Contents:

Review 1 & Response:

Dear Referee, we would like to thank you for taking the time to read this paper and writing your review. Based on your feedback and that of the other reviewer we hope to revise our manuscript. With this brief we hope to address your specific concerns and comments.

General Comment: The case study combines in an innovative way soil nutrient analysis with farmer interviews. This approach is very useful in order to derive management recommendations that are feasible to the farmers. However the research questions should be formulated more clearly and it should be explained how they were developed from existing literature. Being a case study, it is important to explain which general conclusions can be made from the results.

More than creating management recommendations, this case study is meant to create insight among scientists and policy makers and show that when recommendations are made they must be tailored to more than the soil/environment – the receiver and their socio-economic situation are equally if not more important. We received similar feedback from the other reviewer regarding our research questions and we realize that we may have formulated the main research question too broadly for the scope of the research and will look to see if we can more carefully rephrase it during revisions if given the chance. We maintain that he study was carefully selected as a representative case study for a phenomenon that is wide spread throughout the developing world.

4. Is the paper of broad international interest? The relevance and relation to results and questions of international research still needs to be better explained. There is a growing body of research on urban agriculture in Africa, which is not sufficiently mentioned (see e.g. Orsini et al. 2013, Hamilton et al. 2014 –>please see the reference list in the supplement). Regarding Gender Analysis it would be interesting to analyse whether the plots managed by women have a different soil nutrient status than those of men (see literature on Gender Gap in agricultural Productivity) and what constraints women face in their production (access to resources and time issues, ("triple burden" childcare, production and community tasks)

The direct comparison of men and women was not within the scope of this study and there is also no data available from this study to do such an analysis. Though we have tried to use international research to show the relevance and relation of our case study in the broader context we may not have been entirely successful in achieving this. We would like to thank the reviewer for providing us a list of interesting references that we will certainly explore in our revisions if we are given the opportunity.

5. Are clear objectives and/or hypotheses put forward? I think your question "how does women's knowledge influence soil nutrient content through their management" is not quite clear. Do you propose the hypothesis that higher knowledge will lead women to apply more effective management practices and the soil nutrient content will be higher? Consider that knowledge of a technique does not equal implementation of the technique. There might be financial or time constraints and also cultural and individual factors that influence a person's decision to use a certain agricultural practice. Your results show that an advocated technique (intercropping) leads to lower soil nutrient content, did you propose that the women using this technique had less or more knowledge?

We found that the choice of whether to apply the intercropping technique was actually not based on knowledge, but rather that there was a socio-economic motivation as you also suggest. We may have failed to properly formulate this in our results and conclusions and will have to correct this in our revisions. We found that women's knowledge does impact their agricultural management practices, which in turn influences their soil's nutrient content – however their main motivation for choosing one management practice over another was based on personal circumstances. The women practicing intercropping had incomplete knowledge regarding the technique, leading them to improperly apply it, however this improper application led to an improvement of their finances which gave incentive to continue. The soil in this urban garden is of sufficient quality that there is no noticeable difference in crop quality for the women regardless of their chosen management technique.

-Continued- *Maybe it could be an idea to structure your objectives like this: Aim: Derive recommendations for soil management in urban gardens in Kisumu, Kenya Questions: a) What is the soil nutrient content? (Discuss whether the results you are found are favourable or nonfavourable for agricultural production, should the nutrient content be raised? Might leaching be a problem etc.) b) Which of the recommended soil management practices (suggested based on evidence of agricultural science) are feasible to the women farmers? c) What are research gaps and limits of current agricultural extension activities?*

The suggested restructuring is a bit beyond the scope of this case study and another research project all together. We have never attempted to create recommendations for soil management – rather we sought to understand the motivation and the knowledge base of the women farmers of the urban gardens and their impact on the soils nutrient status. The nutrient content in the urban gardens is sufficient considering the current practices and management schemes. The farmers do not use mineral/artificial fertilizers and leaching is a minimal problem. The feasibility of other management practices were not included in this study and as the reviewer suggests above and is shown by this research such recommendations can't be done based purely on soil science/agricultural research if you would like to see implementation.

6. Are the scientific methods valid and clear outlined to be reproduced? There is still information missing: What method did you use to choose the sample plots? In how far are they representative for the area? Regarding the

interview results, there is not sufficiently stated which information was gained from the 2 women farmers cultivating the sample plots, the women group and the mixed group. Did the two women farmers cultivating the plots participate in the FGD? Why did you choose to organize a female and a mixed group instead of a female and a male group, which would have allowed for comparison of male and female knowledge?

This paper describes a case study that has been carefully setup with the local partners from scientific institutes and NGOs with a vast experience in the area, and indeed with the women farmer groups themselves. This in itself is in our view a unique approach that, by extensive use of the local expertise, ensures the case study is representative of a typical urban gardening situation that can be found abundantly throughout Kenya, sub-Saharan Africa and indeed the developing world. We realize we may not have explained the selection process and representability of the case study well enough and aim to do this if we are given the opportunity to revise.

It is clear, based on both this review and the 2nd, that we have not been diligent enough in describing the results of the interviews and the focus group discussions – the raw data of which was not included in the dataset for privacy reasons. The two women farmers whose fields were used in the soil analysis also participated in the interviews and focus group discussions – we look to make more use of this data in the revisions if given the opportunity. It was beyond the scope of this case study to directly compare male and female farmers, which is why there were no separate meetings with only male farmers.

7. Is the soil type/classification adequately described? In your abstract and introduction you refer to nutrient deficiencies in Kenyan agricultural soils and poor soil management as one possible cause. Yet your results are that soil nutrient content is high for both sample plots. Did you record the amount of fertilizer and organic material that was applied to the fields by the farmers? Are the plots examples of high input vegetable production and thus difficult to compare to the average (rural) agricultural soils? (see Predotova et al. 2011; Lompo et al. 2012). Is the overall decline in agricultural productivity in Kenya also observed in Urban agriculture?

8. Are analyses and assumptions valid? See above

The nutrient content is high in the recorded urban garden likely due to the richness of the soil's parent material, not necessarily due to the farmers application of manure. Exact amounts of manure/compost were not noted, but an inventory was made of fertilizers used, as well as fertilization methods and frequency. The case study is meant to be representative of a typical urban gardening situation and as such can't be directly compared to the rural soils. Production and demand for vegetables from urban gardens are high, but the soils and crops are very different from rural areas. There is no evidence of decline in productivity, rather the opposite – this is one of the ways in which urban gardening differs from traditional (rural) agriculture.

9. Are the presented results sufficient to support the interpretations and associated discussion? I think the presentation of the soil nutrient analysis is clear. Please try to document the interview results more clearly. What are interview results, what are FGD results? E.g. how many of the participants know that plants need nutrients from the soil? With which questions did you measure technical knowledge?...

As noted at point 6, we hope to be allowed to more fully incorporate the interviews and focus group discussion results in our revision of the manuscript as this is something that was noted as missing by both this reviewer and the 2nd reviewer. Only a selection of the acquired data was included in the paper. The interview data and the data from the focus group discussion was more extensive than shown and was not included in the attached dataset for privacy related reasons. In revisions we will more fully incorporate these results, whilst continuing to respect privacy.

10. Is the discussion relevant and backed up? Be careful not to mention new results in the discussion part (page 9, 6-15) and do not discuss your results in the results section (p.12 12-14).

We would like to thank the reviewer for pointing out these instances, we shall correct them.

11. Are accurate conclusions reached based on the presented results and discussion? I think the conclusion is written very clearly, could you add your conclusion whether intercropping is useful or not? When you mention gender-differentiated knowledge, could you specify in your results what knowledge was specifically male or female? Did men have less sensory knowledge than women? Did men have more technical knowledge than women? What could be advantages of the traditional practical and sensory knowledge these women have? Do you have results whether male and female farmers apply different techniques and have different yields?

The usefulness of intercropping is largely dependent on ones goals and techniques. As the women are currently doing the intercropping does not improve their soil quality, however it does have positive effect on their financial situation. Considering the richness of their soil there is no direct reason to discourage these farmers from their current practices.
Unfortunately it is not possible for us to show the direct differences between the soil nutrient condition of the men's fields and the women's fields or their technical knowledge as no separate male fields were tested, nor were they included in the interviews. This was simply beyond the scope of this case study – though objectively it would be very interesting to see if such differences could be found. While we lack sufficient data to include the roles of men in the paper, we have noted that men tend to have more access to capital and means, meaning that their practices often differ from that of women on that basis and because of this they also have a different view of agricultural problems.

