This management is desirable when changes and improvements alone have insufficient effect, and more fundamental change is needed. In the case of a technology such as the adoption and use of urine for urban agriculture, the change transcends the scope of the artefacts replacements only, but rather extends to other social factors such as perception. These social factors will call for a

reorientation in thinking and behavioural changes which are beyond the scope of any organisational management. Any attempt therefore to manage transitions in the traditional way of command and control will fail. Transitions will therefore have to be managed by carefully organising, influencing and adjusting the direction and pace of its path. The three main means of doing this is by the mechanisms of markets, plans and institutions.

Markets for instance can be managed by relying on price mechanisms and decentralized decision-making in terms of making product and service choices. Plans can also be formulated in the form of transition goals, policy strategies and objectives that centrally coordinate economic activities. Finally, institutions can equally be coordinated.

Loorbach and Rotmans (2006) have listed four processes that every transition should go through. Figure 3.4 illustrates these various processes. Far from seeing these processes as a one shot activity it must rather be viewed as cyclical, developmental and iterative.

The various developmental rounds are:

- Establishing and Developing a transitional arena
- Developing of a long term vision
- Initiation and Execution of transitional experiments
- Monitoring and Evaluation of the transitional process

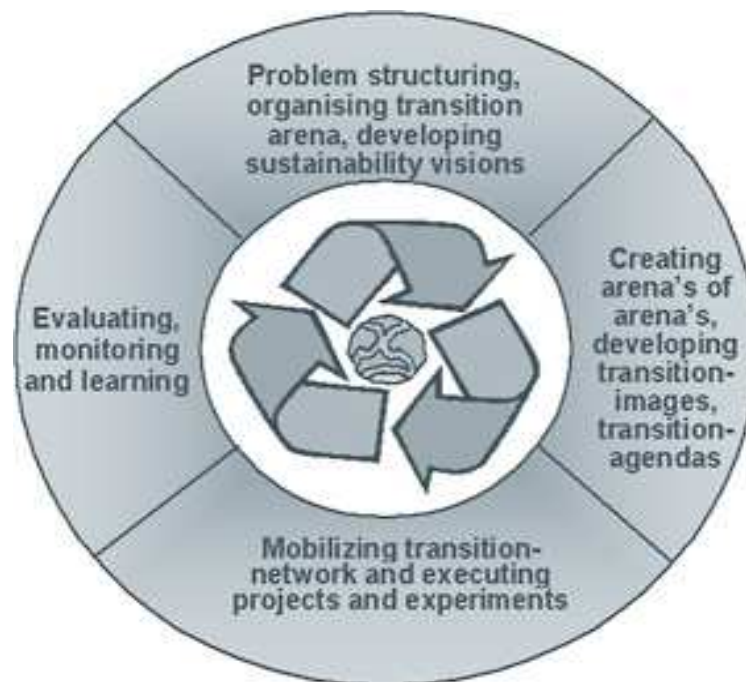


Figure 3-4 Activity Clusters in Transition Management (Source: Loorbach & Rotmans 2006)

Establishing and Developing a Transitional Arena

This phase involves the establishment and development of a transition arena for a specific transition theme. This can only be done after the problem has fully been assessed. The establishment and organisation of a transitional arena forms the basis of the transition management process. These arenas are networks of innovators and visionaries that develop long-term visions and images. This in turn forms the basis for the development of transition-agendas and transition-experiments involving a growing numbers of actors.

The selection of participants for the transition arena is of vital importance since they need to reflect the complexity of the transition at hand. Participants need to have some basic competencies at their disposal: they need to be visionaries, forerunners, able to look beyond their own domain or working area, and be open-minded. They must function quite autonomously within their organisation but they must also have the ability to convey the developed visions and develop them within their own organisations. Aside of these abilities, they need to be willing to invest a substantial amount of time and energy in playing an active role in the transition arena process. It is important to know the criteria upon which these participants have been selected and to document these criteria.

Loorbach and Rotmans (2006): advocates that there must be a transitional manager. One of the most important roles of this manager is to bring together the various parties. The manager must also be responsible for the overall communication in the transition arena, acts as intermediary in discordant situations, and has an overview of all the activities in the arena. The transition manager should also ensure a balanced representation of participants from business, governments, non-governmental organisations, knowledge institutions, and end users/ consumers. After some time, arena participants may be replaced by new participants with other competencies and practical orientations.

Developing of a Long Term Vision

The next phase in the management phase involves the development of a long-term vision for sustainable development and a common transition agenda. This requires questioning one's own paradigm and an insight and imagination to look ahead one or two generations. Lastly, it also requires reaching agreement among often diverging opinions on what sustainability means for a specific transition theme. Many sustainability visions are still imposed by the government upon other parties in a top-down matter, or originate from a select group of experts who are far removed from the broad social setting.

This vision might function as a guide in the formulation of programmes and policies. It also aids in setting short-term and long-term objectives. The vision must be as appealing and imaginative as to be supported by a broad range of actors but must also be realistic. Ideally, the images should be democratically chosen and based on integrated risk analysis. It is also useful to have multiple transitions visions, represented by multiple transition images. Various transition pathways lead to a particular transition image, and from various transition images a particular transition pathway may be derived. The transition images can be adjusted as a result of what has been learned by the players in the various transition experiments. Based on a process of variation and selection, new visions and images emerge, others die out, and existing ones will be adjusted.

.An insufficiently robust and ill-supported transition agenda creates a serious barrier for transition management. If the transition manager under invests in the quality of the transition agenda, many problems remain below the surface which will arise later in the transition process. An adequate transition agenda, however, can form a binding element in the transition process. The transition agenda requires a balance between structure and flexibility. Structure is needed to position the scale levels in which the issue in question plays, and to frame the issue in terms of themes and sub themes. It is an iterative, cyclical and learning process.

Initiation and Execution of Transitional Experiments

From the transition visions and images, transition-experiments are derived. The transition-experiments are supposed to contribute to the sustainability goals at the system level and should fit within the transition pathways. Experiments must be selected and formulated on a sound basis and must be mutually coherent. The crucial point is to measure to what extent the experiments and projects contribute to the overall system sustainability goals and to measure in what way a particular experiment reinforces another experiment.

Specific niches need to be found where experiments can be performed. The attitude of the current regime towards these niche experiments must also be identified. Preferably, these experiments should link up with ongoing innovation projects and experiments in a way such that they complement each other. Often, many experiments exist, but are not set up and executed in a systematic manner, resulting in a lack of cohesion. Because transition experiments are often costly and time-consuming, the existing infrastructure for innovation experiments should be used as much as possible.

Transition processes are beset with uncertainties of different kinds. These uncertainties might be of knowledge or structural nature. It is, therefore, important to keep a number of options open and to explore these uncertainties in the transition-experiments in order to determine which uncertainties are structural and which ones can be reduced.

Through learning within the transition-experiences the estimation of these uncertainties changes in the course of the transition process. This, in turn, may lead to adjustment of the transition visions, images and goals.

Monitoring and Evaluation of the Transitional Process

Monitoring and Evaluation is an important part of the search and learning process of transitions. Both the transition processes itself and transition management should be monitored. Monitoring the transition process itself has to take place at different levels in terms of monitoring the slowly changing macro-developments, the sharply fluctuating niche developments, as well as the individual and collective actors at the regime level.

The monitoring of transition management requires a different form of monitoring at each level. The actors within the transition arena must be monitored to check on their behaviour, networking activities, alliance forming and responsibilities. They must also be monitored in terms of their activities, projects and instruments. Secondly, the transition agenda must be monitored to see if the actions, goals, projects and instruments that have been agreed upon are on course. Thirdly the transition process itself must be monitored with regards to the rate of progress, the barriers and points to be improved.

The whole essence of transitional management is the act of Learning-by-Doing and Doing-by-Learning. Whereas learning-by-doing concerns the development of theoretical knowledge from practice, doing-by-learning is the development of practical knowledge from theory.

This activity is a difficult process therefore explicit and clear learning goals needs to be formulated during transition experiments which can be monitored. The evaluation of the above learning processes is in itself a learning process, and may lead to adjustment of the developed transition vision(s), transition agenda, and the transition management process within the transition arena. The set of interim objectives are evaluated to see whether they have been achieved; if this is not the case, they are analysed to see why not. Have there been any unexpected social developments or external factors that were not taken into account? Have the actors that were involved not complied with the agreements that were made? Once these questions have been answered, a new transition management cycle starts which takes another few years.

Because these transition management cycles take several years within a long-term context of 25-50 years, the creation and maintenance of public support is a continuous concern. When quick results do not materialise and setbacks are encountered, it is important to keep the transition process going and to avoid a backlash. One way to achieve this is through participatory decision-making. Societal support can also be created in a bottom-up manner, by bringing in experiences with technologies in areas in which there is local support. The experience may remove broader fears and give proponents a weapon. With time, solutions may be found for the problems that limit wider application.

4. PROFILE OF THE STUDY AREA

4.1. Profile of Ghana

Ghana is located on the west of Africa. It lies between the latitude of 4° N and 11.5° N and longitude 3.11° W and 1.11° E. It is boarded on the south by the Gulf of Guinea; Togo is on the west, Cote D'Ivoire on the east and Burkina Faso on the North. The size of the country is approximately 239, 460 km²; of these 8,520 km² is occupied by water whilst the rest consist of land. About 13,600,000 hectares of this land is suitable for agriculture but only about 29% of it is said to be under active agricultural production (CIA, 2007).

Figure 4.1 shows the map of Ghana. There are six agro ecological zones dominated by the moist semi-deciduous forest and Guinea savannah. Annual rainfall ranges from a low of 800mm on the coastal savannah ecological zone to a high of 2200mm in the rain forest zone. The climate of the country is essentially tropical and dominated by two air masses. The South-West monsoon and the North-East harmattan. The topography is predominately undulating with slopes of less than 5%.

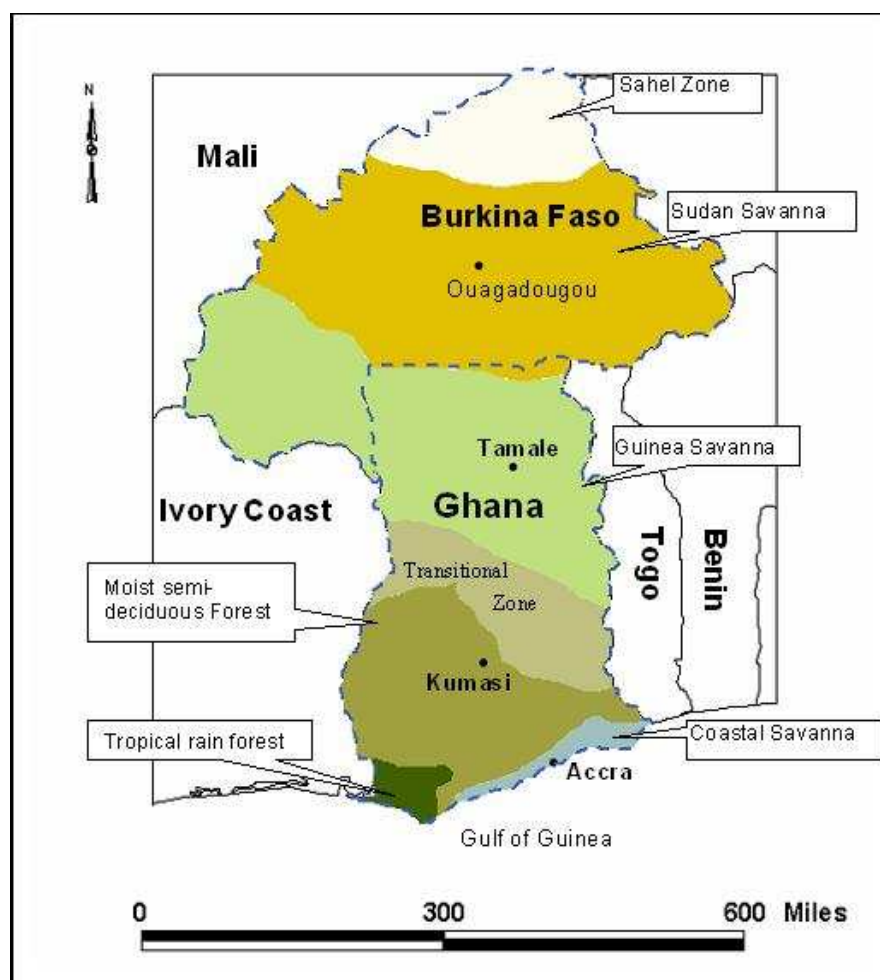


Figure 4-1 Map of Ghana showing the neighbouring countries and the various agro-ecological zones (Source: Obuobie et. al 2006)

Ghana's geology is dominated by the Dahomeyan (lower Precambrian) and Birrimian (middle Precambrian) system. The Voltaian (Palaeozoic) formation covers about 40% of Ghana. Approximately 64% of the country's surface water falls on the Volta Basin which includes the White, the Black and Lower Volta rivers and rivers Daka and Oti. The other hydrological systems are the Bia, Tano, Pra and Ankobra Rivers which are classified under the south western river basin. Rivers Tordzie /Aka, Densu, Ayensu, Kakum, Butre, Ochi-Amissa and Ochi-Nakwa make up the coastal basin (Agodzo et. al, 2003 & Obuobie et. al, 2006).

The population of the country is around 18.4 million with a population density of 77 persons per km². The population growth rate is 2.7 %. Administratively, the country is divided into 10 regions and 170 metropolitan, municipal and district assemblies (GSS, 2002).

Figure 4.2 shows the major ethnic groups in the country. There are 8 main ethnic groups in the country. The largest of this is the Akan ethnic group which makes up about 45.3% of the population.

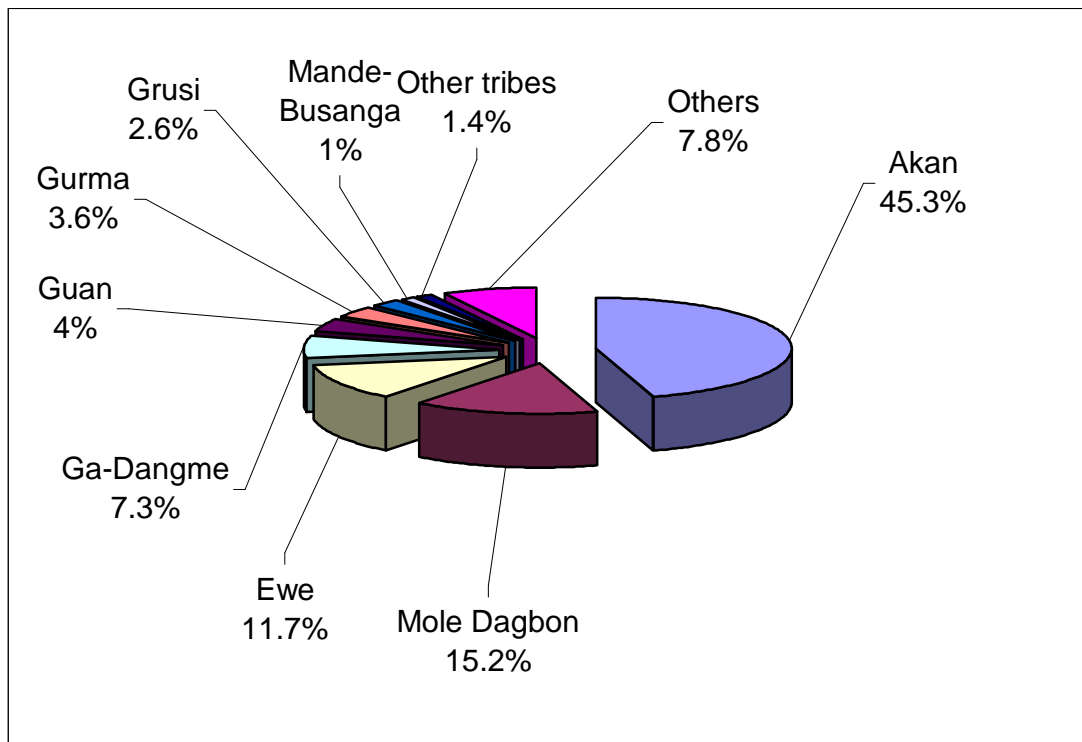


Figure 4-2 Major Ethnic Groupings in Ghana (Source: GSS, 2002)

In terms of religion, almost all the major religions in the world have some followers in Ghana. Figure 4.3 shows the main religious groupings in Ghana. Christians are in the majority making up about 68.8% of the population and they are mainly of the Pentecostal-Charismatic, Protestant and Catholic denominations.

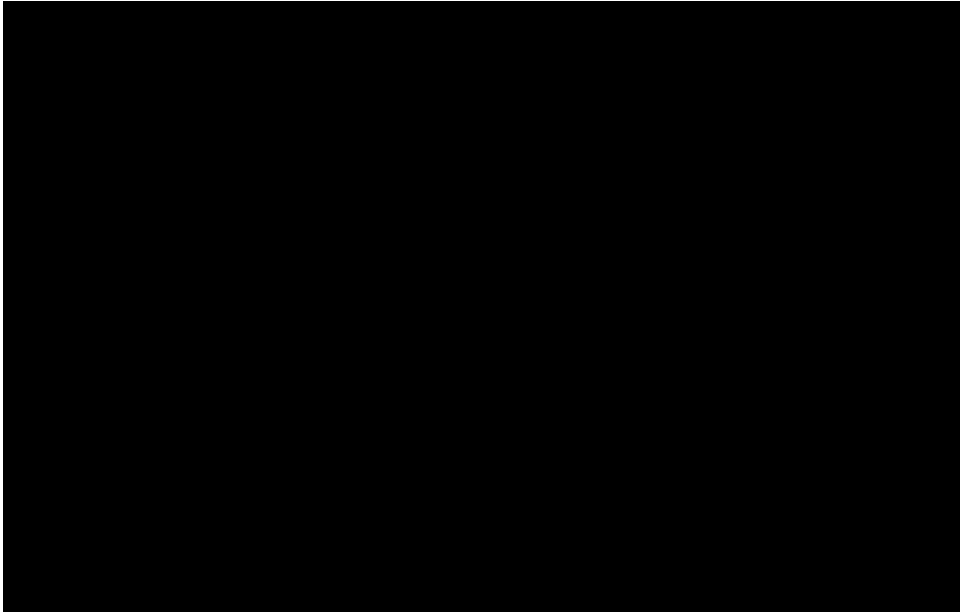


Figure 4-3 Major Religions in Ghana (Source: GSS, 2002)

The country's economy is largely natural resource-based dominated by commodities such as cocoa, gold and timber as the main export earners. The agricultural sector accounts for the bulk of Gross Domestic Product and employs 56% of the labour force. Industry and the service sectors cater for 15% and 29% of the workforce respectively whilst the unemployed account for 11% of the population (CIA, 2007).

4.2. The City of Accra

Accra is the capital city of Ghana as well as the Greater Accra Region (which is the smallest of the 10 administrative regions in Ghana). It is located on latitude 5⁰33' North and longitude 0⁰ 15' West in the southern part of the country. The city is managed by the Accra Metropolitan Assembly. The jurisdiction of the metropolitan assembly is limited to 170 km² but the real city of Accra however goes beyond this boundary. The megacity of Accra as it is known by the urban dwellers covers an area of between 230 km² to 300 km². Figure 4.4 shows a map of the city of Accra with the area controlled by the Accra Metropolitan Assembly.

The Accra Metropolitan Assembly is the highest political and administrative arm of the Government at the local level. It is headed by a Metropolitan Chief Executive who is nominated by the president of the republic but must be accepted by at least 67% of the assembly members. In line with the government's decentralisation policy which is aimed at bringing governance to the doorstep of the ordinary citizens almost all the ministries and departments have been decentralised. Administratively, AMA is zoned into 13 sub-metropolitan areas. These are: Teshie, North Okaishie, Okaishie South, Osu Klottey, Ablekuma North, Ablekuma Central, South Ablekuma, Ayawaso Central, Ayawaso West Wuogon, Ayawaso East, Nungua, La and Ashiedu Keteke. Recently the Teshie and Nungua sub-metropolitan districts have been ceded off to form the new Ledzokuku-Krowor Municipal Assembly. This means that currently AMA has 11 sub-metros and the original land size of 170 km² has been reduced. (However for purposes of this study the AMA shall still be considered to contain the ceded sub-districts).

The functions of Accra Metropolitan Assembly as spelt out by its mandate among others are the:

- Provision of a sound sanitary and healthy environment
- Provision of educational infrastructure for first and second cycle schools
- Provision of markets and lorry parks within the Metropolis
- The planning and development control of all infrastructure within Accra
- Maintenance of peace and security
- Provision of public safety and comfort

There are 1.6 million inhabitants living within the metropolis with an annual population growth rate of 3.4% within the city but extending up to 9.2% within its peri-urban settings. There are three main dominate ethnic groupings. These are the Akans, the Ga-Dangbe and the Ewe groups. Their proportions of the population are 42%, 29% and 14.8% respectively. In terms of religion, the region is dominated by Christians with 82.3% of the population claiming to practice this faith. This is followed by Islam which makes up 12.2% of the population. The percentage of the population who practice Traditional African Religion is just 0.7%. 4% of the population claim they have no religion at all whilst a small proportion (0.4%) belongs to other religions (GSS, 2002, Obuobie et. al, 2006 & AMA, 2006).

Table 4.1 shows the general climatic conditions in the city. The city falls within the dry equatorial climatic region and lies within the coastal savannah agro-ecological zone. It is the region that receives the least amount of rainfall in Ghana with low annual rainfall averaging 810mm which is distributed over less than 80 days. The rainfall pattern is bimodal in nature, with the major rains coming in between March and June and the minor ones around October. The annual mean temperature is 27.1°C and varies from a low 25.1°C in August to 28.4°C in February and March. The relative humidity is around 81% and the wind velocity around 251 km/day.

Table 4-1 Climatic data for Accra (for Southern belt of Ghana)

Month	Mean Temp °C	Relative Humidity %	Wind Speed Km/day	Sunshine Hours	Mean Rainfall mm	Effective rainfall mm
Jan	27.7	77	207	6.8	10.9	10.7
Feb	28.4	78	259	6.9	21.8	21.0
Mar	28.4	79	268	6.9	57.1	51.9
Apr	28.3	80	251	7.0	96.8	81.8
May	27.6	82	216	6.9	131.2	103.7
Jun	26.4	86	242	5.1	221.8	143.1
Jul	25.3	85	294	4.7	66.0	59.0
Aug	25.1	84	328	4.9	28.2	26.9
Sept	25.8	83	311	5.9	67.8	60.4
Oct	26.7	83	259	7.5	62.4	56.2
Nov	27.6	81	199	7.9	27.7	26.5
Dec	27.5	79	181	6.9	18.1	17.6
Annual	27.1	81	251	6.5	810	659

Source: Agodzo et al 2003 (modified)

The soils in the metropolitan area can be divided into four main groups. These are: drift materials resulting from deposits by wind-blown erosion and alluvial and marine mottled clays of comparatively recent origin derived from underlying shale; residual clays and gravels derived from weathered quartzite, gneiss and schist rocks; and

lateritic sandy clay soils derived from weathered Acarian sandstone bedrock formations. In many low lying poorly drained areas, pockets of alluvial black cotton soils are found. These soils have a heavy organic content, expand, and contract easily. Near the foothills are the large areas of alluvial laterite gravels and sands. Many of these deposits are being exploited in an uncontrolled manner for constructional purposes.

There are four main drainage catchments within the city. The Korle-Chemu is the most important. It covers an area of 250 km² and flows through most of the urbanised parts of Accra. The principal streams that drain the catchment are the Odaw River and its tributaries, the Nima, Onyasia, Dakobi and Ado. The principal outlet for water in these catchments is the Korle Lagoon. The other drainage systems are the Kpeshie Catchment, Songo-Mokwe as well as the Densu River and Sakumo Lagoon Catchments.

