Groundwater Resources for Lusaka and selected Catchment Areas

TECHNICAL REPORT NO. 1

Impact of Small Scale Farming on the Chongwe River

Survey on Land Use and Water Abstraction from Chongwe River

by

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Summary

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Title: Impact of Small Scale Farming on the Chongwe River. Survey on Land Use and Water Abstraction from Chongwe River

Keywords: small scale farming, Chongwe, Zambia, agriculture

In order to estimate the amount of water being used by small scale farmers along the Chongwe river, a survey was conducted during February and March 2015. Information from 18 farmers - on cultivated lands, irrigated areas and practices, crop types and cycles, water demand and sources, surface coverage, use of fertilizers and pesticides, and disposal of oil and waste were gathered in the survey. A total of 180 ha are under cultivation with just under 36 ha being irrigated. Tomatoes are the most dominant crop in the area followed closely by maize. Water being abstracted from the Chongwe river for the irrigation is about 1.2 million m^3/a for the 18 surveyed farms. According to Zambian National Farmers Union, there are more than 150 small scale farmers abstracting water from the river. Applying the average water use to the 150 small scale farmers gives an estimated water usage of 10 million m^3/a for the whole Chongwe catchment. This reflects 5% of the potential catchment capacity assuming an average runoff of the Chongwe river at Great East Bridge of 6 m^3/s. However, in comparison to an earlier study on water use by commercial farmers, small scale farmers in the survey are using almost seven times more water per hectare per year than commercial farmers. This could be due to irrigation of different crops, more crop cycles per year and/or poor water management practices. In summary the impact of small scale farming on the Chongwe river is not considered substantial but further assessment and monitoring are recommended.

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approx.	approximately
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)
ca.	circa
DWA	Department of Water Affairs
EFSA	European Food Safety Authority
EU	European Union
FAO	Food and Agricultural Organisation
GReSP	Groundwater Resources Management Support Programme
ha	hectare
IWRM	Integrated Water Resources Management
K	potassium
m^3/a	cubic meter per annum
MMEWD	Ministry of Mines, Energy and Water Development
MAR	maximum application rate
MOP	muriate of potash (potassium chloride)
N	nitrogen
P	phosphate
PAN International	Pesticide Action Network International
WARMA	Water Resources Management Authority
ZEMA	Zambian Environmental Management Authority
ZNFU	Zambian National Farmers Union

Executive Summary

In order to estimate the amount of water being used by small scale farmers along the Chongwe river, a survey was conducted during February and March 2015. The survey targeted small scale users on the Chongwe river and its major tributaries. Information from 18 farmers - on cultivated lands, irrigated areas and practices, crop types and cycles, water demand and sources, surface coverage, use of fertilizers and pesticides, and disposal of oil and waste were gathered in the survey. A total of 180 ha are under cultivation with just under 29 ha being irrigated. Most farmers are following a crop rotation between tomatoes, maize, and garden vegetables. Tomatoes are the most dominant crop in the area followed closely by maize. Due to the size of the farms and need for continuous income, most of the area available for cultivation is being used year round. The survey further shows a high use of fertilizers and pesticides. Many pesticides are used on the tomatoes. Half of the pesticides used by farmers in the survey have been listed on PAN International's list of highly hazardous pesticides. Most sanitation systems are pit latrines found at least 200 m or more from the river.

Water being abstracted from the Chongwe river for the irrigation of tomatoes and garden vegetables is about 1.2 million m^3/a for the 36 ha of surveyed farms. According to ZNFU, there are more than 150 small scale farmers abstracting water from the river. Taking the average water use of the 18 farmers surveyed and applying it to the approx. 150 small scale farmers gives an estimated water usage of approx. 10 million m^3/a for the whole Chongwe catchment. In a previous survey on commercial farming along the Chongwe river, it was found that surface water abstraction rates are almost 15 million m^3/a for ca. 2,400 ha of irrigated land (Mayerhofer et al., 2010). In comparison, small scale farmers in the survey are using almost seven times more water per hectare per year than commercial farmers. This could be due to irrigation of different crops, more crop cycles per year and/or poor water management practices.

In order to discuss these figures, pending water permits for farms of similar size (between 2 and 8 ha) at WARMA in 2015 were analysed for the volume applied for and it is 400 or 500 m^3/day. If daily water abstraction of 500m^3 is permitted and realized, an annual abstraction (with three crop cycles resulting in 270 irrigation days) of 135,000 m^3/a seems a valid estimation. If this figure is scaled up for all 150 small scale farmers on the Chongwe, a total of 20 million m^3/a would be used. Relating this to the total amount of annual water flow in Chongwe river as measured at gauging station 05-25 at Great East bridge, the annual average runoff of 6 m^3/s amounts to almost 190 million m^3/a. Thus, 10 or 20 million m^3/a of water abstractions reflect a mere 5 to 10% of the potential catchment capacity, respectively. In summary the impact of small scale farming on the Chongwe river is not considered substantial but further assessment and monitoring are recommended.

In order to manage the water resources in the Chongwe catchment, it is indispensable to measure and assess the quantities of both, supply and demand also in relation to seasons and flow rates. The water level of Chongwe river on its main gauge, the Great East bridge station 05-25, is recommended to be continuously measured by an automated pressure logger. The abstractions by farmers using submersible pumps need to be measured ideally by water meters and it should be a requirement to the renewal of water permits that the meter readings are submitted on a yearly base.

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- Our drivers Wesley Mabuluki and Joseph Mwela

1. Introduction

1.1 Project Background

The on-going project “Groundwater Resources Management Support Project“ (GReSP) is implemented by the Government of Zambia through the Department of Water Affairs (DWA) and the Water Resources Management Authority (WARMA) at the Ministry of Mines, Energy and Water Development (MMEWD) with support from the Federal Republic of Germany through the Federal Institute for Geosciences and Natural Resources (BGR). The project was planned to fulfil the urgent need for groundwater resource assessment in important areas in Zambia. It started in May 2005 with its first phase being undertaken in Southern Province; the second phase covered a 3-years implementation period which ended in March 2013. The main focus of the second phase of GReSP was to offer support in sustainable groundwater development and protection as well as Integrated Water Resources Management (IWRM) in the surroundings of Lusaka. The current third phase (2013 – 2015) of GReSP focuses on the establishment of the Water Resources Management Authority. The Chongwe catchment is the focus of hydrogeological studies during Phase 3.

