The knowledge spread and role of kitchen gardens in Kenyan drylands

Including a fertiliser experiment with human urine

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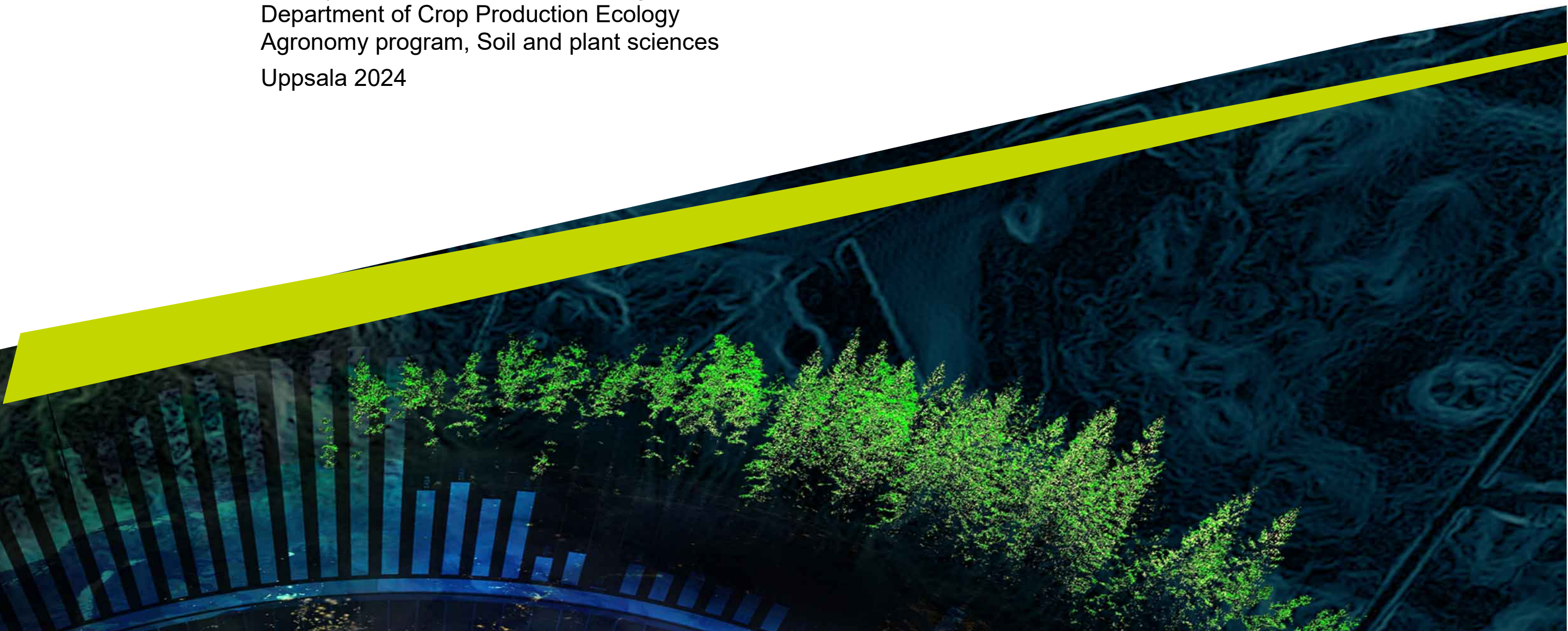

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Abstract

Drylands covers nearly half of the earths land surface and is home to one third of the world's population, i.e. 2 billion people. Poverty and food insecurity resulting from land degradation and climate change is common which leads to malnutrition and other health risk factors for the people. People have lived in the drylands as pastoralists for many years but the development of increased population, climate change and conflicts have caused more and more people to seek alternative livelihoods. A portion of the population in this area experience malnutrition, based on lack of variety of the food intake. The farming situation in drylands is mostly based on stable crops as sorghum, millet, and sunflower, which are adapted to the climate and are both highly ranked in their cultural food, and the crop residues can be given to livestock. However, the periods of drought and flooding disturbs the fields more than it should, due to the degradation and instability properties of the soils. To build up and restore the land and soils again will need both new and old methods to play a role to reduce the vulnerability of farmlands to weather factors.

This study consists of interviews to follow-up after a series of kitchen garden trainings, an on-farm field experiment and evaluation of data from a household survey. The objectives of this study were to understand whether there are differences in food intake and food security in households having a kitchen garden; how the knowledge of kitchen garden farming is shared within the community, and to examine the effect of human urine on the growth of kitchen garden vegetables.

The household data collection was carried out in West Pokot and Turkana Counties in Kenya, as well as in Moroto and Napak Districts in Uganda. These four areas are included in an area called the Karamoja cluster located in semi-arid and arid drylands. The individual interviews and fertilisation experiment was carried out in West Pokot County only. The results showed differences between the areas in consumption of vegetables, and in Turkana all households interviewed, worried more about having enough food as compared to the other dryland sites. Of households not worrying about having enough food, 65% had a kitchen garden, compared to only 35 % of those that were worried about having enough food. The growth experiment did only show one significant result on the watermelon leaf measurements, probably due to poor germination caused by delayed rains. The adoption of half-moon-shaped kitchen gardens had developed among the trainer of trainers were 16 of 20 household had adopted the practise by spring 2023. It had not yet spread in the communities; however, 50% of the people that had been to the training had shared the knowledge with their community.

Keywords: Karamoja district, West Pokot, Drylands Transform, nutrition, Half-moon, agropastoralist

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Abbreviations

SLU	Swedish University of Agricultural Sciences
ToT’s	Training of trainers
Non-ToT’s	People that have not been trained by the Drylands Transform team.
SPAD-502	A measurement tool that is used to measure chlorophyll in growing plants to monitor the effects of nitrogen fertilisation, crop growth, and plant health.

1. Introduction

This thesis is about the spread of kitchen garden farming in the dryland areas around Chepareria in West Pokot County, Kenya. Additionally, it includes an on-farm experiment with fertilisation of vegetables using human urine and an analysis of data from a household survey conducted in four villages within the Karamoja cluster in Kenya and Uganda about the consumption of horticultural crops in combination with practising kitchen garden farming.

Drylands cover roughly 40% of the earths' land surface and are home to around one third of the world's population (Thapa & Stewart 2016). Drylands have harsh and challenging biophysical characteristics, the soils are mostly infertile and the cover of vegetation is sparse; the people do also often live in poverty and food insecurity (Berrahmouni & Parfondry 2015). This also means that this area is sensitive to climate change and human activity (Huang et al. 2016). In Kenya, dryland areas cover about 89% of the total land mass, and in Uganda dryland areas cover about 43% of total land area. Estimated and according to the IPCC reports of arid and semi-arid land (ASAL) in Kenya there are 5.3 million people in acute food insecurity in year 2023 (IPCC level 3), compared to 2022 and 2021 where 3.5 and 2.1 million people, respectively, faced high levels of acute food insecurity (*IPC Global Platform* 2022; *IPC Global Platform* 2023). In the Ugandan side of the Karamoja cluster the acute malnutrition is facing 45% of the population (*IPC Global Platform* 2023). This numbers are going to increase according to the forecast of the IPCC report. Currently, the situation is driven by, among other things, inadequate rainfall, loss of livestock, low access to farmlands, growing population, and high prices on food (*IPC Global Platform* 2023).