12. Do the authors give proper credit to related and relevant work and clearly indicate their own original contribution? You clearly indicated your own contribution. Please have a look at the FAO State of Food and Agriculture Report 2010-2011 "Women in Agriculture- Closing the gender gap for development" and Doss et al. 2018 regarding women having lower yields than men in dev. countries (p. 3, l 15)

We did note from literature that women generally have lower yields than men in developing countries, but that this often has to do with a lack of access and means on the side of the women. We will note your reference and see to include it in our revisions.

13. Does the title clearly reflect the contents of the paper and is it informative? For me nutrient content in relation to knowledge is not clear (see point 5 above)

As stated at point 5, the knowledge of the women does not directly influence their choice of management practice, rather their socio-economic situation generally does. The knowledge of the women does however impact the way they implement their chosen management practice, which in turn influences the soil nutrient content. We hope we will be able to convey this more clearly if given the opportunity to make revisions to the manuscript.

14. Does the abstract provide a concise and complete summary, including quantitative results? The introduction part in the abstract could be shorter and should mention urban agriculture.

A valid point, we will include that during our revision of the manuscript.

15. Is the overall presentation well structured? I think starting the introduction with the global relevance of your topic would help to understand your research aim.

This is a difficult point as our other reviewer notes that they consider our introduction a bit too broad, we will have to consider how to more carefully balance this in our revisions.

20. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? Please clarify the legend of figures 1a-f, available, exchangeable and total (Does total include available and exchangeable?, then the color scheme is misleading).

We would like to thank the reviewer for pointing this out and will attempt to make the figure more clear in the revisions. The total does in fact include the available and exchangeable.

21. Are the number and quality of references appropriate? Please see the references below.

Overall we would like to again thank the review for their valuable comments and also their included list of references and we will look to use their feedback in the editing of our manuscript.

Review 2 & Response:

Dear Referee, first of all we would like to thank you for taking the time to read this paper and writing your review. We hope to edit the manuscript to address your concerns and would like to address your specific feedback and comments with this letter.

The paper aims at combining soil nutrient analysis with women's agricultural knowledge and their management decisions. While in general this is an important question, the paper is lacking theoretical and empirical (data) depth.

Specific Comments:

2. Does the paper present novel concepts, ideas, tools, or data? New data, but too little to be of real relevance.

The paper does concern a case study with a limited scope and the data included may have been too limited to show its relevance. The interview data and the data from the focus group discussion was more extensive than shown and was not included in the attached dataset for privacy related reasons. In revisions we will more fully incorporate these results. Hopefully this will also serve to address the 2nd specific comment of this referee. The case study is meant to serve as an example of the situation of urban gardens that can be found in many cities in sub-Saharan Africa.

4. Is the paper of broad international interest? Theoretically yes, this paper could be of interest. In practice, however the data are too limited in scope and the outlined research question is not really thoroughly addressed (one option might be to reformulate the research question, depending on the data that is available)

As noted above, we will look to incorporate the data from the interviews and focus group discussions more fully to support our conclusions with revisions. At the same time we realize that we may have formulated the main research question too broadly for the scope of the research. Revising the results from the social sciences section as well as re-examining our research question will hopefully allow us to lay these concerns to rest.

5. Are clear objectives and/or hypotheses put forward? While a clear objective is set "understanding how women's knowledge influences soil management and thereby the soil nutrient status", it is not clearly answered. E.g. has any effort been put into understanding whether intercropping or not is influenced by knowledge? Or what the role of knowledge is in the decision to plough manure into the soil, or not?

Our conclusions may not have been formulated well enough and we would like to thank the reviewer for pointing this out. For example, we had hoped to convey that intercropping as done by the women farmers in Nyalenda was imperfectly done due to gaps in the knowledge. While the women farmers have the basics of this management practices, i.e. the intercropping with a legume to improve soil N, they lack the technical knowledge to properly apply this practices. These women do not

plough the legume into the soil after a certain period of time to maximize soil N input, but rather let the legume grow to maturity to harvest it as crop. This essentially leads to a more rapid extraction of nutrients from the soil. We will attempt to formulate this more clearly in revisions and see that it is better supported by data from the interviews and focus group discussions.

6. Are the scientific methods valid and clear outlined to be reproduced? The methods as such seem to be okay, but the data presented is insufficient. Information of the history of soil is missing (how long have they been cultivated with the different method): : :., quantitative estimation about the amount of manure applied is also missing, Sampling on only four fields is not really representative: : : It is unclear how the sampling plots have been chosen: : :.. The interview results should be presented in more depth.

While we do not have all the background information mentioned in the 6th comment, such as quantitative estimates of manure use; there is more information regarding the history of the site available than incorporated in the article, both from literary sources and the interviews and focus groups discussions. The limited amount of fields used in the study is both a reflection of the limitations of this study as a case study, as well as an attempt to make the influence of the two management practices as comparable as possible. The four fields were chosen for being most representative for the studied management practices. The interview results as noted before can and will presented more in depth with revision of the manuscript.

9. Are the presented results sufficient to support the interpretations and associated discussion? I would say the presented results are sometimes unclear or even contradictory. e.g. 5 the paper states that people have limited technical knowledge just to continue a few lines letter saying that the "women spoke of a variety of agricultural meetings". The difference to the knowledge of men is not made clear. In general the difference between male and female knowledge should be made clear. And it should also be shown how the techniques of men and women differ because of differences in knowledge. Another example: Some statements like "no fallow periods because of a lack of land" could be analysed more deeply in order to understand how knowledge is influencing this statement.

We would like to thank the reviewer for pointing out that the results are sometimes unclear or seems contradictory and will seek to clarify the results where necessary. Likely a more thorough incorporation of the interview and focus group discussions will ease some of the concerns. For the specific cases mentioned, while the women spoke of a variety of agricultural management practices during the meetings and interviews they lack the technical knowledge – meaning that they have heard or tried techniques, but did not always have the knowledge regarding its proper application. An example being that those who practice intercropping didn't realize that they had to plough the entire plant into the soil about 3 weeks after planting for the soil to benefit from the intercropping.

The knowledge and techniques of men are not explored further in the paper as they were not the focus of the research and they were only included in the focus group discussions. A more thorough analysis of these might show a more clear difference between the two groups, but the study can't be expanded beyond that as there is no data. We have noted that men tend to have more access to capital and means, meaning that their practices often differ from that of women on that basis and because of this they also have a different view of agricultural problems.

The statement regarding the lack of fallow periods could perhaps be further expanded with results from the interviews – the lack of fallow periods is not because the women farmers lack the knowledge regarding this practice, rather it is their need for revenue forcing them to continue using the land even though they should rest it and know that they should.

11. Are accurate conclusions reached based on the presented results and discussion? From what I can see the main difference in the soils might come from a higher SOM on the plots where no intercropping is made (SOM as important for CEC). The interesting question would however by, why there is more manure on the plots without intercropping. This might help to understand the reasons behind the different outcomes more clearly. Related to this it could be discussed, whether people should know about the difference (in case the difference is influenced by management practices).

The reviewer raises a valid point and while we lack quantative data regarding the use of manure – which may of course be of a large influence on SOM, we do know that at the very least the application method differs. The application method could have a similar if not just an important effect on the SOM levels of the soil as the amount of manure – we could expand on this further during revision of the manuscript.

15. Is the overall presentation well structured? The paper is well structured. However the introduction is not really introducing the state of the art with regards to (female) soil knowledge and management practices: : :. The general truths for overall agriculture in Kenya, might be good to justify the research, however they are not really relevant in answering the question and are a bit too general.

The shortcomings of the introduction and background were also mentioned by the other reviewer and we are thankful for the both of them for pointing this out. We will seek to improve this during coming revisions by using more and also more up to date literature.

Overall we would like to again thank the review for their valuable comments and we will look to use their feedback in the editing of our manuscript.