1.2 Objectives

For a complete assessment of water usage in the Chongwe river catchment the Water Resource Management Authority (WARMA) relies on information from major water users as well as small scale users. The main objectives of this survey are to gain a better understanding of how much water is being extracted by small scale farmers from the Chongwe river.

This survey addresses two main topics:

- Information on land use, irrigation and potential pollution risks from small scale farmers along the Chongwe river area
- Water usage as well as the handling of hazardous substances and effluents by farmers along the Chongwe river

2. Methodology

For an estimation of water usage by small scale farmers from the Chongwe river a questionnaire-based survey was conducted. Prior to the survey, The Zambian National Farmers Union (ZNFU) were approached to obtain information on the locations of potential small scale farmers for this study. A member from the Union was also asked to participate in conducting surveys of farmers. Information from the small scale farmers contributed to an effective completion of this survey. The field work was carried out during February 2015 with a total of 18 farmers interviewed. According to ZNFU, there are over 150 small scale farmers along the Chongwe river.

The assessment on farming targeted small scale farmers along the Chongwe river. These farmers mainly grow cash crops such as tomato and maize. The survey helped to obtain the following data:

- The plot size of cultivated land in the project area
- The size of irrigated land
- Type of crop, crop rotation and growth period
- Surface coverage in non growing seasons
- Irrigation practices
- Water demand for irrigation purposes
- Type of water source
- Application of fertilizer and pesticides
- Sanitation system used on the farm
- Distribution of the farming areas within the project area

The questionnaire used for interviewing farmers is shown in Annex 2.

2.1 Location of Farmers in the Project Area

Figure 1 shows the main catchment areas of surface water in Zambia, these being: Kafue, Zambezi, Luangwa, Luapula, Chembeshi, and Tanganyika. All farms surveyed are located in the Chongwe sub-catchment of the Zambezi, along the Chongwe river.