The definition of food security is "when all people at all times have access to safe, sufficient and nutritious food" (FAO 2009). Hidden hunger is a concept that refers to malnutrition occurring even when the amount of food intake is sufficient for survival and no symptoms of energy deficiency or fatigue are shown. Most often it is the absence, impaired or low intake of micronutrients, especially iron, zinc, iodine and vitamin that is causing hidden hunger (Lowe 2021). Hidden hunger usually happens when the diet lacks diversity and thereby lacks important micronutrients (Biesalski 2013).

Animal herding has existed for many thousands of years and this form of livestock keeping, pastoralism, takes place all over the world. In 2016 pastoralism was practised on 25% of the earth's land surface, but it is declining as agricultural activity including its expansion and industrial development drastically reduces the areas where pastoralists can roam with their livestock leading to more sedentary livestock farming and settlement (Dong 2016). Agro-pastoralism defines a combined lifestyle of pastoralism and crop production (Dong 2016).

The settlement and more sedentary lifestyle are giving the opportunities for developing kitchen gardens. Previous studies have reported that education and training in kitchen garden farming and human nutrition resulted in an increased consumption of fruit and vegetables in rural areas (Schreinemachers et al. 2015).These findings highlights the impact that structured learning and practical guidance can have dietary habits, especially in regions where food diversity is often limited. This shift to a more nutrient rich and variable diet is important for improving overall health and wellbeing in rural areas

To take up new practices such as establishing a kitchen garden in dry areas requires knowledge. A common format of knowledge sharing, that also has been described in a review from rural Tanzania, is done via observations conversations, where the individuals create knowledge by doing and shares the knowledge and experiences they have and find helpful in their day to day life and surrounding activities (Bernard Ronald et al. 2013). Learning how to better manage the farming system, and about field practices and nutrition, will pay back to the farmer and the community in form of, for example, vegetable harvest and animal feed (Berrahmouni & Parfondry 2015).

In rural areas where most people are pastoralists fertilisers are not widely used for crop or vegetable production and when used it is often in low quantity (Waithaka et al. 2007). An easy, cheap, and locally accessible fertiliser alternative is human urine. Using urine as a fertiliser has been practiced in Asia for a long time (Goldstein 2012), but has not yet developed as a common practice in large areas of Africa (Winblad 2004). Studies have shown that urine is a cheap and efficient alternative to nitrogen fertilisers (Stanley & Prof Siraje 2020). Urine together with compost or other organic material can improve the soil environment; in an experiment done in Nigeria it improved soil health and amaranth yield (AdeOluwa & Cofie 2012). There is an increased interest in research on the use of human excreta including urine and faeces as part of the sanitation and healthcare system (Wohlsager et al. 2010) as well as the nutrient recycling and reusable values (Andersson 2015).

The use of urine as fertiliser in Chepareria has not been documented. Experiments in neighbouring Uganda have shown that fertilising crops with urine increased yield significantly and at a low cost and risk, which shows high potential for smallholder farmers (Andersson 2015). Another experiment also from Uganda, showed that weekly watered crops with doses of urine showed a significant yield increase of maize and kales, and the local crop nakati (Solanum aethiopicum, L. type of egg plant) (Semalulu et al. 2011).

1.1 Aims and objectives

The initial idea of this study came from the Drylands Transform project team, who felt that they wanted to deepen their knowledge of the presence and use of kitchen gardens and the kitchen garden's role for nutrition, especially since more and more people live more permanently in one place now compared to earlier (Nyberg et al. 2015). Another reason was the current situation with malnutrition and high food and fertiliser prices as a progressing problem. This study will contribute to the global development goals and especially goal number 2. Zero hunger, that includes the targets; end hunger, achieve food security and improved nutrition, and promote sustainable agriculture (*Goal 2: Zero Hunger* 2020).

In this study, kitchen gardens are defined and referred to as "a small area of land close to home that is intended for the cultivation of horticultural crops such as vegetables, leafy greens, fruits and tubers" (Murphy 2008). The study will furthermore include a growth experiment of the use of urine as topdressing in leafy vegetable production in a local kitchen garden.

The overall aim of this study is to get a wider understanding of the potential role of kitchen gardens to households in a dryland community in Kenya in forms of diverse and nutritious food and diets.

The specific objectives are to:

1. Explore if there is a link between having a kitchen garden and the consumption of different types of fruit and vegetables to achieve dietary diversity.

2. Understand if knowledge about kitchen gardens spread from trainers of trainers to the agropastoral community in Chepareria, West Pokot County.

3. Test the effect of human urine as a fertiliser on chlorophyll content and size of leaves of green leafy vegetables in a half-moon-shaped kitchen garden in Chepareria, West Pokot County.

2. Methodology

This study used quantitative data analysis with data gathered from a household survey in four sites in the Karamoja cluster (Kenya and Uganda); qualitative data from semi-structured interviews on how the knowledge is spreading and field data from an on-farm growing experiment with vegetables and human urine form the study site in Chepareria, West Pokot County in Kenya.

2.1 The livelihoods in the Karamoja region

Hunger and malnutrition is widely spread and the livelihoods and income is based on natural resources and is frequently disturbed by long drought periods, floods, sickness of both human and animals (*UNFPA. Leaving no one behind in Karamoja* 2018). Resource based conflicts, private ownership of firearms and cattle raids are some of the underlying reasons for insecurity in the area (Anno & Ameripus 2022). Health inspections and research about the people living in this area is carried out in different forms to understand how the development of the living situations and how resources can be directed. Common results shows that children have a growth deficit that starts during the women's pregnancy, as a malnourished mother that has a high workload in combination with stress and without proper health care (Nakalembe et al. 2017). A study carried out on the Ugandan side of Karamoja showed that it had widespread malnutrition among children below 5 years old (Muggaga et al. 2023). Children that are malnurished from early age can develop disabilities later in life due to the low intake of macro- and micronutrients (Groce et al. 2014). The unsafe society where risk of armed attacks is common together with the food insecurity have resulted in a consumption of alcohol and locally brewed drinks Even pregnant women and small kids consume the local brews in absence of other food as well as a disconnect from the day to day life (Hanson et al. 1978; Muggaga et al. 2023).

Research in the Karamoja area has shown that agriculture is often practised in small-scale farming, but even though there is a lack of inputs, seeds and knowledge areas with farmland expanded a lot during the years 2000-2011 (Nakalembe et al. 2017).

Livestock production is the main economic activity and other income forms in these areas are charcoal burning, firewood selling, beer brewing, honey production, and a few people are involved in gold mining (Levine 2010). Without climate smart options and cultivation methods, agriculture and areas of crop production will decrease which can negatively affect the livelood options (Nakalembe et al. 2017).

2.2 Study site in Chepareria, Kenya

Kenya is a country located at the equator in East Africa. The country is 580,370 km² and has a population of approximately 53 million people (*Kenya: country data and statistics* 2022). The climate in Kenya is very variable depending on its topography. From the coast, land levels rise sharply and the landscape in central Kenya consists of a high plateau and from north to south stretches Africa's “Great Rift Valley”. The biotopes include savannah, rainforest, and desert (*Kenya – Geografi och klimat* 2020).