4.2.1. Housing and Water Supply in Accra

According to the 2000 Population and Housing Census there are 131,355 houses within the AMA. The estimated number of households within these houses is 365,550. The average number of households also within every house is estimated at 2.8 and the population per household is 12.6 averagely.

Accra's main water supply is from the Weija Dam on the Densu River to the west of the city with some water being pumped from the Kpong Water head works on the Volta River. Piped water supply to the city is mainly provided by the state owned Ghana Water Company. Only about 60% of the population is actually served by the water supply network. Figure 4.4 shows the source of water available to the populace. About 90.7% of households have access to pipe borne water. Of this 43.6% have water inside their homes whilst the other 47.1% rely on water from other sources such as communal standpipes outside the homes or on water from tanker suppliers. Those who do not have this facility rely on other sources such as wells, springs, lakes, rivers, dugouts and boreholes.

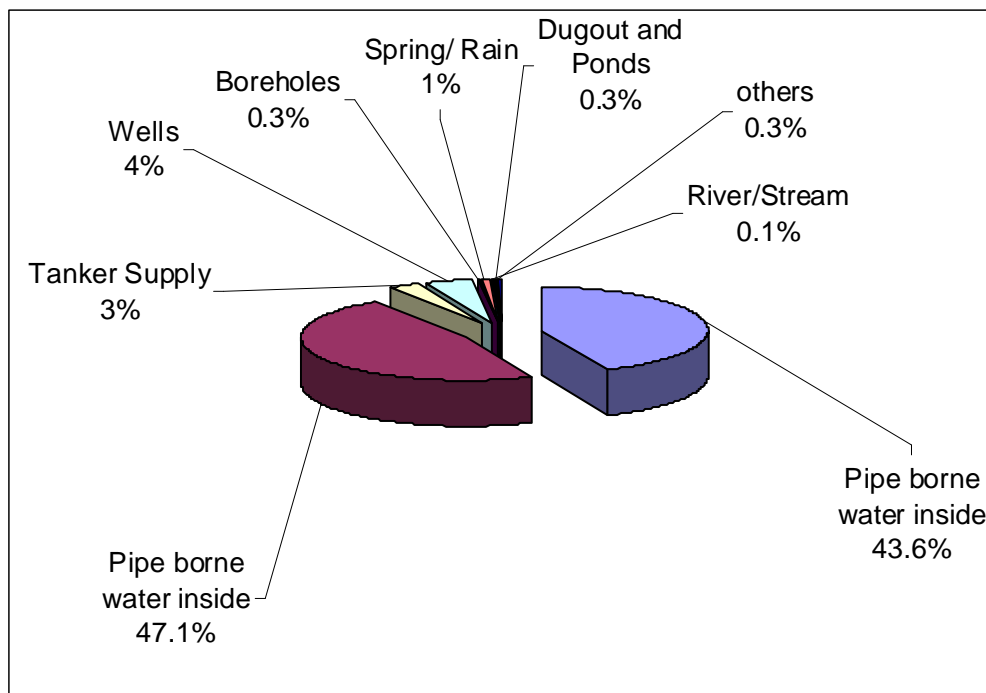


Figure 4-4 Source of Water available within AMA (Source : GSS, 2002)

4.2.2. Sanitation in Accra

The Waste Management Department of AMA is responsible for keeping the metropolis environmentally healthy and sound. Following the publication of the Environmental Sanitation Policy in 1999 by the Ministry of Local Government and Rural Development the department has been mandated to provide these sanitary services either directly or indirectly through private contractors or franchisees. They are also responsible for supervising the activities of the contractors they have engaged (Ayee and Crook 2003).

In spite of the fact that 100% of the metropolis is urbanized not much can be said about sanitation. It has been reported that the two neighbouring cities of Accra and Tema have 22 sewerage systems and sewage treatment plants, but only a few are being operated and maintained in accordance with designers' intentions (Akuffo, 1998; EPA, 2001). Whilst most part of Tema is sewered only about 5-7% of Accra's population have access to the sewer. The largest of this treatment plant is the Up flow Anaerobic Sludge Blanket (UASB) plant at James Town. It started operations in 2000 and in addition to the UASB also has trickling filters, settling tanks and other treatment units for post treatment. The plant was initially designed to handle about 16,000 m³ of sewage per day but now receives less than 5000 m³/day due to the small size of the sewered part of Accra. The plant is partially broken down and hence the sewage is directed into the ocean. Faecal sludge treatment plants in Accra are no better. The Achimota faecal treatment plant with a dumping rate of 250m³/day has now been closed. The Korle Gonno treatment plant popularly known as the lavender hill with a capacity of 50m³/day is also not functioning as it was designed to be. Figure 4.5 shows the pollution that goes on at the lavender hill. Septic tank emptying trucks empty their content into the sea directly without any treatment whatsoever as the treatment plant has broken down long ago. The Teshie-Nungua treatment plant is currently undergoing some renovations.



Figure 4-5 Sewerage being directly dumped into the Ocean at Lavender Hill

Due to the unsustainable municipal waste practice that goes on in the city, there is periodic flooding whenever it rains in spite of the low level of rainfall within the metropolis. Storm water drains which were initially constructed for the management of rain water for instance now doubles as disposal points for solid waste, grey water and excreta. Figure 4.6 shows a typical situation in the city.



Figure 4-6 Typical storm water drain in the city

With respect to household solid waste, the situation is no better. Figure 4.7 shows how households manage their solid waste. Only 20.9% of these wastes are collected. A considerable amount (62.7%) is dumped publicly in places demarcated by the authorities for collection. Unfortunately the Waste Management Department and its contractors had failed to live up to their responsibilities rendering most of these dumpsites an eyesore and a potential health hazard for the citizens.

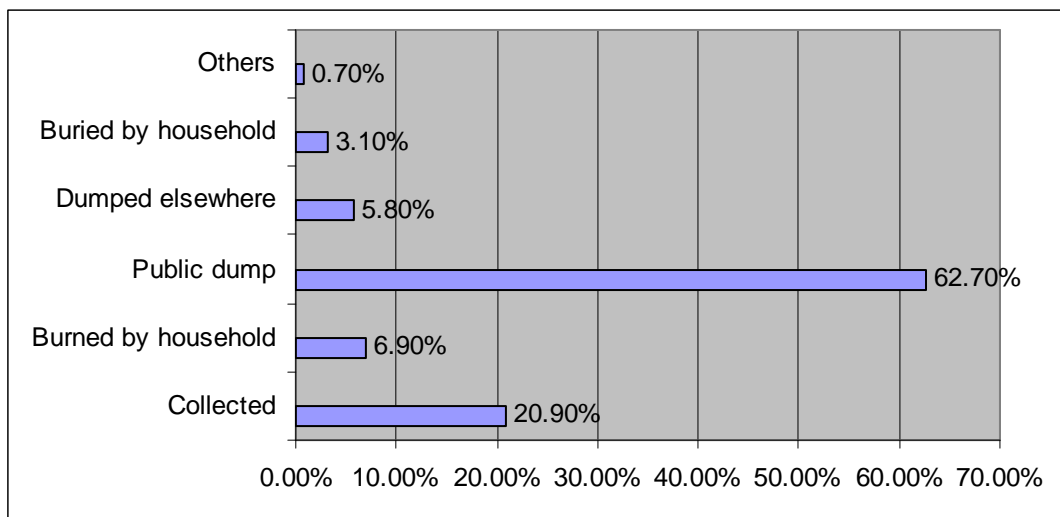


Figure 4-7 Solid Waste Disposal by Households in AMA (Source: GSS, 2002)

Figure 4.8 also shows how grey water which is produced as a result of cooking, bathing and washing, among others is disposed off. Only 13% enters into the central

sewer with the rest going either going into open drains, being poured onto the street or outside the house. This is also an equally dangerous practice if one considers the fact that grey water also may contain pathogens. In fact most of the flood problems that have reported within the city as well as the prevalence of some diseases in the metropolis such as malaria and cholera is as a direct result of the improper manner in which grey water and solid waste is disposed off.

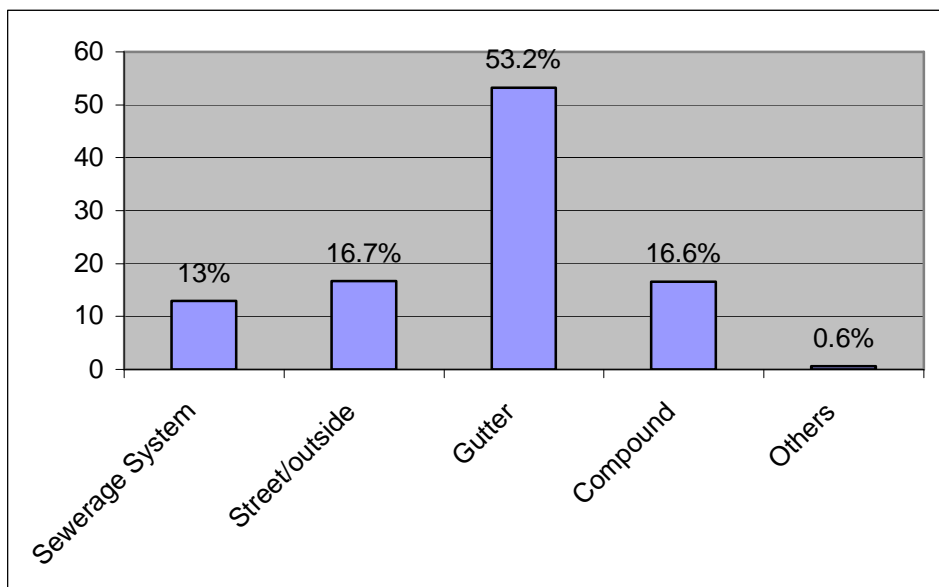


Figure 4-8 Grey Water Disposal (Source: GSS, 2002)

Toilet and bathing facilities within the city is also another great concern. Figures 4.9 show how the various households in the city conduct their toileting activities. 46.3% of households have no access to toilets of their own. 32.7% of all households in AMA rely on public toilets to serve their needs whilst others still use facilities in other people’s homes. A small proportion of the population still defecates in bushes, fields and the beach.

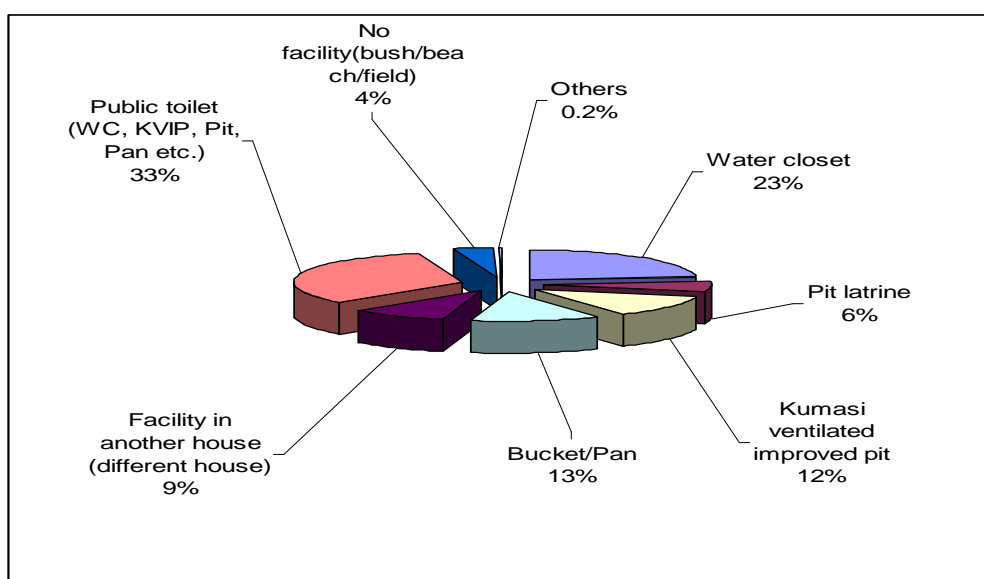


Figure 4-9 Household by toilet Facility (Source: GSS, 2002)

In the case of bathing the situation is not much different. Figure 4.10 shows the bathing facilities within the metropolis. Public bathhouse accounts for 5.1% of the bathing needs of households, another 1.5% bath in open spaces whilst another 1.2% bath in places such as lakes, rivers and pond.

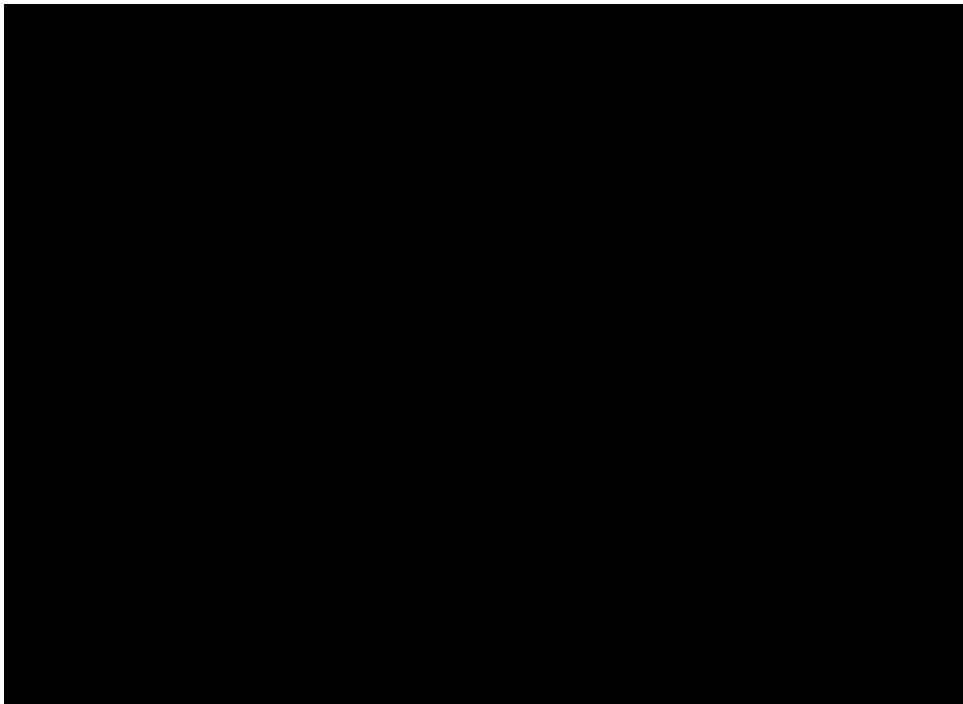


Figure 4-10 Household bathing facilities (Source: GSS, 2002)

Public toilets in AMA

Due to the fact that about a third of the population in Accra relies on public toilets as their main sanitary facility, public toilets have become an important part of the sanitary infrastructure of the city. These toilets were initially created to serve the needs of visitors who come into the city to do business. But with the rapid urbanization which has resulted in an unprecedented population explosion the reverse is now the case. It is estimated that up to 60% of the population of the city live in slums and informal settlements within the centre of the city (Obuobie et. al, 2006). These people generally have no access to basic sanitary facilities. This is because rooms which were initially meant for use as toilets have been converted to shops and sleeping rooms and this has also been rented out due to the high demand for accommodation within the city. For such people the only option left to them so far as sanitary facilities are concerned is to use public toilets. Almost about a third of the city's population use public toilets as their main means of convenience.

According to the Waste Management Department of the Accra Metropolitan Assembly, public toilets were meant for the floating population. Its construction was therefore encouraged at places such as markets and bus stations. It has never been the policy of the assembly to encourage the construction of public toilets in residential areas. However given the nature of the population in some of the areas in Accra and also how the buildings were constructed it is difficult for those who do not have their own toilets now to construct one. In such places public toilets are allowed. Therefore public toilets could be found in virtually all the densely populated areas in the city.

Obiri-Opareh et al (2001) cite some of the reasons for the increasing use of public toilets by residents of the city as the high cost of building and operating one's own toilet particularly when it is not connected to the sewer. Other factors are the lack of water which is prevalent in most parts of the city and the general misconception even among government official that money should not be wasted on toilets (this was because until the 1990s no user fee was charged for the use of public toilets).

The Metropolitan Assembly had taken several initiatives to encourage households to own their own toilets but not much have been achieved in this regard. The most recent initiative was the acquisition of funds from GTZ under the Urban IV project which was aimed at enabling households to own their own toilets under a cost sharing agreement. Under this arrangement, landlords pay for 50% of the cost of the toilets in terms of the provision of building materials whilst the assembly support with another 50% in the form of construction and expertise advice. Although this project is still running and the money from the assembly was meant as a gift, households are not assessing it. They claim the money is inadequate and more so it can only be assessed at the very end of the construction of the building for example when the septic tank is about to be constructed

For the smooth operation and maintenance of the public toilets, a user fee is charged per usage. The charge depends on the location and type of facility. Depending on the location of a facility, a public toilet may have a urinal attached (this is prevalent in places where there is a large commuter population such as Tudu and Okaishie); others also have a bath attached whilst others still have water vending facility as well.

In terms of construction, public toilets are of water closets either connected to the central sewer or a septic tank. Others are of the Kumasi Ventilated improved Pit (KVIP) latrine and there are a few others which are pit latrines or aqua privies. For the onsite treatment systems when the holding receptacles are full, the contents are exhumed and transferred to one of the faecal treatment plants in the city (unfortunately these are not functioning properly and hence the waste enters the environment untreated).

Management of public toilets have been privatised since 1997. Private operators now operate and manage this facility. In cases where the facility is built by the assembly, tenders are invited from the general public to bid for its operation immediately after the construction of the facility. These operators are required to pay a percentage of their net earnings to the assembly after overhead costs such as electricity and dislodging cost among others have been deducted. In some cases, the build operate and transfer system (BOT) operates. Under this arrangement, the private entrepreneur constructs the facility. It is operated for a week after which a headcount is conducted. The headcount will determine how long it will take the investor to pay back his investment. Once again, after deducting the overhead cost, 60% of the earnings go to the entrepreneur to enable him to pay back his investment whilst the 40% comes to the assembly. After the payment period, the arrangement is then changes to 40% for the entrepreneur and 60% for AMA.

4.3. *Economic Activities in Accra*

According to the 2000 Population and Housing census the employment rate within the AMA is 86.8% (GSS, 2005). Figure 4.11 gives the various sectors in which they are

employed. 34% of the population is engaged in sales which is the highest employment sector with the agriculture sector attracting only 3.3%. Out of the number in the agricultural sector, 22.2% are engaged in urban agriculture whilst the rest are mainly into fishing.

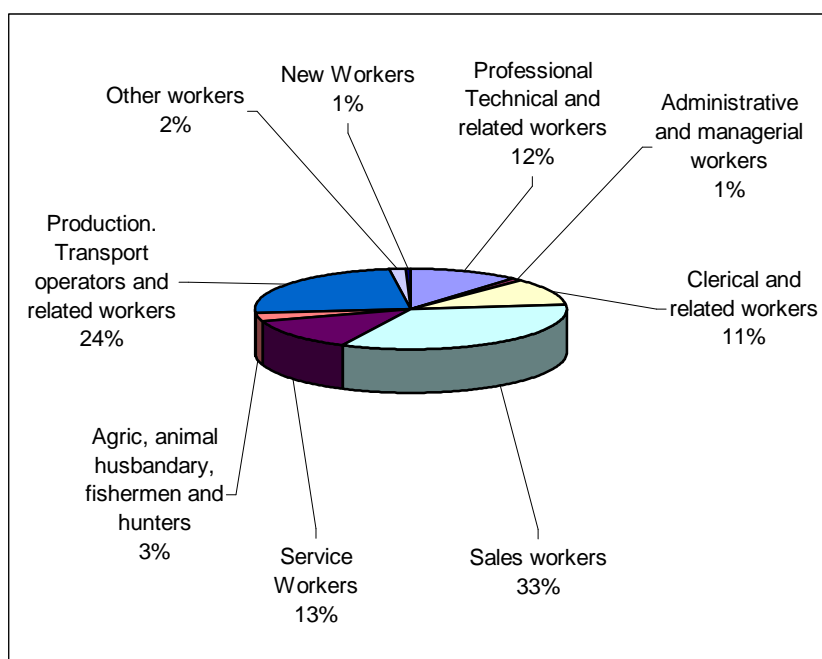


Figure 4-11: Economically active population by type of occupation (Source: GSS, 2000)

4.3.1. Urban Agriculture in Accra

Urban agriculture can be defined as the production, processing and distribution of foodstuffs and non-food products within and around urban areas. Urban farming systems can be classified under many typologies. Often, the selection of a particular criterion is based on the purpose of its use or reflects the disciplinary background of the respective author (Drechsel, 2006). Most of the land under urban farming cultivation belongs to the government or other private individuals who are not yet ready to develop their plots. In most cases these farmers lack security as they are not owners of the land they are farming on.

For purposes of this study the typology of urban agriculture shall be classified under the following headings namely:

- Crop production system
- Non-crop production system
- Inputs and services delivery
- Processing and marketing of farm products.

Crop Production System

Crop production can be classified into three main forms namely open space farming for the urban market, backyard gardens cultivated for home consumption and peri-urban agriculture which takes place up to a distance of 38 km from the city centre.

Figure 4.12 shows the location of the open space farming sites in Accra. These farms are located at the Marine drive near the independence square, Dzorwulu around the plant pool, La and Korle-Bu. Other sites are the Motorway around the Tetteh Quarshie

roundabout, areas around the CSIR and the IWMI offices and the area around the Ghana Broadcasting Corporation.

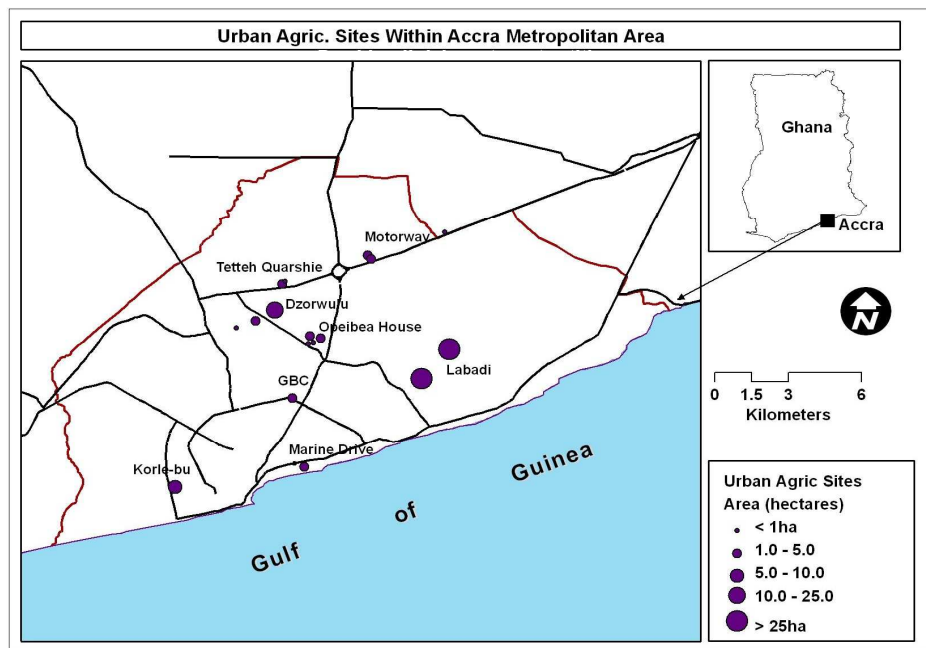


Figure 4-12: Location of Urban farms in Accra (Source: IWMI database)

Most of the farmers in Accra are vegetable farmers. There are about 1000 vegetable farmers. 60% of them grow exotic crops whilst the rest are into local vegetable production. Additionally, some farmers also grow maize during the raining season to supplement their incomes. Figure 4.13 shows a typical urban farm in Accra. Plot sizes for each farmer ranges between 0.1 ha to 0.2ha. It is estimated within the city alone about 680ha are under maize cultivation, 47 ha under vegetable production and 251ha under cereal and vegetable cultivation. (Obuobie et al 2006).



