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TRADITIONAL FARMING PRACTICES AND WASTEWATER IRRIGATION FARMING IN PERIURBAN, ZAMBIA

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ABSTRACT

Studies on urban and peri urban agriculture in Zambia have not adequately tackled issues pertaining to farming practices in wastewater irrigation farming. The investigated the farming practices in relation to heavy metal contaminated wastewater irrigated farming at two peri urban areas in Zambia. The method comprised observation of crop cultivation activities at field plots located at intervals along transects established in the stratified land zones at the two study sites namely New Farm in Mufulira and Chilumba Gardens in Kafue. The results revealed that farming practices were characterised by traditional land management farming practices and traditional multiple cropping systems which were influenced by a combination of agro ecological factors as well as availability of heavy metal contaminated wastewater which has the potential to contaminate soils and crops. The farming practices were based on adaptation of traditional production systems to peri-urban wastewater irrigation farming which confirmed the results from other developing countries.

Key words: Traditional farming practices, heavy metal contamination, wastewater irrigation farming, peri urban areas, Zambia

ABSTRAK

Studi di perkotaan dan pinggiran kota pertanian di Zambia belum banyak menangani masalah yang berkaitan dengan praktek pertanian dalam pertanian irigasi air limbah. Penelitian ini menyelidiki praktik pertanian dalam kaitannya dengan logam berat yang terkontaminasi limbah pertanian irigasi di dua wilayah pinggiran perkotaan di Zambia. Metode pemulihan terdiri dari kegiatan budidaya tanaman di plot lapangan yang berlokasi pada interval sepanjang transek didirikan di zona tanah bertingkat di dua lokasi penelitian yaitu New Farm di Mufulira dan Chilumba Gardens di Kafue. Hasil penelitian menunjukkan bahwa praktek pertanian yang ditandai dengan praktik-praktik tradisional pengelolaan lahan pertanian dan tradisional sistem tumpangsari yang dipengaruhi oleh kombinasi faktor agroekologi serta keterdapatan air limbah terkontaminasi logam berat yang berpotensi untuk mencemari tanah dan tanaman. Praktek-praktek pertanian didasarkan pada adaptasi sistem produksi tradisional untuk pinggiran kota pertanian sampai pada bentuk pertanian dengan irigasi air limbah negara-negara berkembang lainnya.

Kata kunci: praktek pertanian tradisional, kontaminasi logam berat, limbah pertanian irigasi, pinggiran daerah perkotaan, Zambia

INTRODUCTION

Although the introduction of western technologies devalued the native agricultural technologies, the traditional production systems have been practiced in an ostensible sustainable manner in many developing countries [*Lasoda et al.* 1998; *Wood*, 1984; *Pritchard*, 1994; *Thomson*, 1968; Allan, 1969; *Saran et al.* 1998; *Parajuli*, 1999]. The indigenous people have continued to use the traditional multiple cropping systems to grow a large number of different crops despite the efforts of extension services to induce indigenous people to adopt mono cropping practices [*Wood*, 1984, *Pritchard*, 1994]. The mixed cropping systems will continue in developing countries because the complex and expensive external inputs needed to change traditional farming systems will be available to only a few farmers [*Wood*, 1984]. It can be argued that more research is need on traditional farming systems because most traditional farming systems revealed a thoughtful and sophisticated approach to sustain crop production [*Lasoda et al.* 1998; *Wood*, 1984; *Pritchard*, 1994]. Despite the environmental deterioration brought about by new western methods of agricultural and lack of government support to traditional farming systems, the urban dwellers adapted the rural traditional method of farming to the urban production system by devised new ways of using vacant or semi vacant urban land and large volumes of waste in urban production systems [*Lasoda et al.* 1998; *de Neergaard et al.* 2009; *Bradford et al.* 2002; 2003; *Jaeger and Huckabay*, 1986; *Thomson*, 1968; *Allan*, 1969; *Wood*, 1984]. The challenges of wastewater irrigation farming in developing countries [*Raschid-Sally and Jayakody*, 2008; *Hamilton et al.*2007] include inadequate information on the agro-ecological characteristics of the cropping systems [*Page*, 2002; *Bradford e tal.* 2002, 2003], heavy metal contamination of wastewater, soils and food crops [*Hamilton et al.* 2007). The opportunities include provision of food to urban population [*Smit and Nasr*, 1992), support of livelihoods of urban poor [*Faruqui*, 2002; *Buechler et al.* 2002a, 2002b] coupled with the potential for eco-sanitation and organo-phonic technology to grow crops [*Duque*, 2002].