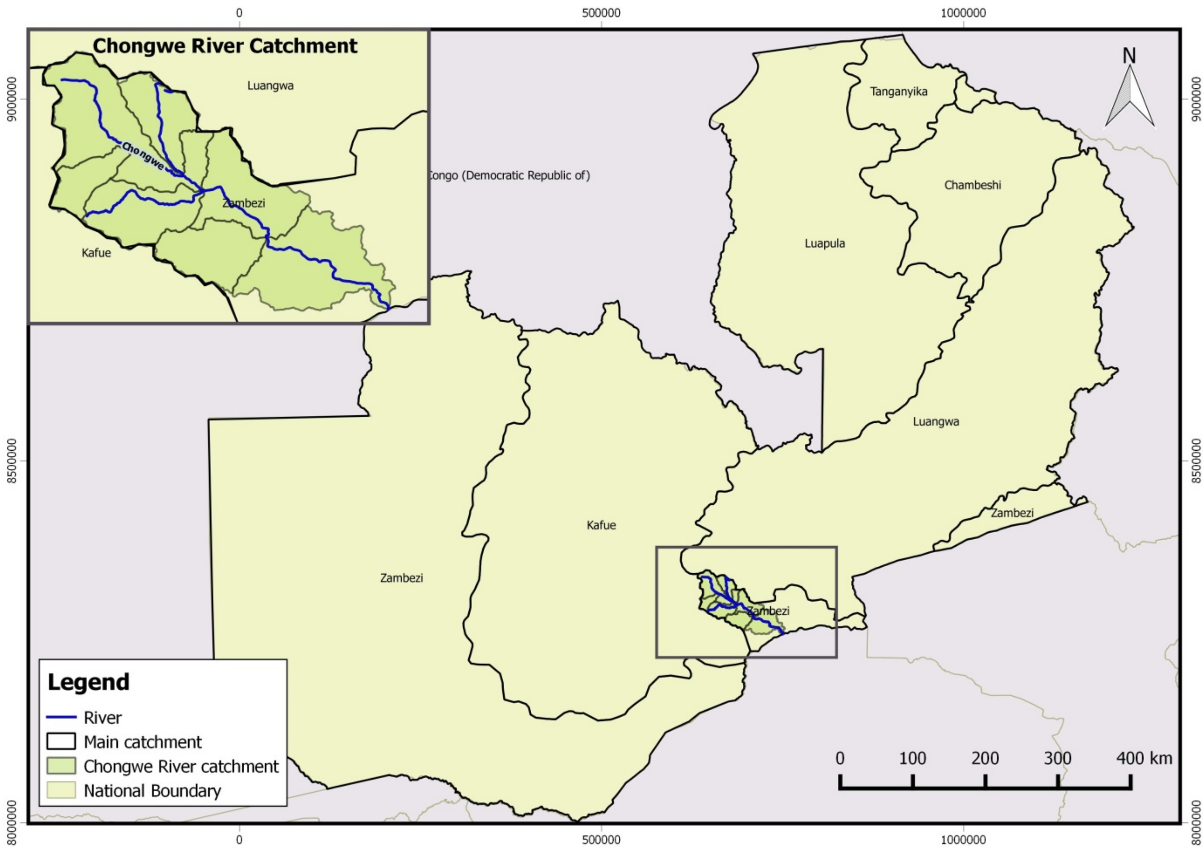

Figure 1 Map of the major catchments in Zambia and the Chongwe river catchment

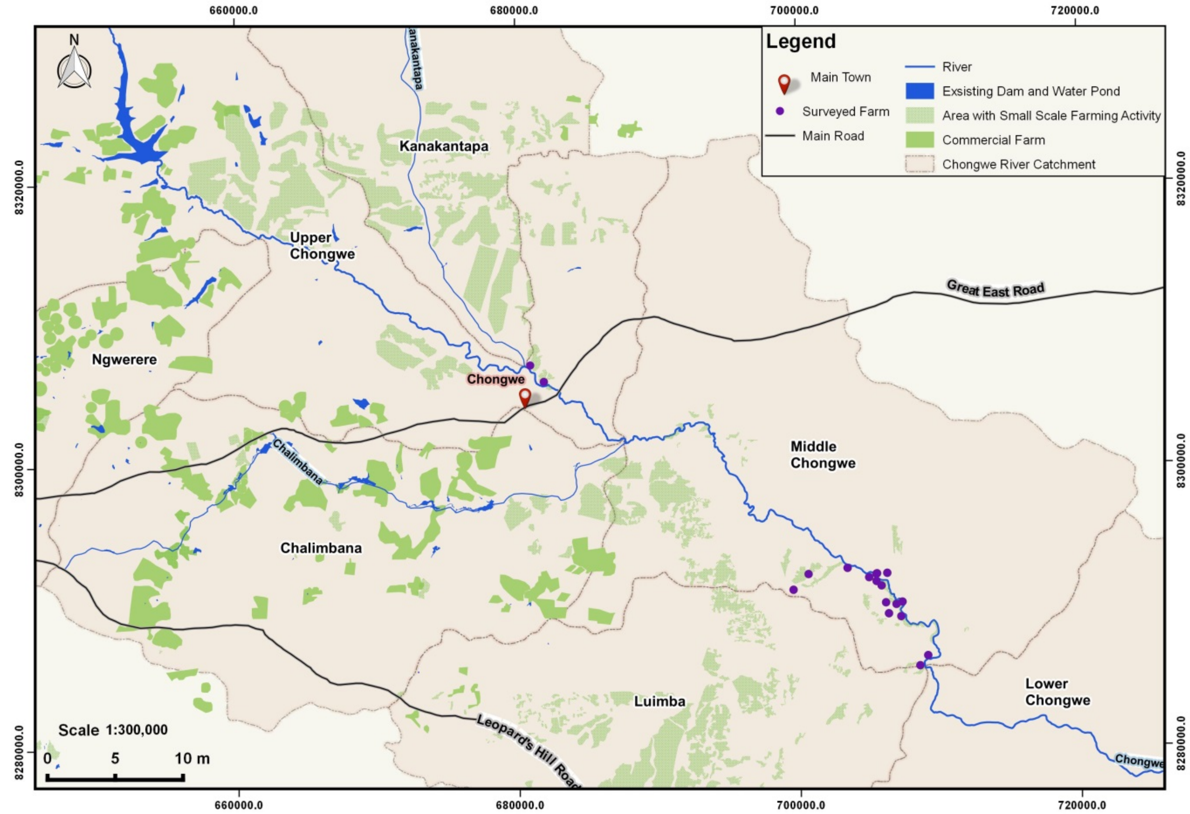

Figure 2 Map of the surveyed area and distribution of small scale and commercial farms along the river

3. Results

3.1 Size of the Small Scale Farming in the Project Area

During the survey period 18 small scale farmers, shown in Appendix 1, were interviewed. The survey showed that 18 small farms cover a total area of 180 ha along the Chongwe river, with a cultivated area of 74 ha and an irrigated area of 35.5 ha. Thus, about 16% of the total area and 48% of the cultivated area is under irrigation.

A satellite-image-based land use survey was done for the Chongwe catchment in the project. Farming areas were identified and compared to the commercial farm areas which were mapped by Hahne & Shamboko (2010). Only the formerly unmapped agricultural areas were outlined and agglomerated to polygons, containing several small scale farms each (see Figure 2). According to this land use survey, small scale farms along the Chongwe river and its major tributaries cover close to 8,000 ha. The total area of the catchment is 5,153 km^2 and the small farms cover 1.5% of that area. ZNFU provides no information on the total size of small farm areas along the Chongwe, hence no ground-truthing for the satellite-image based survey could be done.

3.2 Cultivation Practices

Table 1 shows the main crops grown by small scale farmers in the project area. It lists the total area covered by each crop and the areas covered during rainy and dry seasons. It is clear that there are two main crops, tomatoes and maize. These two crops cover 82% of the total area under cultivation. Other crops included garden vegetables such as rape, cucumbers, cabbage, and peppers as well as groundnuts and sweet potatoes. Together these crops cover 11.6% of the total area under cultivation. The remaining area was kept fallow until brought into a crop rotation.

Table 1 Cultivated area in total and per season

Type of Crop	Area Coverage (%)	Total Area (ha)	Area in Rainy Season (ha)	Area in Dry Season (ha)
Tomato	42.2	31.25	29.25	30.25
Maize	39.8	29.5	29.5	0
Rape	5.4	4.25	4.25	3.75
Groundnuts	2.1	1.62	1.62	0
Cucumber	1.6	1.25	1.25	0.5
Pepper	1.0	0.75	0.50	0.75
Sweet Potato	0.6	0.5	0.5	0
Cabbage	0.3	0.25	0	0.25
Sub-Total	93	69.37	66.9	35.5
Other crops/fallow land	7.0	4.63	7.1	38.5
TOTAL	100	74	74	74

Tomatoes are the dominant crop grown year round by 94% of farmers. Most farmers said they can typically get three tomato harvests (Figure 3) in one year with the season being from January/February to October/November. The dominant crops grown in rainy season are tomato and maize (Figure 4), grown by 94% and 88% of all farmers, respectively. And again, tomatoes are the dominant crop grown during dry season with 94% of farmers. The typical growth period for rainy season is November/December to April/May, depending on the crop. Most of the farmers did a combination of crop residual, plowing, and burning. Crop residual is the most common type of surface cover done by 66% of farmers when land is not in use (49.5 ha). The next most common practice was burning, practised by 38% of farmers (26.5 ha), followed by ploughing used by 33% of farmers (22.5 ha). Due to tomatoes and garden vegetables being grown year round, and the practice of crop rotation by most farmers, it was difficult to define a season or period where land was not being used.

77% of the farmers interviewed followed a crop rotation. The most common rotation was between tomato and other garden vegetables, followed by rotation with tomatoes and maize. Rotation typically happened once a year or every two years.

Figure 3 Tomato harvesting at a small scale farm along the Chongwe river

Figure 4 The second most prominent crop grown by the surveyed farmers, maize

3.3 Water Source and Irrigation Method

The survey has shown that all but one farmer uses an irrigation system. 88% of the farmers use their irrigation systems throughout the year. The remaining 12% only use their systems during dry season or during rainy season to supplement water during dry spells. All the farmers surveyed pulled their water from the Chongwe river. This was done by small diesel pumps that abstracted water from the river and delivered it to the fields through pipes (Figures 5 and 6). The total area irrigated is 35.5 ha and primarily the land is cultivated for tomatoes.

Figure 5 A small pump used to abstract water from the Chongwe river

Figure 6 Intake pipes for water abstraction

The most common used irrigation system is drip irrigation applied by 64% of farmers. This is followed by furrow irrigation at 35% and flooding at 17%; only one interviewed farmer used sprinklers. These systems are typically used to irrigate tomatoes which are the most common crop under irrigation year round. Other garden vegetables are irrigated, but on a much smaller scale. All of the farmers depend on the rains for their maize and therefore do not irrigate maize fields.