List Major Changes:

Introduction:

- Addition of section on the specific challenges of urban agriculture
- Removal of the paragraph focussed on Kenyan (rural) agriculture
- More focus on the position of women and their cultural burdens
- Specification of the selection of the field site and refinement of study aims

Methods and materials:

- Addition of section specifically on the interviews and focus group discussions

Results

- Addition of section specifically on the results from the interviews and focus group discussions
- In-depth information on tested fields from interviews added
- Replacement of figure 1, which one reviewer indicated was unclear

References

- 9 additional references added to list

Soil nutrient content in relation to women's agricultural knowledge in the urban gardens of Kisumu, Kenya

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Abstract. ~~Agricultural production in Kenya has been declining since the 1980s, either because soils are mismanaged or because they lack nutrients.~~ In Kisumu, just under 50% of the workers in the urban gardens are female. On average, women spend more hours a day in the gardens than men. To increase yields, women's knowledge has to be considered in agricultural management. However, women face greater obstacles in land ownership, investment, and farm inputs due to social and cultural constraints as consequence of their gender. This case study aimed to determine what agricultural knowledge the women farmers there hold, where they get their knowledge, what motivates them in their choice of agricultural management and finally how their choices influence the soils nutrient content.~~This case study aimed to determine the nutrient content in soils of the urban gardens of Kisumu, the agricultural knowledge of the women farmers and how their knowledge influences soil nutrient content through their management.~~

Soils were sampled in Nyalenda, one of Kisumu's informal settlements where urban gardening is practiced, to determine soil nutrient contents. To determine how agricultural management practices influences total C and N, available N and P, and exchangeable K, Mg and Ca in the soil, two prevailing practices were compared: 1) applying manure only, and: 2) applying manure while intercropping with cowpeas. Interviews and focus group discussions were organized to determine what knowledge the female vegetable farmers possess, and where they acquired their knowledge.

Soil analysis showed that agricultural management had significant effects on nutrient presence and availability. Intercropping led to significantly lower total soil nutrient contents than when only manure was applied. However, due to socio-economic factors, such as poverty, intercropping was applied in a way that did not increase soil nutrients but diversified revenue. The knowledge of the female vegetable growers was found to be limited to practical and sensory knowledge. This shows that in addition to socio-economic and cultural context, gendered knowledge differentiation has to be acknowledged and used in agricultural training when aiming to improve soil nutrient status and agricultural yields.

1 Introduction

This paper concerns a case study conducted in the urban gardens of Kisumu, Kenya. The study is part of an interdisciplinary study on soil nutrients and women entrepreneurship in Kenya and Burkina Faso and seeks to link women's knowledge on agricultural practices and their motivations in choosing specific practices with the nutrient content of their soils. ~~The women vegetable farmers considered in the present study work in the urban gardens of Kisumu, Kenya.~~ Urban gardening, also called market gardening, is a phenomenon found in most cities in the developing nations and ranges in scale from sack gardening next to houses to several acres being used for food production. ~~Most urban gardens in Sub-Saharan cities are assumed to be marginalized, often polluted, plots of land used for vegetable gardening by the urban poor (Cofie et al., 2003; FAO, 2012).~~ For the urban poor the urban gardens provide employment opportunities and are a source of affordable vegetables. These vegetables are less expensive than those imported from the rural areas due to the lack of transporting costs. Limited infrastructure makes it difficult for some types of produce to be transported from the rural areas. By growing such vegetables within the municipality the costs are reduced and the lower costs of these vegetables allow the urban gardens to contribute to urban diet diversity and food and nutrition security (FAO, 2012; Gallaher et al., 2013). Urban gardening is hailed by many as possible way to increase local food and nutrition security, as well as provide employment, however, there are also many concerns surrounding urban gardening, including some concerning health risks and environmental degradation (Cofie et al., 2003; FAO, 2012).

~~In Kenya, 36.5% of the GDP comes from agriculture, however agricultural production in Kenya has been declining since the 1980s (Okalebo, 2009; World Bank, 2016). The primary cause for this decline is believed to be nutrient deficiencies in the soil, specifically nitrogen (N) and phosphorus (P), and in some cases potassium (K) and organic carbon (Org. C) (Cofie et al., 2003; Okalebo, 2009; Tittonell, 2005). The debate regarding these deficiencies is on their cause; some pose that low nutrient content is an inherent soil property (Tittonell, 2005), whereas others suggest it to be a consequence of erosion due to poor soil management and intensive use of the soil (Cofie et al., 2003; Okalebo, 2009). Many of the farmers in Kenya are limited in their choice of management due to the limited size of the farm area. Farmers working with less than 0.5 ha are known as small holder farmers, and they make up 75% of Kenya's agricultural sector (*KNBS/AWSC, 2014*). The majority of~~

~~the urban gardens in Kisumu fall within the classification of small holder farm, with farm plots between 0.104 and 0.41 ha (Mireri, 2013).~~

Opposition to urban agriculture comes mainly from the sectors of public health, environment and urban planning. In terms of urban planning, land used for urban agriculture may be more productive or valuable when used for other enterprises (Mougeot, 2000). Furthermore, urban agriculture is also often practiced on public lands (Mougeot, 2000). When undertaken on private lands it often concerns farmers whose previous rural land has been overtaken by urban sprawl, now finding themselves in the (peri-)urban sphere (Mougeot, 2000). When urban gardening is practiced on public lands the farmers often work on the roadside, or on riverbanks and floodplains (Mireri et al., 2007; Mougeot, 2000). Agriculture practiced on locations like roadsides especially, risks pollution from vehicle exhaust and industrial waste (FAO, 2012; Mireri et al., 2007). As a result, products from these sites can have contaminants that can threaten the health of the consumers as well as the producers. Urban agriculture is also considered to be an intense form of agriculture that causes soil degradation. Often confined to small areas, there is little room for urban farmers to rest the soil or rotate the crops, and products like mineral fertilizer are expensive for the poorer segment of the urban farmers that are most likely to resort to these practices (FAO, 2012; Mougeot, 2000).

With over half a million inhabitants Kisumu is Kenya's third largest city. Unemployment in Kisumu is high, in 2013 the unemployment rate in Kisumu was determined to be 40% (Mireri, 2013). Over 60% of Kisumu's inhabitants live in informal settlements (Mireri, 2013; Obade, 2014; UN-Habitat, 2005). It is estimated that up to 60% of the inhabitants of Kisumu practice some form of urban agriculture, including livestock keeping. Agriculture has been practiced on the periphery of the city since its founding in 1901, but as the city grew the boundaries between the urban areas and the rural areas have grown vague. Most of the original agricultural areas have fragmented and now fall within the municipal boundary, as such these areas have been reclassified as urban gardens (Anyumba, 1995). Most of the urban gardens are located on the edges of the informal settlements.

Mireri (2013) found that approximately 47% of those working in the urban gardens in Kisumu is female, and that on average the women spend more hours a day on the farms than men. ~~Women are culturally expected to take responsibility for family food provision and many of the women farmers work on a subsistence basis (Kabira, 2007; Kameri Mbote, 2006; Kiriti-Ng'anga, 2015a; Kiriti-Ng'anga, 2015b; Mireri, 2013). Any excess produce is sold by the women to pay for expenses such as their children's school fees (Mireri, 2013; World Bank, 2009).~~ Women are culturally expected to take responsibility for family food provision and practicing urban agriculture allows many women to do so while also performing their other duties. Women are expected to clean the house, provide food and watch over any children. As urban agriculture sites are relatively near the home it is an accessible option to women who also have many other daily tasks (Doss et al., 2018; Mougeot, 2000; Poulsen et al., 2015; Simiyu and Foeken, 2013). Many of the women farmers work on a subsistence basis (Kabira, 2007; Kameri-Mbote, 2006; Kiriti-Ng'anga, 2015a; Kiriti-Ng'anga, 2015b; Mireri, 2013) and any excess produce is sold by the

women to pay for expenses such as their children's school fees (Mireri, 2013; World Bank, 2009). Gender inequality makes it difficult for these women to move beyond subsistence agriculture. Women face greater obstacles than men in regards to land ownership, investment, and farm inputs due to historical, social, cultural and financial constraints as a consequence of their gender (Alunga and William, 2013; Dolan, 2015; Kabira, 2015; Kameri-Mbote, 2006; Kiriti-Ng'anga, 2015a; Kiriti-Ng'anga, 2015b). As a consequence of these obstacles, few modern techniques are applied in the urban gardens. Lack of access to capital and knowledge limits these women to traditional techniques and sensory knowledge passed down within families (FAO, 2012).