Although studies on urban and peri urban agriculture have been conducted in Zambia [*Chibesa et al.* 1982; *Kalumba*, 1982; *Saasa*, 1982; *van den Berg*, 1982; *Williams*, 1986; *Jaeger and Huckabay*, 1986; *Mulenga*, 1991, 2001a, 2001b; *Marshall et al.* 2004; *Sanyal*, 1985; *Rakodi*, 1988; *Hampwaye et al.* 2007; *Gabi and Simwinga*, 1982; *GRZ*, 1994; *Sinkala et al.* 1998; *Sinkala*, 1998] the issues pertaining to farming practices in wastewater irrigation farming were inadequately tackled [*Marshall et al.* 2004; *Kapungwe*, 2011]. The crop cultivators informally engaged in wastewater irrigated cultivation of crops in urban and peri-urban areas in towns in Zambia were not included in the National Agriculture Census [*Central Statistical Office*, 2001a; 2001b; 2003a; 2003b] and were not rendered technical and financial support by the relevant authorities in Zambia. Although the wastewater might have potential value to peri-urban agriculture through the provision of water and nutrients to crops, there are potential health risks due to heavy metal contamination of wastewater [*Smith et al.* 2001; *Kapungwe*, 2011]. The objective of the study was to ascertain the characteristics of farming practices in relation to heavy metal contaminated wastewater irrigation farming at two peri urban areas in Zambia. It was hypothesized that there was no significant relationship between the agro-ecological factors and farming practices in wastewater irrigation farming. The information from this study will used to develop and implement appropriate farming practices which can ameliorate against the heavy metal contamination.

THE METHODS

Theoretical framework

The four common approaches to agricultural research and development in developing countries [*Scoones and Thompson*, 2009) include: (i) transfer of technology; (ii) farming systems research (iii) farmer first/farmer participatory research and (iv) people-centred innovation and learning which is also described as an interactive learning for change. Although the farming systems research approach to investigation of the rural farming systems in developing countries was predominant from the 1970's to 1980's [*Scoones and Thompson*, 2009], it is still used in the research in certain instances. This study used the farming system research approach as a theoretical framework for analysis of farming practices pertaining to wastewater irrigation farming because the farming system takes the holistic view of the farm as a system taking into consideration the cropping system combining with agro-ecological characteristics and socio-economic circumstances of the farmers [*Fresco*, 1984; *Chatterjee et al.* 1994]. It can be argued that it is likely the urban farmers have adapted the traditional farming technologies to urban and peri-urban wastewater irrigation farming in developing countries.

Study methods

Two study field sites were selected in the peri-urban areas of Mufulira town in Copper belt Province in agro ecological region III and Kafue town in Lusaka Province in agro ecological region II in Zambia (Figure 1). The New Farm Extension study site in Mufulira (Figure 2) And Chilumba Gardens study site in Kafue (Figure. 3) experienced tropical savanna climate characterized by three typical seasons namely hot wet (November-March); cool dry (April-July) and hot dry (August-October) with 900-1000mm per year of rainfall [*Kapungwe* 2011]. There was high diversity of crops at New Farm and Chilumba Gardens [*Kapungwe*, 2011] which comprised the field crops such as sugarcane and maize coupled with vegetables such as indigenous and exotic. The indigenous crops included pumpkins, beans, cowpeas, sweet potatoes, aprior rape, aubergines, groundnuts, okra, *mponda* (*Bottle gourda*) and *lubanga* (*Spider plant*) whilst the exotic crops included rape, Chinese cabbage, cabbage, Swiss chard, tomatoes, carrots, and *fwakafwaka* (*Mustard spinach*). The crops were irrigated with heavy metal contaminated wastewater [*Kapungwe*, 2011] from untreated effluents from industries and domestic sewage wastewater from Sewage Stabilization Ponds which had the likelihood of heavy metal contamination of soils and crops at the two study sites.