Most people live in the highlands of the country, where mainly large-scale farmers conduct conventional cultivation with cash crops such as coffee, tea, cut flowers and vegetables which is mixed with small-scale family-owned farms with crops, livestock, and kitchen gardens, mainly for own use (*World Bank Climate Change Knowledge Portal* 2021).

The focus area of Objectives 2 and 3 of this study is in the semi-arid, sub-Saharan region, Chepareria division in the West Pokot County in north-western Kenya. The county has been changing from having mainly pastoralists in the past, to a majority of livestock-based agro-pastoralists at present (Nyberg et al. 2015). The soil in this area is compact and shallow and the water permeability is low (Nyaga et al. 2022).

West Pokot’s varied altitude contributes to the variations in climate and agro-ecological zones. In West Pokot in general, the annual rainfall is 128 mm (*West Pokot, KE Climate Zone, Monthly Weather Averages and Historical Data* 2022). Chepareria is in the lowlands of West Pokot and the altitude varies from around 900 to 1900 meters above sea level (*Chepareria topographic map, elevation, terrain* 2023). Because of the large differences in altitude, the climate changes rapidly and can differ a lot in different areas of Chepareria.

Farming in the area is mainly through cultivation on fenced fields (so called enclosures). Small kitchen gardens can be found in some homesteads, but they are not a common practice. The small fields are mostly cultivated with dryland crops such as maize, millet and sorghum. The livestock kept is a mixture of goat, sheep and cows for milk and meat, chicken for egg and meat and donkeys for transportation uses (Nguluu et al. 2014).

2.3 Drylands Transform project context

This study was conducted in connection to the research project Drylands Transform (www.slu.se/drylandstransform.) Drylands Transform is being implemented in the Karamoja border region of Kenya and Uganda. The aim of the project is to better understand the links between land health, animal husbandry and human well-being and contribute with new knowledge on degraded land restoration and management options for a more sustainable development of rangelands (*Drylands Transform* 2021).

The Drylands Transform Research project has four project sites (Rupa and Matany in Uganda's Moroto and Napak districts, respectively and Lokiriama and Chepareria in Kenya's Turkana and West Pokot Counties, respectively) in the Karamoja region (Fig 1). The northern sites Turkana and Moroto are dominated by pastoralist communities while the southern sites have more agro-pastoral based livelihoods. In each site, Drylands Transform has a knowledge sharing-hub known as the "livestock café". In these four livestock cafés, various technologies for restoring degraded rangeland are practiced and demonstrated. This includes water harvesting, reseeding with indigenous grasses and forage legumes, planting of multipurpose trees and shrubs, harvesting hay and setting up regenerative kitchen gardens. Trainings of local trainers, using the so called 'training of trainers' (ToT´s) method has been applied in establishment of kitchen gardens have been carried out in e.g West Pokot. The purpose is to spread knowledge and have high participation in the experiments to involve the local community. Through high involvement, people can better understand and get interested and engage in the different activities in the project, like for example understanding different crop growing requirements, propagation and harvesting.

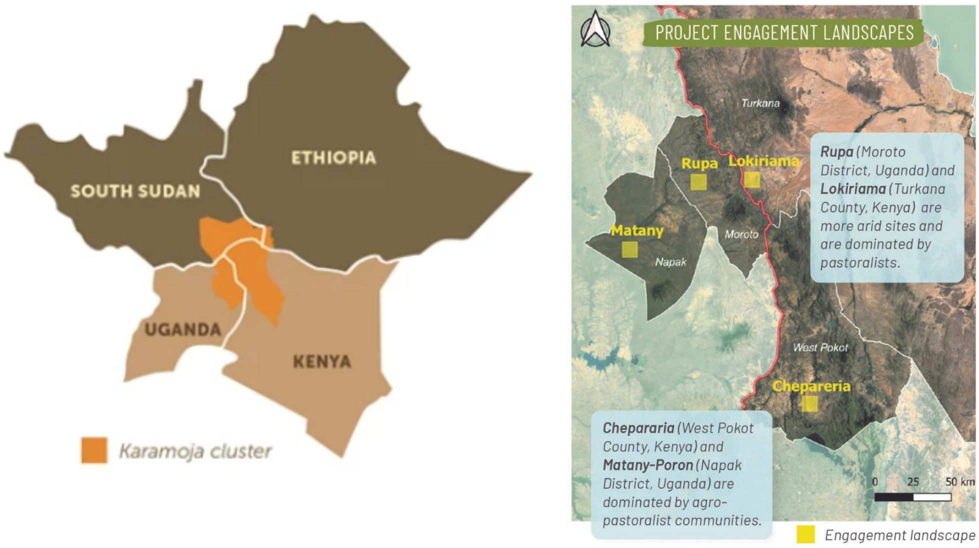

*Figure 1. Left: Map showing the Karamoja cluster marked in orange. Right: Map of the border region of Kenya and Uganda showing the four project sites in both countries (*Drylands Transform *2021)*

2.4 Objective 1. Household survey data

Drylands Transform has been collecting data in a household survey covering topics including land ownership and use, health and nutrition of household members, livestock, shocks and crisis, assets and information sources. The survey was carried out in the Karamoja area in June 2022. The sample size was calculated using the Cochran (1977) method and two stage random cluster sampling that involved 77 villages and 943 households, the villages were selected randomly, household listed, and 12 households were interviewed per day, per village (Mureithi 2024).

For the analysis of the household survey data on the intake of fruits and vegetables in relation to having kitchen gardens, all four sites will be included. The knowledge transfer interviews focused only on Chepareria, West Pokot County in Kenya, where also the growing experiment with human urine was carried out.

The household survey included questions about if households had or not a kitchen garden as well as eating habits for one child and its mother, considering the last 12 months, this information was used to answer the first objective "Explore if there is a link between having a kitchen garden and the consumption of different types of fruit and vegetables to achieve dietary diversity".

The kitchen garden term was explained as a place that “belongs” to the female respondent or her household, not shared with the community members. The questions asked were: Do you have a kitchen garden where you grow vegetables or fruits? In the past four weeks, did you worry that the household would not have enough food?

The nutrition part of the survey was asked to the female respondent, and the child is the youngest child in the household aged 6-59 months old. The 24h Recall method (*24-hour Dietary Recall (24HR) At a Glance | Dietary Assessment Primer* 2024) was used, which is described as yesterday's first meal to the last meal during the night before getting up today and includes snacks, small meals as well as main meals whether they ate at home or somewhere else. The questions used can be found in Appendix 2.

In each question directed at fruit and vegetables, it was asked to note wild varieties or other intakes. Some traditional vegetables were listed together with herbal juices and drinks as local brews and if alcohol was given to the child.

Children under 25 months were excluded from the analysis as it is common that they are still breastfed and in this study we are looking at the average intake, so it was therefore chosen to remove that age range from the analysis (*Infant and young child feeding* 2023)

2.4.1 Survey data analysis

The selected parts from the survey were put together and loaded into the analysis program R (R Core Team 2023). A logistic regression analysis was done by using the GLM (generalised linear model) function in R. The dependent variables female or child, against the intake of different vegetables and fruits listed above was regressed on the independent variable’s kitchen garden and study site, which indicates if the female or child had access to a kitchen garden and where they lived. A summary model was used to get the coefficients, degrees of freedom and deviance values to assess the significance.