Due to a lack of equal access to technologies such as fertilizers, women consistently have yields that are on average 20-30% less than men in developing countries (FAO, 2006). At the same time, there is evidence of gender differentiated access to knowledge. The results of a food security survey held by the African Women's Studies Centre and the Kenyan National Statistics Bureau in 2013 showed that women respond differently to food security issues and consider challenges differently than men. For example, up to 80% of men believe that a small, uneconomical area of land is a hindrance to achieving food security, whereas only 20% of women consider this to be a major hindrance (*KNBS/AWSC, 2014).* There is further research that suggests that women could potentially produce up to 20% more on the same surface area than men if given equal access to resources (Saito et al., 1994). However, there is also research showing that due to a lack of education and training, women farmers use practices that are less environmentally friendly and can lead to a more rapid degradation of the soil (Doss et al., 2018).

~~Through this interdisciplinary study we aim to determine the soil nutrient status of the soil as reflected by the contents of total soil C and N, available soil N and P and exchangeable soil Na, K, Mg and Ca in the Nyalanda urban gardens. Furthermore, we aim to determine how agricultural management of the women working in the Nyalenda urban gardens determines this soil nutrient status, and how the choice for a particular form of agricultural management is linked to the specific knowledge these women poses as well as to socioeconomic factors. Soil nutrient content and the effects of the two most common agricultural management practices on soil nutrients were assessed through soil sampling and laboratory analysis. Questions regarding knowledge acquisition and sharing were addressed through interviews and single gender and mixed gender focus group discussions. These methods are used to triangulate and provide complementary information.~~

This raises the question of what knowledge women working in urban agriculture have on agricultural practices, and how their practices affect their soil. In close partnership with local partners from scientific institutions and NGO's, Nyalenda, a location in one of the urban gardens of Kisumu, Kenya was selected as representative of the area and farmers groups in the urban gardens of the city, and characteristic for the urban gardening situation that can be found throughout other cities of Kenya and (sub-)tropical Africa in general. With an approach that combines semi-structured interviews and focus group discussions with women food entrepreneurs (WFE's) working in Nyalenda, and soil analysis of their urban garden plots, we aimed to determine how the agricultural knowledge and motivations of women farmers influences their soil's nutrient status

as reflected by the total soil C and N, available soil N and P and exchangeable soil Na, K, Mg and Ca in the Nyalanda urban gardens. The methods used were designed to triangulate and provide complementary information.

2 Materials and Methods

Kisumu is a city of approximately half a million inhabitants on the northern shores of Lake Victoria. The city is the headquarter of the Kisumu district and the Nyanza Province (Mireri, 2010). Temperature averages at 22 ^{0}C year-round and annual rainfall averages between 1000 and 1400 mm. There is a short rain season in November and December and a long rain season lasting from April until June. The city lies on Quaternary sediments and Tertiary Volcanic deposits. Due to the tropical climate, deeply weathered soils can be expected in this area, but the parent material is relatively young and rich in nutrient bearing minerals (Orodho, 2006).

There are several informal settlements in Kisumu, including Nyalenda. Nyalenda lies on the southern edge of the city and is one the largest of the cities six informal settlements, both in number of inhabitants and surface area covered (UN-Habitat, 2005). Divided over two blocks, A and B, Nyalenda houses nearly 50.000 people within an area of 8.1 km^2. Existing infrastructure, access to electricity and access to sanitation are limited in the informal settlements (UN-Habitat, 2005). All along the southern edge of Nyalenda there are active vegetable farms adjacent a river and wetland area. One of the groups active in these urban gardens is the Mesopotamia group. The group consists of 14 members, 8 women and 6 men, who cultivate an area of 3-4 ha. Most Mesopotamia members have inherited their land and some rent extra plots within the area; the group is diverse in age and experience. The decision to work with the Mesopotamia group was made after various meetings with local NGO's and scientists in conference with the Mesopotamia group itself in January 2016. The Mesopotamia group is seen by the scientists gathered at the conference as representative for many of the urban gardening groups in Kisumu, and especially those working on the border of the Nyalenda informal settlement.

The Mesopotamia group had previously been informed by government extension services that their soil might be lacking in N. In response to this apparent lack of N at least 5 group members changed their practices, they started to intercrop the local staple crop Sukuma Wiki, a kale (*Brassica oleracea var. Sabellica*) with a legume with nitrogen fixating root nodules, cowpeas (*Vigna unguiculata L. Walp*) (Likoko and Jonkman, 2016).

The four fields selected for soil sampling were all used to grow kales, in two of the fields the kales were intercropped with cowpeas. All four sampled fields are centrally located in the urban gardens, limiting the differential influence the nearby river might have on fields lying closer or farther away from it. The soil on these fields were classified as Vertisols (FAO, 2014), characterized by the presence of heavy clay which shows shrinking and swelling behaviour. All samples were collected in May during the dry season. On each of the four fields 12 samples were collected from the topsoil (0-15 cm) to

limit the influence of spatial variability, 48 samples total. All samples were subsequently dried at 70^{0}C, sieved at 2 mm and stored for analysis.

~~The four fields sampled are owned by two female members of the Mesopotamia group, each member owning two of the fields. One of the women grows exclusively kales on her fields and the other woman intercrops the kales with cowpeas on her fields. Both women used manure as fertilizer, however one ploughed it into the soil while the other applied it as a topdressing. The two women that owned the sampled fields, along with the 6 other female members of Mesopotamia, were interviewed to determine how soil nutrient contents were influenced by women's agricultural knowledge. The eight women varied in age and experience, capturing a broad spectrum of views and knowledge. The semi-structured interviews used open questions to determine what knowledge women farmers had about the effects of fertilizers on crops and soil, where they received this information, and to what degree and with whom they shared this knowledge.~~

~~In addition to the interviews two focus group discussions were held with members of the Mesopotamia group. One focus group discussion was held with 6 female participants and another with 11 participants, 6 women and 5 men. A women's only discussion was held because women are more likely to speak their mind when they are not in the company of their male counterparts. The focus groups discussions were based on questions used in the interviews and aimed at determining the extent of agricultural knowledge in the Mesopotamia group as well as their information sources and the relative importance of these to the farmers. Due to the open platform and the presence of multiple participants the focus groups discussions provided more in-depth answers and clarifications, which support the information from the interviews.~~

2.1 Interviews and Focus Group Discussions

The four fields sampled are owned by two female members of the Mesopotamia group, each member owning two of the fields. One of the women grows exclusively kales on her fields and the other woman intercrops the kales with cowpeas on her fields. Both women used manure as fertilizer, however the farmer who grows exclusively kales ploughed the manure into the soil while the intercropping farmers applies the manure as a topdressing. The two women that own the sampled fields, along with the 6 other female members of Mesopotamia, were interviewed to determine what agricultural knowledge the women have, where they get their information and how this influences their management choices. The eight women varied in age and experience, capturing a broad spectrum of views and knowledge. The semi-structured interviews used open questions to determine what knowledge women farmers had about the effects of fertilizers on crops and soil, where they received this information, and to what degree and with whom they shared this knowledge. A set list of questions was use for the interviews to gather complementary and comparable information on the women's knowledge and views. The interview were conducted with the aid of an interview guide including an introduction, opening questions, key questions and a summary (adapted from Woodhouse, 1998; Curry, 2015a).