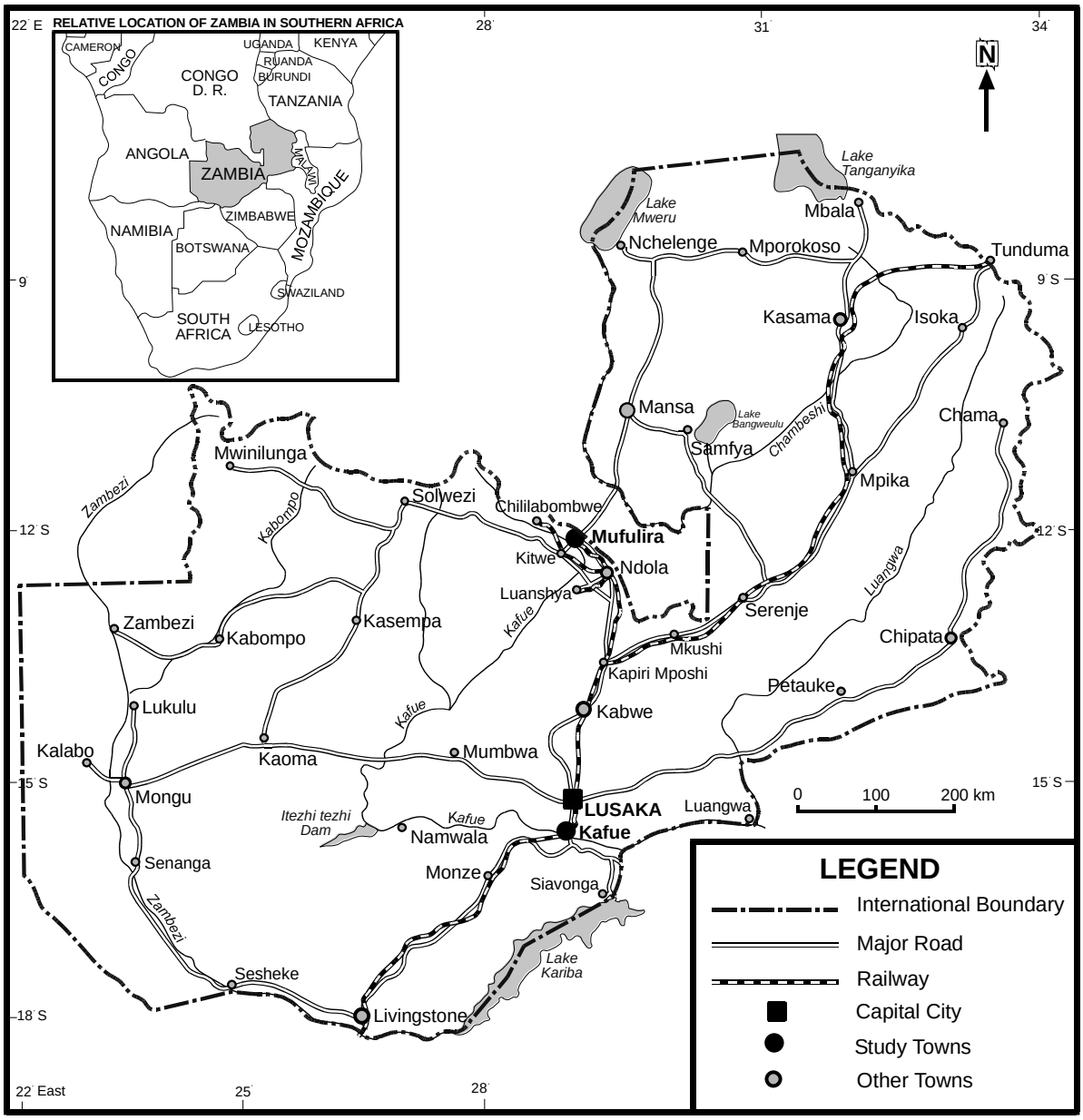


Figure 1. Map of Zambia showing the study towns of Mufulira and Kafue (Adapted from Kapungwe, 2011)