3.4 Water abstraction

Most farmers were not able to provide exact data on their water abstraction for irrigation. They were able to provide pump specifications and the amount of hours their pumps were running per day. To supplement this information, crop water requirements, applied by the Food and Agriculture Organization of the United Nations (FAO), are given for the main crop tomato: 400-600 mm per growth period. Exact values depend on climate and soil conditions (Brouwer, 1986).

One mm equals 10 m^3/ha of water. Assuming a farmer grows irrigated tomatoes on a total area of 100 ha, the water demand for this crop would roughly be: 500(mm) x 10(m^3) x 100(ha) = 500,000 m^3. This estimation was used during the previous survey by Mayerhofer et al. (2010) for comparison with the data given by farmers on their water use.

Water use was determined by multiplying daily water usage by 30 (days) to determine the amount of usage per month. This is assuming that farmers are using irrigation every day. That number was then multiplied by 9 since most farmers grow tomatoes for 2.5-3 months, 3 times a year, thus a total of 9 months.

The annual water use for all farmers surveyed is approx. **1,2 million m^3/a** (Table 2). Applying an estimated crop water demand of 500 mm based on the information given by FAO, water usage on the ca. 30 ha tomato cultivated/irrigated area should be in the order of 150,000 m^3/period and 450,000 m^3/a. This means farmers are possibly using more than twice (2.67 times) the amount of water necessary to grow tomatoes.

If the average water usage by the 18 interviewed farmers is applied to the 150 small scale farmers on the Chongwe river, an estimate of total water usage for the Chongwe catchment would result in about **10 million m^3/a**. Table 2 shows the amount of water being abstracted by small scale farmers for irrigating tomatoes, the FAO water requirements for tomatoes, and an estimation of water usage by 150 small scale farmers.

Table 2 Estimated (and rounded) abstraction rates for surface water compared to crop requirements

Abstracted surface water in m^3/year (assuming three crop cycles, on 18 surveyed farms, based on pump specifications and duration)	1,221,000
Abstracted surface water in m^3/period	407,000
FAO water requirements for 31,25 ha tomatoes in m^3/period (assuming crop requirement of 500 mm, period = 3 months)	156,250
FAO water requirements for tomatoes in m^3/year (assuming three crop cycles)	468,750
Estimated water abstraction for 150 farmers in m^3/year	10,175,000

These figures are especially surprising when compared to the survey on commercial farmers in the same (and an adjacent) catchment in 2010 by a team from GReSP and DWA (Mayerhofer et al., 2010).

In this previous survey on water usage by **commercial** farms in the Chongwe catchment it was found that abstraction of surface water is close to 15 million m^3/a for an area of 2,373 ha (Mayerhofer et al., 2010). This means that commercial farmers are using ca. 6,300 m^3/ha/a of water for irrigation. The small scale farmers in this survey are using 42,100 m^3/ha/a of water to irrigate their fields. This is seven (7) times more than what commercial farmers are using to irrigate their fields.

In order to clarify the water abstraction by small scale farmers, a second short field study was done. In the original survey, pump specification were noted down only as amount of water used per day, with the specification of the pump in m^3/h multiplied by the amount of hours the interviewed farmer indicated the pump is running. This partly yielded very high amounts of water used – in one example 30 m^3/h * 16 hours per day, giving 480 m^3/day of water use for irrigation of an area of 3 ha. In the second field trip flow rates from the pump were measured by bucket and stopwatch. This post-assessment however does not clarify the situation. Two farms show a lower flow rate than the pump specification indicated: measured flow rates were 80 and 0.4 times less the specified yield of the pump, respectively (instead of 60 m^3/h only 0.7 m^3/h and instead of 60 m^3/h only 43 m^3/h). At one farm the measured flow rate exceeded the pump specifications, yielding 43 m^3/h instead of the specified 30 m^3/h, resulting in 690 m^3/day in 16 hours of irrigation. Thus the farmer uses approximately 12 times as much water on his tomatoes as is recommended by FAO.

As the project was not able to invest more resources in the survey, the large difference between small scale and commercial farmer water abstraction remain questionable and unexplained. Reasons for a higher water use by small scale farmers could be:

- the type of crops being grown (tomatoes instead of fully irrigated maize/soybean and supplemented wheat),
- the number of crop cycles (3 instead of 1-2)
- poor farming / water management practices on the part of small scale farmers (two thirds use drip irrigation, but even then seem to over-irrigate).

It should also be noted that a cultivated area of ca. 30 ha of small scale farms are compared here to almost 3,000 ha of commercial farmland and that, while Mayerhofer (et al., 2010) visited almost all commercial farmers in the catchment, only 12% of small scale farmers were visited in this survey.

3.5 Potential Pollution Sources of Groundwater

3.5.1 Fertilizer

Artificial fertilizers are applied by all farmers surveyed. Most farmers follow recommended application guidelines for fertilizers that call for a basal dressing at planting, followed by one or more top dressings at different stages of growth. The amount and type of fertilizer per application depends on the crop and soil type. The most frequently used fertilizers according to this survey are as follows: D Compound (N 10%, P 20%, K 10%), applied by 89% of farmers, Calcium-Nitrate 83%, Urea 61% (N 46%, P 0%, K 0%), Ammonium-Nitrate 55%, Ammonium-Sulphate 39%, Potassium-Sulphate 27%, Potassium 22%, MOP 11%, Potassium-Nitrate and Magnesium-Nitrate both 5%. D Compound and Urea are used to fertilize maize as basal and top dressings. The remaining fertilizers are used for tomato production throughout the growing season. According to the farmers, tomatoes require large amounts of nitrogen and potassium as well as phosphorus. The total amount of fertilizer being used for tomato is 36,360 kg/a and 8,800 kg/a for maize. Tomatoes need 100 to 150 kg/ha N, 65 to 110 kg/ha P and 160 to 240 kg/ha K (Unit, 2013). The total amount of fertilizer then needed for tomatoes range from 325 kg/ha/period to 500 kg/ha/period. The farmers in this survey produce at least 3 tomato crops each year on 31 ha. Therefore, according to FAO, the farmers should be using 30,225 kg/a to 46,500 kg/a of fertilizer. Their use of 36,360 kg/a of fertilizer on tomatoes is within the FAO standards. Maize requires 200 kg/ha N, 50 to 80 kg/ha P and 60 to 100 kg/ha K (Unit, 2013). The total amount of fertilizer needed for maize is 310 kg/ha/period to 380 kg/ha/period. The farmers in this survey are cultivating one cycle of maize on 29.5 ha each year. Using the FAO standards then, and the total area of maize, the range of fertilizer should be 9,145 kg/a to 11,210 kg/a. The farmers are actually below the recommended amount at 8,800 kg/a. Along with artificial fertilizers, organic fertilizers such as animal manure are being used by 33% of farmers.