Figure 4-13 A Typical Urban Farm in Accra (Source: IWMI database)

Backyard gardening also known as home gardening is also extensively practiced in the city. These farms are often based on agro-forestry systems, utilizing a combination of tree and vegetable crops that are occasionally integrated with livestock rearing .

It is estimated that about 50-70 ha are under backyard garden cultivation. Figure 4.14 shows a typical backyard garden in Accra. In this case plot sizes are usually small averaging about 0.04 ha. Within the city, it is estimated that up to 67% of households are engaged in backyard agriculture. Crops are mainly produced for subsistence purposes unlike open space farming which is meant for the markets. Crops that are grown include: fruits, Millet, Maize, cassava, beans, okra, tomatoes, garden eggs, grain legumes, soybean and pepper (Cofie *et. al*, 2006).

The last type of farming is the peri-urban agriculture which takes place normally on the fringes of the city. Peri urban agriculture is now on the increase as many urban agricultural farmers are relocating to this area. Plot size in this case often extends up to 2.0ha.



Figure 4-14 A Typical backyard farm in Accra (Source: IWMI database)

Non Crop Production System

Non-crop production system within the city of Accra includes poultry, livestock husbandry, aquaculture, and grass cutter rearing among others

These activities are normally undertaken on small scale basis and either as a full time or a part time activity. Poultry farming activities for instance are normally undertaken as a part time activity with the number of birds per farmer ranging between 35 and 2500. They serve as a source of income generation for the farmers as the chicken can be sold to make money and also the dropping can also be sold to the urban vegetable farmer as manure. Livestock productions in the city also consist of the rearing of animals such as cattle, pigs, goats and cattle. This can be done on a no-grazing basis where all the animals are kept at one place and feeds collected for them. The other technique is the free grazing where the animals are led to graze between different

areas where feed can be found. They are normally led by a herder. The number of animals owned per farmer ranges between 4 and 200 animals. The grasscutter which is a bush-animal is also another area in the non-crop system that has received a lot of attention. This animal which is basically a bush animal has been targeted for domestication as it is a delicacy for many of the urban dwellers in Accra. This is done through the use of cages or pens, which not only allows livestock rearing to be conducted in confined areas, but also supplies a very lucrative market as such meat products have an extremely popular demand in all Ghanaian cities. Indeed, grasscutter rearing has been found to be one of the very lucrative farming systems in the city lately. (Cofie *et. al.* 2005)

Only a few farmers are involve in aquaculture production but the market for this is also increasing as the demand for fresh water fish such as tilapia is now on the increase.

Input Services

Under the input service only those related to crop system will be considered. The input in this sector comprises of labour, land and water issues as well as farm tools, pesticides and fertilizer usage.

Most of the urban farming sites in Accra are on land belonging to the government. A variety of land tenure system applies here. In the case of Dzorwulu for instance, there is a mutual agreement between the farmers and the Volta River Authority who are the owners of the land to keep the area under the high tension pole clear and free of weeds. At the Marine drive and Cantonments sites there is a permanent maintenance and cultivation agreement. These lands were initially earmarked for the Parks and Gardens for landscaping and the beautification of the city but have since been handed over to the farmers. No permanent tree is to be cultivated in these areas. At the Korle Bu farming site, this land belongs to the hospital. They have been given to the farmers because the hospital authorities are not yet ready to develop the land yet. These farmers could lose their land anytime at all. The last land tenure system operates at La around the Trade Fair. On this site, there is a formal agreement between farmers and the traditional owners. Farmers can farm on this land until the land is finally disposed off. Rent is paid in the form of cash or by shared cropping.

The water mainly used for irrigation comes from the drains and streams or from pipe borne water. Most of the farmers use the water from the drains and streams and do not pay for its usage. The dangers associated with the use of drain water had necessitated the AMA to introduce pipe borne water in the farms at Dzorwulu and La. Farmers pay a flat rate for this type of water irrespective of the volume of water used.

As a result of the low fertility of soil in the city a lot of fertilizers is required in order to bring the crops to the required yield. Table 4.2 shows the fertility of some of the soils in the country. The Greater Accra of which Accra is part is among one of the regions with the poorest soil condition.

In terms of fertilizer usage, the main types of fertilizers that are used by the urban farmers are: NPK15-15-15, Ammonia Sulphate, Urea and Muriate of Potash. Other fertilizer such as poultry manure, cow dung and compost is also in use. But among most urban farmers the use of poultry manure is the most preferable as they are affordable and effective in terms of food nutrients for plants. The cost of a bag of 30-35kg is 50 pesewas including transportation. The availability of this manure is

however a problem as there is not that many commercial poultry farmers in Accra. This development has therefore led to most of the farmers using a combination of chemical fertilizer and the poultry manure.

Table 4-2 Average soil fertility status of some regions

Region	Soil pH	Organic matter (%)	Total Nitrogen (%)	Available P (mg/kg soil)	Available Ca (mg/kg soil)
Ashanti	4.3 - 7.8	1.5 - 3.0	0.1 - 0.3	0.1 – 12.0	0.4 – 11.3
Brong Ahafo	3.5 - 6.7	0.3 - 1.7	-	0.1 – 64.3	16 – 140
Greater Accra	5.4 - 8.2	0.1 - 1.7	0.05 – 0.9	0.1 – 64.3	14 – 470
Northern	4.5 - 6.7	0.6 - 2.0	0.02 – 0.05	2.5 – 10.0	45 – 90
Upper East	5.1 - 6.8	1.1 - 2.5	0.06 – 0.14	1.8 – 14.8	44 – 152
Upper West	6.0 - 6.8	0.5 - 1.3	0.01 – 0.07	2.0 – 7.4	52 – 152
Western	3.8 - 7.1	1.0 - 5.7	0.06 – 5.4	0.4 – 11.3	28 – 420

Source: Soil Research Institute (SRI) CSIR – Kumasi.

Chemical fertilizers are expensive and the prices are ever on the increase. Appendix 3 shows the general prices of fertilizers in Ghana. The NPK 15-15-15 cost GH¢ 45.00 for a 50kiogram bag whilst urea is GH¢39. The use of compost have not however caught on well with the farmers. This is because of the poor quality of the compost as a result of the presence of broken bottles and other undesirable materials in the mix. Other factors is the heat build within the compost resulting in the burning of the plant as well as the high water demand that is normally associated with the use of compost. Lastly, the high cost of the product (GH¢1.00/50kg) also discourages the use of this product.

Processing and Marketing

The processing and marketing sector comprise mainly of how the products are sold. Within the urban agricultural set up most of the farm products such as the lettuce, cabbage, ornamental flower and mushrooms are sold at the farm gate, in local markets or at the supermarkets. Women are mostly involved in this sector and they constitute a very important group within the sector.

The small agro-processing area which is of key interest to the urban farming sector is the home base processing which involves the doughing of maize and cassava, the roasting and frying of fish, plantain and yam as well as the brewing of cereal based local drinks. These activities are normally undertaken on small scale basis and once again women are the main entrepreneurs in this sector

4.4. Conclusion

- According to the 2000 population and housing census, the population of Accra is about 1.6million however the functional population is between 3.0 – 3.4million people. The annual population growth rate extends from 3.4% within the city centre extending up to 9.4% in the peri urban settings.
- Public toilets are a predominate feature in the city as close to a third of the population use this type of toilet

- Waste management in the city is generally poor resulting in the pollution of the water bodies and periodic flooding whenever it rains.
- Urban farming is vibrant in Accra but the main impediment is the high cost of mineral fertilizers and the unavailability of a suitable substitute.

5. CLOSING THE LOOP

5.1. *Background of Ecological Sanitation*

The problems of urbanization in Accra include food scarcity and environmental pollution. Food scarcity has been partly brought about as a result of the breaking up of the link between the rural and the urban centres (which hitherto were the bread basket of the urban centres). The urban farmer who was supposed to step into this gap has also not been able to do so fully as a result of the unavailability and the high cost of agricultural inputs such as fertilizers. Meanwhile the city continues to suffer from severe environmental degradation as a result of the unsustainable manner in which municipal waste is disposed off.

Ecological sanitation has the potential of solving this problem by closing the loop between sanitation and agriculture. This system is based on the fact that sanitation problems could be solved more sustainably and efficiently if the resources contained in excreta and wastewater were recovered and used rather than discharged into the water bodies and the surrounding environment. It is therefore a new paradigm in wastewater treatment which intends to shift the approach from a centralised mixed system to a decentralized system based on source control and separate treatment of concentrated and diluted household wastewater flows (Switch, 2006).

The advantages envisaged by ecological sanitation (Ecosan) include: the improvement of health. This is done by minimising the introduction of pathogens from human excrement into the water cycle. Another advantage envisaged is the promotion of recycling by the safe and hygienic recovery of nutrients, organic matters, trace elements, water and energy for reuse. Others are the conservation of resources, by the lower water consumption as well as the substitution of chemical fertilizers and minimisation of water pollution. Finally Ecosan will contribute to the preservation of soil fertility and improvement of agricultural productivity and hence contribute to food security (GTZ, 2005).

The sanitation practices promoted and practiced today which is known as the conventional system are either based on hiding human excreta in deep pits or flushing them away in sewer networks that discharge the wastewater, either treated or untreated into surface water. Both systems have come under severe criticism of late. For not only are they linear in character but they also present a typical end-of-pipe solution. Furthermore they are economically and ecologically unsustainable as they pollute surface and ground water sources.

The drop-and-store system for instance is relatively simple and affordable to construct. However it cannot be used in areas where the population is dense and crowded as it requires the digging of a new pit every few years which is unavailable in urban centres. It can also not be used on rocky grounds and where the groundwater level is high. The flush-and-discharge system on the other hand requires large amounts of water for flushing, an extensive network of pipe networks, and the installation, operation and maintenance of a treatment system. The system is expensive and unaffordable for many of the municipalities particularly in the developing world. According to Winbald & Simpson-Hébert, 2004 over a year for each person, some 400-500 litres of urine and 50 litres of faeces are flushed away with 15,000 litres of pure water. Water from bath, kitchen and laundry may add up to another 15,000-30,000 litres for each person. Further down the pipe, rainwater from

streets and rooftops and wastewater from industries are often added. Thus at each step in the flush-and-discharge process the problem is magnified.

It is obvious that both systems of sanitation were based on the old agenda of the 1970s and 80 which sort to design sanitation systems just to satisfy the requirements of public health. However in the face of the current urban challenge there is the need to change this approach to one which see this wastewater as a resource in this new era of sustainable development..

5.2. *Constituents of Household Wastewater.*

Waste water is defined as any water that has been adversely affected in quality by anthropogenic influence. It comprises the liquid waste discharged from domestic residences, commercial properties, industries, and agriculture. They might contain a wide range of potential contaminants and concentrations. Table 5.1 shows the wastewater stream from the household. It consists of the grey water and the black water (which is a combination of the brown and the yellow water) as well as the white water.

Table 5-1 Definition of Wastewater Fractions in Households

Wastewater Fraction	Description
Grey water	Washing water from kitchen, shower, washbasin and laundry
Black water	Toilet wastewater (urine, faeces, toilet paper (if used and put in the bowl) and flush water)
Yellow water	Urine with or without flush water
Brown water	Faeces, toilet paper (if used and put in the bowl) and flush water

Source: Gajurel & Wendland, 2007

On average a normal human being discharges 50 litres of faeces, 500litres of urine and produces between 25,000 -100,000 litres of grey water every year. The nutrients produced from this wastewater are on average about 4.5kg of nitrogen, 0.6kg of phosphorous and 1kg of potassium (Otterpohl, 2002). Figure 5.1 and table 5.2 shows the constituents of the household waste water stream. Urine by far contains the most essential nutrients accounting for 87% of the nitrogen, 50% of the phosphorous and 54% of the potassium. It also makes up less than 0.5% of the household wastewater and is virtually pure. Grey water also constitutes the bulk of the waste water carries very little pathogen and can easily be treated and reuse for many domestic purposes such as toilet flushing and irrigation. Faeces is by far the fraction that contains most of the pathogens in the wastewater but also contains a lot of organic matter which is useful as a soil conditioner (Jönsson et al. 2000)

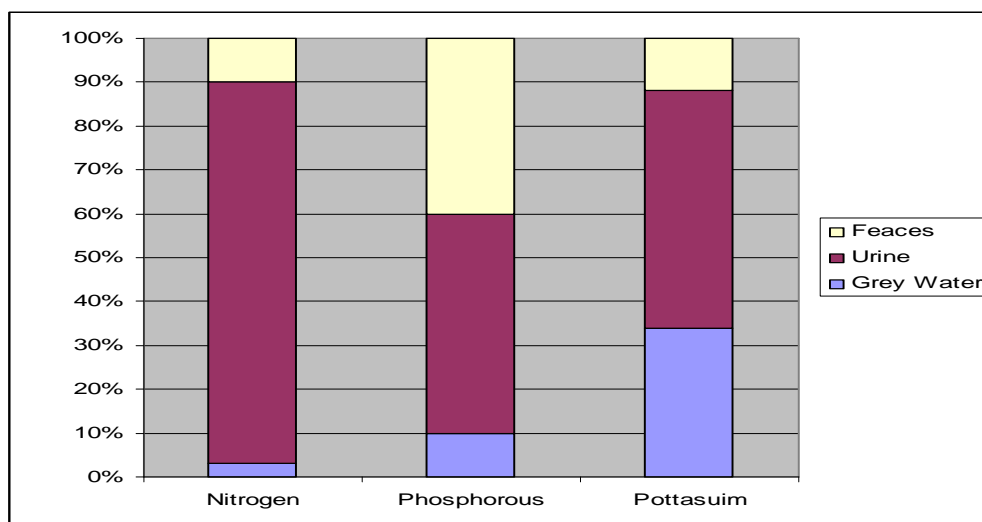


Figure 5-1 *Constituents of Household Wastewater (Source: Hoglund, 2001)*

Table 5-2 *Approximate Composition of the dry weight of feeces and Urine*

Constituents	Approximate composition (percentage of dry weight)	
	Feeces	Urine
Calcium (CaO)	4.5	4.5-6.0
Carbon	44-55	11-17
Nitrogen	5.0-7.0	15-19
Organic Matter	88-97	65-85
Phosphorous(P ₂ O ₅)	3.8-5.4	2.5 - 5.0
Potassium(K ₂ O)	1.0-2.5	3.0-4.5

Source: Feachem, 1983

What this means is that if these flows are separated and collected; the wastewater from the household can supply fertilizer from urine, soil conditioners from feeces and irrigation water from the grey water. This will solve most of the input problems of the urban farmer.

5.3. *Urine Harvesting*

Urine constitutes less than 0.5 % of total domestic wastewater, and yet it plays a major role for water pollution control (Larsen and Lienert, 2003). Winblad & Simpson-Hébert (2004) confirm that urine contains only a few disease-producing organisms, while faeces may contain many. Additionally, urine contains most of the soluble nutrients in domestic waste water. Grey water, despite its very large volume contains only a small amount of nutrients whilst faeces, which is about 10 times smaller in volume than urine although also containing nutrients has the largest part of pathogens (Gajurel & Wendland 2007). It therefore makes sense to separate and harvest the urine if the sole purpose is for fertilization.

There are quite a number of ways in which urine could be harvested. Like the Ecosan concept, a whole variety of systems are available. The system may range from a low cost-low technological system to a high cost-sophisticated one. Urine might either be harvested from a no-mix toilet or from a stand-alone urinal.

In a no-mix toilet, the special feature in these toilets is a specially designed pedestal which makes it possible for the urine to be diverted at source so that it is not mixed with the faeces. Figure 5.2 shows a urine diverting toilet of a high cost-sophisticated type. In these toilets there is either a separate flushing mechanism for the urine and faeces or the flush water rinses both bowls. The urine is usually collected in tanks which are placed underground or in a basement under the house. Figure 5.3 also shows a special tank meant for urine collection at the Valley View University in Ghana.



Figure 5-2 Urine diverting toilet at Valley View University



Figure 5-3: Urine Collection Tank at Valley View University, Accra, Ghana.

Cheaper methods of urine harvesting are also possible. Figure 5.4 and 5.5 shows the method used in harvesting in some developing countries. Figure 5.4 shows a type available with a squatting bowl using minimal water as it is a pour flush type whilst figure 5.5 shows one that is currently used in South Africa for dry toilets



Figure 5-4 Harvesting of urine using a squatting closet (Dragnet, 2003)

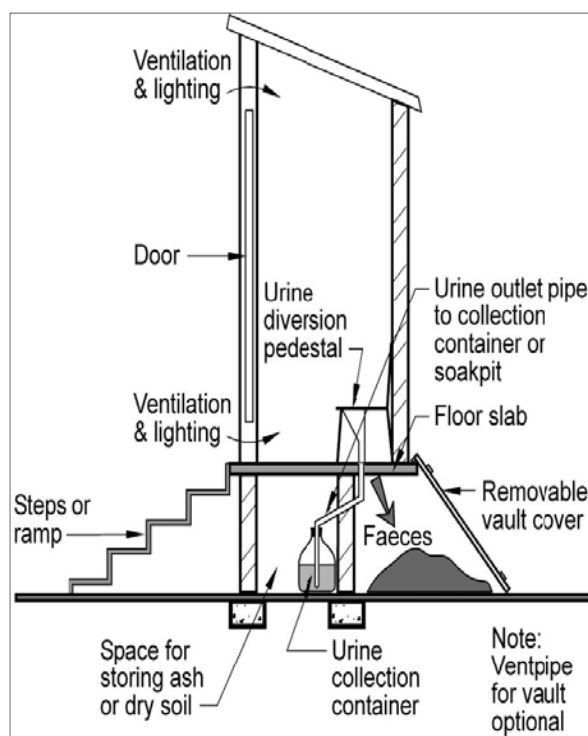


Figure 5-5 Urine harvesting from a dry toilet (Mnkeni and Austin, 2004).

There is also a wide variety of standalone urinal which could be adopted for the purpose of urine harvesting. Figure 5.6 shows an example of a waterless urinal at the Valley View University. These urinals have recently been introduced into the market and are ideal for situations without reliable water supply and also in public places where people use the toilet more for urinating than for defecation. The urinal have special valves which seal off the content of the tank from the urinal itself and therefore produces no smell as compared to the traditional type. The advantage of harvesting urine from this source is that there is no risk of pathogenic contaminations from the cross contamination of the faeces particular in areas where anal washing is practice. A further advantage is also that men are free to stand and urinate unlike the previous instance where they have to sit. Other types could be adapted for use by women.



Figure 5-6 Waterless urinal at Valley View University

5.4. Fertilizing Value of Urine

Diet influences the volume of faeces a person will pass according to the digestibility of the food whilst the amount of urine depends on the temperature and humidity. For this reason, the volume of faeces and urine produced by an individual varies from region to region and depend on factors such as climate, the age of a person, their water consumption, diet, and occupation (NWP, 2006). Averagely, a person excretes about 500 litres of urine in a year which is ten times the volume of the faeces. Urine contains mostly water, 93–96%, and the dry solid amounts to some 18–25 kg per person per year. Human wet faeces on the other hand contain a large proportion of water (70–85%) and weigh 50–180 kg depending on food intake. The solid part is mainly organic material, including micro-organisms (Drangert, 1998).

Mass balance exists over the human body also for plant nutrients. This means that the flow of nutrients within the urine and also the concentration of nutrients in the urine varies with diet and therefore varies between countries and individuals. Table 5.3 shows the concentrations of nutrients in urine assuming 1.5 litres of urine per person per day from different countries around the globe. In Ghana preliminary results obtained from the Valley View University indicates a nutrient content of 2650mg/l NH_4^+N , 200mg/l $\text{P}_2\text{O}_4\text{-P}$ and 830mg/l K (Fries, 2006).

Table 5-3 Excretion of Nitrogen, Phosphorous and Potassium in urine from different parts of the world

	Nitrogen (kg/person, year)	Phosphorous (kg/person, year)	Potassium (kg/person, year)
Sweden	4.0	0.37	0.9
Kenya	2.1	0.23	0.8
China	3.5	0.4	1.3
Haiti	1.9	0.2	0.9
India	2.3	0.3	1.1
South Africa	3.0	0.3	1.2
Uganda	2.2	0.3	1.0

Source: Jönsson & Vinnerås, 2004

Nutrients present in human urine is mainly sodium chloride (NaCl) and urea [CO (NH₂)₂] although urine also contains other nutrients such as potassium, calcium sulphate and phosphorus (Lind et. al 2001). Interestingly, these nutrients so excreted in the urine are in ideal forms for uptake by plants. In freshly excreted urine; nitrogen is in the form of urea which readily degrades to ammonia. In the process the pH is raised from between 4.8 – 7.5 to around 9. This process sanitises the urine. The ammonia is later nitrified to nitrate in the soil. Phosphorus is also present in the urine as phosphate ions, whilst potassium exists as potassium ion and sulphate as sulphate ions. This makes urine a unique biologic fertilizer. Furthermore, the nutrient balance and content of the urine well reflects what the crops have removed from the fields and thus the average need of fertilisation. This means that the nutrient content and balance of the urine is similar to that of the consumed food (Höglund, 2001).

The use of human urine as a fertilizer is still at its initial stages of investigation. Nevertheless, results from studies conducted so far indicates that it is comparable to fertilizers such as animal urine mineral fertilizers. Table 5.4 shows the relationship between human excreta (with urine containing most of the nutrients) and some manure such as: plant matter, pig, sheep, poultry and cow manures. Human excreta contain the largest nitrogen as well as the phosphorous content and have comparable potassium content although not as high as that of plant manure. Urine is also a quick-acting fertilizer and its effect can be compared with chemical fertilizers with a high mineral content. Furthermore, the relationship between the content of nitrogen, phosphorus and potassium is well-balanced and largely corresponds to the need of cereal crops if the dosage is appropriate. It also contains very low levels of heavy metals.

Table 5-4 Comparison of human excreta with other organic fertilizers (figures from Ghana in brackets)

Type of Manure	Percentage of nutrient by of dry solids		
	N	P ₂ O ₅	K ₂ O
Human excreta	9-12	3.8	2.7
Plant matter	1-11	0.5-2.8	1.1-11
Pig manure	4-6	3-4	2.5-3
Cow manure	2.5 (1.2)	1.8(0.17)	1.4(0.11)
Sheep	(1.55)	(0.31)	(0.15)
Poultry	(2.2)	(1.8)	(1.1)

Source: Strauss (1985) & SRI - CSIR, 1997

Figure 5.7 to 5-9 show some experiments that were carried out on spring barleys in Sweden using human urine for fertilization and reported by Johansson, 2000. The trials were carried out in 1997, 1998 and 1999. The trial revealed that spring barley yields in 1997 on plots fertilized with human urine amounted to about 80% of those on plots fertilized with mineral fertilizer. The dosage was 100 kg of nitrogen per hectare for human urine and a dose of 90 kg per hectare for mineral fertilizer nitrogen for the same hectare.