Each dependent value and independent value were contacted one by one and a list of the results with significance and coefficient is presented in the result part (Table 1).

2.5 Objective 2. Kitchen gardens

Objective 2 of this thesis/study is based on the ToT training where 16 persons that attended the ToT's was interviewed.

The Drylands Transform project had a kitchen garden training at the Chepareria livestock café, West Pokot, Kenya, in June 2022, attended by around 30 individuals. The training sessions were held in Swahili, so it was recommended to understand Swahili to follow along. The participants were all trained as 'trainers of trainers', the so-called ToT's, with the aim that they would in turn teach others in their homes, especially when preparing their kitchen gardens. Therefore, the four individuals outside the 16 ToT persons were interviewd.

Primarily the kitchen garden training focused on sunken beds in half-moon shapes along contours to have an advantage of rainwater harvest and moisture retention with a depth of around 30-35 cm of the half-moons. This allowed the space for the roots of the annual crops and as well as it acted as a surface water reservoir. Soil from the sunken bed was removed and after that it was filled with a layer of sawdust to hold the water for a longer time. On top of sawdust a mixture of the soil together with sand taken from the river as well as manure were mixed and placed to create a seedbed. In this bed, crops that require more water were grown, for example, tomato (*Solanum lycopersicum*, L.), kales (*Brassica oleracea, L.)*, and other leafy vegetables. The raised part of the half-moon beds was created from the rest of the soil behind the sunken bed. In the raised bed, crops that required less amounts of water and were drought tolerant, like e.g. cassava (*Manihot esculenta*, L.) sweet potato (*Ipomoea batatas, L.)*, and Pigeon peas (*Cajanus cajan, L.)* were grown.

Both sunken and raised beds had mulching material on top to prevent water evaporation and reduce the number of weeds, as well as adding nutrients and organic material to the soil when they decompose. The training took place over a period so the participants could follow along the growing seasons, from building the gardens, sowing the seeds, taking care of the plants and harvest.

2.5.1 Semi structured interviews

To understand how knowledge on kitchen gardens spread, and how people adapted the knowledge about kitchen garden farming to their personal situations, as well as transferred the knowledge to others, semi-structured interviews were conducted. The interviews were held with 16 trainers of trainers (ToT's) that had attended the training within the project Drylands Transform on establishment and management of kitchen gardens. Four persons were also interviewed who had been taught by the ToT's (mentioned as non-ToT's). All interviews were carried out with informed consent by the participants. The interviews were focused on if they had used the knowledge on kitchen garden establishment in their own homestead and questions around that process. See the interview guide in Appendix 1.

When selecting interviewees from those who participated in the training on kitchen gardening, it turned out that several of the people belonged to the same household and in those cases, only one from each household was interviewed. The caretaker of the land where the Livestock Café is located, the homestead where the experiment (objective 3) was carried out, and the people that had moved away from the area were not included in the interviews. The total number of people interviewed were 20, where 16 of them were ToT's and four non-ToT's. Notes were taken during interviews, but no recordings were made.

2.6 Objective 3. Human urine fertiliser experiment

Objective 3 included a growth experiment with urine as fertiliser based on the techniques and methods used in practice. The urine experiment was based on the kitchen garden training that Drylands Transform provided in June 2022 including the use the half-moon shaped kitchen garden beds. A similar approach was used during the construction and with extended focus on how to provide an easily accessible and low-cost fertiliser to the plants in the form of human urine diluted with water.

The use of urine as fertiliser in Chepareria had no documentation of practise or experimentation since earlier in the area. Nitrogen (N) is often the limiting nutrient for plant growth and the usage of N as a fertiliser is often much higher than that of other nutrients (Richert et al. 2010). Urine consists of high levels of the plant required macronutrients especially Nitrogen (N) Phosphorus (P) and Potassium (K) the N:P:K ratio in % is around 0.3:0.03:0. (Schönning 2002). The nutrients are in ionic forms and therefore easily accessible for plants. The quantity of urine from a single person per day depends mainly on how much a person drinks, but roughly numbers are between 0.8-1.5 liter per day, children produce about half of what an adult does (Richert et al. 2010). The amount of nutrients excreted in urine depends on the food consumption and the diet (Jönsson et al. 2004). Components of urine are primarily (91-96%) water, also including organic solutes as urea, uric acids, fatty acids, hormones, creatine as well as the inorganic ions of sodium, potassium, chloride, magnesium, calcium, ammonium, sulphates and phosphates (Sarigul et al. 2019).

Urine contains N in the form of urea $CO(NH_2)_2$, urea degrades by microbial processes, to ammonium NH_4^+ and both these compounds are good nutrient sources for plants. Ammonium can evaporate as ammonia (NH_3) which can cause bad smell and have environmental impact (Heinonen-Tanski & van Wijk-Sijbesma 2005).

2.6.1 Establishment of the kitchen garden experiment

The designated place for the experiment was in the homestead of one of the ToT's in the village Chepukat (Chepareria, West Pokot, Kenya), which was located around 800 metres from the Livestock café site. The area for the kitchen garden experiment was 1093 m^2. A fence was built to prevent animals to intrude. 10 half-moons were dug for the research; five replicates of each treatment (see Figure 2).

The kitchen garden concept used was based on planting crops in a half-moon structure having a sunken and a raised bed including water harvesting function within the design. The half-moon sunken bed was designed for the rainwater to be trapped and slowly infiltrate the soil. The bed was filled with dried Sisal leaves (*Agave Sisilana, L.)* that had been torn into stripes to make it easier to work with and to replicate the sawdust from the original design as much as possible. Sisal is commonly used in the area for enclosures and fencing material and was therefore accessible to everyone at no extra cost. The purpose of using the Sisal leaves was to keep the moisture in the soil as well as to add organic material into the soil. Above the sisal layer was a mixture of manure, river sand and soil. The manure was collected from the household's livestock (goats, sheep, chicken, and cows). The river sand was collected from a nearby river. The sand would improve the physical properties of the soil for water infiltration and the pore structure of the soil due to the high soil clay content. The raised bed was made from soil that was dug from the sunken bed, the top is flattened and topped with a mixture of manure and river sand. This bed allows deep rooted plants to grow in a looser material.

Mulching material was added to the seedbeds when the plants were tall enough for a coverage of 5-10 cm of grass that was harvested from the Drylands Transform experimental site the prior season.

Figure 2. Top left shows the empty halfmoon. Top right shows the halfmoon pit filled with pieces of dried sisal leaves. Bottom left shows the halfmoon pit covered with 11 cm of a soil mixture consisting of 4 wheelbarrows of soil, 1 wheelbarrow of river sand and 1 wheelbarrow of composted manure. Bottom left shows the raised halfmoon bed with a dressing of a mixture with 1 wheelbarrow of manure and half a wheelbarrow of river sand. Photo: Cecilia Ward

2.6.2 Vegetable growth

A variety of vegetable seeds (see variety and placement in Figure 3) were sown three days after the first rains (16 March 2023). The first signs of germination of the seeds were seen two days later. After 11 days most of the seeds had germinated except for the spinach that germinated a bit uneven and was therefore reseeded. Seeds were planted in both the sunken and the raised beds of the half-moons according to Figure 3. The plants that germinated well and where it was possible to take measurements later, were spinach in the raised bed, and watermelon and green collard in the sunken bed.