3.5.2 Pesticides

The survey showed that all but one farmer apply pesticides on their fields. Most of the pesticides were being used on tomatoes and other garden vegetables. Of the farmers interviewed, 15 apply pesticides weekly on their tomatoes, 2 apply more than once a month, and one farmer applies weekly and after every heavy rain. The amounts of applied pesticides the interviewed farmers provided are given in liter per year while international maximum application rates are given as per kg active component per ha. Therefore a comparison and placement of amounts is difficult. For further reference the European maximum application rates for some of the components used are nevertheless listed below. The following pesticides were found to be most frequently used:

- Dursban (Chlorpyrifos, organophosphate, insecticide)
- Cypermethrin (Pyrethroid, insecticide)
- Endosulfan (organochlorine, insecticide)
- Azoxystrobin (fungicide)
- Tebuconazole (systemic fungicide)
- Chlorothalonil (non-systemic fungicide)
- Diphenhydramine
- Trimangol

Four of the above chemicals are on the Pesticide Action Network (PAN) International List of Highly Hazardous Pesticides. Dursban (chlorpyrifos) and cypermethrin (pyrethroid) are both classified as environmentally toxic due to their high toxicity to bees. Endosulfan and chlorothalonil are both acutely toxic and classified ‘fatal if inhaled’. Endosulfan’s long term effects are that it is an endocrine blocker or potential endocrine blocker. Chlorothanlonil is a probable/likely carcinogen (PAN International, 2014).

The highest amount given by the interviewed farmers is 12 litres per week of Cypermethrin, Diphenhydramine and Chlorolthalonil on an area of 2 ha of tomato plants.

For Azoxystrobin the maximum yearly application rate in the European Union is at 1000 g active component/ha, in 4 applications of max. 250 g/ha (EFSA 2013). For Tebuconazole the maximum yearly application rate in the European Union is at 1125 g active component/ha, in 3 applications on tomatoes of max. 375 g/ha. Outside the EU, some countries record higher MAR e.g. Brazil, where 1200 g/ha are applied on mangoes and papaya (EFSA 2011). Chlorothalonil has a maximum yearly application rate in the European Union of 12 kg active component/ha. In Latin America up to 15 kg/ha are applied to bananas (EFSA 2012).

Water to dilute the pesticides in drums before applying (Figure 6) was also being abstracted from the Chongwe river. Overall the farmers surveyed are using 367 m^3/a of water to use in application of pesticides.

Figure 7 Drums (210 l) used to dilute pesticides

3.5.3 Used Oil

Used oil on these small scale farms typically comes from the pumps and generators used to extract water. Most of the farmers reused the oil around their farms for painting posts to prevent termites, use in bicycle repair and maintenance, or they gave to other local farmers for the same uses. Few farmers disposed of oil by throwing it in designated areas such as a pit latrine or trash pit. Only one farmer was disposing of his oil next to the river at the pump site.

3.5.4 Sanitation System

Sanitation systems can be another source of water contamination. All but one farm surveyed has pit latrines. The one farm without a pit latrine did not have living quarters on site and therefore used open defecation. The latrines are buried when full and another is built nearby. On average the latrines were 290 m from the river with the nearest being 50 m and the furthest being 500 m.

4. Discussion and conclusion

The most important and at the same time highly contestable results from this study comprise the water abstraction by small scale farmers from the Chongwe river and the use of pesticides on the main crop, i.e. tomato. In the following subchapters a final discussion of the issues is done and further work ahead outlined. A conclusion of the impact of small scale farming on the Chongwe river is then drawn.

4.1. Water abstraction

Deriving surface water abstraction rates from the specifications given by the pump manufacturer holds a number of error sources. Measuring flow rates from the pumps by bucket and stopwatch however did not prove to be more reliable in this study. Pump specifications normally overestimate the actual flow rate of pumped water, as leakages can occur, the difference in elevation between pump and outlet must be overcome, and pumps also become less efficient with time and siltation of the inlet (especially in surface waters). The authors were therefore prepared to state the water abstraction rates as maximum amounts, most likely to be underscored. The post-assessment comprising flow rate measurements with bucket and stopwatch included two farms, where measured flow rates were 80 and 0.4 times less the specified yield of the pump, respectively (instead of 60 m^3/h only 0.7 m^3/h and instead of 60 m^3/h only 43 m^3/h), which confirms the outlined theory. At one farm, in contrast, the measured flow rate exceeded the pump specifications, yielding 43 m^3/h instead of the specified 30 m^3/h.

In order to obtain another indicator on the reliability of the surveyed water abstraction figures, the applications for water permits at WARMA were gathered for Chongwe river. Five pending licences were found for farms of similar size (between 2 and 8 ha) and the volume that was being applied for is 400 or 500 m^3/day, except for one applicant with 50 m^3/day. If daily water abstraction of 500m^3 is permitted and realized, an annual abstraction (with three crop cycles resulting in 270 irrigation days) of 135,000 m^3/a seems a valid estimation. If this figure is scaled up for all 150 small scale farmers on the Chongwe, a total of 20 million m^3/a would be used. The survey's initial estimation is only half of this amount, 10 million m^3/a (see Table 2).

Relating this to the total amount of annual water flow in Chongwe river as measured at gauging station 05-25 at Great East bridge, the average runoff of 6 m^3/s amounts to almost 190 million m^3/a. Thus, 10 or 20 million m^3/a of water abstractions reflect a mere 5 to 10% of the potential catchment capacity, respectively. Still the impact during low flow periods should be assessed.

The discrepancy between commercial farmers using only 6,300 $m^3/ha/a$ of water for irrigation and the small scale farmers sevenfold amount of 42,100 $m^3/ha/a$ remains to be explained. As offered in chapter 3.4, reasons for a higher water use by small scale farmers could be:

- the type of crops being grown
- the number of crop cycles
- poor farming / water management practices on the part of small scale farmers.

On the other hand, an update or reconfirmation of water abstraction by commercial farmers could also be considered by WARMA.