Interview questions:

Opening questions:

- *Can you describe what you do on your field on a typical day?*
- *How do you fertilize you fields?*

Key Questions:

- *What do you know about what the soil needs for growing crops?*
- *What do you know about the effect of fertilizer on the soil?*
- *What methods to fertilize your fields do you know?*
- *How do you know this? Where did you get your knowledge?*
- *Did you ever see differences in crops or the soil when you or somebody else changed their methods?*
- *Did you ever share this information with others?*
- *Is there an opportunity to share knowledge within the farmers group?*
- *Do you feel your knowledge is valued by others?*
- *Is it easier to share knowledge with other women?*

In addition to the interviews, two focus group discussions were held with members of the Mesopotamia group. One focus group discussion was held with 6 female participants and another with 11 participants, 6 women and 5 men. A women's only discussion was held with the 6 women participating to go more in depth on the knowledge of women. The focus groups discussions were based on questions used in the interviews and the methodology proposed by Curry (2015b), Krueger & Casey (2002) and Johnson & Mayoux (1998). The discussions were aimed at determining the extent of agricultural knowledge in the Mesopotamia group as well as their information sources and the relative importance of these to the farmers. Both focus group discussions had the same format and started with a short opening and introduction followed by an explanation of the goal and guidelines for the discussion. The opening was followed by a set of discussion questions and an exercise. The discussion was closed with a short summary. Due to the open platform and the presence of multiple participants the focus groups discussions provided more in-depth answers and clarifications, to support the information from the interviews.

Focus group discussion questions and exercise:

- *What does your day on the farm look like?*
- *How do you take care of your fields and crops? How do you decide on this?*
- *How do you know what you have to do to take care of your fields and crops? Where do you get this information?*
- *Can you rank the sources of information on validity and give a short explanation about their final ranking?*

- *When do you share your knowledge, to whom and why?*

2.1 Laboratory analyses and data processing

Water extracts of the soil samples were created (ratio 1:2.5) and used to determine pH and EC. These water extracts were then filtered and available P, K, S, Ca and Mg measured using a Perkin Elmer Optima 8000 ICP-OES Spectrometer. Available NH_4^+, NO_x, PO_4^{3-} and SO_4^{2-} in the extracts were determined on a Skalar SA-40 continuous-flow analyzer. Total organic and inorganic C in the extracts were measured using a Shimadzu TOC/TN analyzer.

Filtered $BaCl_2$ extracts were used for the determination of exchangeable Fe, Mn, Mg, Ca, Al, and K with ICP-OES (Schwertfeger and Hendershot, 2009). Extracts were prepared using 100 ml $BaCl_2$ 0,125 M and 4 grams of milled soil sample (<2 mm). CEC was calculated as the sum of the values for exchangeable Ca, Mg, K and Na in $cmol_c/kg$.
Total C and N were determined with 50 mg of soil (<2mm, milled) by using a Elementar Vario EL cube CNS analyzer. Total P, K, Ca, S and Mg were determined by measuring HNO_3/HCl extracts with ICP-OES; extracts were prepared with 250 mg soil (<2 mm, milled), 6 ml HCl 37% and 2 ml HNO_3, and underwent microwave destruction (60 min;Tmax 220◦C; Pmax 75bar). Total elemental composition of the soil samples was also determined using XRF analysis, using the Thermo Scientific XRF Analyzer Niton; setting: mining Cu/Zn; Standard: NIST 2709a PP 180-649; 160 seconds.

Variance within each field and between fields with different management practices was determined using analysis of variance test. ANOVA was used in case of normal data distribution and Kruskal Wallis with non-normal data distribution (Burt et al., 2009). The strength and direction of the relationship between different parameters was determined using a correlation coefficient, Pearson's R. All statistical analysis was done in Matlab, version R2014b. The measured results and calculated variances where corroborated with the results of the interviews and focus groups discussions..

3 Results

3.1 Interviews

While the interviews started with enquiring into the typical daily activities these turned out to vary too much from person to person and season to season to provide a meaningful clustering. Fertilizer use is mostly in the form of locally produced or homemade compost (4 of 8) or the use of unprocessed cow manure (2 of 8). The other two interviewees used either mineral fertilizer or cow manure with occasional application of mineral fertilizer. All interviewees named fertilizer as something the soil needs for growing crops, but none really knew what fertilizer does for the soil in technical terms. The knowledge regarding the effects of fertilizer is limited to visible effects only.

When it comes to other methods to increase soil fertility the results are more divided. 2 interviewees knew no other methods aside fertilization, 3 named mulching, 4 mentioned fallow periods, and 4 mentioned crop rotation. All interviewees that named other fertility increasing methods also apply these methods when needed and many noted that they see a visible difference in their crops when one or more of these methods is applied. The agricultural information sources named during the interviews were relatives, including parents, grandparent, or husband, trainings by NGO's or extension workers, elementary school, and observing others. Information from relatives was most common, being named by 5 of the interviewees, followed by trainings by NGO's or extension workers, named by 3 interviewees. As point of interest, one of the interviewees got her information from her grandmother, who was also interviewed, and who got her information from training by NGO's and extension workers.

"*Next to the information we got from our ancestors, we get information from the look of things, when you come and see somebody farming and you ask what they are doing and how it is going. So by observing is also how we get information"* (FGD 1, participant I5).

All interviewees noted that they meet either monthly or weekly with others and feel that they can speak freely and that their input is valued in general. Of the 8 women interviewed 5 responded that it is easier to share knowledge with women and 3 responded that they share equally easily with men. However all interviewees noted that women overall seem more open to input or that they listen and understand better. Many felt that the shared circumstances of women, meaning similar problems and the care for the household and children, spending more time at the house or on the field, is the leading cause of this. Two of the women said that men are less open to advise and can even become violent.

"*Women are easier to work with because they are the people who take responsibility in the houses and can solve this."* (FGD 2, Participant I5).

3.2 Focus group discussions

Much of the information from the interviews was confirmed in the focus group discussions (FGD). The exceptions were as follows. Although the types of fertilizers named during the FGD were mostly the same as those in the interviews, more of those responding appear to be using a form of mineral fertilizer. It also became apparent, in contrast to what came forward from the interviews, that the farmers do have knowledge of the way to work intercropping in a manner that can add N to the soil, but that they have a different name for this method: green manuring. The management of the farms and decision regarding using one of the various methods to restore soil fertility is largely reactionary - actions are undertaken only when the crops seem to do less well than previously.

While mineral fertilizers seem to be used more than inferred from the interviews, the participants do show a preference for organic types of fertilizer. According to them vegetables grown with organic fertilizers taste better and keep longer and mineral fertilizer damages the soil.

During the women only FGD we learned that most of the women work in the urban gardens as a way of generating income, to provide for themselves and their children. At least half of the women participating in the FGD are widows and agriculture is their sole form or income. Their main issue in working with men is a lack of mutual understanding and the men's tendency to refuse to share resources with them. They believe it would help if there was at least 1 women on the groups' board and this would lead to more equal distribution of resources among the group members. There are some limitations on the women's activity due to cultural restriction, but not all of them are still actively followed. One that still is followed and limits the women is the prohibition for women to plant and own trees. Banana trees for example can bring higher profits than some other crops, yet women are forbidden from planting them.

When asked about the sources of agricultural information the participants of the FGD name 5 different sources. All rank family as the first and most important sources, followed by trainings and demonstrations. Observation and visiting others is ranked third. Media and exhibitions are ranked fourth and fifth respectively, and the farmers indicate that this is because of their lack of access to media and the expenses involved in visiting exhibitions.

3.3 Soil Analysis

The soil of the Mesopotamia group was analyzed on the nutrient content, and by FAO standards generally fell within the ranking 'high' (FAO, 2006). Table 1 provides the average values for the main soil parameters. The pH of the soil in the sampled fields ranged from very slightly acid to very slightly alkaline, with an overall average of 7.25 (Table 1). The CEC was high overall with an average value of 33.5 $cmol_c\ kg^{-1}$, likely as a consequence of the high clay content of the soil (Table 1). Similarly, with an average of 36.6 g kg^{-1} the total soil carbon was also high. The laboratory analyses showed relatively high amounts of water soluble and exchangeable cations, however there is a significant difference in nutrient content depending on the management practice.