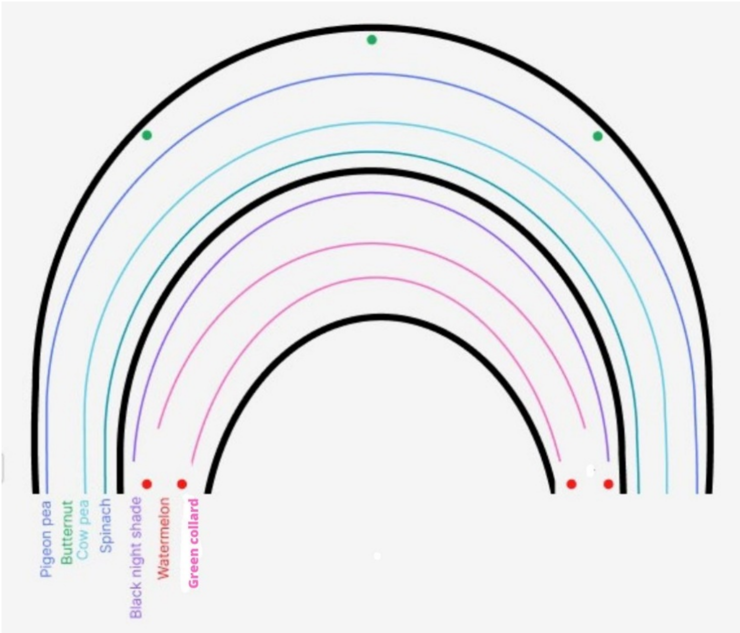

Figure 3. Illustration of vegetable species in the sowing scheme. The black line marked the edges of the halfmoon. Butternut squash (Cucurbita moschata, D.), was marked as a green dot and watermelon was marked as a red dot, The following vegetables, from the edge of the raised part towards the centre, were marked as coloured lines: pigeon pea (Cajanus Cajan, L.), cow pea (vigna unguiculata, L.), spinach (Spinacia olaeacea, L.), black night shade (Solanum nigrum, L.), and green collard (Brassica oleracea, L.). Illustration: Cecilia Ward

Numerous weeds sprouted in the beds, clearing these weeds was a challenge due to the soil crust that had form and the weeding could easily harm the seeded plants. Example of the soil crust, crops and weeds can be seen in Figure 4. There was an issue with the presence of weeds in the beds. Through their ability to adapt to the environment and withstand stresses, they can limit the access of water and nutrients that were meant for the seeded plants (Sharma et al. 2021).

Figure 4. Green collard, (Brassixa oleracea, L.), weeds and soil crust from a urine treated seed bed. Photo: Cecilia Ward

2.6.3 Watering and urine fertiliser doses

The half-moons were watered once a week. The control treatment beds (marked with a blue drop in Figure 5) with two litres of water. The urine treatment beds (marked with a yellow drop in Figure 5) with one litre of urine diluted with two litres of water.

To avoid pouring water or urine mixture directly on the leaves, a furrow was created in between the rows of the plants (Figure 6). After 4 weeks of watering the doses of water were regulated so the plants got the same amount of moisture; three litres of water to the control pits and two litres of water mixed with one litre of urine in the fertilised treatments. The ratio of the diluted urine is based on literature (Jönsson et al. 2004). The positive influence by diluting the urine is that when too concentrated it can be toxic to the plants. The dilution will also control the nutrient and water dose the plants needs and thus limit the stress factors (Raghuram & Jangam 2015).

The collection of urine was done by the household hosting the experiment (wife and husband together with their children). The urine was stored in jerricans in a dark space. An example of the family's diets consists of black tea with maize porridge for breakfast, Ugali with Sukuma wiki (maize porridge with collard, or locally sourced leaves) for lunch, and beans and maize for dinner.

During the experiment, the rains failed. To keep the vegetables alive, additional irrigation was initiated on 7th of April 2023. Six litres of water were added to every pit and to the border of the raised bed twice a week using a watering can with a shower nozzle.

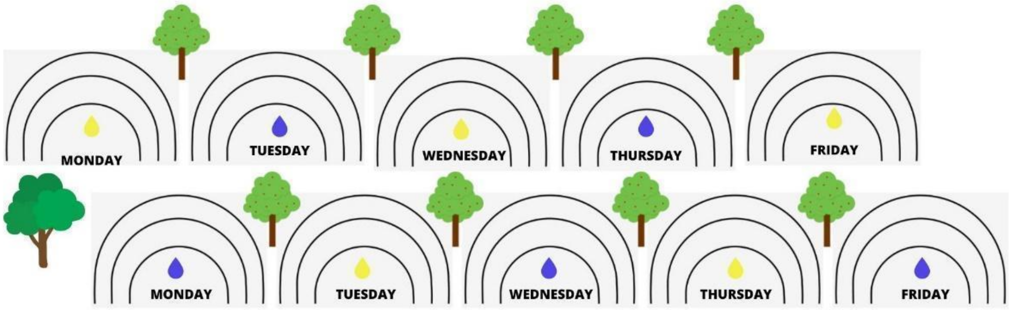

Figure 5. Illustration of the half-moon design, with names of the day of watering (Monday to Friday). Yellow drops equals urine treatment and blue drops equals control beds. Illustration: Cecilia Ward.

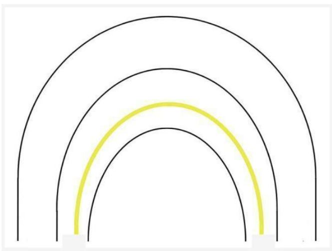

Figure 6. Illustration of the furrow placement. The blacklines indicate the borders of the halfmoon raised and lowered parts, and the yellow line shows the location of the irrigation. Illustration: Cecilia Ward

Figure 7. Example of how the plants suffered from the lack of rains and how they could look like during the experiment. Left: A spinach plant from a urine treated bed on 10th of April. Right: A Spinach plant from a control bed on the 20th of April. Photo: Cecilia Ward

2.6.4 Chlorophyll, and size measurements

Physical measurements were taken on the plants and leaves of green collard, spinach and watermelon. The measurements were taken on the 27th of April of green collard and the 31st of May on green collard, spinach and watermelon. It included height of the plant, from soil base to tip of the stem, length of the leaves, from leaf base to leaf tip, and the width of the leaf. The SPAD values of the same leaves were conducted and the mean of three measurements were used in the analysis. A handheld chlorophyll metre (SPAD-502) was used to detect the chlorophyll content in leaves. The chlorophyll content gives an indicator on photosynthetic activity and relates to the nitrogen concentration in the leaves. The chlorophyll metres were placed on the leaf surface where there were no bigger leaf veins (Xiong et al. 2015).

The selection of plants that were used for the size and SPAD measurement takings were the ones that were big enough to place the measurement tool on the leaves in both the control and the urine fertilised treatment. The different half-moons were marked as weekdays (Monday to Friday) when they were watered to facilitate the maintenance of irrigation. The weekdays will further on not be mentioned as it has no influence in this analysis which day the beds were watered. The statistical analysis was done to estimate if there were any significant differences between the two treatments' mean value, a pair-wise T-Test was done. The T-Test analysis was chosen as a method because of the ability to detect differences. The significance level was chosen to 0.05 as it is commonly used and an accepted threshold for significance.