As work ahead, the authors suggest that WARMA conducts volumetric ("bucket") measurements to estimate pump rates while visiting a small farm as part of the water permitting process. Even more important but perhaps less economically feasible is the installation of water meters on all farms, small- and large-scale/commercial. WARMA will also need to (re)define the terms commercial and small scale (non-commercial) farming, as three crop cycles of water intensive tomato- and maize-farming are very likely to serve for commercial purposes as well.

4.2. Use of pesticides

The survey found that all but one farmer use pesticides on their crops, mainly on tomatoes; most of the farmers apply them weekly. Half of the most frequently used pesticides are internationally classified as highly hazardous, some of them can be fatal if inhaled. On the applied amounts farmers were only able to indicate how many liters they use, not the amount of active substance per hectare. In order to compare the pesticide application rates of the surveyed farmers to international standards as set by the European Union for example, a further analysis of the pesticide products and their active component concentration needs to be done. The topic should draw attention by WARMA and/or the Zambian Environmental Management Authority (ZEMA) as the hazardous substances are ecologically toxic. A well-planed sampling campaign is needed to assess the remaining concentrations of pesticides in the river and also in the soil and groundwater. Zambian authorities will need to work with an internationally accredited laboratory which is able to analyze pesticides, as such laboratory does not exist in Zambia. It is essential that transport times and cooling of samples are elaborated upfront and adhered to meticulously. One question to be answered by such study is if concentrations in the rainy season are increased due to more frequently applied (and washed off) pesticides or decreased due to dilution in higher runoff volumes.

After establishing the impact of the currently used hazardous pesticides and their application rates WARMA and ZEMA should elaborate a list of banned substances and/or regulate the application rates to avoid environmental pollution and threats to public health.

4.3. Conclusion

In summary the impact of small scale farming on the Chongwe river is not considered substantial but further assessment and monitoring are recommended. In order to manage the water resources in the Chongwe catchment, it is indispensable to assess the supply and demand quantities. The water level of the Chongwe river on its main gauge, the Great East bridge station 05-25, is recommended to be continuously measured by an automated pressure logger. The abstractions by farmers using submersible pumps need to be measured ideally by water meters. It should be a requirement to the renewal of water permits that meter readings are submitted on a yearly base with a prescribed reading schedule. Farmers using groundwater should be obliged to either install meters or automatic groundwater level loggers in their borehole with the same requirement to hand in the data.

In addition to this quantitative monitoring approach, water quality should also be examined routinely in both surface and groundwater. An initial pesticide sampling campaign will inform the authorities if this parameter needs to be reviewed consecutively or if other, substances that are easier to detect can serve as indicators.

5. References

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Annex

Annex 1 List of famers and their location in the Chongwe catchment

Farm/Farmer	Interviewed Person	Location	GPS Coordinates
Fotson Mbewe	Dianas Kakala	Chombwa Village	S 15.31925, E 028.69419
Mwambilwa Farm	Mwambilwa Mathias	Chombwa Village	S 15.39335, E 028.26815
Bright Muntali	Bright Muntali	Musokota Village	S 15.46120, E 028.92817
Kachibani Farm	George Shilanga	Musokota Village	S 15.45972, E 028.93218
Christoph Malumo	Christoph Malumo	Musokota Village	S 15.46018, E 028.92127
Abraham Nyambe	Abraham Nyambe	Musokota Village	S 15.44937, E 028.91833
Muntu Sali Bwino Farm	Makosa Tembo	Mwachiaka Village	S 15.44655, E 028.91496
Josephat Chida	Josephat Chida	Mwachiaka Village	S 15.44411, E 028.91005
Cephas Gondwe	Nicholas Gondwe	Kambeba Village	S 15.43817, E 028.89572
Pearson Banda	Agnes Banda	Mwalina Village	S 15.44213, E 028.86985
Kaisiaho Mutinta	Precious Lupanga	Mwalumina Village	S 15.45220, E 028.85988
Douglass Zunga	Douglass Zunga	Musokota Village	S 15.46719, E028.92320
Noel Chilima	Noel Chilima	Ndombwe Village	S 15.46902, E 028.93139
Crispin Ngandu	Beauty Ngandu, Elijah Ngandu	Chikoloma Village	S 15.50042, E 028.94403
Patrick Nyeleti	Patrick Nyeleti	Chikoloma Village	S 15.49395, E 028.94924
John Hamabwe	Titus Hamabwe	Shipanuka Village	S 15.44132, E 028.92207
Edson Mwinga	Betina Mwinga	Chilonda Village	S 15.44162, E 028.91530
Christopher Mwale	Joeseph Mooya, Atlas Machona	Chilonda Village	S 15.44187, E 028.91489

Annex 2 Survey format

REPUBLIC OF ZAMBIA
Ministry of Energy and Water Development

COOPERATION
REPUBLIC OF ZAMBIA
FEDERAL REPUBLIC OF GERMANY

FEDERAL REPUBLIC OF GERMANY
Federal Institute for Geosciences and Natural Resources

BGR

Survey on farming in the Lusaka area as part of the "Groundwater Information System & Management Program for Lusaka"

- Department of Water Affairs -

Farm/Farmer:……………………………………………………………………………………………………

Interviewed Person: ………………………………………………………………………………

Location: ……………………………………………………………………………………………………

GPS Coordinates: ……………………………………………………………………………………………

Date: ……………………..

Survey No.: ……………..

1.) What is your total farm, plot size?

…. ……………………………………………………………………………………………..

1.1) What is the size of the area only used for cultivation?

……………………………………………………………………………………………………

1.2) For how long has this farm been existing? …………………………………………

2.) What type of farm do you run? *(Two answers possible)*

- ☐ Crop agriculture
- ☐ Livestock agriculture ***(Livestock only Q⟹stion 6.1)***

Animal					
Amount					

3.) What type of crop do you grow?

Type of crop	**Size**	**Rainy season**	**Dry season**	**From….. - ……**
Maize				
Sorghum				
Millet				
Potatoes				
Mixed Beans				
Soybeans				
Groundnuts				
Cassava				
Cutting flowers				
Sunflower				
Cabbage, Lettuce				
Sweet corn				
Seed cotton				
Rice				
Wheat				
Sugarcane				
Tomatoes				
Onion				
Fresh asparagus				
Strawberry				

Green beans				
Carrot				
Pepper				
Citrus fruits				
Banana				
Peaches				
Barley				
Butternut				
Pumpkin				
Peas				

4.) Do you follow any crop cycle?

□ NO ⇨ *Question 5.)*

□ YES

└→ **Rotating every**………. **years with the following order of crops:**

Type of crop	From….. - …..