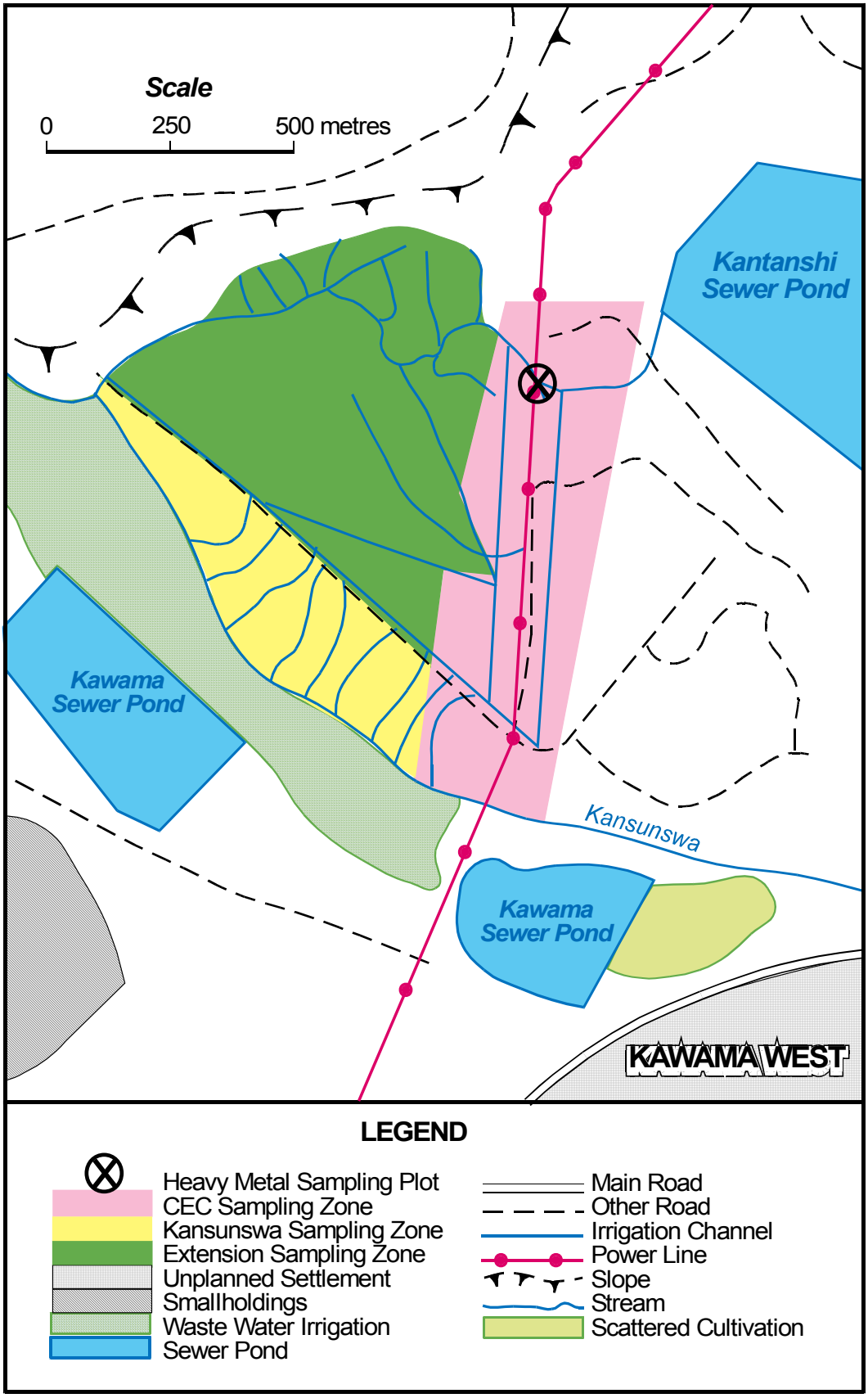


Figure 2. Sampling land use zones at New Farm study site in Mufulira (Adapted from Kapungwe, 2011)

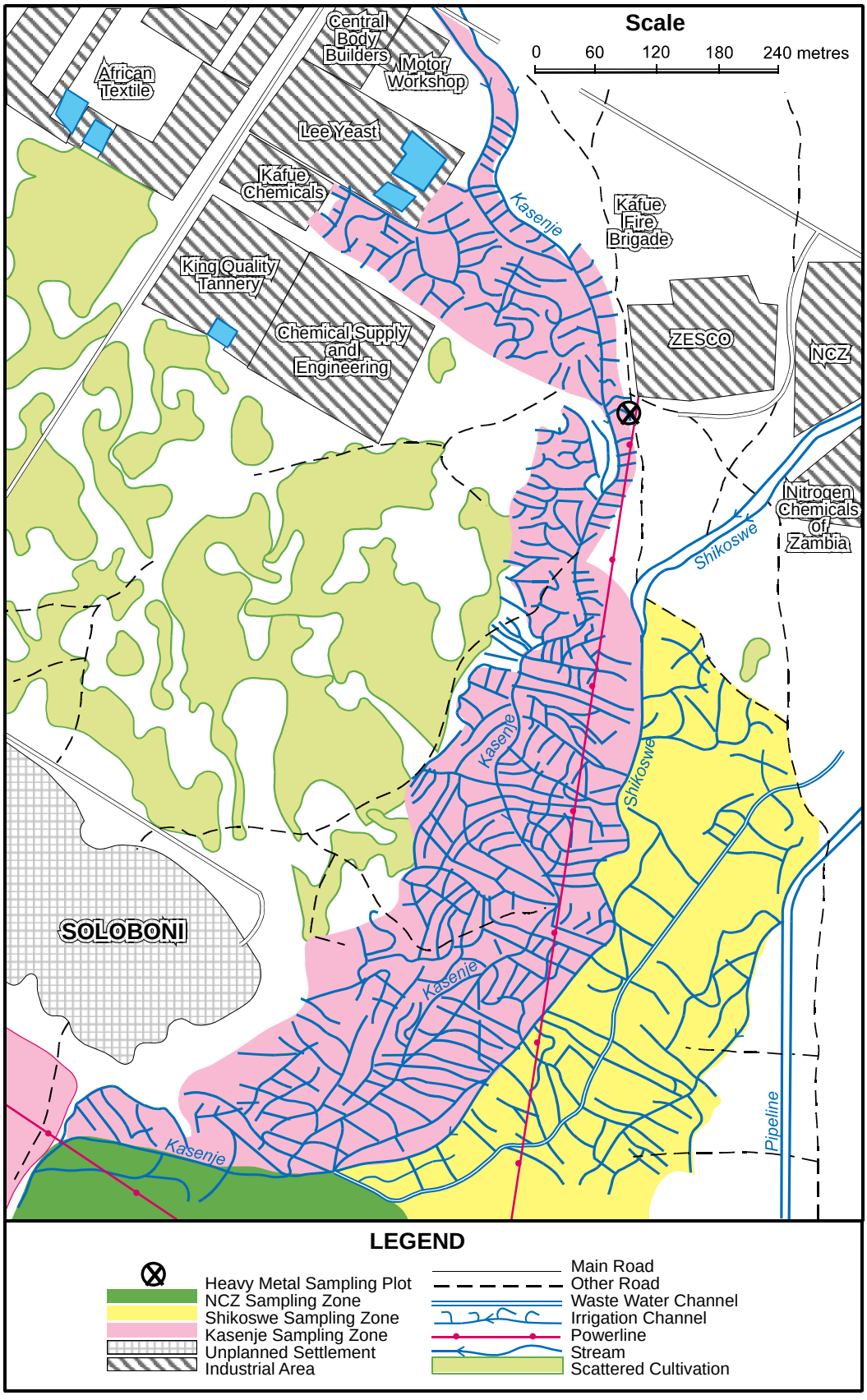


Figure 3. Sampling land use zones at Chilumba Gardens study site in Kafue (Adapted from Kapungwe, 2011)