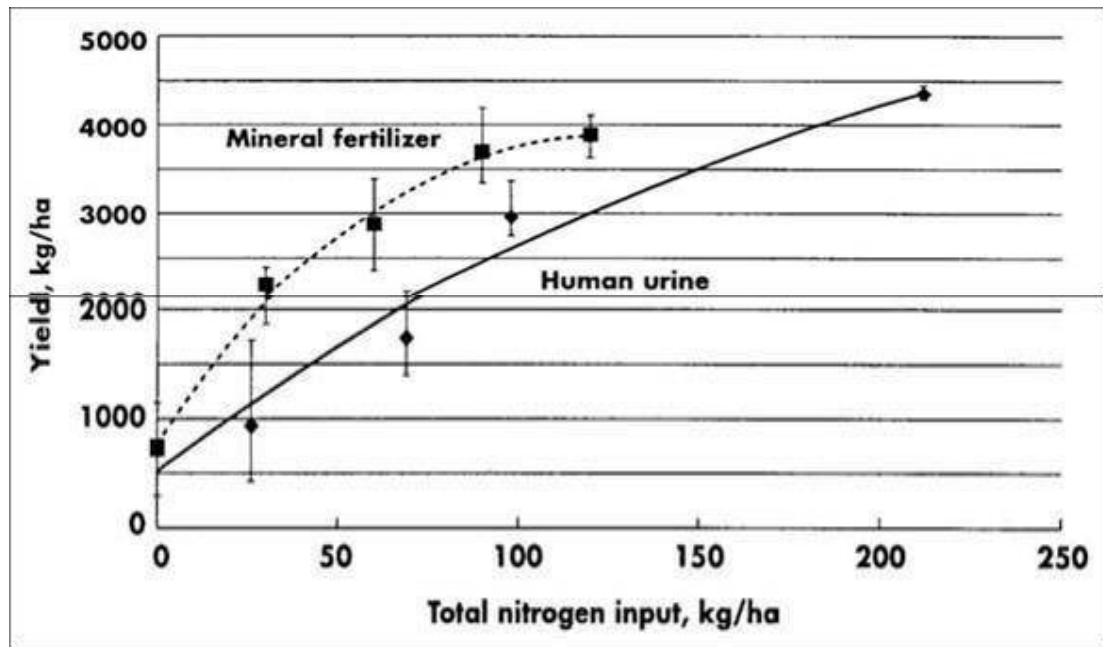


Figure 5-7: Barley yields in plots fertilized with human urine and fertilizer in 1997.

The weather in 1998 caused high nitrogen mineralization in the soil. The effect of mineralization was greater than the effects of fertilization. In that year the yield in plots fertilized with human urine was greater than in those fertilized with mineral fertilizer, but the difference was small since the yield was mainly determined by other factors. In 1999, the yield resulting from a dose of about 80 kg nitrogen/ha of human urine corresponded to 85% of that in plots fertilized with 90 kg of mineral fertilizer/ha

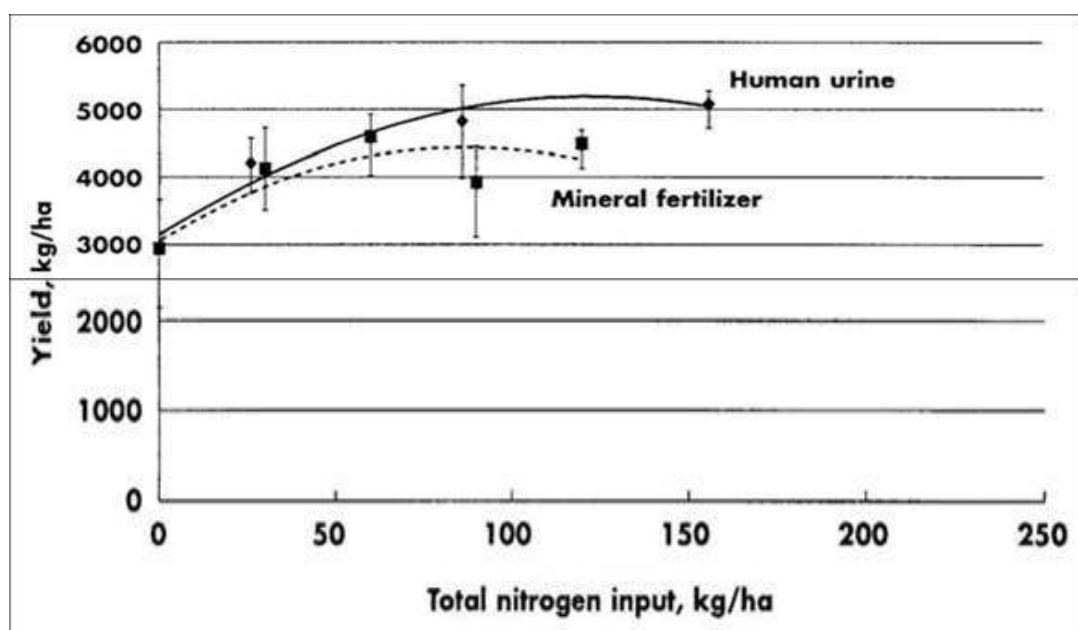


Figure 5-8: Barley yields in plots fertilized with human urine and fertilizer in 1998.

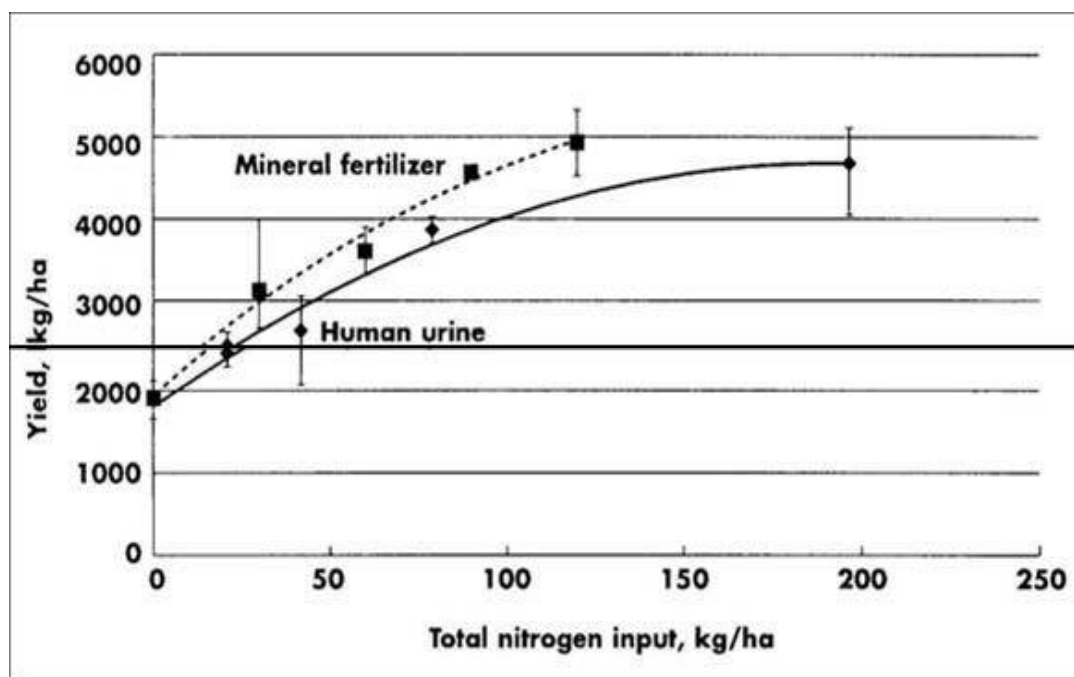


Figure 5-9: Barley yields in plots fertilized with human urine and fertilizer in 1999.

Winblad & Simpson-Hébert (2004) also report that in a series of experiments carried out in Harare, Zimbabwe, during 2002, it was shown that by adding the 3:1 water: urine mix to vegetables planted in 10-litre containers three times per week, with all other irrigation carried out with water alone, spinach yield was increased up to 6 times, covo yield 1.5 – 4 times, lettuce yield was doubled and the weight of tomatoes increased up to 3.6 times compared with similar plants grown in similar soil and similar containers, but irrigated with water only as shown in Table 5. 5.

Table 5-5 : Plant trials with urine for various crops

Plant and growth period	Weight at cropping (water application only) grams wet weight	Weight at cropping (3:1 water: urine application 3 x week) grams wet weight
Lettuce – 30 days	230	500
Lettuce – 33 days	120	345
Spinach – 30 days	52	350
Covo* – 8 weeks	135	545
Tomato – 4 months	1680	6084

Source: Winblad & Simpson-Hébert (2004)

Sundin (1997) also compared the yields of Swiss chard fertilized with urine and those without urine. She discovered an average yield of 3.9times higher yield in those fertilized with urine as compared to those without.

Figure 5.10 also shows some demonstration trial that were done on maize. This shows a substantial increase in the weight of the maize as the amount of urine fertilizer was increased. Whilst the maize which was in the controlled group just weighed 63g, the one fertilized with 750ml of urine weighed 406g and the one with 1750ml of urine weighed 954g.

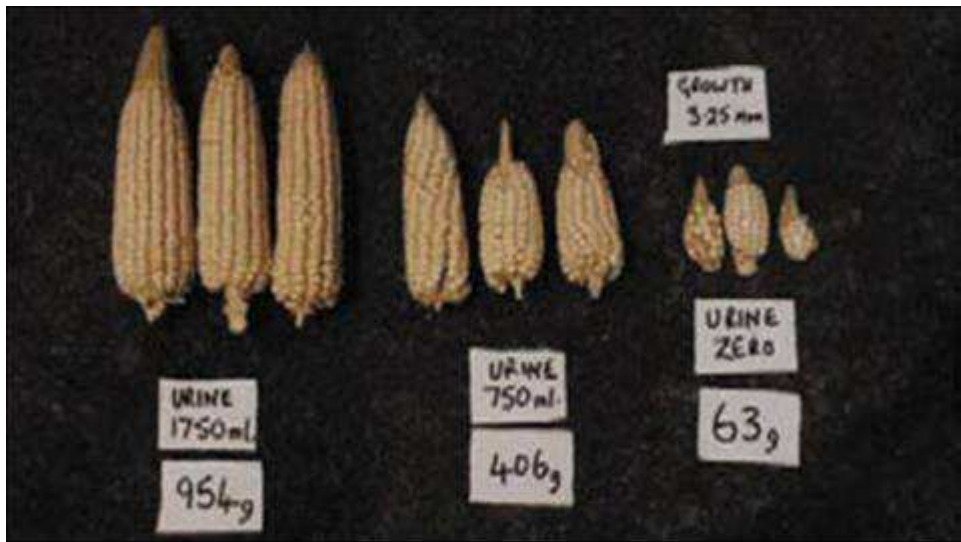


Figure 5-10 Maize fertilized with urine (Source: Morgan, 2005)

Table 5.6 also shows the results of crop yield on a demonstration program on ECOSAN (ecological sanitation) in seven West African countries. CREPA is the organization in charge of this. In this case, phosphorous and potassium were added to support the deficiency of this nutrients in urine. The demonstrations showed that crops fertilized with hygienise urine and faeces often gave a higher yield during a longer harvest period than crops fertilized with chemical NPK fertilizer

Table 5-6: Crop yield from crops fertilized with urine as compared to mineral fertilizers

Plant		Aubergine	Gombo	Tomato	Lettuce	Chou	Sorghum	Maize
Country		Burkina	Burkina	Burkina	Togo	Togo	Burkina	Benin
Reference plot	Harvest: Ton/ha	2,8	1,7	2,1	6,8	19,1	2,3	2,4
NPK Urea	+ Harvest: Ton/ha	17,1	2,6	5,8	13,3	31,0	4,1	3,5
PK Urine	+ Harvest: Ton/ha	16,0	2,3	5,2	15,7	32,0	3,8	3,6

Source: Urban Agriculture Magazine # 19 (forthcoming)

From the above, it could be seen that urine has comparable fertilizing qualities as chemical fertilizers. Also the increase in crop yield with crops fertilized with urine is between 2 to 6times higher than those without fertilization. When using urine however it must be borne in mind that ammonia and nitrate which are present in urine are both toxic to plants. It is therefore appropriate to apply it a few days before seeding. However if it is required to be applied later on, then care should be taken not to apply it directly on the plant as the ammonia content of the urine might burn them. It should also not be applied on the root so as to get them soaked as the plant will also die during the few days that the fertilizer is available as nitrate. The recommended method is to apply it a small distance away from the plant but still close enough to allow the roots of the plant to reach it.

5.5. Health Implications of Urine Usage:

Urine in itself presents virtually no risk of infection. However, it can be contaminated by pathogens present in faeces (Johansson, 2000). This is particularly in urine diverting toilets and also in places where anal rinsing is practiced. In a healthy individual the urine is sterile in the bladder. When transported out of the body however different types of infections might be picked up.

The pathogens traditionally known to be excreted in urine are: *Leptospira interrogans*, *Salmonella typhi*, *Salmonella paratyphi* and *Schistosoma haematobium*. Leptospirosis is a bacterial infection causing influenza-like symptoms and is in general transmitted by urine from infected animals and not human beings. *Salmonella typhi* and *Salmonella paratyphi* only cause excretion in urine during the phase of typhoid and paratyphoid fevers when bacteria are disseminated in the blood; however urine-oral transmission is probably unusual compared to faecal-oral transmission. Schistosomiasis, or bilharziasis, is one of the major human parasitic infections mainly occurring in Africa. These eggs are excreted in urine, during the whole life of the host. The eggs hatch in the environment and the larvae infect specific aquatic snail species, living in fresh water. After a series of developmental stages aquatic larvae emerge from the snail, ready to infect humans through penetration of the skin. (Feachem et.al, 1983). Sexual transmitted pathogens might also be occasionally excreted in the urine of persons infested but their survival outside the body is not of a public health concern. Table 5.7 shows some of the pathogens that are excreted in urine and the importance of urine as a transmission route. It could be seen that the transmission of urinary excreted pathogen is of limited concern environmentally. Even in instances of *Schistosoma haematobium* it only becomes ineffective when there is an intermediate snail host.

Table 5-7: Pathogens that might be excreted in Urine and the importance of urine as a Transmission route.

Pathogen	Urine as a transmission route	Importance
<i>Leptospira interrogans</i>	Usually through animal urine	Probably low
<i>Salmonella typhi</i> and <i>Salmonella paratyphi</i>	Probably unusual; excreted in Excreted in systemic infection	Low compared with other transmission route
<i>Schistosoma haematobium</i> (eggs excreted)	Not directly, but indirectly. Larvae infect human in fresh water	Needs to be considered in endemic areas where the snail intermediate host are present
<i>Mycobacterium</i>	Unusual, usually air borne	Low
Viruses: cytomegalovirus, polyomavirus, JCV, BKV, adenovirus, hepatitis virus and others	Not normally recognized. Other than single cases for hepatitis A and suggested for Hepatitis B. More Information needed.	Probably low
Microsporidia	Incriminated but not confirmed	Low
Sexually transmitted pathogens	No. Do not survive for significant period outside the body.	Insignificant
Urinary tract infection	No. No direct environmental transmission	Low to insignificant

Source: WHO, 2006

The greater concern therefore lies in the faecal cross contamination. Storage eliminates or reduces the number of pathogens in the urine. The reduction is greater if

the urine is stored for a long time, at high temperature, with a high concentration of nitrogen and a high pH level in the solution.

Table 5.8 shows the new World Health Organisation standards for the safe use of urine. A storage time of 6 month at a temperature of 20⁰C will make urine safe for application even in food crops. The time it takes for the actual elimination of pathogens however depends on the original quantity of pathogens and on storage conditions. Storing at a higher temperature in all cases significantly decreases the number of pathogens in the urine. Depending on the type of crop to be fertilized, urine can be stored between periods of 1 to 6 months at a temperature of between 4-20⁰C. Furthermore, when urine concentrated a faster die-off of pathogens is ensured as the environment then becomes too harsh for them to survive. Again, for urine that is highly contaminated a longer storage period and a higher temperature is required than urine that is for instance harvested from the household level. For this reason it is normally not recommended to harvest urine in places where the excretion of pathogens and medicines is known to be higher than normal in the population. In the storage process also, urine should be stored in an airtight container to prevent humans and animals from being exposed to the urine, to reduce the level of odour and also to prevent the loss of plant available nitrogen

During application, steps should be taken to reduce the formation of aerosols and the exposure of the farmer. Aerosol formation can be reduced by applying the urine close to the ground and harrowing soon after application or by the addition of water. Food crops should not be fertilized with urine for a period of one month prior to harvesting (Johansson, 2000). Additionally, farmers should wear gloves and thorough wash their hands after using urine.

Table 5-8: The relationship between storage conditions, the pathogen content of the urine mixture and recommendations for crops in larger systems (a)

Storage Temp	Storage Period	Presence of pathogens In the urine Mixture (b)	Recommended Crops
4 ⁰ C	>1 month	Viruses, protozoa	Forage and food crops that are to be processed
4 ⁰ C	> 6 months	Viruses	Food crops that are to be processed, forage crops (c)
20 ⁰ C	> 1 month	Viruses	Food crops that are to be processed, forage crops (c)
20 ⁰ C	> 6 months	Probably none	All crops (d)

(a) "Larger systems" in this case means that human urine is used to fertilize crops that are consumed by persons other than the members of the household where the urine is collected.
 b) Gram-positive and sporulating bacteria are not included.
 c) Except grassland for the production of animal feed.
 d) In the case of food crops consumed raw it is recommended that fertilization with urine be discontinued at least one month prior to harvesting and that the urine is incorporated into the soil.

Source: WHO, 2006

5.6. Conclusions:

- Urine could be harvested either from the toilets by means of urine diversion toilets or from stand alone urinals.
- The increase in crop yield for crops fertilized with urine is between 2 to 6 times higher than crops not fertilized at all but comparable to crops fertilized with chemical fertilizers
- In terms of health aspects, urine is comparatively safe. The storage is a low cost effective treatment which achieves pathogen die-off thereby rendering urine safe for application on crops.

6. REQUIRED INFRASTRUCTURE, LOGISTICS AND FINANCIAL IMPLICATIONS OF URINE HARVESTING AND USE

6.1. Potential for Urine Harvesting in Accra

The potential for urine harvesting in Accra is very high. This is due to the population of the city and also the high number of people who use the public toilet. Table 6.1 shows the estimated population of the city based on the 2000 population and housing census which gave the city's population as 1.6million with an annual population growth of 3.6%. As at 2008 the population is estimated at 2.123 million excluding the commuting population.

Table 6-1 Projected Population of Accra from 2001-2010

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Pop. (mil.)	1.6	1.6576	1.717	1.779	1.843	1.909	1.978	2.049	2.123	2.200

Table 6.2 also shows the potential nutrients which could be harvested at the public toilets in Accra. The estimated amount of urine to be collected from these public toilets is based on the third of the population who use this facility (707, 937 people). Averagely an individual excretes 500litres of urine a year. This amounts to 354,663 m³ a year. This is equivalent to 1064 tons of nitrogen, 70.93 tons of phosphorous and 294.4 tons of potassium. Currently these volumes of nutrients enter into the environment untreated causing environmental degradation at the expense of urban agriculture.

Table 6-2 Potential Nutrients to be harvested from Public toilets

Current Population	No using public toilets	Potential urine to be harvested for the year (m ³)	Nitrogen Content (Tons)	Phosphorous Content (Tons)	Potassium Content (Tons)
2,123,000	709,327	354,663.5	1064	70.93	294.4

Table 6.3 on the other hand also shows the fertilizer demand for urban agriculture in the city of Accra. Whilst 978ha of land is under active cultivation, most of these lands are under rain-fed maize or maize-mixed system and this hardly get any fertilizer in the city. In fact it is only vegetables which receive intensive fertilization. Currently the area under vegetable cultivation is only 100ha (Obuobie et.al.2006). Given that the fertilizer required per hectare per year is 70kg for nitrogen, 50kg for phosphorous and 50kg for potassium then the total fertilizer required for the city is 7tons for nitrogen, 7 tons for phosphorous and another 7 tons for potassium. It therefore follows that if all the urine from the public toilets is harvested (which from Table 6.2 is 1064 tons of nitrogen, 70.93 tons of phosphorous and 294.4 tons of potassium) it will be far in excess of what is required for urban agriculture in Accra.

Table 6-3: Fertilizer demand for urban agriculture in Accra.

Fertilizer type	N	P	K
Fertilizer demand (kg/ha/yr)	70	50	50
Area under vegetable cultivation (ha)	100	100	100
Total Required (kg)	7000	5000	5000

Source: Tettenborn et al 2008 (modified)

In fact Cofie et al (unpublished) recently conducted out a study on some 20 public urinals within the Central Business District. This district mainly contains the commuter population with a lot of business enterprises around. The urinals are privately owned and the franchise to operate these was given by the WMD of the AMA in line with its privatization policy. The main purpose behind the mounting of these urinals was to alleviate the difficulties people were facing when they want to urinate in the CBD.

Figure 6.1 shows a typical urinal in the CBD. These urinals have attendants attached to them who clean the facility and also collect user fees of between 5 pesewas to 10 pesewas per usage. The initial agreement between the WMD and the urinal entrepreneur was that the entrepreneur was to store, transport and dispose the urine collected from these urinals into one of the sanitary sites of the WMD. But unfortunately this is not the case anymore as all the urine are now led into either the central sewer or the open drains which eventually ends up at the Korle Lagoon.



Figure 6-1: A typical stand alone urinal in the City of Accra.

There are four main types of urinals within the Central Business District. The first type is the cast iron urinal. These units have no water connection and are used strictly for urine excretion. Figure 6.2 shows an example of this type of urinal the men are required to stand and urinate whilst the women sit whilst urinating. It is the commonest type of urinal within the city. The second type is the concrete double urinal units. This also has no water connection and is used strictly for urine excretion. The third type is the concrete multi seater water-closet units with a water connection but no running water. They are used strictly for urine excretion, but can handle faecal excretion when there is running water. The last type is the concrete multi seater water closet units with a water connection and water reservoir, used for both urine and faecal excretion



a) Male Urinal

b) Female Urinal

Figure 6-2 Typical urinal in Accra

During the study and from the data generated from 14 attendants it was estimated that up to 7264 litres of urine could be generated in a day. This amounts to 2.65 million litres a year.

Figure 6.3 shows the yield of urine generated per day from the study area. Urinal KTSS which is located on the Kojo Thompson Road displayed the largest urine generation rate of 1104 l/day whilst the MMTS and the TIA which are located at the Metro Mass transit Station and the Tema Station respectively generated the minimum of 120 l/day. In terms of nutrients, the volume of nitrogen, phosphorous and potassium that could be obtained per year is 7.95 tons, 0.53 tons and 2.2 tons respectively. This is equivalent to 114%, 11% and 44% of the nitrogen, potassium and phosphorous requirement for urban agriculture in Accra.