Green collard (*Brassica oleracea, L.)*

Measurements were taken on two different occasions, 27th of April and 31st of May 2023.

Watermelon (*Citrullus lanatus, L.)*

The size and chlorophyll measurements were taken on one occasion, 31st of May 2023.

Spinach (*Spinachia oleracea, L.)*

The size and chlorophyll measurements were taken on one occasion, 31st of May 2023.

3. Results

3.1 Objective 1. Consumption when having a kitchen garden

The number of households that had a kitchen garden (in total n=352) and that corresponds to approximately 37%. The mean sizes of the kitchen gardens (between 1m^2 to 500 m^2) can be seen in Table 1. The site that had the most kitchen gardens was Moroto with 64% of the interviewed households, followed by West Pokot 37%, Turkana 24% and Napak with 16%. The mean size varied from 1.4-20 m^2.

Tabell 1. Number of households included in the survey and that had a kitchen garden in numbers and percentages. The mean sizes of kitchen gardens between 1m^2 and 500m^2 were also shown. All parameters specified by country and county/district

Country and County/District	No of households	No of households having a kitchen garden	% of household having a kitchen garden in the areas	Mean size of kitchen garden (m^2)
Kenya	424	131	31	20
Turkana	202	48	24	22
West Pokot	222	83	37	19
Uganda	519	221	43	6
Moroto	289	185	64	10
Napak	230	36	16	1.4
Tot	943	352	37%	-

The analysis done on the Drylands transform household survey data showed that having a kitchen garden seemed to benefit more for the children compared to their mothers. Having a kitchen garden seemed to be positive for the child as they had a significantly higher intake of the food category's orange fruits, beans and peas, grains, and other vegetables (Table 2). The presence of a kitchen garden seemed to reduce the intake for children of the food categories dark green leafy vegetables and white roots and tubers. For the female, having a kitchen garden they seemed to eat more nuts and seeds as well as more relief food compared to those not having a kitchen garden. They were eating less of the category's dark green leafy vegetables and white roots and tubers.

The four sites (Moroto, Turkana, Napak and West-Pokot) differed significantly in most of the food intake. In Turkana, people worried more about not having enough food, while West-Pokot people worried the least. Turkana also consumed significantly more supplementary feed for the children, more relief food and more grains compared to West-Pokot who had the least intake of those categories. White roots and tubers seemed to be consumed significantly more in Napak than the rest of the sites for booth female and child. At the same time, it also seemed that having a kitchen garden decreased the consumption of white roots and tubers and dark green leafy vegetables, for both female and child. Orange fruit seemed to be consumed most in Turkana, and least in Napak.

Tabell 2. Results from statistical analyses (using R) from the household survey. Data for intake of different fruits, vegetables, and other food items for female caretakers n=943 and young children n=554 (below 5 years, and above 25 months old). Coefficients for kitchen garden indicates, when positive: increased consumption of the vegetable category when having a kitchen garden. When negative, it indicates a decreased consumption of the vegetable category when having a kitchen garden. Coefficients for the regions indicates, when positive: the vegetable category were consumed relatively more compared to West Pokot, which was set to 0, and, when negative: vegetables were relatively less common consumed compared to West Pokot. The significance levels indicate consistence of the coefficients and if there were any significant differences between the sites or in terms of having a kitchen garden or not.

				UGANDA		**KENYA**		
		Kitchen garden		Moroto	Napak	Turkana	W-Pokot	**Site**
		Coeff	Signi	Coeff	Coeff	Coeff	Coeff	Signi
Orange vegetables & tubers	F	0.18		-1.92	-2.30	-1.88	0.00	***
	C	-0.28		-1.43	-1.81	-1.68	0.00	***
White roots & tubers	F	-0.99	***	-0.70	0.54	-1.24	0.00	***
	C	-0.98	***	-1.23	0.41	-2.00	0.00	***
Dark green Leafy vegetables	F	-0.37	*	-0.56	-0.10	-1.59	0.00	***
	C	-0.25	*	-0.13	0.27	-0.37	0.00	
Orange Fruit	F	-0.32	.	-0.42	-0.90	0.72	0.00	***
	C	0.32	**	0.83	-0.73	0.87	0.00	***
Beans & peas	F	0.32		-0.26	-1.08	1.47	0.00	***
	C	0.35	*	-0.22	-0.92	1.62	0.00	***
Grains	F	-0.24		-0.29	-0.51	2.02	0.00	***
	C	0.37	*	0.24	-0.08	2.01	0.00	***

Nuts & Seeds	F	0.10	*	4.11	3.60	0.11	0.00	***
	C	-0.09		2.34	1.82	-0.36	0.00	***
Other Vegetables	F	0.06		-0.73	-0.65	-1.70	0.00	***
	C	0.58	*	-0.63	-0.34	-1.14	0.00	*
Other Fruit	F	-0.24		-1.57	-2.00	-0.73	0.00	***
	C	0.00		-1.26	-1.53	-0.19	0.00	**
Relief food	F	0.17	*	0.61	0.41	4.79	0.00	***
	C	0.47		0.08	1.23	4.25	0.00	***
Supplementary Feeding Programme	F	0.83		0.22	0.88	3.10	0.00	***
	C	0.67		1.16	1.30	3.83	0.00	***
Worry about having enough food last 4 weeks	F	-0.30		3.06	2.33	18.93	0.00	***

3.2 Objective 2. Kitchen Garden knowledge spread

Objective two was to “understand if/how knowledge about kitchen gardens was spread from trainers of trainers to the agropastoral community in Chepareria, West Pokot County”. The data was collected through interviews and visits to the people’s homesteads, in total 24 households were visited and interviewed. The semi-structured interviews included questions about how the Tot’s built their own kitchen garden and how they had adapted the knowledge about kitchen garden farming, as well as if they had started to train other people in kitchen garden farming. Seven of the Tot’s had started their kitchen garden in 2022, and all of them were able to harvest from their kitchen gardens the same year, though they did not continue to keep their gardens after that due to moving out or rearranging the garden and fields.

Two people had started to train people in their own garden. One person had started to train others even though they did not have any half-moon-shaped kitchen garden beds in the household yet, and the training was done by drawing on the ground and explaining how to do it. Seven people had made plans to start training other people. The plans varied from rotating to work at each other's houses to showing and talking. Ten people had not started to train others or made any plans to start. None of the non-Tot’s had started to train other people by March 2023.

The number of half-moons located at the homesteads of the people interviewed varied from 0-12 half-moons (Figure 8).