The women of the Mesopotamia group possess limited technical knowledge and are aware of the effects of the management practices that they apply only in terms of the visible effects of these practices. From the interviews it is clear that there is a range of agricultural management practices known and practices within the Mesopotamia group, but it also became clear that while the farmers know that these methods work when aimed at improving soil quality – they do not why these methods work. They know that plants need nutrients from the soil and that they can add nutrients to the soil by applying fertilizers, mineral or organic, but how the fertilizers add these nutrients to the soil is unknown. The agricultural management practices that the women spoke of during the interviews were: crop rotation, fallow periods, fertilization with manure, compost and

mineral fertilizer, intercropping, and mulching. The women spoke of a variety of agricultural management practices during the meetings, including: crop rotation, fallow periods, fertilization with manure, compost and artificial fertilizer, intercropping, and mulching. Not all of the mentioned practices were familiar to all of the women, and some of the women found that they were limited in choice of management practice due to their socio-economic circumstances. For example, for many women fallow periods are not an option as their lands are simply too small. A certain yield is needed for sufficient income generation and leaving the land or a portion of it fallow would mean a significant reduction in income. A consequence of the lack of fallow periods is more pressure on the land, which can lead to increased erosion and may result in diminished soil nutrient content (*KNBS/AWSC, 2014).*

	pH	C	N	Mg	Ca	K	Na	CEC	NO_x^-	NH_4^+	PO_4^-	SO_4^{2-}
	-	g kg^{-1}		mg kg^{-1}				$cmol_c$ kg^{-1}	mg kg^{-1}			
Mean	7.3	36.6	2.8	572.6	4842.1	1768.4	116.0	34.0	85.5	5.9	24.0	59.0
Std	0.2	11.0	0.4	89.2	761.2	879.2	30.3	5.4	62.7	3.7	15.6	44.5

Table 1. Average pH, total C and N (g/kg), exchangeable Mg, Ca, K and Na (mg/kg), CEC ($cmol_c$/kg) and water soluble ions NOx, NH^{4+}, PO_4^- and SO_4^{2-} (mg/kg) in the soil of Nyalanda field site (0-15 cm depth, 4 fields, with 12 samples per field; n=48).

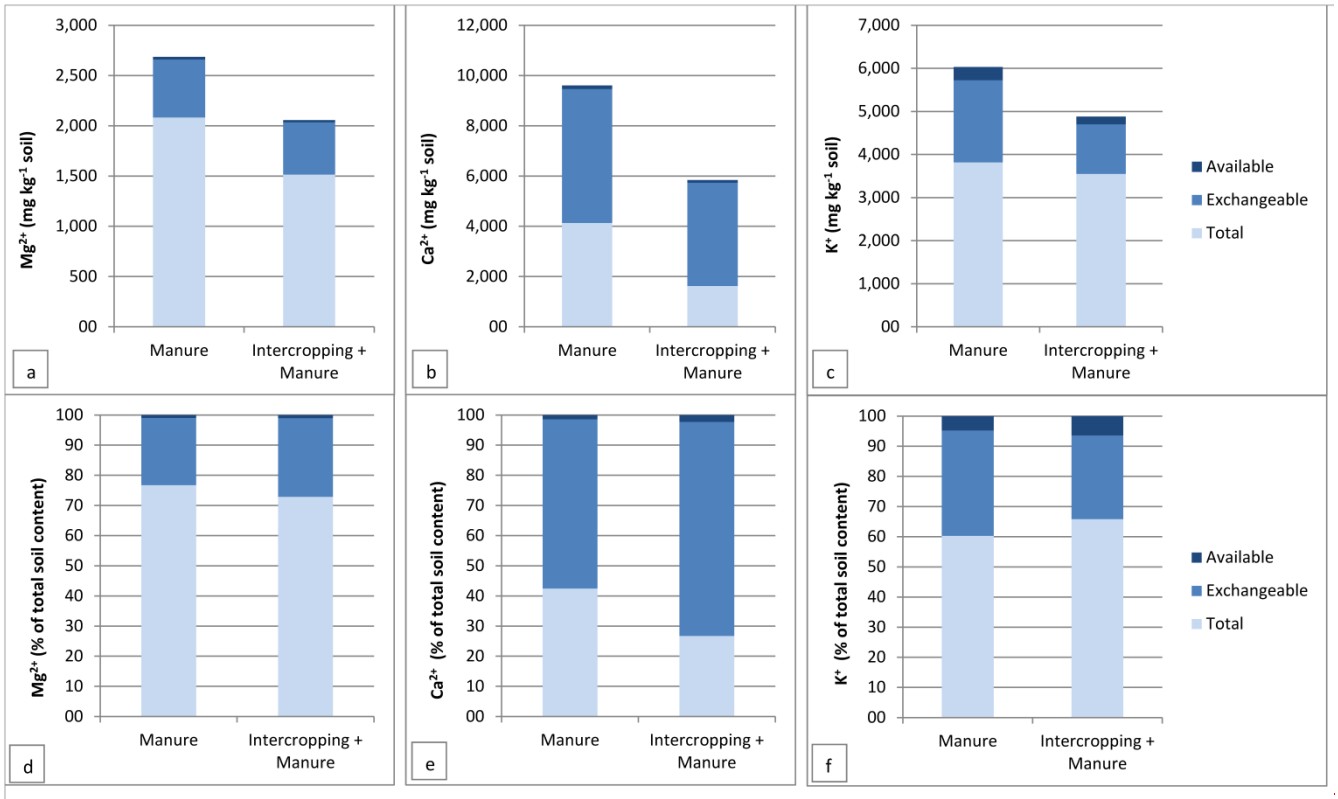
An alternative practice to fallow periods practiced by two of the women at the Nyalenda site is the seasonal rotation of their crops, which gives the soil time to recover as different crops have different nutrient requirements. Intercropping is done by some (n=4), Intercropping is done by 4 of the women in the Mesopotamia group, mainly with cowpeas, which should theoretically improve soil nutrient content. However, the intercropping technique is not always applied in a way that would accomplish this: the plants are harvested and not ploughed into the soil. Ploughing the cowpeas into the soil is needed for the nutrients accumulated to become available for other crops through the enrichment of the soil with organic matter (Okalebo, 2009). The women also use intercropping to prevent soil erosion while the main crop, often kale, is still growing. Intercropping also provides a source of income while the farmer waits for the kale to mature as cowpeas mature faster. Soil analysis shows that the application of intercropping has a significant effect on the soil nutrient content (Figures 1, 2, Table 1).

To support the soil analysis the two farmers whose fields were sampled were interviewed more extensively than the other interviewees. Both farmers have at least 5 years of experience and principally grow kales. The fields of the farmer that only uses compost have a slightly higher clay content and lower drainage capacity than those of the farmer that practices intercropping. The intercropped fields have a coverage of approximately 60-65%, less than those where only kale is grown, which have an approximate covering of 80-85%. The manure of both farmers is made of manure from cows and chicken mixed with organic waste. The farmer using only the manure applies this at time of planting and then again every 4-12

weeks as she feels is necessary. The application is ploughed into the soil. The farmer practicing intercropping applies manure as a topdressing at planting and approximately 8 weeks after planting. The cowpeas are broadcast on the field and a number of the plants is removed after 2 weeks to make room for the kales to grow. The farmer using manure weeds and ploughs her field every 10 days, whereas the intercropping farmer weeds every 14 days and ploughs her fields only every 26 weeks. In the fields of the farmer that uses only manure kales were grown in the fields in the previous growing season. The fields of the intercropping farmer were left fallow for 6 months before planting the current crops; in one of the fields maize was grown before the fallow period.

In case of manure application combined with intercropping the pH leaned towards being very slightly acid, whereas in case of only manure application the pH leaned towards very slightly alkaline (FAO, 2006). The CEC was nearly 10 $cmol_c\ kg^{-1}$ higher in fields under only manuring than in the fields where there is also intercropping. Similarly, total soil carbon is nearly 20 $g\ kg^{-1}$ higher in the fields where only manure was applied in comparison with the fields where there was also intercropping (Table 1; Fig. 2a). While the soil organic carbon was slightly higher in the manured fields versus the intercropped fields the difference was not significant (Fig. 2c).The contents of the macronutrients N, P, K, Ca and Mg were almost all higher under the field management type manure application only, as compared to manuring combined with intercropping (Fig. 1; Fig. 2).