5.) If you do not use your fields during dry season, what kind of surface coverage do you have?

□ Fallow land

└→ Size: ……………………………………………………………………

└→ Period: …………………………………………………………………

□ Crop residual

└→ Size: …………………………………………………………………………

└→ Period: …………………………………………………………………………

□ Others ……………………

└→ Size: …………………………………………………………………………

└→ Period: …………………………………………………………………………

6.) Do you use any irrigation system?

□ YES, during dry season

□ YES, during dry and rainy season

□ YES, but only on a specific area – about ………………ha

□ NO ⇨ *Question 7.)*

If YES,

6.1) What type of water source do you use? *(Livestock only ⇨ Question 6.4)*

□ Groundwater (borehole, well, etc.)

└→ **Number of boreholes**: ………………………………………………..

□ Surface water

└→

- □ stream…………………………………………………………………..
- □ dam

□ Others………………………………………………………………………………..

6.2) How do you irrigate?

□ Drip irrigation

□ Furrow irrigation

□ Flooding

□ Treadle Pump

□ Bucket (size of the bucket in litres: …………………………)

□ Others………………………………………………………………………………..

6.3) What is the amount of water used for irrigation purposes?

Method	Field size	Amount of water/buckets

□ …………………………………………………………………………………………..

□ Less than 1,000 m³/day

□ More than 1,000 m³/day

□ Pump is running for …….. h/day, fills up a tank with the volume ………. m³,

this takes about ……… h and the water lasts for ………. days;

□ Pump specification…………………………………………………………………………..

6.4) What is the water demand for Livestock? *(Livestock only ⇨ Question 9.)*

…………………………………………………………………………………………

7.) Do you apply any fertilizer?

□ NO ⇨ *Question 8.)*

□ YES

└─▻ **7.1) Type of fertilizer?**

□ Mineral

└□→Nitrate

□ Phosphate

□ Potassium

□ Organic

└□→Animal manure

□ Compost

└→**7.2) Frequency of application?**

□ Once per growing period

□ Split application

└□→2 times per period

□ 3 times per period

□......................

└→

7.3) Kg of fertilizer per application?...............................kg/ha

└→

7.4) The exact name of the fertilizer used?...

Compound D	MOP	Amm. Nitrate		
Urea	Calc. Nitrate	Potas. Sulphate		
Amm. Sulphate	Potassium	Amm. Phosphate		

8. Do you use any pesticides?

□ NO ⇨*Question 9.)*

□ YES

└→**8.1) Frequency of application?**

- □ Once per growing period
- □ Once per month
- □ More than once per month

└▻ **8.2) Date of application?** ……………………………………………………..

└▻ **8.3) Average amount per application in kg/ha?** ……………..……………..

└▻ **8.4) The exact name(s) of the product(s) used:** ……………………………………

Dursban	Alsystem	Azoxy-strobin	Chlorothalonil	
Cypermethrin	Pyrethroide	Tebuconazole		
Endo-sulphide	Diphenhydramine	Trimangol		

09.) How do you dispose used oil?

…………………………………………………………………………………………….

…………………………………………………………………………………………….

10.) What kind of sanitation system do you have?

- □ Pit latrine
- □ Septic tank
- □ …………………………………………………………………………………………….

If pit latrine or septic tank:

10.1) How often do you have to empty it? ……………………………………………..…….

10.2) How do you empty it? ………………………………………………………..…….

(Additional: How close is the sanitation system to boreholes and river?)

…………………………………………………………………………...

Thank you very much for your cooperation.

Please place any additional information and comments here:

Annex 3: Tables of Survey Results

Survey #	Farm Size (ha)	Cultivated area (ha)	Maize (ha)	Season	requires [m3/ha] (FAO)	Tomato (ha)	Season	requires [m3/ha] (FAO)	Rotation
1	0.85	0.5	0.5	rainy	4000				
2	5	3	1.5	rainy	12000	0.24	rainy/dry	1200	
3	6	6	4	rainy	32000	2	rainy/dry	10000	Tomatoes planted in maize field during dry season
4	5	5	1.5	rainy	12000	1	rainy/dry	5000	Groundnuts/maize, rape/tomato, sweet potato/maize
5	70	4.5	2.5	rainy	20000	2	dry	10000	Tomato with pepper, rape, cuccumber
6	10	10	2	rainy	16000	1	rainy/dry	5000	Tomato and maize
7	15	6	4	rainy	32000	2	rainy/dry	10000	Twice a year- tomato with rape/cuccumber
8	10	7			0	7	rainy/dry	35000	
9	10	4	0.5	rainy	4000	3.5	rainy/dry	17500	Tomato with rape/maize
10	10	2.5			0	2.5	rainy/dry	12500	tomato with rape
11	1	1	1	rainy	8000	1	rainy	5000	rotate every year between maize and tomato
12	6	4	3	rainy	24000	1	rainy/dry	5000	rotating every 2 years- tomatoes with garden veg
13	8	8	5	rainy	40000	0.5	rainy/dry	2500	rotate maize with tomato and tomato with rape
14	10	3	1	rainy	8000	2	rainy/dry	10000	tomato with maize, rape and tomato during dry season
15	4.5	3	2	rainy	16000	1.5	rainy/dry	7500	tomato with maize, rape and tomato during dry season
16	3	2.5	0.5	rainy	4000	1	rainy/dry	5000	tomato with garden veg
17	3	3	0.5	rainy	4000	2	rainy/dry	10000	tomato with rape
18	3	1			0	1	rainy/dry	5000	
TOTAL	**180.35**	**74**	**29.5**		**236000**	**31.24**		**156200**	

Survey #	Irrigation System	Irrigation Season	Source	Irrigation method	Amount of Water Used (m^3/day)	Area (ha)	Water Demand for Livestock (l/day)
1	None						
2	Yes	Dry	Groundwater/Chongwe Ri	Furrow/Buckets	22.53		
3	Yes	Dry	Chongwe River	Drip	721.44	3	
4	Yes	Rainy/dry	Chongwe River	Furrow	270	1.75	40
5	Yes		Chongwe River	Furrow/ Buckets	300	2.5	125
6	Yes	Rainy/dry	Chongwe River	Drip	360.72	1	
7	Yes	Rainy/dry	Chongwe River	Drip, sprinklers	360.72	2	100
8	Yes	Rainy/dry	Chongwe River	drip	480	3	
9	Yes	Rainy/dry	Chongwe River	drip	300	3.5	15
10	yes	Rainy/dry	Chongwe River	drip, flooding	300	2.5	
11	yes	supplementing rainy	Chongwe River	drip	210	1	25
12	Yes	Rainy/dry	Chongwe River	drip, flooding	180	2	210
13	Yes	Rainy/dry	Chongwe River	drip	90.18	1	
14	yes	Rainy/dry	Chongwe River	drip, flooding	90	2	210
15	yes	Rainy/dry	Chongwe River	drip	240.48	1.5	40
16	Yes	Rainy/dry	Chongwe River	furrow	176	1.5	40
17	Yes	Rainy/dry	Chongwe River	furrow	210	2.5	130
18	Yes	Rainy/dry	Chongwe River	furrow	210	1	
TOTAL					**4522.07**	**28.75**	**935**