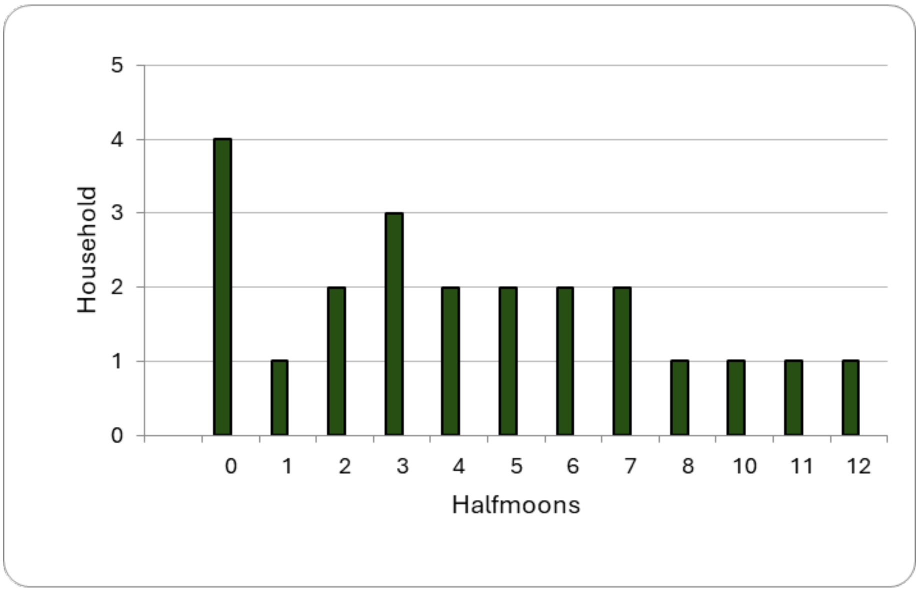

Figure 8. Numbers of households having a certain number of half-moons. Both Tot's and Non-Tot's in spring 2023 (n=20)

The filling material used in the original half-moon sunken beds that were taught on the drylands transform training were sawdust, mixture of soil and fine coarse sand from the river and manure.

In total 20 households had or planned to established half-moons (Tot’s and Non-Tot’s), and among them it was one household that had done the half-moons as the original design they learnt from the dryland transform training (Figure 9). Six of the household had replaced the sawdust with another organic material. Five household had excluded sawdust but not replaced it with other organic material, and eight household had not started to fill up the pits after digging them by the time of the interview and they did not know what to use.

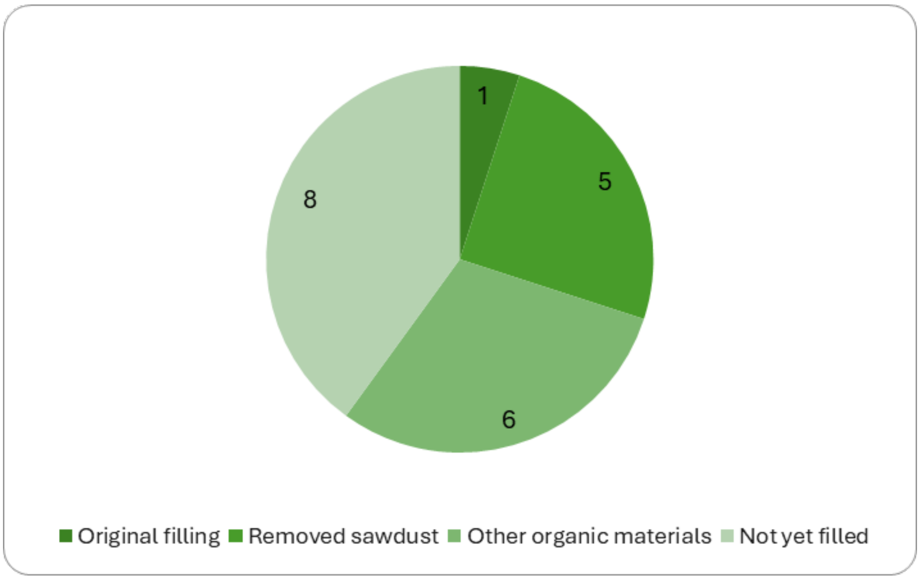

Figure 9. The filling material that had been used in the half-moons of the ToTs. The original filling is with sawdust and mixture of soil and fine coarse sand from the river and manure, one household had used those materials. Five households had used the original filling but removed sawdust. Six people had used other organic materials i.e. leaves and bark. Eight people were in the progress of digging the half-moons and had not started to fill up.

Other adaptions to the half-moon done by the people were the amount of sand, the fine coarse river sand, some had only put a small amount in, some have skipped it and some others had used sand from other places.

The fertiliser usage (manure) from the training were as a component in the soil mixture. The most common fertiliser or fertilising method today is a combination of animal manure, especially cow, goat and sheep manure. No top dressing occurred during the growth periods. The 20 households with half-moon-shaped kitchen garden beds were asked if they were open to try using human urine as a fertiliser. Eleven households with half-moons were interested in the use of urine as a fertilising method but wanted to know more about how to collect and store the urine. They also wanted to have more practise and see some results, etc., bigger harvest, before they started practising it themselves. Five of the households were willing to try using urine, three of the households did not want to answer the question, and one household said no to using human urine as a fertiliser.

3.3 Objective 3: Urine experiment

Objective 3 was to "test the effect of human urine as a fertiliser on chlorophyll content and size of leaves on green leafy vegetables in a half-moon-shaped kitchen garden in Chepareria, West Pokot County".

The different treatments, human urine watered beds and only water watered beds, used in the fertiliser experiment did not show any significant result in the chlorophyll measurements during the short duration of the experiment (Table 3).

Tabell 3. This presents the p-values (through T-tests) indicating the statistical significance of chlorophyll levels measured on each date from the result of chlorophyll content analysis using the SPAD-tool for green collard, spinach and watermelon in urine fertilised and control halfmoon shaped kitchen garden beds April and May 2023. No significant differences were found.

Vegetable	Date	p-value
Green Collard	27 April	0.43978
	31 May	0.46107
Spinach	31 May	0.29886
Watermelon	31 May	0.331181

The result from the plant size measurements did not show any significant results for green collard or spinach (Table 4). Watermelon had a significant result on the width of the leaves, and the positive correlation showed that urine had a higher mean than the control plants. The same was the case for the length of the leaves. There were no significant differences in the height of the plants.

Tabell 4. Physical size measurements (cm) of green collard, spinach and watermelon for the height of plant, length of the longest leaf and width of the longest leaf for the urine and control treatment as well as p-values comparing the same.

	Means values of size measurements (cm)	Urine	Control	p-value
Green Collard	Height	5.8733	4.9067	0.25527
	Length of the leaves	5.1667	4.5133	0.10405
	Width of the leaves	3.65	3.3867	0.47577
Spinach	Height	1.575	1.75	0.65742
	Length of the leaves	5.3167	6.375	0.39577
	Width of the leaves	3.5416	4.45	0.10142
Watermelon	Height	2.9333	5.8	0.22133
	Length of the leaves	4.9666	4.5288	0.02027 *
	Width of the leaves	2.611	1.73	0.00748 **

Observed results when harvesting was that the urine watered once were crispier when consumed as well as a harvest from the halfmoons watered with urine withstand the family for longer compared to the control watered halfmoons.

4. Discussion

4.1 Links between having a kitchen garden and the consumption of fruit and vegetables

The results on how many people had kitchen gardens and how big the gardens were showed that 43% in Uganda, and 31% in Kenya had kitchen garden. The reason to why kitchen gardens were more common in Uganda could be due to a slightly wetter climate. The larger sizes in Kenya, 20 m^2 versus 6 m^2 in Uganda, could be due to the same reason, since crops cannot be grown too close when limited by water. A possible source of error could be that no measurements of kitchen gardens were taken, the sizes were estimated by the respondents.