Observation of farming practices in field plots at study sites

The field observations were conducted between February, 2006 and January, 2007. The farming practices were observed in field plots located at intervals along transects established in areas which were stratified into zones in order to collect information on different variables pertaining to farming practices. The two study sites were stratified into zones (Figure 2 and Figure 3 and Table 1). The zoning of the wastewater irrigated areas at the two study sites was based on the physical land characteristics comprising slope, type of soils and drainage. Each zone represented a sub-frame from which samples of field plots were selected. Transects were established in each zone along rivers, footpath, roads and main irrigation furrows which were accessible by foot or vehicle. Field plots were selected at a regular interval of 100 paces along transect with a start at a beginning of each transect. A total of two field plots were observed on each observation point. The range of observation at each point was 20 meters radius around each observation point. In other words at each sampling points two fields were observed which were located on both sides of the traversed transect. A cumulative total of 1111 fields were observed at New Farm Extension in Mufulira and 2148 fields were observed at Chilumba Garden in Kafue. Descriptive methods comprising frequencies and percentages were used to analyze data on farming practices. The hypothesis was tested using Chi-square test values at significance level of 0.05, two tailed.

RESULTS AND DISCUSSION

Traditional land management farming practices

The results indicated that the conservational land management practices at New Farm and Chilumba included mulching and residues of crops whilst the conventional land management practiced included burning of residues, slush and burn, ridges, raised beds, sunken beds as well as overall digging of land known as flat tillage (Table 2). The ridges were similar to findings from the study by *Jaeger and Hackabay*, [1986] on seasonal farming in Lusaka Zambia where the urban crop cultivators cultivated a variety of crops during the rainy seasons on ridges (large mounds) and the study by *Wood*, [1984] on traditional mixed cropping system in Eastern Nigeria where a varieties of crops were cultivated on the artificial mounds. The Chi-square tests indicated that there was a significant association between burning of residues and study sites (χ^2=20.02, df=1, P≤0.05). According to results from this study the crop cultivators used traditional farming practices such burning of residues, slush and burn which were similar to the traditional farming systems comprising shifting cultivation based on slash and burn which were practised by the different ethnic groups in Sub-Saharan Africa [*Wood*, 1984; *Pritchard*, 1994], Zambia [*Thomson*, 1968; *Allan*, 1969] and Central America, Mexico in Mexico valley of Mexico city where the indigenous people practised traditional production systems comprising slush, fell and burn [*Lasoda et al.* 1998]. It can be argued that the crop cultivators used the conventional traditional land management practices which remove the crop residues either through burning or slush and burn that culminate in reduction of organic matter hence the desorption of metal ions [*Holmgren et al.* 1993; *Mcgrath and Loveland*, 1992] which can lead to heavy metal contamination of soils and crops at the two study sites.

Table 1. Land management practices at two study sites

Land management practices	New Farm			Chilumba Gardens		
		Frequency	Percentage		Frequency	Percentage
Conventional land farming						
Flat tillage	1081	892	82.5	2098	1755	83.7
Ridges	1081	23	2.1	2098	330	15.4
Sunken beds	1081	76	7.0	2098	44	2.1
Raised beds	1081	59	5.5	2098	73	3.5
Slash and burn	1081	5	0.5	2098	6	0.3
Slash and clear	1081	8	0.7	2098	1	0.0
Burning of residues	1081	88	8.1	2098	89	4.2
Slashing	1081	3	0.3	2098	4	0.2
Soil loosening	1081	107	9.9	2098	305	14.2
Furrow	1081	112	10.4	2098	348	16.6
Land preparation	1081	58	4.9	2098	88	4.1
Field cleared	1081	6	0.6	2098	11	0.5
Over digging	1081	1	0.1	2098	0	0.0
Conservation land farming						
Mulching	1081	171	15.8	2098	40	1.9
Fallow	1081	24	2.2	2098	45	2.1
Residues of crops	1081	156	14.4	2098	12	0.6
Pot holing	1081	0	0.0	2098	25	1.2
No field existing	1081	58	7.6	2098	63	3.0

Source: Field data, 2006, 2007

The Chi-square tests indicated that there was a significant association between land preparation and types of soil at New Farm in Mufulira (χ^2=6.664, df=1, P≤0.05) whilst there was a significant association between ridges and drainage at Chilumba Gardens in Kafue (χ^2=54.643, df=3, P≤0.05). According to results from this study the practical limit of cultivation of land is set by physical factors such as soil types and drainage which was similar to results from studies on traditional farming systems in Zambia [*Thomson*, 1968; *Allan*, 1969] where the land cultivation under the traditional farming system was influenced by the soil types and drainage.

The cycle on land management practices at the two study sites indicated flat tillage and furrow were practiced throughout the year at New Farm in Mufulira (Table 3) whilst flat tillage, ridges and furrows were practiced throughout the year at Chilumba Gardens in Kafue (Table 4). The χ^2 tests indicated that there was a significant association between land management practices slush and burn and seasons at Chilumba Gardens (χ^2 test=17.80, df=2, P≤0.05). The burning of crop residues, slush and burn was practiced in dry seasons at Chilumba Gardens in Kafue (Table 4). The results from this study indicated that the cycle on land management practices at the two study sites was similar to seasonal termitaria gardening in City of Lusaka Zambia [*Jaeger and Huckabay*, 1986] and the traditional farming systems among the Bemba, Lala and Lamba people in Zambia [*Thomson*, 1968; *Allan*, 1969; *Wood*, 1984].