Survey #	Fertilizer Type	Name	Frequency	Amount Tomato (kg/period)	Amount Maize (kg/period)
1	Mineral	Compound D, Urea	2 times per period		200
2	Mineral, Organic	Compound D, Urea, animal manure	2 times per period		300
3	Mineral, Organic	Compound D, Urea, Calc. NO3, Potassium, Amm. NO3, animal manure	4-5 times per period	1000	1600
4	Mineral, Organic	Compound D, Urea, Calc. NO3, animal manure	2 times per period on maize, weekly tomato	350	600
5	Mineral, Organic	Compound D, Urea, Amm. SO4, Calc. NO3, Potas. SO4, animal manure	2 times per period	400	1000
6	Mineral, Organic	Calc. NO3, amm. NO3, animal manure	weekly	400	800
7	Mineral, Organic	Compound D, Urea, Amm. SO4, Calc. NO3, amm. NO3, Potas. SO4, manure	6 times per period	500	1600
8	Mineral	Compound D, amm. SO4, calc. NO3, potassium, amm. NO3	more than 5 times per period	1050	
9	mineral	compound d, urea, amm. SO4, calc. NO3, potassium, amm. NO3, potas. SO4	every 2 weeks	1250	200
10	Mineral	compound d, calc. NO3, potas. SO4	4 times per period	1000	
11	mineral	compound d, calc. NO3, potas. SO4	once per month	150	400
12	mineral	compound d, urea, amm. SO4, calc. NO3, amm. NO3	twice for maize, weekly for tomato	250	500
13	mineral	compound d, calc. NO3	twice for maize, every 2 weeks for tomato	500	400
14	mineral	compound d, amm. SO4, calc. NO3, amm. NO3	2 times for maize, 15 times/growing period	1500	400
15	Mineral, Organic	compound d, urea, amm. SO4, mop, amm. NO3, potas. SO4	9 times per growing period	900	400
16	mineral	compound d, urea, calc. NO3, amm. NO3	2 times for maize, tomato weekly- 10 times	1000	200
17	mineral	compound d, urea, amm.SO4, calc.NO3, amm.NO3	every 2 weeks for 3 months tomato	120	200
18	mineral	mop, calc. NO3, potassium, pota. NO3, magnesium NO3	weekly	1750	
TOTAL				**12120**	**8800**

Survey #	Pesticides	Frequency	Exact Product	Amount per Application (l/week)	Water Use per Application (l/week)
1	None				
2	Yes	2 times per period	Boxa	0.24	50.4
3	Yes	weekly for tomato	Cypermethrin, Diphenhydramine, Chlorolthalonil	12	2520
4	Yes	More than once/month	Dursban, Cypermethrin, Diphenhydramine	1	210
5	Yes	weekly for tomato	Dursban, Cypermethrin, endo-sulphide, diphenhydramine, tebuconazole, chlorothalonil	2	420
6	yes	weekly for tomato	cypermethrin, diphenhydramine, tebuconazole, chlorothalonil	1	210
7	Yes	weekly for tomato	dursban, cypermethrin, diphenhydramine, azoxy-strobin, tebuconazole, chlorothalonil	2	420
8	yes	weekly for tomato	diphenhydramine, tebuconazole, chlorothalonil	7	1470
9	yes	weekly	cypermethrin, endo-sulphide, diphenhydramine	3.5	735
10	yes	weekly	cypermethrin, endo-sulphide, tebuconazole	2.5	525
11	yes	every two weeks	diphenhydramine	1	210
12	Yes	weekly for tomato	cypermethrin, diphenhydramine	2	420
13	Yes	weekly for tomato	cypermethrin, diphenhydramine, tebuconazole, chlorothalonil	1.5	315
14	yes	weekly for tomato	diphenhydramine	4	840
15	yes	weekly for tomato	cypermethrin, diphenhydramine	1	420
16	yes	weekly for tomato	cypermethrin, diphenhydramine	0.4	630
17	Yes	weekly for tomato	cypermethrin, diphenhydramine	0.5	420
18	Yes	weekly, after rains	diphenhydramine, tebuconazole, trimangol	0.5	630
TOTAL				**42.14**	**10445.4**

Survey #	Disposal of Oil	Sanitation System	Waste Removal	Proximity to River (m)	Comments
1	None	Pit Latrine	Bury when full	200	Uses river water for household chores- about 4 buckets/day
2	Local farmers, or use	Pit Latrine	Bury when full	50	
3	Local farmers, or use	Pit Latrine	Bury when full	400	Uses 12 drums of water once per week for spraying. One drum is 210 liters.
4	Local farmers, or use	Pit Latrine	Bury when full	250	
5	Local farmers, or use	Pit Latrine	Bury when full	200	
6	Local farmers, or use	Pit Latrine	Bury when full	400	
7	Local farmers, or use	Pit Latrine	Bury when full	400	Uses DDT to reduce smell and mosquitoes in pit latrine
8	local farmers or throv	Pit Latrine	Bury when full	500	
9	throw away from fiel	Pit Latrine	Bury when full	400	
10	use around farm	Pit Latrine	Bury when full	250	
11	use around farm	Pit Latrine	Bury when full	not at farm site	GPS points were taken at residence, not actual farm
12	throw away from fiel	Pit Latrine	Bury when full	100	
13	Throw away near pur	Pit Latrine	Bury when full	200	
14	use around farm	Pit Latrine	Bury when full	500	
15	use around farm	Pit Latrine	Bury when full	500	
16	use around farm	Pit Latrine	Bury when full	200	
17	Thrown in pit or use c	Pit Latrine	Bury when full	300	
18	use around farm	Pit Latrine	Bury when full	100	
TOTAL					