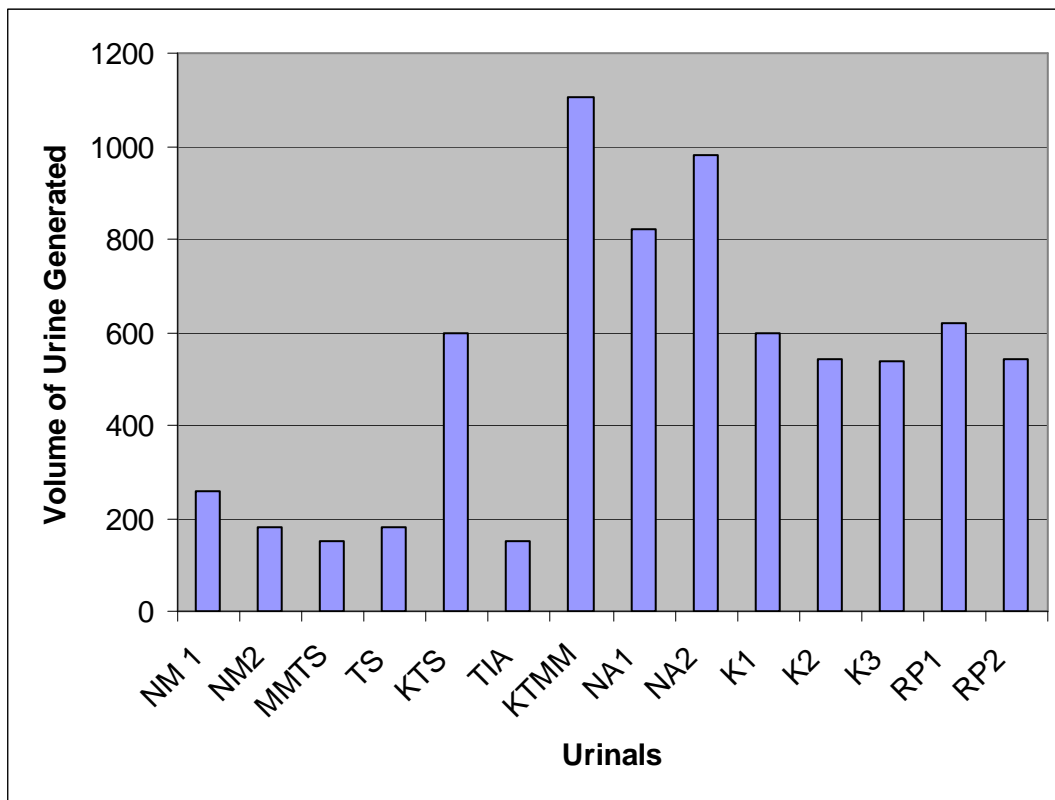


Figure 6-3 Urine Generation rate within the CBD (Source: Cofie *et. al* - unpublished)

6.2. Infrastructure required for Source Separation and Application of Urine

Figure 6.4 shows the infrastructure required to make urine harvesting and its application on the field possible. At the urinal level, some infrastructural works need to be done to re-route the urine into a holding tank which should preferably be underground.

Pipes need to be laid from the urinal to underground holding tanks which will store the urine. These tanks should be airtight in order to prevent the contact of urine with oxygen. This will ensure the retention of plant available nitrogen as well as the reduction of odour. Plastic tanks are best suited for this purpose. These tanks should also be fitted with an adaptor to make suction possible. An overflow should be fitted to the tank so that in the case of emergencies, the urine will flow into the drain.

When these tanks are full, trucks are required to empty their contents and take them to a storage point or a disposal point whatever the case might be. Although urine is relatively pure it requires some period of storage to achieve pathogen die-off prior to application on the farm. The storage site could be at the farm or at one of the sanitary sites of the WMD. Currently there are no entrepreneurs in the transportation of urine. This means that a new entrepreneur must be sought if this system is to be practiced. The use of the suction trucks used by the septic tank operators lead the fecal contamination of the urine and therefore the introduction of pathogens in the urine



Figure 6-4 Infrastructure required for urine harvesting and application

As stipulated under the agreement between the WMD and the urinal operators; urinal operators should construct their own tanks. The Accra Metropolitan Assembly must however be relied upon to implement this directive. Additionally, the conveying of transportation of the urine to the collection point is also the responsibility of the entrepreneur. Appendix 1 shows how often a urinal holding tank will have to be dislodged. This is based on the rate of current usage and the projected increase in population of the city. It ranges from an average of 1.5 times a month to 7.6 times a month. Appendix 2 also shows the cost of constructing a holding tank and installing an 8000 litre plastic tank for urinal collection.

This will mean that for urine harvesting to become possible an estimated amount of GH¢2,977.88 is required over and above the current cost of installing a normal urinal as well as a monthly operational cost of dislodging ranging between GH¢82.50 and GH¢418. Urinal entrepreneurs will not be prepared to bear this cost and therefore there must be a policy to ensure that this is done.

At the storage point, tanks are also required to be mounted on the farms to receive the urine prior to their usage. A minimum of two tanks will be required for this exercise. An 8500 litre capacity tank will cost GH¢988.00. The two tanks with other plumbing installation will cost GH¢2000. This investment must come from the farmer and it is a onetime investment.

6.3. Comparative cost Analysis

Table 6.4 shows the comparative cost analysis of bringing the urine to the site in comparison to other known fertilizer sources such as poultry manure and chemical fertilizer. The calculation is based on the nitrogen contents of the fertilizers only.

The urea that is sold by Dizengoff (Ghana) Limited contains 46% of nitrogen. Currently it costs GH¢39 (appendix 3). A bag of chicken manure contains approximately the same amount of nitrogen as urea (Ibsram, 2000). Chicken manure is delivered in bags weighing between 30kg and 35kg. They are brought to the site and sold to the farmers there and therefore requires no transportation. The cost per bag is GH¢ 0.50. Approximately, 33 bags of this will make up one tonne and therefore equivalent to a bag of urea

Almost all the urinals in the CBD are waterless and therefore the urine produced is concentrated. The nitrogen content is approximately 3000 mg/litre. This means that 7500 litres of urine is required to equal 1 bag of urea and consequently a tonne of poultry manure. Currently there is no entrepreneur in the urine transportation business. Suction trucks of 7500litres operated by a septic tank emptier charge an amount of GH¢55 for services within Accra.

Table 6-4 Comparative cost analysis for urea, poultry manure and urine (Based on nitrogen components only).

Item	Description	Qty	Unit Cost (GH¢)	Transportation to Site (GH¢)	Total Cost (GH¢)	Infrastructure requirement on site
1	Urea (46%N) ¹	50 kg	39.00	5.00	44.00	A covered and secured shed
	Poultry manure ²	33 bags	0.50	-	16.50	Can be left in the open
3	Urine ³	7.5m ³	-	55.00	55.00	Tanks are required to be bought and mounted on farms

¹ 46% N in Urea = 46/100 x 50kg = 23kg

² Poultry manure= 50kg urea is app. 1 ton of poultry manure. This are also sold in sack of 30-35kg. Including the cost of transportation to site it sells for GH¢0.50.

³ Concentration of N in Urine is 3 g/l. For a 7500 litre truck concentration is 3g /l x 7500 l = 22.5kg which equals approximately 23kg nitrogen.

General comments: Both poultry manure and urine contain other nutrients such as phosphorous and potassium which are not in urea and which were not taken into consideration for this calculation.

6.4. *Conclusions*

- Every year an enormous amount of nutrients is released into the environment untreated. The greatest point of discharge is the public toilets. If urine is collected and harvested at source, it could provide for more than the city demand of nutrients for urban agriculture.
- The volume of urine from the stand alone urinals in the CBD can supply all more that the nitrogen requirement of urban agriculture in Accra as well as a substantial part of the phosphorous and potassium
- Urine harvesting and application will however require a substantial initial capital cost for purchase of tanks and construction of holding tanks.
- There is no entrepreneur currently engaged in the urine transportation business. But engaging a suction tank operated by the septic tank emptying companies will cost GHC55 for the conveying of 7500 litres of urine to the farm
- The nitrogen value of urine produced in Accra is 3grams/litre. 7500 litres of urine is therefore equivalent to 1 bag of urea and 1 tonne of poultry manure. Comparatively urine is by far the most expensive amongst all the three.
- Given that the increase in crop yield is similar for all these types of fertilizers, urine is not competitive at the moment. However, urine should also not be allowed to enter the environment untreated as they will pose substantial environmental damages such as eutrophication of the receiving water bodies..

7. NETWORKS, CO-OPERATION AND TRANSITION

7.1. Introduction

This chapter will mainly be focused on my analysis of the finding of those who I believe are in the socio-technical regime of the existing system as well as those who will make up my potential candidates for the new transitional arena.

Currently the regimes existing are the actors involved in the urban agricultural sector (who are directly involved in urban agriculture) and those in the wastewater sector (who are to be brought in to close the loop). The given list of actors (although, not meant to be exhaustive) covers all the relevant actors.

The study will therefore begin by first analysing the roles of each of the actors. Their activities and interest in the social technical regime will also be observed and finally their perception of the new arena will then be solicited. From this a network of potential members within the new arena will then be built.

7.2. Actors involved in Urban Agriculture

A regime refers to the cognitive, social and technical rule sets that are embodied in practices, artefacts and organization (van Vliet, 2006b). These rule sets are carried out by a heterogeneous network of actors. Within the urban agricultural sector the actors could be classified as direct stakeholders (those who are directly involved in urban agriculture) and indirect stakeholders (those who have some interest in urban agriculture but are not directly involved). They could still furthermore be classified into the following groupings:

- Government actors: These are mainly involved in policy formulation and implementation.
- Local associations: such as the farmers, market women and consumers who are involved in production, selling and consumption of urban farm products.
- Research institutions: who are engaged in knowledge development and transfer in the field of urban sanitation and agriculture.
- Non-Governmental and other organizations: who have recently taken up an interest in the activities of the urban poor and consequently the urban farmer.

7.2.1. Government Institutions

Government institutions who are involved in urban agriculture are normally required to formulate policies and ensure that such policies are complied with. In view of the recent decentralization policy which seeks to bring governance to the doorsteps of the masses, most of these agencies have offices at the metropolitan level.

Department of Food and Agriculture (Ministry of Food and Agriculture)

The decentralization process in 1997 saw the merger of the departments of Veterinary Services, Crops services, Extension, Fisheries, Animal Production, Plant Protection and Regulatory Services & Agricultural Engineering coming together to form the new umbrella organization of the District Agricultural Development Unit (DADU). This development has facilitated grassroots participation in the implementation of agricultural policies and programmes. The department has the mandate for all agricultural activities within the city and is a very important stakeholder in urban agriculture.

Metropolitan Planning Coordinating Unit:

This department, also known as the District Planning Coordinating Unit (DPCU), serves as a Secretariat to the Metropolitan Planning Authority. It advises on the planning, programming, monitoring, evaluation and coordination of all development plans, policies, programmes and projects. Some of its functions are: the collection and preliminary analysis of data as well as the rationalisation and harmonisation of development policies. Others are the implementation of strategies and programmes and also the preparations of projects documentations and direction. Furthermore, it is responsible for the management of the integrated development planning process and projects of the various sectoral departments. They are responsible for planning and therefore have an interest in urban agriculture as they have to plan it as part of the city.

Metropolitan Environmental Health Unit:

This is an important department within the metropolis. It protects, promotes and safeguards public health. It is involved in educating and regulating the activities of the urban farmer on the risk associated with their activities. It also advocates the use of portable water to irrigate vegetable farms. Their regulatory activities involves enforcement of bye-laws and prosecution of offenders particularly those who use waste water in irrigation.

Town and Country Planning Department:

The department is one of the decentralised departments which have been integrated into the Assembly. It is involved in the collection, collating and analysis of data on the natural and human resources of the Metropolis. It is also responsible for the identification of resources within the metropolis and the determination of their potential for commercial, industrial, housing, transport and other developmental activities. It also co-ordinates diverse types of uses and developments of land promoted by various departments and agencies of Government and private developers to facilitate the achievement of the highest possible means of health efficiency and order in the physical environment. It is responsible for zoning of the metropolis and directly has an influence in urban agriculture.

Ghana Export Promotion Council:

The council is the public agency tasked with promoting Ghana's non-traditional products in international markets. The Council also provides private and government parties with a range of market information and statistical trade data services. Exporters receive business advisory services, product development assistance and representation at major trade events. The GEPC is a public organisation working under the aegis of the Ministry of Trade and Industry. It is of importance here as some of the urban and peri-urban farmers produce for the export market.

7.2.2. Research Institutions

International Water Management Institute:

IWMI is a non-profit scientific research organization supported by the Consultative Group on International Agricultural Research (CGIAR) and about 30 other donors. Their focus in West Africa is on poverty reduction and food security through sustainable use of water and land resources in agriculture and water needs. In collaboration with the Resource Centre on Urban Agriculture and Food Security (RUAF), it has launched a 4-year programme called "Cities farming for the future" in Accra and other West African countries. The main aim of the programme is to

facilitate the integration of urban and peri-urban agriculture in the policies and programmes at all levels of government.

Council for Scientific and Industrial Research - Science and Technology Policy Research Institute (CSIR-STEPRI).

The Science and Technology Policy Research Institute is a division of the Council for Scientific and Industrial Research. It carries out research and policy recommendations on agriculture, medicine and environment amongst others. It also in addition provides research and support necessary for the formulation and implementation of science and technology policy that promotes innovations and create enabling environment for sustainable development. It plays a key role in the Resource Centre on Urban Agriculture and Food Security-Cities farming for the future (RUAF-CFF) programmes in Accra and has capacity for training and advisory services.

Valley View University

Valley View University was established in 1979 by the Seventh Day Adventist Church. The university is located at Oyibi near Accra. It is the first private university in Ghana. Programmes offered at the university include: Theology, Religious Studies, Business Administration, Computer Science, Information Technology, Education, Development Studies and Nursing.

In 2003, the university started a pilot scale project on ecological farming. The programme was initiated when the German Ecological Society adopted the VVU to make it a case study and a model ecological campus with financial sponsorship from the German Ministry of Education. Since then, VVU has been engaged in the use of urine as fertilizer to grow crops. The university collects the urine through plastic tanks, sterilize it and transport it to its farms to fertilize crops such as: sorghum, maize, mangoes, cashew and moringa.

7.2.3. Local Associations

Farmers Group:

There are about 800-1000 vegetable farmers scattered throughout the 7 urban farming sites in Accra. In addition to this there are a considerable number of households who are also involved in backyard gardening.

Some of these farmers are organized into co-operatives. The formation of such co-operatives had been advocated by Ministry of Food and Agriculture (MOFA) as a means of enabling the farmers to have more bargaining and negotiating powers with the authorities and other groups in the society (FAO, 2005). The farmers by the role they play as providers of food in the urban centres are the main implementers in the urban agricultural sector.

Consumers:

There is hardly any organized consumer protection organization involved in food safety issues: however PNDC Law 305 B sets out the standards for food production that is fit for the market. The agency in charge of the enforcement of this law is the Food and Drugs Board.

The consumer is very important in the chain of actors in the urban agricultural set up in that he is the final consumer of the crops that are produced from the urban farms.

Traders Association:

The traders association in Ghana is mostly of the informal sector. These traders are mainly the link between the urban farmer and consumers. They are mainly women and are organised and powerful and often headed by a Market Queen. They operate either as wholesalers and retailers. Although they are a very powerful group they lack recognition and no particular attention is given to them during decision making process. The Metropolitan Environment and Health Unit for instances places so much emphasis on the use of portable water by the farmers but have no such restriction for the market women who can also play an important role in the safe handling of food from the farm to the table.

Non-Governmental Organisations and other International Organisations:

A whole lot of NGOs are involved in agriculture but most of them are focused in the rural areas as they see agriculture to be a largely rural activity. Of late a few of them have begun to venture into the urban centres. In Accra the Adventist Development and Relief Agency and the Catholic Relief services are a few that can be mentioned. They normally help in policy dialogue, networking and training of the urban farmers. Other organizations such as the Food and Agricultural Organisation, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and People Dialogue are also some of the important stakeholders within the urban agriculture framework.

Fertilizer Producers:

Some major fertilizer companies are based in Ghana. Some of these are Dizengoff (Ghana) Limited, Weinco (Ghana) Limited, Chemico and Yara. In an attempt to reach urban farmers they have repackaged their pesticides and fertilizers into smaller packages of 1 kilogramme each. Some of the fertilizers on sale in the city include: NPK-15,15,15; NPK-20,20,20, Urea-46%, Sulphate of Ammonia, Dolomite, TSP, MOP, 19,19,19+ME, MAP, Starter, Finisher, Potassium Nitrate, Multi NPK, Multi Rice NPK and organic fertilizers for mangoes and other tropical crops. They also guide growers on adopting latest industrial technologies such as fertigation programs and fast control programs.

The mentioned agricultural actors are heterogeneous in the sense that they are guided by certain principles and practices. For the loop to be closed therefore requires a realignment of relationship and the breaking up of some. Again closing the loop will also require those within the regime of urban sanitation to join the scheme. Fortunately, already some actors such as the Town and Country Planning Department, the Metropolitan Environmental Health Unit and the Metropolitan Planning and Coordinating Unit all play a role within the urban sanitation framework.

7.3. Actors involved in Urban Sanitation

The actors in this sector are those who will be relied upon to produce the much needed nutrients. The organizations which have not been mentioned previously and which will be discussed here include the Environmental Protection Agency, Waste Management Department, Metropolitan Works Department and Environmental Services Providers Association. These organizations among others are the main stakeholders in urban sanitation.

Environmental Protection Agency:

It is a national agency charge amongst other things to perform functions such as the co-ordinating of the activities of all bodies that it considers appropriate for the

purposes of controlling the generation, treatment, storage, transportation and disposal of all forms of waste.

Waste Management Department of Accra Metropolitan Assembly:

The department handles issues related to sanitation in the metropolis. Amongst them are liquid and solid waste disposal. It also monitors and supervises the activities of private contractors engaged by the assembly in solid and liquid waste management. The operation of public toilets and urinals are directly under the jurisdiction of this department in conjunction with the other sub-metros. In line with its privatization policy many of its activities have been privatized. The operation of public toilets and the collection of waste have fully been diversified to private operators.

Metropolitan Works Department of Accra Metropolitan Assembly:

This department works with the other departments of the AMA such as the Waste Management Department to develop and maintain facilities such as markets and sanitary structures. It also manages the assembly's landed properties and the designing of all building projects of the Assembly.

Other Organisations: Organisations such as the Environmental Services Providers Association is an association of entrepreneurs engaged in the transportation of excreta and solid waste. The association has around 45 members. Some of them are exclusively involved in excreta collection whilst others are solid waste service providers. There are some few who operate as both liquid and solid waste operators. Unfortunately there is no operator who is involved in the transportation of urine. Again, in line with the privatization programme of the assembly, a lot of entrepreneurs have arisen in the public toilet sector. Until recently the focus was on toilets but recently some entrepreneurs have emerged into the urinal sector who are actively operating within the Central Business District.

7.4. Perception among members of the socio-technical regimes

7.4.1. Official Stance

Actors within the socio-technical regimes all perceive of the new innovation differently. Institutionally there is hardly any bye-law banning the use of wastewater in urban agriculture in Accra. The only law which touches on this aspect is the Accra Metropolitan Authority (Growing and sale of Crops) Bye laws, 1995 section 2 under the heading of watering and irrigation. This law specifies that "No crop shall be watered or irrigated by the effluent from a drain from any premises or any surface water from a drain which is fed by water from a street drain". Section 7 specifies the penalty which is a fine of ₵100,000 (GH₵10) or a prison term not exceeding three months or both. The official explanation given by officials of the AMA for the passage of this law is that they want to protect the public against bacterial gastrointestinal infection which is contracted through the consumption of unwholesome food that has been irrigated with polluted water from the drains (Obuobie et. al, 2006).

In an interview with the Public Relation Officer of the Waste Management Department, he confirmed that the assembly has no policy in relation to the reuse of waste. There have however been instances in the past where AMA has done something on its own in relation to waste reuse. He cited the Teshie Compost Plant and the UASB plant at Mudor, James Town from where compost and dry sludge were generated for use in urban agriculture. On the reuse of urine for agriculture, he promised the commitment of the assembly in this sector as it will contribute towards

the saving of the environment and reduction of the pollution load on the treatment plants. The Director of Sanitation at the Ministry of Local Government Rural Development and Environment also affirmed that the ministry is seriously looking at the reuse of waste and wants to integrate it into the country's developmental policy. He said the current draft policy on waste currently before the cabinet of government seeks to introduce sustainable financing and cost recovery into waste management and therefore any form of recycling or reuse will be welcomed.

An official of the Crop Services Unit of Department of Food and Agriculture when interviewed revealed that already the department as part of its extension services have been educating farmers on improved farming practices such as nursery management and the right use of organic manure. He emphasised that the department is in the forefront in encouraging farmers on the use of alternative manure such as cow dung and poultry manure because they are cheaper, readily available and less toxic. On the use of wastewater for urban agriculture, he pointed out that there is already a study between the department and IWMI on the use of wastewater for urban agriculture at the Dzorwulu site. He affirmed that bringing urine on board will not be that different significantly. He pledged the unit support in terms of supervision and technical support should the project take off.

The Director at the Metropolitan Environmental Health Unit on the other hand stated that he will like to be familiar with the system and know the results from some of the experiments conducted already before he can give his blessings. Health was his main concern as a result of the contamination of the crops. Already there is a series of confrontation with the farmers on the use of urban runoff for irrigation. He however indicated his willingness to work with the demonstration team and indicated that already the unit is working together with IWMI and other stakeholders on an experimental basis on the safe reuse of wastewater on some of the urban farms in Accra.

7.4.2. Perceptions of households and urban farmers

Household perception

Danso et al. (2003) and Obuobie et.al (2006) have carried out studies to analyse the perception of households in relation to the use of household waste in urban agriculture. The study by Danso et al (2003) was carried out in the three Ghanaian cities of Accra, Kumasi and Tamale. It was to assess the level of interest of the various households in relation to their attitude towards the separation of waste as well as toilet facilities, which separate urine from excreta. The study by Obuobie et al (2006) was also aimed at studying the perception of some stakeholders on the use of irrigation with polluted wastewater sources as well as open space urban agriculture

In the first study, 2500 households were interviewed with focus on source separation, and about 650 households were also assessed to ascertain their perception, knowledge and interest in reuse of human excreta and urine. Most households suggested that urine could be used as medicine while dried excreta are good manure. Although only a few households were interested to sell their new resources, about 60-80% believed that there should be a market. In general, nearly all household (94%) were interested in a toilet system which allows the separation of human excreta and urine, giving that it is provided for free

Urban farmers

A study was conducted by Obuobie et.al (2006) to solicit the perception of some stakeholders on the use of wastewater (urban water runoff from drains) for irrigation. The study population consisted of 138 farmers, 50 vegetable sellers and 400 vegetable consumers in Accra. From the study, 65% of the farmers expressed satisfaction with the use of wastewater for irrigation. They gave reasons for their choice as reliability of flow as this stream of water is relatively continuous (36% of the farmers mentioned this). 32% also said that the use of this water is free and does not require the payment of bills as those farmers using the pipe borne water which is expensive and unreliable. Less than 5% of farmers referred to nutrients in water as reason for its use. Indicating that farmers use wastewater mainly to satisfy their water needs and not for its nutrient aspects as such.

This analysis was confirmed by a study that was undertaken within this MSc. research at 2 of the farming sites in Accra, namely the Dzorwulu and the GBC urban farm sites. Figure 7.1 shows the location of the farms and also the religious affiliation of the farmers interviewed. In all a total of 20 farmers were interviewed. 13 were from Dzorwulu (one of the larger farming sites). 15.38% of these were Christians whilst the rest were Moslems. At the Ghana Broadcasting Corporation farming site (also one of the smaller farming sites) seven farmers were interviewed of which all were Moslems.