Figure 1a, 1b and 1c show the amounts of water soluble and exchangeable Mg, Ca and K as part of the total amount of the cation present in the soil, clearly demonstrating that the levels are higher under the practice of applying manure only. Figure 1d, 1e and 1f show the proportion of the total amount of Mg, Ca and K in the soil that is water soluble or exchangeable. Notable is that while the absolute amounts are higher under manuring only, under the practice of manure application combined with intercropping, often a larger proportion of the nutrients was water soluble or exchangeable (Fig. 1). Specifically, the average exchangeable fraction was higher for Mg and Ca under intercropping + manuring, and the average water soluble fraction was higher for Ca and K under intercropping + manuring. The Kruskal Wallis and ANOVAs tests showed that all the described difference between the fields and between the management practices were significant for these characteristics at a confidence interval of 95%.



~~**Figure 1. 1a, 1b and 1c: Bars total length show the total amount of Mg, Ca and K in mg kg^{-1} soil under management 'manure' and 'intercropping and manure', darker sections of the bar diagram depict the portion of the total that is exchangeable and plant available/water soluble. 1d, 1e and 1f: Water soluble and exchangeable Mg, Ca and K as percentage of total.**~~

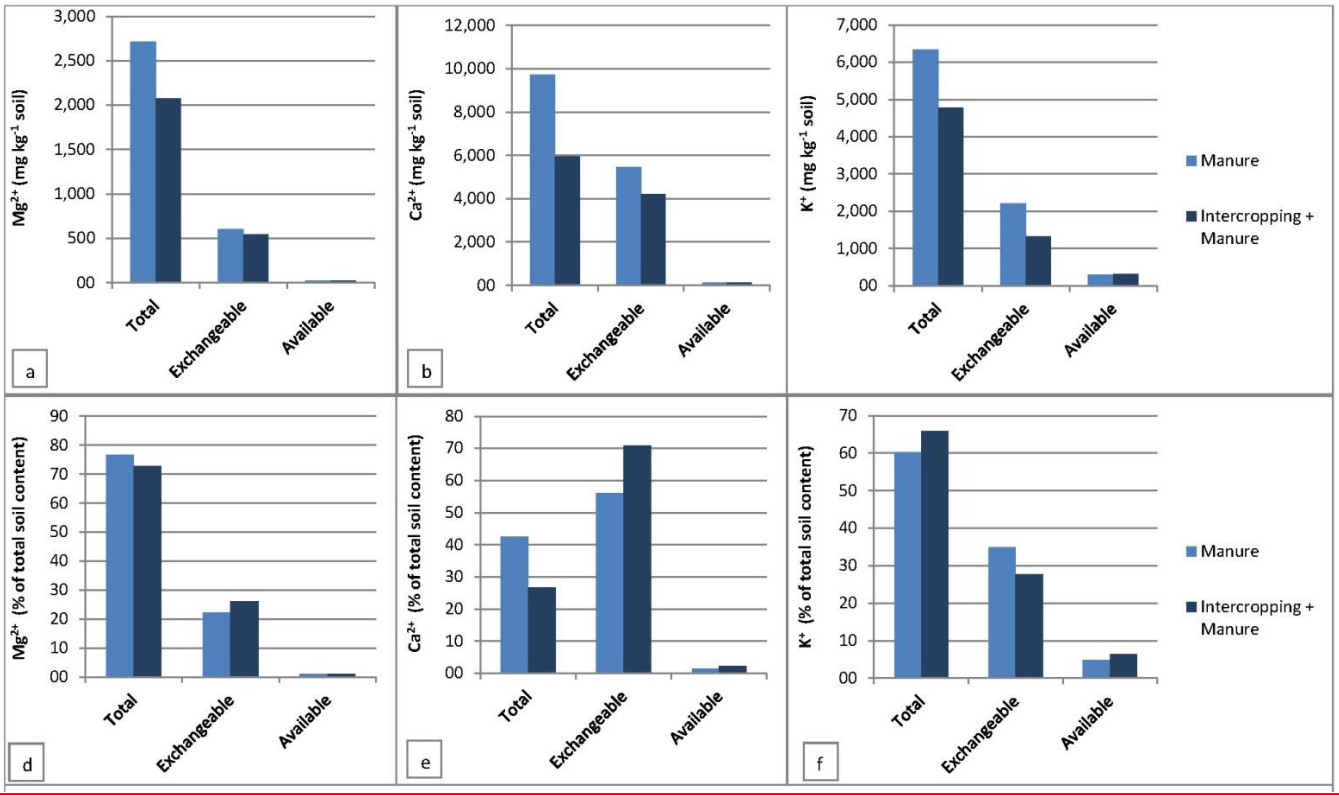


Figure 1. 1a, 1b and 1c: Bars length show the total, exchangeable, and plant available/water soluble amount of Mg, Ca and K in mg kg^{-1} soil under management 'manure' and 'intercropping and manure'. 1d, 1e and 1f: Total, exchangeable and plant available/water soluble Mg, Ca and K in the soil as percentage of the sum.

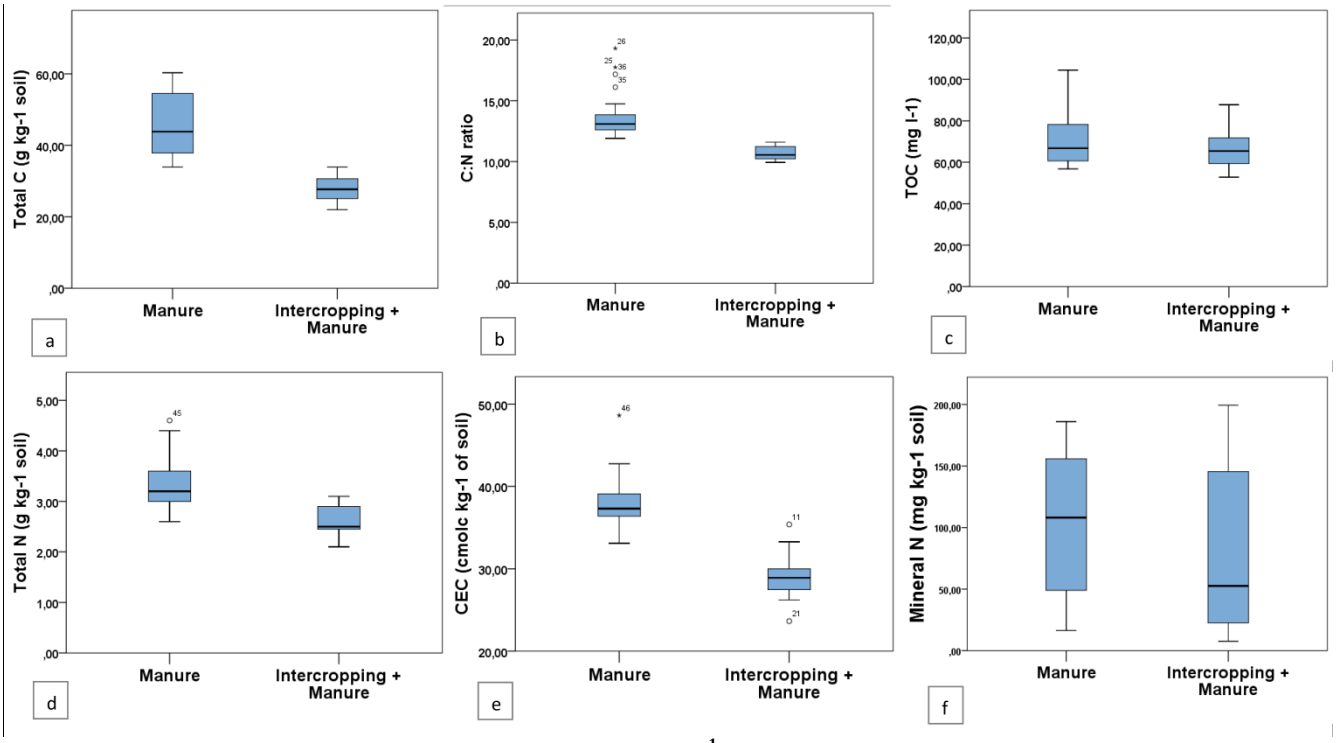


Figure 2. Boxplots showing the differences between 2a: total C (g kg^{-1} soil), 2b: C/N ratio, 2c: total organic C in the extracts (mg C l^{-1}), 2d: total N (g kg^{-1} soil), 2e: cation exchange capacity (CEC in $cmol_c$ kg^{-1}) 2f: Mineral N (mg kg^{-1} soil), for the agricultural management practices of 'manure' and 'intercropping and manure'.