Table 2. Cycle on land management farming practices at New Farm Extension, Mufulira

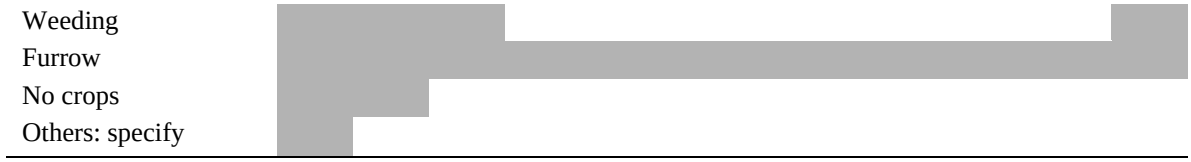
Farming practices (n=1111)	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct
	Hot wet season						Coo dry season			Hot dry Season		
Flat tillage												
Ridges												
Mulching												
Overall digging												
Sunken beds												
Soil loosening												
Fire burning												
Land clearing												
Burning of residuals												
Residuals heaped on boundary												
Residuals removed from field												
Raised beds												
Slashed grass												
Slush and burn												
Fallow												
No field												
No cultivation/fallow												
Removal of grass												
Slash and clean												
Weeding												
No crops												
Furrow												
Clean tillage												

Source: Field data, 2006, 2007

Table 3. Cycle on land management farming practices at Chilumba Gardens, Kafue

Farming practices n=(2148)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct
	Hot wet season					Cool dry season				Hot dry season		
Flat tillage												
Overall digging												
Ridges												
Clean tillage												
Soil loosening												
Burning of residuals												
Fire burning												
Mulching												
Sunken beds												
Raised beds												
Slashing												
Clearing of land												
Pot holing												
Residuals heaped on boundary												
Fallow												
No field												

Continue Table 3.



Source: Field data, 2006, 2007

Traditional multiple cropping systems

This study identified the crop cultivators practiced multiple cropping systems at New Farm Extension (Table 5) and Chilumba Gardens (Table 5) comprising vegetable growing, sugarcane mono cropping, maize mono cropping, sugarcane-vegetables, maize-vegetable growing sugarcane- maize cropping and sugarcane-maize-vegetable cropping system. The probable reasons for multiple cropping systems at the two study sites included: (i) insurance against crop failure; (ii) reduced labor cost of crop production; (iii) high returns on crops per field plots; (iv) spread the risks for heavy metal contamination of food crops because the different plant species have different capacity and capability to accumulate the heavy metals [*Hobbs and Streit*, 1986; *Gharbi et al.* 2009; *Nirmal Kumar et al.* 2009]. The multiple cropping systems at the two study sites were similar to the African traditional multiple cropping systems [*Wood*, 1984; *Prichard*, 1994] because the informal crop cultivators adapted the traditional farming methods to wastewater irrigation farming in urban and peri urban areas.

Table 4. Types of cropping systems at New Farm and Chilumba Gardens

Types of cropping system	New Farm, Mufulira		Chilumba Gardens, Kafue	
	Observations		Observations	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Mono cropping system				
Sugarcane mono cropping	687	71.9	744	41.8
Maize mono cropping	16	1.7	114	6.4
Mixed cropping system				
Vegetable cropping	124	12.9	87	4.9
Sugarcane-vegetable cropping	79	8.2	431	24.2
Maize vegetable cropping	13	1.4	135	7.6
Sugarcane-maize-vegetable cropping	34	3.5	212	11.9
Sugarcane-maize cropping	5	0.5	53	3.0
Other cropping system	0	0.0	2	0.1
Total	958	100.0	1778	100.0

Source: Field data, 2006, 2007

The Chi square statistical test indicated there was a significant association between cropping system and type of wastewater at New Farm in Mufulira (χ^2 =19.68, df=6, P<0.05) and Chilumba Gardens in Kafue ((χ^2 =329.51, df=7, P<0.05). Furthermore, the Chi square statistical test indicated there was a significant association between cropping system and drainage at Chilumba Gardens in Kafue ((χ^2 =6.23, df=6, P<0.05). In Mufulira at New Farm, the vegetable cropping was dominant in CEC land use zone which has readily available wastewater in the furrow and good drainage whereas at Chilumba Gardens in Kafue the vegetable cropping was dominant in the Kasenje land use zone which had readily available admixture wastewater and river water and in places where the drainage was either fair or good. The Chi-square statistical test indicated that there was significant association between types of soil and cropping system at New Farm in Mufulira (χ^2= 12.65, df=2,

P≤0.05) and Chilumba Gardens in Kafue (χ^2= 42.20, df=18, P≤0.05). The sugarcane mono cropping system was predominantly practiced on late rite at New Farm whilst the sugarcane mono cropping systems and vegetable cropping system were dominant on clay loam soils at Chilumba Gardens. The results from this study indicated that types of soil, type of drainage and availability of wastewater [*Kapungwe*, 2011] significantly influence the kind and nature of cropping system at the two study sites which were similar to findings from studies by *Bradford et al.* [2002; 2003] on wastewater irrigation farming in Hubli-Dharward where soil types, drainage and availability of wastewater influenced the cropping systems.