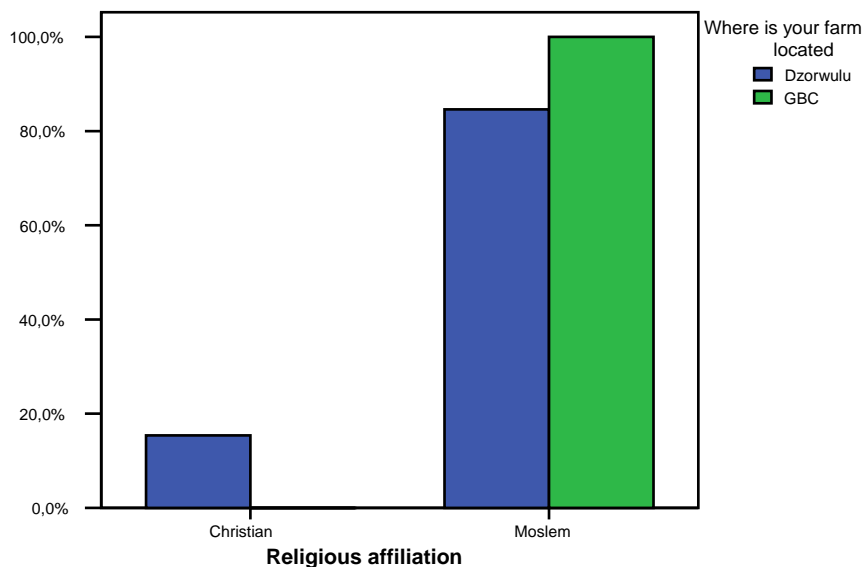


Figure 7-1 Religion affiliation of farmers and location of farms in Accra

All the respondents were men. Figure 7.2 shows the age group of the farmers and their level of education. 7 of the farmers has had no education. 3 of these were between the ages of 31-45 years old, 2 were between the ages of 46 and 60 whilst the other two were over 61 years old. Another seven had also had some basic education. Of these 1 was below the age of 30, 2 were between the ages of 31-45 whilst the rest were between the ages of 46 and 60. 6 of the interview farmers have also had secondary

education. Of this 4 were between the ages of 31-45 whilst the rest were below 30 years.

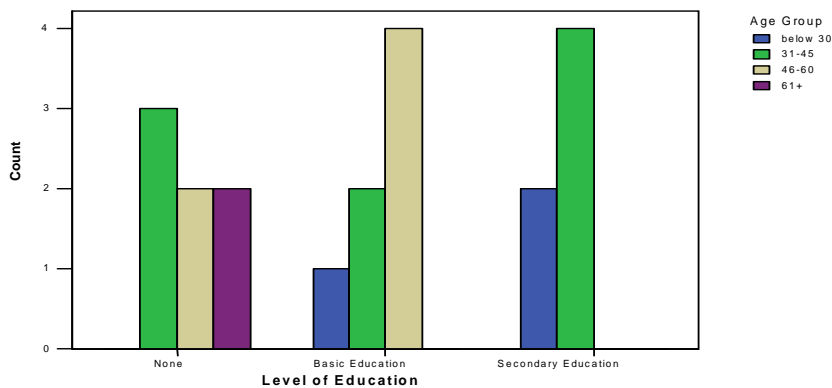


Figure 7-2 Age groupings and Educational level of farmers in Accra

They were asked about the type of fertilizers they used, how long they had been farming as well as their commitment to the use urine on their farms. All the 20 respondents answered that they use a combination of chemical fertilizer (mainly NPK15-15-15, urea, ammonia sulphate) and poultry manure whenever this is available. The respondents have a farming experience ranging between 1-5 years (10%), 6-10 years (15%), 11-15 years (15%), 16 – 20 years (35%) and more than 20 years (25%). All the farmers were prepared to use urine on their farms.

Figure 7.3 shows the farmers willingness to use the urine on their farms and their commitment to bear the cost of transportation. All the 20 respondents expressed their willingness to use urine for fertilization. However when they were about their willingness to foot the cost of transportation: 35% agreed to pay for the cost of transportation which was GHC55 for 7500 litres of urine which is the same as a bag of urea. The 65% however said that it was too expensive.

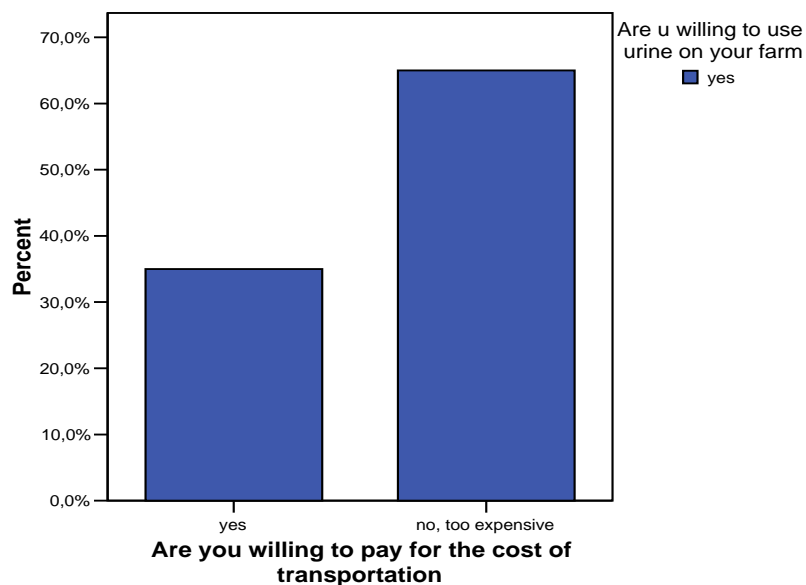


Figure 7-3 Willingness among the farmers to pay and use the urine

On willingness to donate land for the mounting of a tank and the investment in a tank; 60% of the respondents were prepared to donate the land and also purchase the tank. 35% were prepared to donate the land but were not prepared to purchase the tank whilst the final 5% although were prepared to purchase the tank but was not prepared to donate land.

Figure 7.4 shows how the farmers commented when they were asked to give their comments on what they think about the whole concept of urine application in urban agriculture. 2 of the respondents thought it was good but it was necessary to seek the views of the consumers who are the buyers. 1 was below the age of 30 whilst the other was in the age group of 31 - 45; 2 people between the ages of 31-45 commented that the cost of application should be affordable and cheaper than the other fertilizers in the system. 13 people asked for a demonstration to be conducted for them be familiar with the technology. 1 respondent wanted urine to be converted to struvite for ease of handling. 2 of the respondents had provided no comment at all.

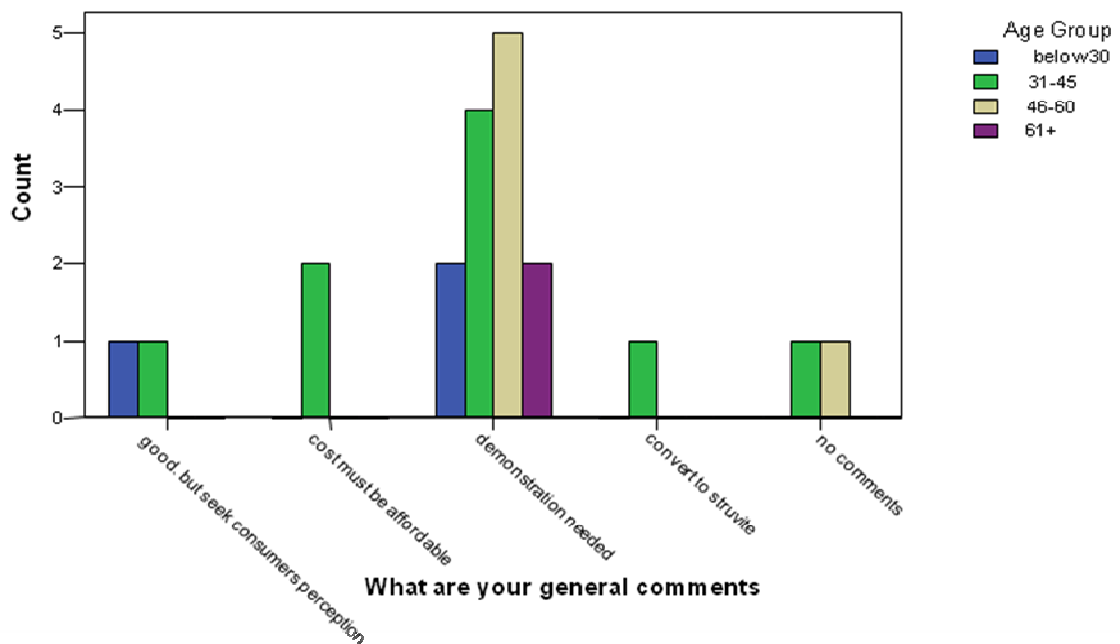


Figure 7-4 General comments about the use of urine among the various year groups of farmers in Accra

From the study that was conducted by Obuobie *et al* 2006: it revealed that vegetable sellers on their part are more concern about the quality of their produce. They normally evaluate this on the basis of its size, freshness, colour, firmness of leaves as well as absence of spots, dirt and holes but not bacteria contamination level. According to the study 70% out of the sellers were aware of the various source of water that is used for irrigating the vegetables. Nearly all the vegetable sellers replied that such practice should be stopped without any compromise citing reasons such as contraction of diseases by consumers as the main reason. When asked if they could offer higher prices for produce fertilized with clean water: 76% answered in the

affirmative. Most sellers however admitted that it is difficult identifying vegetables fertilized with wastewater as against those fertilized with pipe-borne water.

The consumers in Accra who were interviewed were equally concerned about the quality of food they buy. They however admitted that the discussion held with sellers during the purchase usually concerns the price and not the origin of the produce or the type of water or pesticide used in cultivating. They further indicated that it would be difficult to distinguish between contaminated and uncontaminated vegetables and doubted if vegetable sellers will tell the truth if questioned on this. The study further revealed that nearly all the consumers (75%-95%) indicated that they will not buy the vegetables if they know if it is fertilized with wastewater citing the contraction of disease as the main reason. A minority of this however believed that adequate washing could clear all the pathogens from the vegetables. When consumers were asked what they would do in a scenario where all vegetables in the city are irrigated with wastewater between 60% -80% of the population indicated that they will stop purchasing vegetables from the market all together; another 20% -40% indicated that they will wash the vegetables adequately.

7.4.3. Perceptions among Entrepreneurs

Fertilizer industry

The fertilizer industries in Ghana play a very significant role in urban agriculture. In an interview with an agronomist attached to Dizengoff (Ghana) Limited (which is one of the main fertilizer companies in the country), he disclosed that the urban farmer is one of the company's main clients. In fact in order to reach them they have repackaged some of their products into 1 kg bags to serve their needs. He admitted that he was aware of the depletion of phosphate rock and their principal overseas suppliers have reacted to this by carrying out research and producing fertilizers which releases phosphate into the soil in very limited amounts.

He enumerated that the use of urine will face some challenges. Key amongst them is its handling. He however stated that things could be easier if a technology could be developed to convert the urine into struvite. In that way, handling becomes easier and it can be collected when it accidentally spills. Secondly, urine being in a liquid form will require it been bottled in airtight containers, which will bring about additional challenges. He further pointed out that every crop requires a specific amount of nutrients. For example, in bulk fertilizers one knows what amount of nutrients is available. He doubted if the same can be said for urine and if the application rate can be determined to that exact level. The loss of ammonia which results in the scorching of plants is another issue which he thinks forms a challenge. On joining the arena of research, he thinks it is too early and a lot of research still needs to be done.

Another fertilizer company which was interviewed was Weinco (Gh.) Limited. Their main overseas partners are Yara International and Yara Ghana Limited. The agronomist of this company was also aware of the depletion of phosphate rock. He however does not see it as a threat as he believes alternatives could be found to this in no time. He thinks the ecological sanitation idea is a nice one and the use of urine laudable but still thinks more research is needed. On the probability of his company joining the arena, he feels that it is too early for this.

Exporting companies

Since some of the urban farmers produce for the export market, it was decided to interview an exporter. An agronomist attached to the Ghana Trade Hub which is an

exporter of crops to Europe and affiliated to the GEPC was interviewed. He stated that most of the farmers who are registered under them use organic manure such as farm remains which is an excellent form of fertilizer. He felt that the use of urine is far too expensive. When asked if he would recommend the use of urine to farmers, he answered in the negative. He indicated that their farmers operate under the EurepGap and Fair Trade Standards which require high standard of good sanitation and agricultural practices. He was fearful that the urine will harm his crops. He retorted “what do I do when there is blood in urine (such as in menstruating women)”. He was also not convinced that diseases like HIV and tuberculosis will not be passed on through urine. He was also very doubtful whether the six month period will be enough to sterilize the urine. He even went on further to point out that there was a time when some crops were reported to be contaminated by his suppliers. When he carried out an investigation, he found out that it was at a place in a farm where the farmer had been urinating. Finally, he indicated that he would not like the stigma that will go with the use of urine. According to him a single publication from a newspaper about a farmer who is using this will crash his business forever.

Urinal operators and urine collectors

In pursuance of its privatization policy the AMA has given concession to some entrepreneurs to operate urinals within the Central Business District to step up its efforts in sanitation. One of them is Big 2 limited. The initial agreement between the entrepreneur and the WMD was that he should collect the urine and dispose of it in one of the treatment plants. This is however not the case now. When the entrepreneur was asked why he was throwing into the drain such a potential resource, he indicated that he knows the value of urine as a fertilizer. He was initially collecting it but due to the rate at which the holding tanks were filling up and also his inability to find market for it he was compelled to dispose off the urine into the drains. Additionally, the disposal of the urine which would consist of transporting it from the Central business district to the Lavender Hill was expensive and eating deep down into his pocket.

He now expressed his intention of joining the arena should he be offered the chance as he is even on his own looking for a market for his products. He also indicated his willingness to lease some of his urinals for experimental purposes.

Ghana Environmental Service Providers

Many of the members of the Ghana Environmental Service Providers (although not all service providers belong to this association) are becoming wary of the unsustainable way in which waste is disposed off. This has motivated some of them to look for partnerships for recycling. In an interview with the President of the association, he indicated that he is already in association with some partners from Denmark to go into the recycling of plastics and other organic waste. Zoom lion, also another environmental service provider has also indicated his willingness and is making plans to go into the recycling business.

7.5. *Networking and cooperation*

Due to the high cost of chemical fertilizers there has been an upsurge in the use of organic fertilizers. The main organic fertilizers used are poultry manure, farm remains and cow dung. Composting have not catch up that well partly because of its high cost and also because of its poor quality as compared to the other fertilizers. Urine application is also applied on a very minor scale.

There are various organizations currently involved in the development of the alternative fertilizer concept. Some of them are the International Water and Management Institute which is working on a project “The Safe use of wastewater in Peri-(Urban) agriculture”. This project is seeking to explore the possibilities for alternative cropping areas and safer water sources. It will ensure that where wastewater treatment remains insufficient or absent, consumers could be protected through different low cost methods such as safer irrigation techniques, low-tech water filters, and simple water treatment methods. There is also the Valley View University who is also working on ecological agriculture using urine for fertilization. There are also organizations involved in other forms of organic agriculture such as the use of farm manure, poultry manure, cow, sheep and pig dung as well as composting by means of organic solid waste and excreta. However there is no clear link among all this organisations.

7.6. Conclusions

- The stakeholders in the current socio-technical regime are those related to urban agriculture on one hand and urban sanitation on the other hand. They are quite separate but to close the loop they must come together
- The members in the regime comprise of the government agencies who are responsible for the formulation and implementation of policies, the research institutions who are also engaged in policy recommendations and sustainable use of water and land resources, the local organisations which are interested in the production, marketing and consumption of urban agricultural products and the other organisations whose activities in the sector is focused on the practice of urban agriculture as a means to poverty alleviation.
- Almost all the stakeholders are favourably inclined towards the use of urine as an alternative fertilizer the main driver being the high cost of the mineral fertilizers. The only exceptions are the mineral fertilizer companies and the export companies. The farmers are willing to use it but the reaction of the consumers is unclear.

8. DISCUSSIONS

8.1. *Introduction*

The current practices within the urban agricultural set up gives an indication that there is generally an agreement regarding the need for a change in farm inputs. This is because synthetic fertilizers are expensive and way beyond the means of many of the urban farmers who fall into the bracket of the urban poor. This development has resulted into the development of several experimentations on the use of alternative fertilizers. However these experimenting arenas are disjointed and they lack a coherent vision thereby resulting in the development of multiple visions and many transitional arenas none of which is too strong to break into the existing socio-technical regime. In this section, the transitional theories discussed in Chapter 3 will be applied to see how the innovations in the new alternative fertilizer regime could be up scaled to a higher level.

8.2. *The Levels of Transition*

The urban agricultural sector is on its own a complete technological system. The system works because all the components within the system such as the farm inputs, the farmers, the supporting institutions amongst others are linked and work together to achieve a societal function. The substitution of one of these components will therefore require that all the other artifacts have to be reconfigured. This therefore requires the development of a complete technological transition.

A technological transition requires a radical change in the way things are done not just in terms of the hardware of tangible physical infrastructure such as the farming implements but also the software of know-how, practices and organisational skills surrounding the farming practices. It also requires the formation of new alliances and the dissolution of old ones. It also requires the development of coherent and consistent visions which must come from the group and not be imposed by an outside party.

8.2.1. *The landscape of the Macro level*

The landscape is found at the macro level. At this level are the background variables. In the urban agricultural sector these are the farms and irrigation channels and for the urban sanitation these are the sanitary blocks and the cultural practices that surround their use. A lot of money has gone into the construction of sanitary blocks and the harvesting of urine will mean an additional cost to the entrepreneur. Additionally, urine harvesting will mean an increase in operational cost as the urine will have to be carted separately aside of the excreta. Meanwhile there is this general perception even among government officials that money should not be wasted on toilets because it is a waste. Any attempt therefore to try to add to the cost of this sanitary blocks will be met with resistance. Again there is a social-cultural thinking about urine been a waste and also dirty and that it has to be dispose off as a municipal waste. This perception however only exists in the minds of people.

Although these practices are structural in character, the development in the city of Accra shows that this will not last for long. For instance the dispose and forget concept as a practice which was prevalent among the sanitation sector is now changing as the space for waste disposal are now becoming unavailable. The AMA has for instance even passed a law which prohibits urinal operators from dumping their waste into the drain. Although this law has not fully been enforced to the letter it at least indicates a kind of change is on the way.

8.2.2. *The Regime of the Meso Level*

The meso level is formed by the socio-technical regime. This is the institutional structures that link technical artifacts and actors. Within the urban agricultural sector, the technologies in place are those related to the use of agricultural inputs such as irrigation methods, fertilizer usage and the use of farming tools and implements amongst others. The actors also include those from the government sector who are involved in the formulation and implementation of policies. The others are: the research institutions that are given into investigating the current practices as well as researching into alternative practices. The last group is the local associations who are involved in the production, sales and consumption of farm implements and products. Finally, the rules are policies related to urban agriculture as well as the laws that relate to the use of alternative agricultural practices such as wastewater in agriculture.

The regime is characterized by many interesting developments. Although Ghana's economy is predominately agricultural based, there is currently no fertilizer manufacturing company. All the mineral fertilizers are therefore imported from abroad. This means that the price of the product is not in the control of the local partners coupled with this is the withdrawal of subsidy on fertilizers. This development has led to the sky rocketing of fertilizer prices (although there was recent reintroduction of some subsidies on fertilizers by the government in the face of the current global upsurge of food prices; it remains to be known if this will in anyway affect the price of this product). The increase in the prices of mineral fertilizers has led to the loosening up of the relationship that existed between some of the actors who are in the urban agricultural regime. Key amongst them is urban farmers who fall into the bracket of the urban poor and also the Ministry of Food and Agriculture (MOFA) which provides extension services. The fertilizer companies on their part have tried to reinstate this relationship by repackaging their products into smaller packets of 1kg from the previous 50kg and 25kg. But the fact still remains the same. The price is just too high for the farmer. To counteract this effect, MOFA has for some time now been advocating on the use of alternative fertilizers such as poultry manure as well as cow and sheep dung. The current practices among most of the urban farmers are the use of both the mineral fertilizers as well as the poultry manure. Many farmers are comfortable with the use of poultry manure but it is not always available.

Fortunately, there are no laws within the city banning the use of household wastewater for irrigation. The only exception is an AMA bye-law which prohibits the use of water coming from drains and urban runoffs. The current development at the regime level gives a clear indication that the urban agricultural sector is ripe for the introduction of an alternative fertilizer because poultry manure which was expected to fill in this gap could simply not do as it is simply not sufficient within the urban settings of Accra.

8.2.3. *The Niche at the Micro level*

At the micro level are the niches. Within this level in the urban agricultural setup are the alternative fertilizers that have recently come into the market. The development of these alternative fertilizers in Ghana has generally centred on the use of manures such as crop-residue, green and animal manures and also legume cover cropping. There are hardly any studies on the use of human waste for agriculture (Cofie et al. 2004).

Figure 8.1 shows the position of the various fertilizers within the multi-level framework of transition in the urban agricultural setup in Accra. Mineral fertilizer still remains at the socio-technical regime phase as it is still the most preferred option and to a large extent all the rules and institutions are somehow linked to it. At the niche level are the poultry manure, compost and urine.

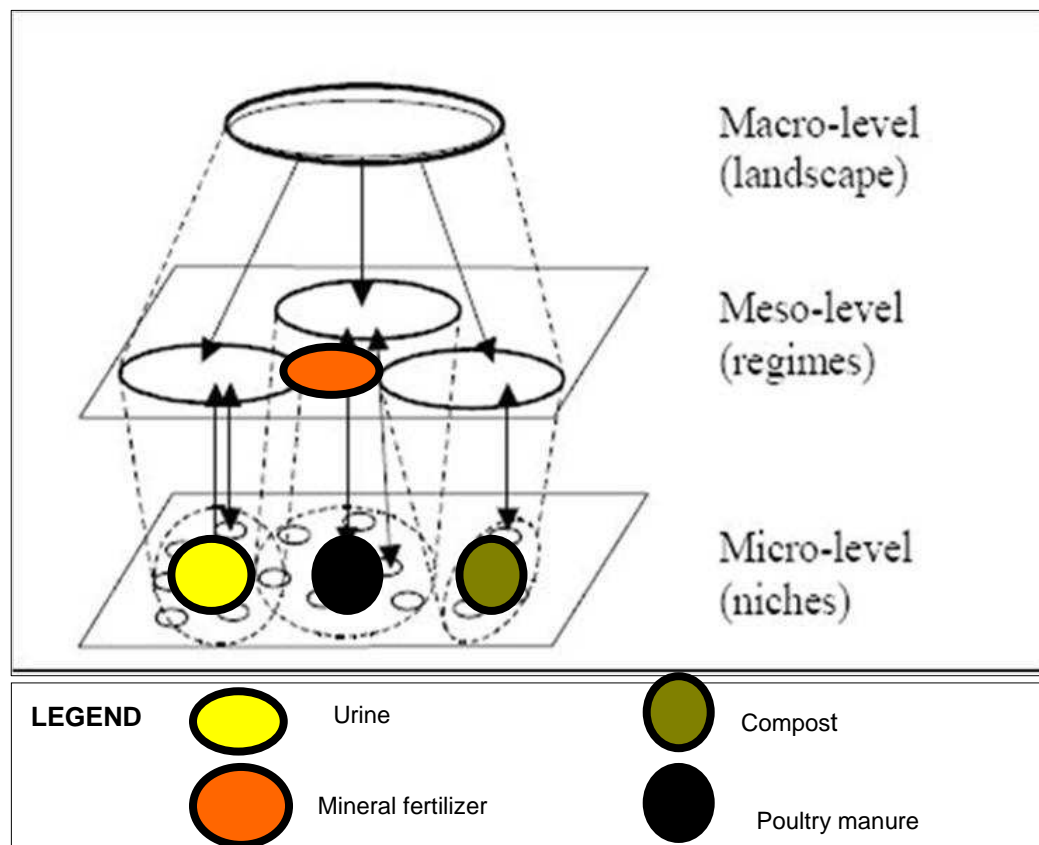


Figure 8-1: Various fertilizers within the Multi Level Phase of the Transitional Framework in UA in Accra

Within the city, the most important alternative fertilizer in use is poultry manure. This manure comprises of the dropping of chickens and wood-shaving litter. After some time, the wood-shavings with the chicken droppings are removed from the coop and allowed to decompose before being applied to the soil. This type of fertilizer is in a very high demand as a result of its high nutrient content and its affordability. However, this fertilizer is scarce and not always available because there are not that many commercial poultry farmers within the city.