4 Discussion

Results of the sample analysis of the soil of the urban gardens in Nyalenda showed a pattern consistent with the soil typology. The soils in the Nyalenda urban gardens can be classified as Vertisols, locally known as black cotton soils, which are soils characterized by a high clay content that shows shrink and swell patterns (FAO, 2006; FAO, 2014). Vertisols are generally fertile and productive soils, high in Ca, K and Mg, but often poor in N and P (FAO, 2006, FAO, 2014). Soil analysis has shown the rating for exchangeable Ca and K was very high and the rating for Mg was high according to FAO classification (Table 1; Fig. 1) (FAO, 2014). ~~In comparison, Tittonell et al., (2005) analyzed topsoil conditions in 3 smallholder farms in western Kenya. Their analyses showed N values almost 1 g kg^{-1} lower, similar P values, and K values a tenth of the values found in Nyalenda.~~ The high amounts of nutrients in the Nyalenda soils is most likely because of the parent material, which consists of river and lake sediments with inputs from the African rift valley, and the limited age of the soil material.

Earlier research on soil nutrients and possible solutions for soil fertility problems in western Kenya concluded that socio-economic factors determine how likely it is that scientific findings are taken up by farmers (Gicheru, 2012; Okalebo, 2005).

The results from the interviews and the FGDs show that this is also the case in a more urban setting. This might be because the gardens were originally located in a more rural surrounding, but the urban centre of Kisumu has since spread to that area; effectively changing the gardens environs from rural to urban.

Gender-aware research has shown that women possess important knowledge regarding agricultural management, distinctly different from the knowledge of men in agriculture (Saito et al., 1994; KNBS/AWSC, 2014). When farmers do not use scientific findings it is often regarded as a sign of unwillingness, lack of understanding, or ignorance. This view is particularly damaging for the collaborative interactions between different institutions and farmers, and the success of any potential innovations in agriculture that are adaptive, affordable and applicable to the context.

When asked to name and rank their primary sources of information all farmers of the Mesopotamia group, male and female, indicated a preference for inherited knowledge, followed by trainings and demonstrations. ~~"*Next to the information we got from our ancestors, we get information from the look of things, when you come and see somebody farming and you ask what they are doing and how it is going. So by observing is also how we get information"* (FGD 1, participant I5).~~ There was some discussion on the differences between demonstrations and observations, and some of the farmers consider them equal in importance. Information from training and demonstrations is however often lost because techniques or elements thereof are forgotten over time and/or materials needed are unavailable or too expensive. Using and adapting techniques by observing other farmers is more common. Information from television or internet has less impact because these farmers lack access to these media. Exhibitions are considered good, but the expense to go and visit them is often considered to be too high.

Limited access to sources of information means that most of the Mesopotamia farmers possess limited technical knowledge regarding soil processes; however they are aware of soil processes and their consequences in practical terms from sensory knowledge and daily experience. For example, the women are aware of the need to rest the soil with fallow periods or crop rotation and that mulching improves soil structure. The majority of the women in the Mesopotamia group possess knowledge regarding agricultural management practices and the effects of these practices on soil in these basic terms. As this knowledge is mainly passed down from previous generations or disseminates through observation of other farmers in the group or community, this knowledge does not travel far (Alunga and William, 2004; Kabira, 2007).

The women farmers of Mesopotamia report that they prefer to share information with other women. The women are wary of sharing information with men, as men might feel offended by 'being taught' by women. The women believe it is easier for other women to understand their knowledge because of their shared backgrounds and responsibilities and they indicate that they often continue beyond scheduled meetings to further discuss issues and solutions. ~~"*Women are easier to work with because they are the people who take responsibility in the houses and can solve this."* (FGD 2, Participant I5).~~ On occasion

they will choose not to share information with another, if for example they believe that the other woman does not have the resources to apply the technique.

In Nyalenda, a context where poverty is widespread, agricultural management and decisions are heavily influenced by social-economic constraints. These constraints can work against sustainable farming practices. For example, the farmers explained that some had taken to intercropping with cowpeas originally because they were told that they needed to increase N in the soil by government extension workers. The analysis of the soil samples shows that the soil nutrient content is significantly lower when the kales are intercropped with cowpeas (Table 1, Fig. 1, 2).

Soil samples from fields with intercropping show lower amounts of soil nutrients on average (Figs 1a, 1b, 1c, 2), however a comparison on the availability ratios of some of the nutrients showed that they have a higher availability or are more readily exchangeable under intercropping (Fig. 1d, 1e, 1f). The cause for this difference is not clear, but may be the influence of the presence of a legume species. The presence of the rhizobacteria on the root nodules of the legume can promote the availability or exchangeability of nutrients beyond nitrogen by immobilizing nutrients and preventing them from leaching from the soil (Lavakush et al., 2014; Vejan et al., 2016). Furthermore, the lower amount of nutrients in the intercropped fields may be due to the different approaches that the farmers have to applying manure. Farmer I2, who applies intercropping, applies the manure as a topdressing only. Farmer I7, who does not practice intercropping, ploughs the manure into the field. Ploughing the manure into the field preserves the N and promotes the biological breakdown of the manure, which increases the availability of the nutrients therein (Baligar, 2001). The decrease in soil nutrients in intercropped fields (Fig. 1) was most likely caused by the farmers not ploughing the cowpeas into the soil in combination with the different manuring practice (Okalebo, 2009).

During the interviews it became clear that instead of ploughing the cowpeas into the fields, the farmers are harvesting the cowpeas for sale. Harvesting the cowpeas means a greater uptake of nutrients from the soil and no additional organic material is added to the soil. Selling the cowpeas has become the primary motivation for intercropping as it gives the farmers a source of income in the period before the kales are mature and the advantage of doing so is more readily apparent to farmers than a potential increase of N in the soil. This shows that the lack of effect of intercropping on soil N contents in the examined soils is most likely not the cause of a lack of women vegetable farmers' knowledge of proper application or the technical knowledge of intercropping. Rather it appears to be a conscious choice related to a shift in the aim to be achieved by intercropping, i.e. gaining a secondary crop to be harvested and sold rather than increasing the yields or quality of the primary crop.

5 Conclusion

The results of the soil analysis showed that the soil in the Nyalanda urban gardens is rich in macronutrients. Further analysis indicated that, while seemingly small, the impact of different agricultural management practices on soil nutrients is significant. The growing of the cowpeas beside the kales causes a more rapid extraction of nutrients from the soil. Growing cowpeas and ploughing them into the soil should increase soil N content, however the farmer that applied intercropping sold the cowpeas on the market rather than ploughing them into the soil. This practice resulted in the observed decrease in nutrient contents, but provided the farmer with income at a time when the kales were still maturing.

The interviews and FGDs with the Mesopotamia group showed that there is knowledge of a wide range of agricultural management practices present. However, the interviews with the individual women member of the group showed that the knowledge on these practices is unequally distributed and that while they may be known to a technique they do not always possess technical knowledge on effects of their management practice. We conclude that the incomplete knowledge of these farmers is a consequence of the way they acquire and rank knowledge. During the FGDs a clear preference was given by all farmers to knowledge gained from family members. Observation of other farmers and trainings by outside groups were also appreciated, but considered less important. Knowledge from the trainings was often forgotten or materials needed were unavailable or unaffordable, making the training virtually ineffective.

The ineffectiveness of trainings showed that these should be adapted to take the socio-economic circumstances of the trainees into account. Furthermore, the gender differences in ability and access should similarly be taken into account in order to improve the effectiveness of a given training or agricultural recommendations. While this paper covers a case study of limited scale, meaning that this should be taken into consideration when viewing the results and drawing conclusions, the circumstances found within the Mesopotamia group are representative for many other groups in the urban gardens of cities in Kenya and subtropical Africa. The case study showed that women are influenced by their socio-economic and cultural status when making decisions in agricultural management and that these decisions may differ from those of men in the same or similar circumstances due to a lack of access to knowledge, contacts, or materials and capital.~~.~~ While the women of the Nyalenda group are willing to share their knowledge with other women, they are more wary of sharing with men. This wariness on the part of women contributes to the presence of gender differentiated knowledge and hampers the spread of knowledge in general.

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