The cycles of cropping systems at the two study sites indicated that sugarcane mono cropping, vegetable cropping and sugar-cane-vegetable cropping patterns were practiced throughout the year at New Farm in Mufulira (Figure 4) whilst the sugarcane mono cropping and sugarcane-vegetable cropping were practiced throughout the year at Chilumba Gardens study site in Kafue (Figure 5). The Chi square statistical test indicated that there was a significant association between cropping systems and seasons at New Farm, Mufulira (χ^2=41.15, df=12, P<0.05) and Chilumba Gardens (χ^2=484, df=14, P<0.05). The maize-vegetable and sugarcane-maize-vegetable cropping systems were predominant in the hot wet and hot dry seasons at New Farm (Figure 4) whereas at Chilumba Gardens the sugarcane-vegetable cropping system was predominant in the hot dry season whilst the sugarcane-maize-vegetable was predominant in the hot wet season (Figure 5). The cycles of cropping systems at the two study sites indicated that the sugarcane mono cropping patterns and vegetable cropping patterns were predominantly and simultaneously practiced throughout the year. This implies that crop cultivators preferred vegetable cropping patterns with short cycles which provide vegetable which were quickly harvested and sold in order to raise the revenues which were used to continue tending for sugarcane mono cropping system with long cycles which facilitate sugarcane crop that provide high crop yield and financial returns. The agricultural cycle on cropping systems (Figure 4 and Figure 5) in wastewater irrigation farming at the two study sites in Zambia was similar to the urban crop agricultural cycle on seasonal termitaria gardening in Lusaka City, Zambia and rural crop agricultural cycle on traditional farming system among the Bemba, Lala and Lamba people in Zambia [*Thomson*, 1968; *Allan*, 1969; *Wood*, 1984] based on the multiple cropping system.