Compost is also another niche that is undergoing experimentation within the urban agriculture setting. Composting is the biological decomposition of organic matter by a mixed population of micro-organisms in a warm, moist and aerated environment. This treatment is reputed to eliminate the pathogens in the waste thereby rendering it safe to use. This type of fertilizer even received state approval as the WMD of AMA itself built a plant in Teshie which was generating compost. This plant has however broken down and it is undergoing repairs currently. But prior to the breakdown, the demand for the product was exceeding low. In addition to the WMD there are also other organisations propagating the compost technology. Generally, most farmers are sceptical about the use of compost because of its poor quality. This is as a result of the

presence of broken bottles and other undesirable materials in the mix. Other factors are the heat built up within the compost resulting in the burning of the plant as well as the high water demand that is normally associated with the use of compost. Lastly, the high cost of the product (GH¢1.00/50kg) also discouraged the use of this product.

The use of human excreta, as a fertilizer in general is known among the farmers but it is hardly used in the city as the farmers fear the reaction of the authorities. This is understandable if one reasons from the fact that for a very long time the crops of farmers were destroyed by the authorities on suspicion that they were using wastewater for irrigation. A new development is currently taking place at the Valley View University in Oyibi near Accra. There is an ecological farm where urine is used as a fertilizer on the farm. Crops under cultivation include: sorghum, mangoes, and moringa. The project is supported by the German Ecological Society. It has been running for the past 5 years on a pilot phase. The project has receiving widespread attention from the academia. However this practice is done in isolation and not supported by any local agricultural institution such as MOFA.

8.3. *The multi level phase of transition*

Rotmans et al. (2000) see transitional management as a deliberate and collective attempt to explore and bring about a transformation in a functional domain. Transition in this sense is therefore a gradual, forward-looking and reflexive way of achieving a paradigm shift using a participatory approach.

Figure 8.2 shows the position of the alternative fertilizers in the multi-phase of the transitional framework. The adoption and use of urine could be likened to the beginning of the pre-development stage with compost and poultry manure still leading it in terms of time and system indicators.

In fact within the urban agricultural set up, so far as the use of urine as an alternative fertilizer is concerned, there appear to be a dynamic equilibrium in the status quo as there does not seem to be any visible change as yet towards the adoption and use of urine. The separation and use of the product is not yet on the agenda of even the most innovative proponents of alternative fertilizer usage. The only exceptions are the International Water and Management Institute (who are currently involved in helping to test the new WHO guidelines with regards to the use of wastewater for irrigation). But even in the case of this body, the agenda on urine is still lumped up together with their general agenda of sustainable water use. It is true that very interesting development is going on at the Valley View University, with regard to the use of urine but this development remains as an island of success. The infrastructure for the system is expensive and mostly imported from Germany. The cost of the urinal alone is GH¢600 furthermore, the university is isolated from the main framework of urban agriculture and many farmers as well as other official stakeholders within the urban agricultural sector do not have a stake in it with some even claiming that they do not even know about it.

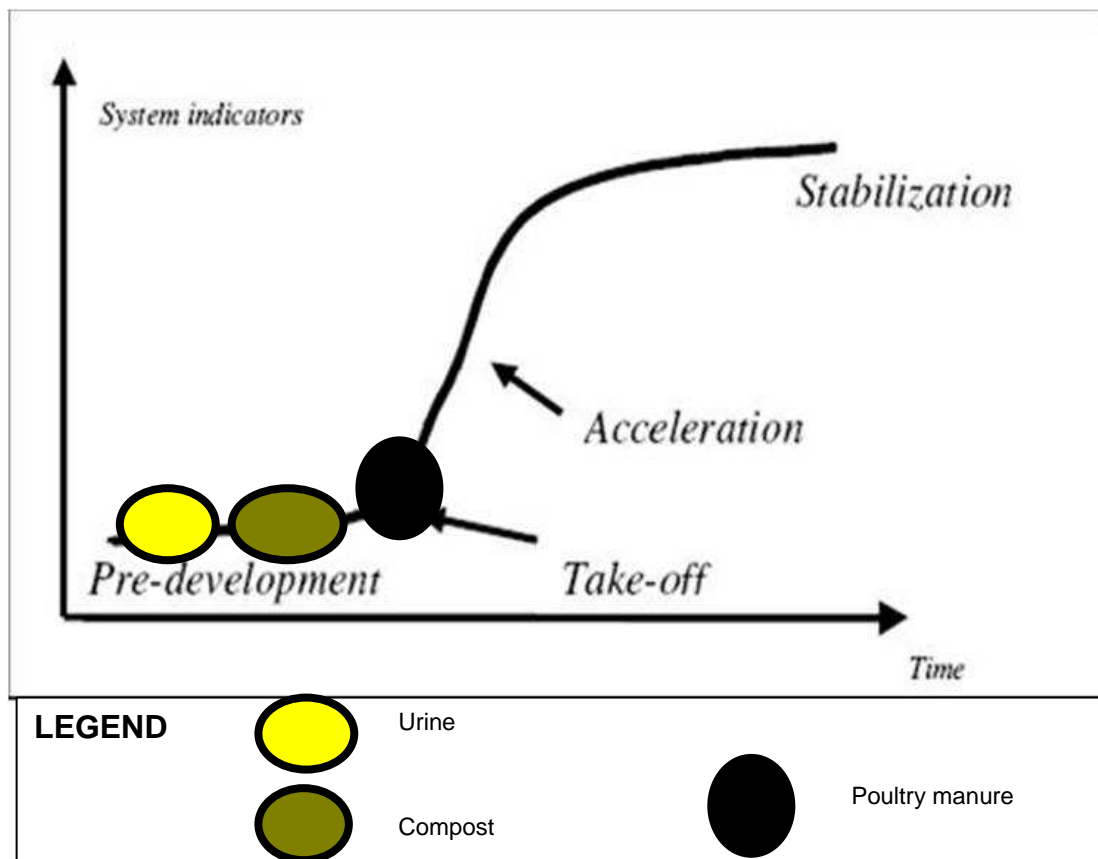


Figure 8-2 Position of alternative fertilizers in the multi-phase of the transitional framework of UA in Accra

If however we are to broaden the horizon and see the whole transitional concept with regards to the use of alternative fertilizer in general then we will come to a different conclusion. The use of poultry manure could for instance be said to be at the take-off stage. This is the phase where the process of change starts to get under way because the state of the system then begins to shift. Some stakeholders even place it at the acceleration phase because they believe there is a visible structural change which is resulting in the accumulation of socio-cultural, economic, ecological and institutional changes within the urban agricultural set up. But if one considers that at the acceleration phase there are collective learning processes, diffusion and imbedding processes then it might be too premature to place it there. Although it is not likely that there will be a time when this manure will take over completely from mineral fertilizers, it is certain that because of the high prices of the mineral fertilizers new visions and practices of finding alternative source of fertilizers will continue to dominate. But will the development of this fertilizer be hampered by its scarcity in Accra?

The development and use of compost could also be placed in the middle of the pre-development stage. Although this fertilizer received all the blessings of the government which saw it as a logical way of disposing of its waste it never caught on well with farmers. Will urine also receive the same official blessing if government gets to know that urine is the main contributor of nutrients into the water bodies and perhaps one of the greatest contributors to eutrophication in our water bodies?

In a narrow technological sense, the success of these alternative fertilizers may not constitute a breakthrough in the wastewater paradigm or Ecosan as a whole. However, in the broader socio-cultural sense it is different. The success of this manure has really softened the attitude of the regime players. Many players in the regime have softened their stand on the use of household waste for irrigation. Currently a network of actors has even begun to build up to discuss the safe use of household waste in urban agriculture.

8.4. *Barriers to Up Scaling of the Urine Usage in Urban Agriculture*

There are two ways in which the up scaling of a technology could occur. The first one is evolutionary transition in which the outcome of the transition is not planned in any significant way. Whilst in the second case which is the goal oriented transition; the goals and visions of the end state are guiding actors and the orienting strategic decisions of private actors (Kemp and Rotmans, 2004). Rotmans et al (2000): in defining transition based on the second concept describe it as consisting of a deliberate attempt to bring about a transition in a stepwise and interactive manner which involves a sequential and participatory decision.

Transition is normally recommended at places where changes and improvement alone have insufficient effect and more fundamental changes are needed. Looking at the development of alternative manure developing in Ghana in general the emphasis has been on the use of crop residue management, green and animal manure as well as the cropping of legumes with hardly any study on the use of human excreta (Cofie et. al. 2004). This development is reflective of the fact that if the up scaling of urine as a technology would ever be achieved then there is the need to adopt a step-wise transitional management. Because the current approach of changes and innovation in alternative fertilizer usage in urban agriculture and indeed agriculture as a whole in Ghana will never put urine on the agenda.

Transitional management requires for a first step that a transitional arena should be set up. These arenas are however only established after the problems have clearly been assessed and identified. The problems relating to the adoption and use of urine are mainly related to price, perception and some gaps in research findings. In terms of price, the cost of bringing the product to the farm is higher than mineral fertilizers. In the case of perception, some stakeholders still believe that it is impossible to get the exact constituents of the nutrients in urine and therefore the product might be over applied or under applied and this might have some side effects on the crops. Finally, in terms of the research gaps: one particular stakeholder, who is an exporter, was fearful about the effect of blood and spittle in urine. He was also of the view that the application will bring with it stigma from the press and the boycott of their products by organisations such as EUREGAP. These concerns could be addressed when a transitional arena is in place.

A transitional arena is a participatory network of people coming from different backgrounds with a manager who is normally responsible for communication. This network requires that the members be people who are innovators and visionaries who can develop long-term visions and images. It also demands that members have some basic competencies at their disposal and be open-minded and also have the ability to address the agenda on the table. Unfortunately what is happening at the Valley View

University does not have these important requirements and can therefore not be classified as a transitional arena in the true sense of the word.

Furthermore, within the arena, there is the need to set up a long-term vision and possibly a common transition agenda. This will guide the actors in the formulation of programmes and policies that will aid in setting up the long term and short term agenda. As there is currently no transitional arena in place, there is no such vision. The current development at the Valley View University once again, does not have these elements which are so important in every transitional management development. Although IWMI is currently involved in the testing of the WHO standards on wastewater reuse; their agenda on urine is once again lumped up with the use of wastewater in general and they therefore do not have any specific vision and image for urine adoption and usage.

Initiation and execution of transitional experiments is the next logical step after the development of the transitional visions and images. In the urban agriculture setup, this could ideally be the establishment of a demonstration farm. There is currently an ecological farm at the Valley View University where urine is applied on crops. But if this farm is to be brought into the limelight of the true sense of transitional management, then there is some elements which are missing. For transitional management requires monitoring and evaluation by Learning-by-Doing and Doing-by-Learning. This approach requires that specific niches (in this case demonstration farms) be set up within a place where experiments are to be performed and where useful lessons can be learned. This will lead to the adjustment of the transitional visions and images and the further development of the transitional arena. From its current location, the farm at the Valley View University is far removed from the UA setting and can therefore not qualify as a demonstration farm

8.5. *Conclusions*

- There is the general need for an alternative fertilizer as a result of the high cost of mineral fertilizers.
- On the multi level framework, there are several niches on the ground but none is strong enough to break through to the regime level. The niches are characterized by problems such as scarcity, poor quality of the product or a lack of a proper transitional arena
- The use of urine remains at the beginning of the pre-development stage and not very prominent even on the agenda of the innovative thinkers of alternative fertilizers.
- There is only one institution practising urine reuse on a pilot basis but this institution is far removed from the urban farming sector and not supported by any of the major stakeholders. It can therefore not be considered as a transitional arena
- The lack of a transitional arena as well as issues relating to contaminants in urine and its rightful application still remains a barrier.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1. *Conclusions*

Public toilets are a predominate feature in the city as close to a third of the population of the city use this type of toilet. This constitutes a point where cheaper alternative fertilizer in the form of urine could be harvested. As urban farming is vibrant in Accra the urine from this toilets could be channelled into the agricultural stream thereby closing the loop between sanitation and agriculture. The nutrients in the urine emanating from these toilets are enormous and if harvested it could even exceed the fertilizer need of the city. However these nutrients together with all the other nutrients from the various households and industries are released untreated into the environment causing severe environmental damages particularly to the water bodies. In fact, if urine from the stand alone urinals in the Central Business District alone is harvested it could supply the entire nitrogen requirement as well as a substantial part of the phosphorous and potassium requirements of urban agriculture in Accra.

The harvesting and consequent application on the field will produce a win-win situation for both the city managers and the urban farmer. The city managers will win by a reduction in the amount of nutrients that enters into the water bodies which is posing a threat to the sustenance of the aquatic and marine lives. On the other hand, the plight of the urban farmer will be reduced as the availability of urine will provide him with an alternative fertilizer to replace the mineral fertilizer and the other alternative fertilizers which are either too expensive or limited in supply.

Urine is a comparatively safe fertilizer containing plant available nutrients. The increase in crop yield for crops fertilized with urine is between 2 to 6 times higher than crops not fertilized at all. Its crop yield is also comparable to crops fertilized with chemical fertilizers. Storage is a low cost effective treatment which achieves pathogen die-off thereby rendering urine safe for application on all types of crops. Like all other types of fertilizers, its application requires some precautions to be taken.

The harvesting and subsequent application of urine on the field requires some infrastructural modification as well as the provision of transportation services. Substantial initial capital is needed for the provision of these infrastructures and also transporting the urine. As there is no entrepreneur who is engaged in the transportation of urine the only option will be to use the suction trucks operated by the septic tank emptying companies with the inherent risk of faecal contamination.

The nitrogen content of concentrated urine is approximately 3grammes per litre. Comparatively cost analysis based on the nitrogen contents only of urine, poultry manure and mineral fertilizer indicates that urine is by far the most expensive and the least attractive option to the farmer due to its high cost.

The stakeholders who are involved in the socio-technical regime are those in the urban agriculture sector on one hand and urban sanitation on the other hand. They form two separate regimes but they need to come together if the loop is to be closed. These stakeholders could further be divided into the categories of the government agencies that are responsible for the formulation and implementation of policies and the research institutions who are also engaged in policy recommendations and sustainable use of water and land resources. Others are the local organisations which

are interested in the production, marketing and consumption of urban agricultural products and the other organisations whose activities in the sector is focused on the practice of urban agriculture as a means to poverty alleviation.

The regime is warm as those in the urban agricultural sector are looking for an alternative fertilizer as a result of the high cost of the mineral fertilizers. Whilst those in the urban sanitation sector are also looking for a logical means of waste disposal and they see the agricultural sector as the most likely candidates. Almost all these stakeholders are favourably inclined towards the use of urine as an alternative fertilizer the only exceptions are the mineral fertilizer companies who are fearful of losing the grip on their markets and the export companies who are fearful of the contamination in urine. Studies previously undertaken, also indicated that although customers do not ask about how their crops are fertilized when they are making purchases: they might respond negatively if they know that their crops were fertilized with urine.

On the search for alternative fertilizers there are several niches on the ground but none is strong enough to break through to the regime level. Urine is one of such niches and it is currently at the beginning of the pre-development stage and not very prominent even on the agenda of the innovative thinkers of alternative fertilizers. There is only one institution practising urine reuse on a pilot basis but this institution is far removed from the urban farming sector and not supported by any of the major stakeholders. It can therefore not be considered as a transitional arena. The lack of a transitional arena as well as issues relating to contaminants in urine and its rightful application still remains a barrier.

9.2. Recommendations

Having identified urine as the major cause of eutrophication among the household wastewater, a policy should be formulated and enforced against the discharge of such large volumes of urine (particularly those coming from the public toilets and public urinals) into the urban wastewater stream. This policy should compel the urinal and toilet operators to collect and dispose of their urinals separately. Where there is already a kind of agreement existing such as the case between the WMD and the urinal operator at the CBD this should be enforced to the letter. In addition to this policy, those operators who collect their urinals separately and dispose it as such should be motivated by providing incentives such as tax rebate and a reduction in the commission they pay to the assembly.

Secondly, the collection of the urine to the farm should not be left into the hands of the suction trucks operated by the septic tank operators. Instead an entrepreneur should be found to invest into the purchase of a truck which will deal exclusively in the transportation of urine. An ordinary pickup truck mounted with a tank could be a right at the initial stages.

In view of the fact that the cost of transportation of the urine is too high, farmers should be encouraged to store the urine on the farm site. In this case, the urinal entrepreneur delivers the urine when it is needed on the farm site and dispose of it when it is not required. In this way, the operational cost to the farmer is then erased as the urine entrepreneur will now consider these farms as an extension of his disposal site.

Furthermore, research should be intensive into the concentration of urine without the urine losing any of its nutrients. For instance, if urine could be concentrated by a factor of 5, then the nitrogen level will rise to 15 grammes per litre. This means that for the same volume of 7500 litres of urine, the farmer gets an equivalent of 5 bags of urea which will currently cost GH ¢220 or 5 tons of poultry manure which will cost GH¢82.50. This will really make urine competitive provided the cost of concentration does not rise abnormally. This will make economic sense and the farmers will really consider it as an alternative fertilizer.

For urine harvesting and application to become really viable, a transitional arena should be build around the technology. Such a transitional arena should include members from the government agencies such as the Department of Food and Agriculture, the AMA Waste Management Department, the AMA Planning & Coordinating Department, Metro Public Health Department, the Town & Country Planning, the Ministry of Trade and Industry, the Ghana Standard Board, the Environmental Protection Agency, the Food and Drugs Board. From the research institutions such as IWMI and CSIR – STEPRI would be helpful. Other local organizations such as the various farmers association, the Vegetable Producers and Exporters association and the Market Women would be handy. Other organizations such as the FAO, GTZ, CRS, ADRA, Action AID and People’s Dialogue should also be needed. The media would also come in handy and last but not the least the urinal and toilet entrepreneurs. The Valley View University farm can still serve as an experimental base for future development but more importantly a demonstration farm should be cited in one of the urban farms.

From the chosen institutions and organisations a transitional manager should be chosen who should lead all the stakeholders. In view of the fact that IWMI is already engaged in similar experiments at the Dzorwulu farm site, they should be given the lead role. It is also important that, an institutional analysis is conducted to determine who does what within the arena.

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APPENDICES

Appendix 1: The Design for the Holding Tank

Location (A)	Code (B)	Qty (lts) (C)	Estimated rate after 10 yrs (lts) $P_t = P_o (1+x)^n$ (D)	Peak flow (40%) $(D \times 1.4)$ (E)	Total Urine generated per month (m ³) $\{E \times 30\}$ (F)	No of dislodging per month (G)	Monthly operational cost (7.5m ³ tank) (GHC)
Novotel Mkt. 1	NM 1	260	419	587	17.61	2.348	129.14
Novotel Mkt 2	NM 2	180	251	352	10.56	1.408	77.44
Metro Mass Transit stn	MM TS	150	210	294	8.82	1.176	64.68
Tema Stn	TS	180	251	352	10.56	1.408	77.44
Kinbu Road	KTS	600	838	1174	35.22	4.696	258.28
Mobil Ind. Avenue	TIA	150	210	294	8.82	1.176	64.68
Kojo Thompson Road Makola Market	KT MM	1106	1545	2163	64.89	8.652	475.86
Nkrumah Avenue 1	NA1	820	1146	1604	48.12	6.416	352.88
Nkrumah Avenue 2	NA2	980	1369	1917	57.51	7.668	422.84
Kantamanto 1	K1	600	838	1174	35.22	4.696	258.28
Kantamanto 2	K2	540	810	1134	34.02	4.536	249.48
Kantamanto 3	K3	538	768	1075	32.25	4.3	236.50
Rawlings Park 1	RP1	620	866	1213	36.39	4.852	266.86
Rawlings Park 2	RP2	540	810	1134	34.02	4.536	249.48
Total		7264			434.01	55.52	3054.7

Key

P_t = final population
n=number of years

X= population growth rate
 P_o =Initial population

**Appendix 2: Bill of quantities for holding Tank with Sandcrete Block for Rambo
850. Size of trench: 3.02 x 3.02m x 2.950 deep.**

Item	Description	Quantity	Unit	Rate	Amount
	Exc. and Earthwork				
A	Excavate pit for chamber starting from reduced level, exceeding 1500mm deep but not exceeding 3000mm deep	27	m ³	7.55	203.85
B	Excavate trench for foundation starting from reduced level not exceeding 1500mm	1.25	m ³	7.55	9.44
C	Load up and remove excavated material from site	18	m ³	4.49	80.82
D	Backfill selected excavated material around walls in foundation	10.69	m ³	2.21	23.63
	Concrete Works				
E	Plain in-situ concrete (1:3:6-38mm aggregate) in foundation column bases	1.25	m ³	110.00	137.5
F	Ditto, in floors	1.37	m ³	110.00	150.7
G	Precast concrete slab in 750mm x 3020mm x 100mm thick	4	No		257.85
	Block work				
G	150mm solid Sandcrete block work in cement and sand mortar (1:4)	36	m ²	15.00	540
	Finishing				
H	50mm screeded bed laid on concrete and finished smooth	9	m ²	8.45	76.05
I	19mm smooth cement and sand (1:4) internal rendering on walls	36	m ²	3.87	139.32
	Plumbing Work				
J	Allow a provisional sum of One Hundred Ghanaian Cedis for all plumbing Works	Item			100.00
K	8500 litre capacity Poly tank	1	No	988.00	988.00
	Sub-Total				2707.16
	Allow 5% Preliminaries				135.36
	Allow 5% for Contingency				135.36
	Total				2,977.88

Appendix 3: Prices of Dizengoff Fertilizers as at 21st May, 2008

Item	Fertilizer	Packing	Retail(GH Cedis)
	Special Fertilizers		
	Soluble Potassium Sulphate	25kg	23
	Potassium Sulphate (Standard Powder grade)	50kg	41
	MOP Soluble	25kg	26
	Soluble magnesium sulphate	50kg	30
	Kleserite Powder 27Mg0+22S	50kg	28
	Calcium Chloride	25kg	18
	Million more	1kg	3
	Mr. Bean	1kg	3
	Mrs. Bean	1kg	1.90
	NPK 19-19-19	25kg	58
	NPK 19-19-19	1kg	3.3
	Potassium Nitrate 13-0-46	25kg	48
	Potassium Nitrate 13-0-46	1kg	2.40
	MAP	25kg	64
	MAP	1kg	3.6
	Multi Cote 4M 15-15-15 +3MgO	25kg	51.50
	Multi Cote 4M 17-17-17 +3MgO	25kg	64.20
	DAP	50kg	81.00
	Bulk Fertilizers		
	NPK	50kg	45.00
	Sulphate ammonia	50kg	30
	Urea	50kg	39
	TSP	50kg	60
	Liquid Fertilizers		
	Citroboost / Vegeboost / Mangoboost	0.5l	3.2
	Cassava starter/ Finisher	0.5l	2.1
	Iron 6% FE	10l	51
	Iron 6% FE	0.5l	3
	Maize starter/finisher	300ml	3.2
	Feromax	100ml	2
	Zink Max	0.5l	3

Appendix 4: Summary of Interviews with Stakeholders

4a: Interview with the Manager of Big 2A Limited. A urinal service operator in the Central Business District

The operation of the urinal facilities started in 2001 as a pilot project as part of the WMD activities towards private public partnership of sanitary facilities. In 2008, the company has been licensed to operate on a full scale basis. The company started with 7 urinals and from this humble beginning a lot of lessons had been learnt. Currently the urinals under operation are located at the Kojo Thompson Road around the Makola Market, the Kinbu Road near the State Transport Corporation bus terminal, the Tema station and the Kaneshie Market all in Accra.