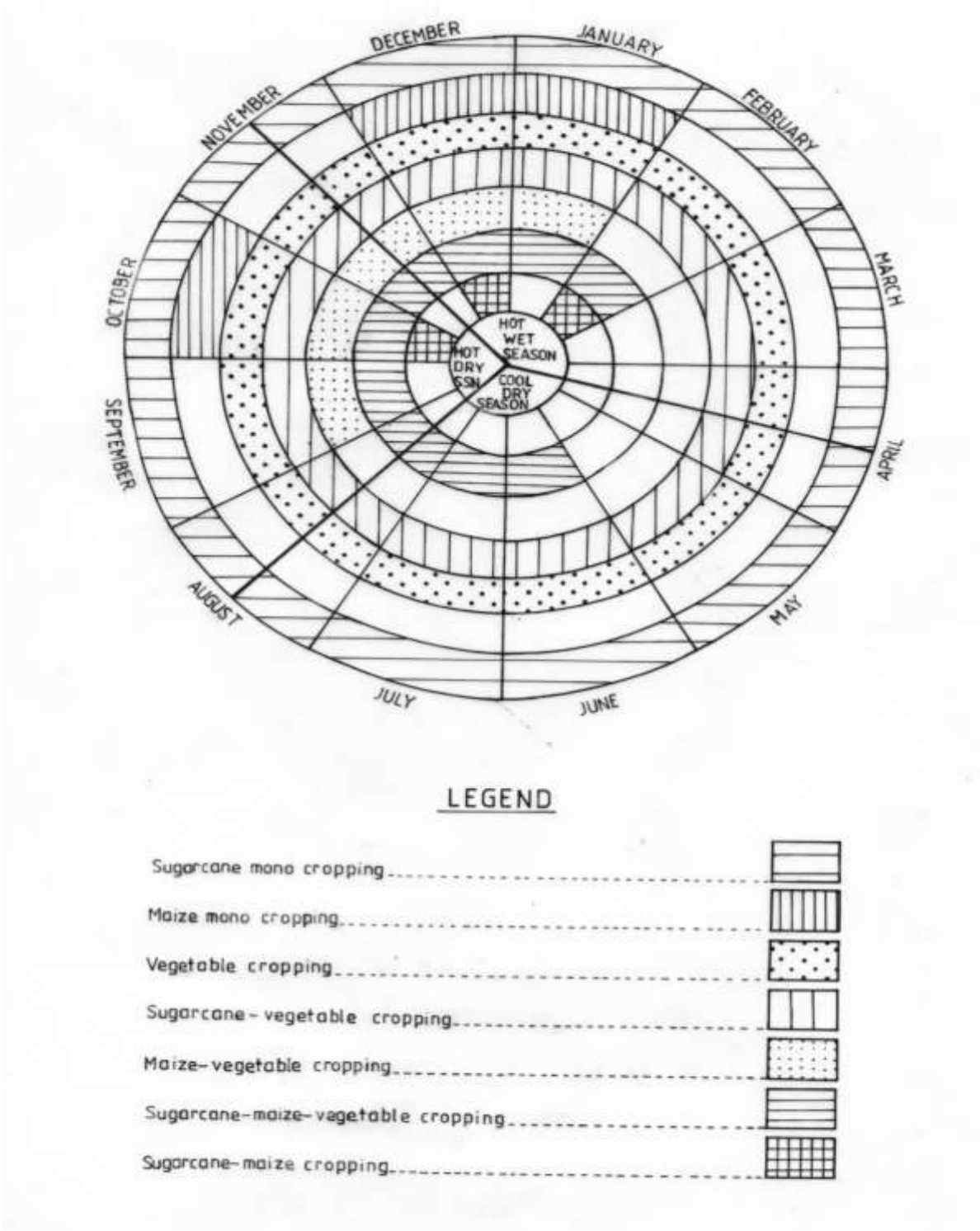


Figure 4. Cycle on types of cropping systems at New Farm, Mufulira

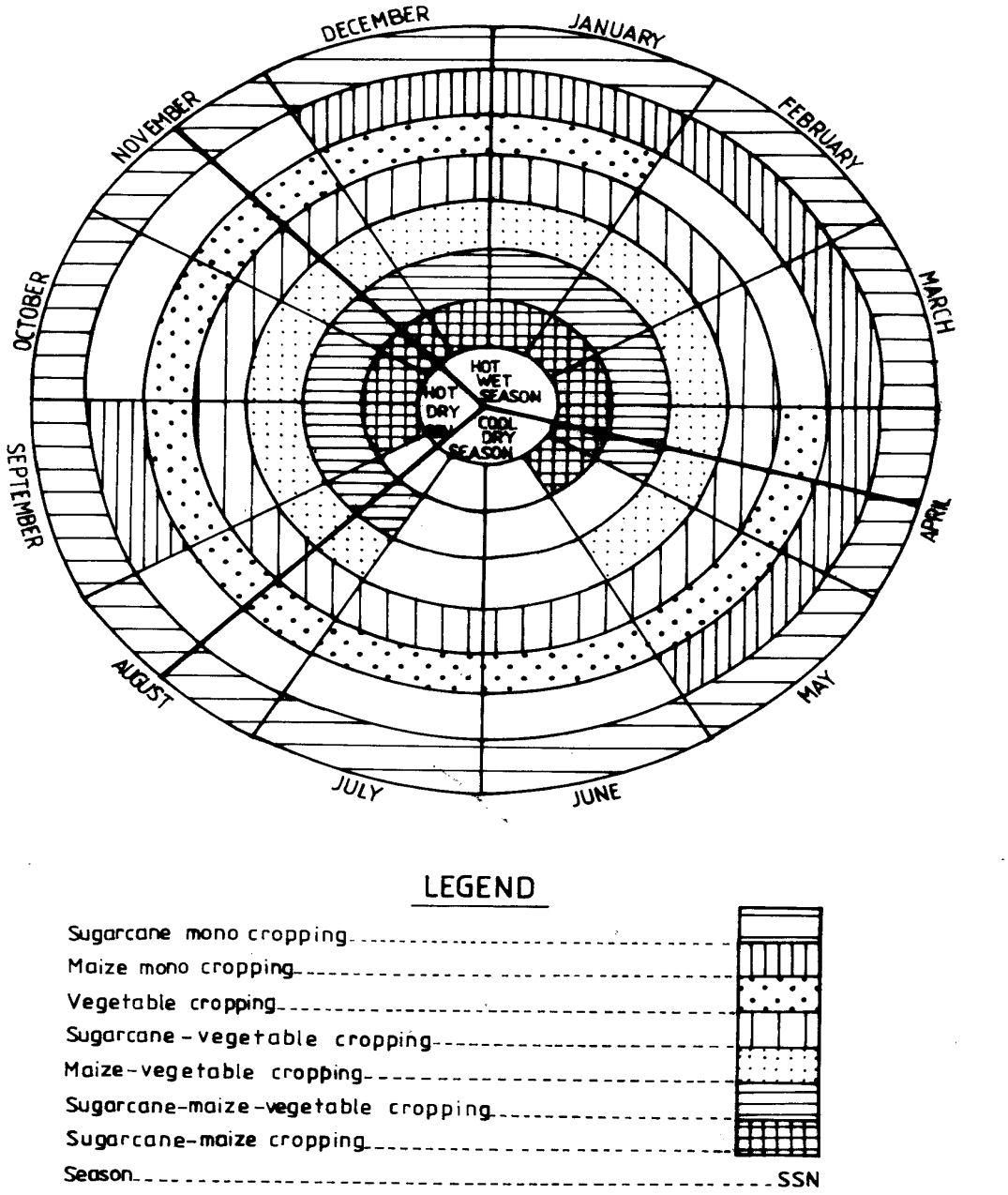


Figure 5. Cycle on types of cropping systems at Chilumba Gardens, Kafue

CONCLUSION

The traditional farming practices at the two study sites were characterized by traditional land management practices and traditional multiple cropping systems. The traditional farming practices on the wastewater irrigation farming were influenced by combination agro ecological factors as well as available heavy metal contaminated wastewater which has the potential to contaminate soils and crops. The farming practices in wastewater irrigation farming at the two study sites were based on adaptation of traditional production systems to urban agriculture which was linked to urban environment and multiple land use practiced at two study sites and surrounds which confirmed that traditional production systems have been practiced in an ostensible sustainable manner in peri urban and urban areas in developing countries. There was a need to develop and implement appropriate farming practices

which can ameliorate against the heavy metal contamination.

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