Initially, when the company started, the materials that were used for the construction of the urinal stall were steel metal sheeting. In the men's compartment, the main unit is a urinal whilst a bidet is fixed in the women's compartment. These metallic stalls are tiled internally with ceramic wall tiles to make cleaning easier. With time it has been realised that the metallic stalls are rusting rapidly as a result of the sea breeze and so there is now the intention to shift from the metal containers to plastic containers. There is therefore an ongoing negotiation with an investor to import 1000 of these units into the country.

These urinals are serving a very important purpose in terms of sanitation. Prior to their installation, women particularly were having a hard time in finding where to urinate. They therefore resorted to means such as urinating in empty water sachets and empty beverage containers and disposing them by the side of roads. Men were also found urinating in the open gutters and other such places. The construction of these facilities has therefore come as a relief to many of these people as this practice has been abated.

The main challenge has been the space in which to locate the stalls. The market women, for whom these facilities are been built feels that we are taking away the space where they are doing their business. They have fought us on a number of occasions. Again, people sometimes defecate in the unit and since the facility is not meant for the carriage of excreta it becomes a nuisance.

As to why the company decided to discharge the urine into the drains as against the initial agreement with the WMD; the main reason was that we never anticipated such a high patronage of the facility. Because of this high patronage, the containers were getting full at very regular intervals and they have to be emptied twice a day. Additionally, there was also no means of transportation. So men were hired to lift the containers manually onto push trucks and convey them to the lavender hill treatment plant. This ordeal was done twice a day. It was clearly a burden to the company as well as the market women who were plying their trade around the area as the stench was simply unbearable. In order to stop this ordeal, the company decided to channel the urine into the open drains/gutters and then invest in chemical detergents which will bring the stench down to a bearable level. This approach has so far proved successful.

There is however still the pressure on the company to desist from the practice of urine discharge into the open drain. This we intend to comply with by constructing underground storage tanks which are big enough to hold the urine for a considerable number of days. This will also require that we fix valves in the urinals which will close automatically when there is no urine flow so as to control the stench (most of

this facilities have no supply of water and they are therefore being operated as waterless urinals although that was not the intention of the designers). Additionally, we are also looking for a market for the urine as we are aware of its fertilizing value. The landscape industry at this moment is our main target, although we have not made the approach yet.

On the issue of transportation, it is quite a challenge. There are plans far advance to purchase a small truck, on which we will mounted a tank and pump. This truck should be able to maneuver into obscure corners for dislodging. This is what we intend to use for dislodging.

On joining the arena of urine usage, the company is fully prepared to join. Our main contribution will be to supply the urine to the farmers initially for free but after some time, a fee will be charged once the technology have been understood and adapted.

4b. Interview with the Chief Agronomist (Agric Division) of Dizengoff (Gh) Limited
Dizengoff (GH) Ltd started operations in Ghana in 1957 under the name Dizengoff West Africa. In 1976 however the company's name was changed to Dizengoff (Ghana) Ltd. Today it is a subsidiary of Balton CP Ltd of England. The company has therefore been operating in Ghana for more than 50 years.

The company deals in items related to crop protection, fertilizers, seedlings, machinery and irrigation. In terms of fertilizers, the company deals in both the folia and bulk fertilizers. The folia fertilizers are helpful in the growth of the plant whilst the bulk fertilizers boost the nutritional status of the crops.

For the folia fertilizers it is recommended to use the 12-0-62 for root generation, 19-19-19 for the vegetative growth stage and 13-0-46 for the flowering stage which is the final stages of plant growth. For the bulk fertilizers the most popular one is the NPK 15-15-15. The normal application rate of the folia fertilizer is recommended as 1kg per hectare whereas the bulk fertilizer recommendation rate is 100 kg/acre.

Dizengoff (Gh.) Limited is basically an importer of fertilizer. There are as yet no plans to manufacture the fertilizer locally as this is more of a policy issue which should come from the government. The principal suppliers of the company include Taifa of Israel and Sico Fertilizers of Belguim. The company caters for the needs of almost all the farmers in Ghana. Within the urban and peri- urban setting in Accra, our clients include: the vegetable farmers, cassava farmers and the maize farmers amongst a host of others.

On the importance of nitrogen to the crops, yes every plant needs some nitrogen and hence almost all our fertilizers contain some amount of nitrogen. On the depletion of the phosphate rock and the threat it poses to the fertilizer industry we as an industry is aware of it and therefore our principals are carrying out some research into other fertilizer sources which will release particularly the phosphate into the soil in very limited amounts. There is also the possibility that some other alternatives might be found within the very near future as research and development is a core activity of this organisation

On the challenges that urine faces as an alternative fertilizer, it will be ideal if a technology could be developed to convert it to a powdery form. In that way, handling becomes easier and it can be collected when it accidentally spills. If it is to be used in

a liquid form then it should be bottled in airtight containers. Again, every crop requires a specific amount of nutrient. For example in a fertilizer one knows what amount of nutrients is available in an NPK 15-15-15 fertilizer and the amount that each soil type will need. I doubt if the same can be said for urine and if the application rate can be determined to that exact level. Another challenge is the loss of ammonia which results in the scorching of plant which would also be another challenge.

On joining the arena, as I had already pointed out, it is even possible that some level of work is already been done although I am not so sure of it myself.

4c. Interview with Public Relations Officer WMD of AMA

The Accra Metropolitan Assembly is currently divided into 13 sub-metropolitan areas. These are: Teshie, North Okaishie, Okaishie South, Osu Klottey, Ablekuma North, Ablekuma Central, South Ablekuma, Ayawaso Central, Ayawaso West Wuogon, Ayawaso East, Nungua, La and Ashiedu Keteke. Recently the Teshie and Nungua sub-metropolitan areas have been ceded off to create the new Ledzokuku-Krowor Municipal Assembly. This means that currently AMA has 11 sub-metros and the original land size of 170km² has been reduced.

In terms of sanitation, the public toilet is an important part of the sanitary infrastructure of the metropolis. For that matter, the assembly is encouraging their construction. But these toilets are meant for the floating population, and therefore its construction is encouraged at places such as markets and bus stations. It has never been the policy of the assembly to encourage public toilets in residential places as the assembly had never had the intention of making public toilets an extension of private residence. The exception to this rule is densely populated areas. In these areas due to the way in which buildings were constructed, it is difficult for those who do not have their own toilets to construct one now. In such places the assembly reluctantly allow the construction of such facilities as public toilets are better than no toilet at all. But even in such places, the construction of new toilets is becoming more difficult since land is simply not available.

On the operation of these toilets, currently the WMD has totally diversified it. Private operators are now doing this. In cases where the facility is built by the assembly, immediately after its construction tenders are invited from members of the general public to bid for its operation. These operators are required to pay a percentage of their net earnings to the WMD (after overhead costs such as electricity and dislodging cost among others have been deducted). In some cases however, we have the build operate and transfer system (BOT). Under this arrangement, the private entrepreneur constructs the facility. The facility is run for a period of one week after which a headcount is then organised. The headcount enables the assembly to estimate how long it will take the contractor to pay back his investment based on the 60% to 40% sharing arrangement (after the deduction of the overhead cost). After the payment period, the arrangement is then changes to 40% for the entrepreneur and 60% for AMA.

The assembly on its own has been soliciting for the ownership of private toilets in residential areas. The last of this attempt is the Urban 4 project. This project was meant to assist landlords to own their own toilets. Under this arrangement, landlords pay for 50% of the cost of the toilets in terms of the provision of building materials whilst the assembly support with another 50% in the form of construction and expertise advice. Although this project is still running and the money from the

assembly was meant as a gift and was not refundable many households are not coming for it. This because the amount is small and can only be assessed at the tail end of the construction like when you are constructing the septic tank.

On public urinals, the idea behind their creation was due to the fact that people were finding it increasingly difficult to find a place to urinate particularly in the Central Business district. Due to this, an investor came in and the WMD granted him the concession to mount urinals within the central business district. 7 of these urinals have so far been constructed. The agreement was that, collection tanks were to be constructed near the urinals where the urine will be collected. When they are full, these are to be collected in suction trucks and then sent to one of the waste treatment facilities in the city. About 6 months ago, it had been discovered that he has connected the urinals into the drain. A notice had been sent to him to desist from this as this was not part of the original agreement. Aside of this urinals, the WMD also has its own urinals which are also attached to the public toilets.

On the reuse of waste, the assembly has no policy in relation to that. There have however been instances in the past where AMA has done something on its own. The Teshie Compost Plant is one example. This plant was set up to convert organic solid waste into compost but this plant is not functioning well as a result of lack of maintenance. Another attempt is the UASB plant at Mudor, James Town. From this treatment plant, dry sludge was produced which was purchased by entrepreneurs in the landscape sector. Achimota Golf Club for instance was one of the main patrons. This plant is also not functioning to its full capacity because the bills which are collected from households goes to the Ghana Water Company and not to us. All attempts to have the water company to hand over this money had not yielded any dividend and we are still pursuing it. The assembly is therefore cash strapped when it comes to the operation of the plant.

On the collection and reuse of urine, the assembly will welcome this idea. This is because this will mean saving the environment and reducing the pollution load on the treatment plants. One constraint, which the entrepreneur of the urinals at the central business district faced and which motivated him to direct the waste into the drain was the unavailability of space. Most of these urinals are located in densely populated areas surrounded by traders and other commuters. But if the operator had contacted the department this could have been easily resolved. This is because since the tanks could be constructed underground it would not posed any problem. On a closer look, the main reason for his decision was the high cost of dislodging which the entrepreneur had wanted to avoid.

On the current status of the WMD, almost all our activities have been privatised. For example almost all the public toilets are in the hands of private operators and so also is the collection of household waste and excreta. Currently, the assembly has only two suction trucks which are used for dislodging of septic tanks. But these are for protocol and emergency services

On the benefits that an entrepreneur will get who invest into the collection of urine, I will indicate that first a proposal will have to be given to the assembly stating the intents of the entrepreneur. From this, the authority might provide some relief. This relief might be in the form of a rebate which will be given in terms of the percentage of money to be paid to the assembly. On land for the storage of urine prior to its

transportation to the farmers we can easily allocate part of the land we have on our sanitary sites as these lands are quite big.

4d. Interview with Director of Physical Development and other staffs of the Ecological Department of the Valley View University

The Ecosan project has been in existence since 2003. The pilot scale is over and the university is trying to scale up the technology to cover every building on campus. Very soon all the rain water, grey water and black water from every building will be harvested for use on the campus.

The VVU ecological project began when the German Ecological Society adopted the VVU to make it a case study and a model ecological campus. The project is presently a joint collaboration between the German Ministry of Education and Research who are the main sponsors, Berger Biotechnik GmbH (Project Architects), Palutec Ecological Engineering Systems (Project Consultants) all of Germany and the Valley View University which is a Seventh day Adventist Institution of higher learning based in Oyibi near Accra, Ghana. The project has been running since 2003 which means it is in its fifth year. The original contract between the university and the German Ministry of Education has since expired this year but the VVU has been informed that the ministry is going to extend the contract by a further 18 months. This extension phase will involve the construction of dry toilets and rainwater harvesting and treatment. As at now, the construction of the toilet infrastructure (which is the VVU's part of the contract) is completed and the university is now waiting for the German partners to supply the buckets for harvesting of the black water.

On urine, a lot of work has been done in that area. This includes the successful cultivation with crops such as: sorghum, maize, mangoes, cashew and moringa. The next stage is to pass on this technology (as part of the university corporate social responsibility) to the surrounding communities. The VVU intends to do this in order to improve the livelihood of the farmers and also improve the environment. There have been a lot of outreach programmes in the form of educating the surrounding communities about the benefits and use of urine in agriculture and although some of them have shown the interest, none has come forward to participate. By and large, this is due to the fact that the farmers are content with their rain-fed agricultural practices.

The major challenge that the university is facing in terms of this project concerns mainly the breakdown of the mechanised pump which is attached to the suction truck. When this occur, suction of the urine from the tank is not possible and therefore when the tanks are full, it presents an obnoxious smell rendering the whole area around the urinal highly contaminated. A better alternative could have been allowing the urine to flow by gravity to a central system (say the farm) or to use a non-mechanised pump.

In terms of the general performance of urine as a fertilizer, the result has been very impressive. At the beginning of the project, the fertility of the soil was low and crop yield was unsatisfactory. But the reverse is now the case. In the sense of publication, no publication has so far been done by the VVU but a lot of visitors come around to see the work.

On joining the arena of innovative thinkers particularly on the use of urine for urban agriculture, the university is all ready for it. VVU is prepared to share its expertise any partner into this area as part of the VVU's corporate social responsibility.

In an interview with the landscape consultant attached to the facility, he confirmed that urine is excellent as a fertilizer. He was however disappointed that the university offers no course in agriculture. This in his opinion will affect the up scaling of the technology.

Another concern which was raised was the expensive imported appliances that are used in the urine harvesting project. He feels locally available materials could easily be found to replace the expensive foreign components which could then make its adoption by other local entrepreneurs possible and affordable.

In another interview this time with the Farm Manager, he confirmed that gradually, the project has now moved from the experimental stage and is gradually reaching a commercial phase. At the research stage, trials were conducted on maize using various fertilizers such as poultry manure, cow manure, mineral fertilizers and urine. Poultry manure was initially the best among the lot in terms of crop yield but since the last 2 years urine has taken over. The reason for the sudden takeover by urine from poultry manure is still under investigation. The farm manager claims that the other manures such as the poultry manure and urine are performing better than mineral fertilizers. Further trials were also conducted on mangoes and cashew using 5 rolls of 15 crops each. They were subjected to different treatments of urine ranging from 0 / 3 / 6 / 9 / 12 litres per plant. Results of this experiment have been forwarded to Germany for the necessary works.

4e. Interview with District Officer-in-Charge of Crops at AMA-MOFA

The agriculture sector within the urban city can be grouped into three main sectors. These are the animal section which comprises of the poultry, sheep, goat, cattle and pig farming sectors. The ruminants section which comprises of rabbits and grass cutters and the crop sector.

In the crop section, vegetables are the main crops that are grown in the city. They are of the local and exotic type. There is a big market for this sector as apart from the local production some traders even go beyond the borders of this country to bring in the said vegetables from the neighbouring countries. In the city, vegetable farming takes place normally at the banks of rivers where water is readily available.

Among the services provided by MOFA to the farmers are: Extension services and education of farmers on good farming practices from nursery right up to harvesting and also the rightful application of pesticides. On fertilizers, the extension service normally advise farmers to use organic fertilizers such as cow dung and poultry manure since they are cheaper, readily available and less toxic.

On the use of wastewater for urban agriculture, I have personally been involved in some study on it. There was a study sponsored by WHO which was code-named "Save Ghana vegetables" which wanted to make vegetable produced in Ghana more to be devoid of any harmful pathogens.

MOFA is collaborating with IWMI in the use of wastewater for urban agriculture at the Dzorwulu site so bringing urine on board will not be that different significantly. The worry about wastewater from the beginning had been the micro-organism in them and not the heavy metals and hence all effort is geared towards trying to hygienise the wastewater.

As to joining the arena, the ministry will be ever prepared. The ministry will provide extension services and technical support when needed.

4f: Summary of Interview with Mr. Victor Schafer of VS Marketing Service Limited (Ghana Trade Hub -Exporters of Crops to Europe and other Countries).

The use of urine as a fertilizer can only be recommended in my opinion after a careful analysis of its content. It is also important to know where the urine is coming from. Harvesting of urine from public places such as Tudu and Okaishie is not proper because the probability of contamination is high. It is true that sanitise urine can be collected but that means sanitise urinals must be installed and this is very expensive. At this point, who will be paying for these urinals; “I do not know who will pay for this but I do know that the Accra Metropolitan Assembly is not interested in this venture at least not at this stage”.

The first challenge is that confront the use and adoption of urine is its cost. Sometime ago, BP and Shell (which are big Oil companies) began a similar study on converting slurry from the biogas plant into pellets which could be used in agriculture. The cost was around US\$150 to US\$180 per kilogram of pellet. This was much more expensive than the normal mineral fertilizer and hence the project could not continue.

Another challenge which should be considered is who will need the urine. The small scale farmers in Accra will definitely not need it. This is because they are far too small to afford the infrastructure that goes with the urine usage such as the holding tanks for the storage of urine. On the other hand, all the big farmers are located up north beyond Kumasi. Here comes the issue of transportation more so as there is no railway system to convey urine in large quantities to them.

On recommending the use of urine to our farmers, I will hesitate to do this. “This is because there is a demand of high standards from the farmers from international organisations such as EurepGap and I cannot guarantee that the use of urine will not harm my crops”. There had once been an instance where contaminants were detected in some of the crops of the farmers and this was traced to a farm and to a point where the farmer was urinating on a certain portion of the farm.

Again on the issue of contamination, “I am personally worried about the effect of diseases such as TB and HIV which could be transmitted through urine and its effect on crops. Also important are the effect of blood (such as those from menstruating women which can easily be passed in urine) and its effect on the crops and soil. I am not convinced that research has totally proven that such contaminants cannot be transmitted to crops”. The next issue to consider is the stigma attached to the use of urine. A single publication from a newspaper about a farmer who is using this will crash his business forever.

On the Valley View University project, “I am sceptical about the whole thing. On my part, if I will ever recommend urine for any crop then perhaps I will talk about mushroom because this has the ability to filter out impurities through its substrate. Even for this I will not recommend urine from public urinals. If ever I will touch urine, then it will be from a controlled environment such as a school (where I know there are no infections and where the women are not menstruating) and institutions such as a prison where I know inmates are controlled”.

On joining the arena of urine adoption and usage, “I think there are still many things that remain to be done. First is the smell. Research should be conducted to see how this could be taken away. Again, laws existing in Europe where crops are mainly export to do not encourage its use. Lastly is the cost. Cheaper organic fertilizers from food remains, crop pruning and weeds are plentiful so why use urine when all this is available”.

4g. Interview with the Secretary of the Dzorwulu Co-operative Vegetable Farmers Society

Dzorwulu Co-operative Vegetable Farmers Society is a society that is registered with the Department of Co-operatives. The numerical strength of the society is 26 and it is headed by a chairman.

The average size of each member’s farm is around 0.25acres (0.1ha). Exotic vegetables such as cabbage, lettuce and cauliflower are mainly cultivated. Planting is done all year round and the average cropping session is 3month (One month for nursing and 2 month for planting). This means that for each year planting is done on an average of 4times. Traders who normally purchase the vegetables come from the Mallam Atta Market as well as the Agboglobloshie Market. Occasionally some consumers come to the farm gate to do direct purchasing.

The main types of fertilizers used are mineral fertilizers and poultry manure. The mineral fertilizers that are used include: NPK 15-15-15, Sulphate of Ammonia, Urea and the folia fertilizers. These are normally bought from Agrimat, Agro and Dizengoff. Occasionally, some members make purchases from roadside shops when the small quantities of fertilizers are needed. It cost a minimum of GHc2.00 to transport an average bag of 50kg of fertilizer from the shop to the farm. The poultry manure is also supplied by the poultry farmers. These poultry farms are located at the New Town and Kotobabi areas. The manure is brought to the farm gate in variety of sizes ranging from 25kg bags to 30 – 35kg bags. The 25kg is sold at GHc0.20 whilst the 30-35kg is sold for GHc0.50. Occasionally some poultry farmers approach our members and ask them to clear their coops. In that case all that the farmer pays is the cost of transportation which is about GHc8.00 per ton of manure.

On fertilizer usage, an average farm of 0.1 ha uses either one bag of NPK 15-15-15, Sulphate of ammonia or Urea per cropping season. Additionally, about 2kg of folia is also used up for this area. In terms of poultry manure, an average of 15 sacks of the 30-35kg is also used. This is applied twice per farming season when it is available. The fertilizers are normally applied 1 week after transplanting whilst the folia is applied on a 10 day basis.

Some of the major challenges facing us as farmers are the lost of land to estate developers and the high cost of synthetic fertilizers. Poultry manure is good but this is always not available whilst experimentations with compost had not also been very successful as a result of the high water demand that the compost demands and also the intensive heat that sometimes threaten the survival of the crops.

As an individual I am willing to use urine on my land but as results of experimentations have not always been good, I will like to play it safe by first hiring out part of my land for experimental purposes. As a Muslim, I do not have a problem

with the handling of urine. Handling urine is not like handling pork which gets you contaminated. All that one needs to do after handling urine is to wash his hands thoroughly thereby making himself clean again.

Appendix 5: Farmers Questionnaire

Ecological Sanitation is a new paradigm in waste water management which sees wastewater not as municipal waste but as a resource that can be used beneficially. The concept emphasis the recovery, treatment and hygienically safe agricultural use of valuable nutrients that is available in human waste.

Most of the nutrients in household wastewater are contained in urine. Again urine contains little or no pathogen whilst faeces contain a lot of pathogens. The plant nutrients in both urine and faeces emanated from arable fields and thus should be recycled as fertilizers to support sustainability and to retain the fertility of the fields. This practice is known as closing the loop.

The need to adopt this practice has become more demanding in the face of the elimination of fertilizer subsidies in Ghana. This has aggravated the situation of many as more farmers are buying even less fertilizer for food production resulting in continuous cropping without addition of adequate external nutrients.

Many studies have been conducted which shows that urine is comparable to chemical fertilizers and relatively safe. It contains all the essential plant nutrients such as nitrogen, phosphorous and potassium and very little heavy metals.

I will therefore be very grateful if you would spare a few minutes of your time to answer this questionnaire.

No	Question	Response			
1	Age	30 and below		31-45	
		46-60		61+	
2	Educational qualification	None		Basic Education	
		Secondary Education		Tertiary	
3	Religion;	None		Christian	
		Moslem		Traditional African Rel.	
		Others (please state):			
4	Sex:	Male		Female	
5	Where is the farm located				
6	What is the size of your farm?				
7	How long have you been farming?				
8	What is the main type of crops that you grow on your farm?				
9	How many times do you plant				

	each crop in a year?			
10	Who are your main customers?			
11	What type of fertilizers do you use for your crops?	none		
		Poultry manure		
		Cow dung		
		Chemical fertilizers		
		Farm remains		
	Others, please specify			
12	How much volume of the following do you use at any given time?			
	Poultry manure			
	Cow dung			
	Chemical fertilizers			
	Farm remains			
	Others, please specify			
13	How often do you use it during the cropping season?			
	Poultry manure			
	Cow dung			
	Chemical fertilizers			
	Farm remains			
	Others, please specify			
14	How much do you buy each type of fertilizer per unit (including transportation)?			
	Poultry manure			
	Cow dung			
	Chemical fertilizers			
	Farm remains			
	Others, please specify			
Having understood the benefit of ecological sanitation and the fertilization value of urine				
15	Are you willing to use it on your farm as an alternative fertilizer?	Yes		No
16	If no, why			
It will cost about GHC55 to transport 7000l to the farm. (Equivalent to 1ton of chicken manure)				
17	Are you willing to pay at least for the cost of transportation?	Yes		No
18	If no, why?			
The use of urine on farms will require some land for the mounting of a plastic tank				
19	Are you willing to invest in the purchase of this tank ?	Yes		No
20	Are you willing to donate land for the mounting of the polytank?	Yes		No

21	Are you willing to release part of your land for a demonstration plant?	Yes		No	
22	Are you willing to go for the urine yourself if you think the transportation cost is expensive	Yes		No	
23	Comments:				