Comparing the results of the 24h recall questions on dietary intake by the female and the index child and the responses related to kitchen gardens showed that growing vegetables had effects on what the children and female (often mothers) ate. Children had a significantly higher intake of orange fruit, beans and peas, grains, and other vegetables for children when having a kitchen garden. Women with a kitchen garden had a significantly higher intake of nuts and seeds as well as relief food. It is not clear why women ate more relief food when having a kitchen garden. Perhaps they had more energy to go and get it.

Grains (maize, *Zea mays*; rice, *Oryza sativa*; wheat, *Triticum aestivum*; sorghum, *Sorghum bicolor*; millet, *Pennisetum glaucum*, and their products such as noodles, bread and porridge) are carbohydrates and not seen as vegetable/horticultural crops. In addition, they are most often grown at larger-scale fields than in kitchen gardens. These carbohydrate rich crops show an increased consumption among children in households with kitchen gardens. This can perhaps be because people having a kitchen garden likely also have other crop fields. Crop fields and kitchen gardens can be hard to distinguish between if you don't know what's included or not in the different terms. Especially since most people do not have large scale fields but rather small plot fields and only grow for their own consumption. The dark green leafy vegetables (sweet potato leaves, *Ipomoea batatas*; cassava leaves, *Minihot esculenta*, and pumpkin-leaves, together with the local masuku and gradnilla) decreased in consumption among both children and women having kitchen gardens. One reason to this can perhaps be that the solution in these areas when having shortage of food is to gather and eat leafy greens harvested from trees nd shrubs in the surroundings as an option, if you have other food to eat from a kitchen garden, there is no need to look for those green tree leaves.

Other vegetables (eggplant, *Solanum melongena*; okra, *Abelmoschus esculentus*; tomatoes, *Solanum lycopersicum*; cucumber, *Cucumis sativus*) show a statistically significant increase in consumption when having kitchen gardens. The reason to this might be that these are the vegetables commonly grown in kitchen gardens. Even though we do not have any specific results on how the consumption affects the people's health, the literature shows that a varied diet is relevant to get all the nutrients that the body requires and to reduce and prevent malnutrition and hidden hunger (Lowe 2021). We understand that the situation in the sites where this survey was conducted can be difficult and during periods the communities have major problems supplying the family and household with enough food. In drylands, relying on rain fed cultivation the fields and plots dries when the rain late. In addition, there are usually no fences around the field plots and grazing animals can easily be encroaching the crops.

Comparing the two Kenyan sites, households in Turkana worried significantly more of not having enough food compared to households in West Pokot. In Turkana, the majority of households worried about having enough food and of those, 35% had a kitchen garden. Of the households, who did not worry about enough food, 65% were having kitchen garden. Why they worried more in Turkana can be because of replicated years of unstable rainfall, as well as insecurity in general, with local turbulence and armed attacks. They worried the least in West-Pokot that can be because of the more developed agro-pastoral livelihood as well as the weekly market providing food continuously.

There were significant differences between the four sites for all vegetables except green leafy vegetables, probably since that is commonly eaten, only that the type of leaves can differ a lot. The four sites differ in climate, livelihood strategies, infrastructure, and other conditions that can affect the kitchen garden farming. The southern site, in Uganda, Napak, do have more widespread croplands which could be a reason to why kitchen gardens are more common in the northern part, Moroto District, were there is less croplands. People focus perhaps more on getting a harvest that serves them the whole year in the southern sites than growing a few vegetables during the wet season.

The study sites were located in two different countries, with different approaches on how to assist people in these dryland regions.

4.2 Understand the knowledge spread of kitchen gardens

The fact that water is a big problem in the area and that animals are kept free ranging affects how much time people have available to spend on taking care of their kitchen gardens and crops. Livestock entering the kitchen garden is one of the biggest problems was a concern expressed by people in the interviews. If a proper fence has not been built, this results in plants being eaten and/or destroyed by the ranging animals.

To find the people that had attended the Drylands Transform kitchen garden training was a bit tricky because some of them had only attended parts of the training. Due to the recommendation of speaking Swahili many of the people were from the same family and household. Households that had started establishing their own kitchen garden along the training did get some harvest the first year and some of the people were inspired to keep on with practising kitchen garden farming. The households that had established kitchen gardens after the training during the interview time (2023) were 16, and some of them had up to 12 half-moons already in their gardens, while others had fewer. The households that had not yet started establishing kitchen gardens were mostly occupied with caretaking of animals and others waited for the rains. They thought that the soil was too hard to dig when not wet.

The filling materials in the half-moons varied a bit and was probably depending on how far away from the river people lived since sand is heavy, and transportation is mostly by hand. The use of sawdust was low and that may depend on availability, saw dust is a by-product of cutting woods and there was no sawmill in the area. The people that used other organic materials collected that from the surroundings, such as sisal, tree leaves, bark, and other organic materials that are not consumed by the animals.

Most of the interviewed households were willing to try fertilising with urine, but only if they could see the differences first and learn if/how the new method works. People were generally interested and wanted to know more about the practice and learn how to collect the urine. Out of people that were interviewed it was only two that said that they did not want to try it. In the research by Andersson (2015), the author cited a saying from the discussion group that one of the bigger barriers of urine usage and knowledge sharing was “fear of the unknown” as well as to talk about urine, which was a taboo.

Families having kitchen gardens had difficulties in estimating how much vegetables they ate, and it could be because they had not harvested anything yet or it can be a definition problem, of what is seen as a vegetable/horticultural crop if they interpreted vegetables as everything that grows.

The knowledge and skills spread in this study showed that people were not yet willing to teach other people about a method that they had not yet tried themselves. If this is because of uncertainty of doing wrong and failing or something else is something not included in this report, but it is certainly interesting. Further studies are needed to understand this better. The time in the field for this study was not enough to clearly see how knowledge spread beyond the Tot's. Continued studies can follow this up and see the potential in the ToT concept.

The interests of learning were great, even though it was sometimes hard to find people that were willing to work and help with the assembly of the garden. Many people showed up to the few workshops that were held to inspire people and curiosity of people also made them come to check out the kitchen garden.

4.3 Urine as a fertiliser on green leafy vegetables

The results from the urine experiment did not show many significant results when comparing the urine fertilised treatment with the control only receiving water. Leave chlorophyll measurements did not show significant differences. However, watermelon leaves were significantly longer and wider when fertilised with urine. The reason to why there were no other clear significances can have been several. Stress factors such as drought, too much or too little nutrients (Raghuram & Jangam 2015) and the prevalence of weeds are some of the biggest factors that can explain the outcome (Sharma *et al.*, 2021). Other factors that may contributed to the lack of significant affects can be the timing of the measurements and data collection. The plants were still quite small, and the development of the plants may not have had enough time to show any differences yet. Many of the plants were too small to put the SPAD tool on the leaves. The majority of the measurements were done by the team when the farmer took care of the garden, and therefore there is a risk that the sampling procedure was not carried out in the same way.

The reasons for significant results for watermelon could be because of the seeds' physical characteristics, such as the fact that the seed and sprout are larger and therefore can absorb more water and nutrients and can thus perhaps be the dominant plant against the weeds (Wang et al. 2021). The limited time in field after the onset of the rain made it difficult to follow the development and growth of the plants and to carry out replicate measurements during growth as well as to collect measurements at harvest.

5. Conclusion

The kitchen garden seemed to contribute to reduce the worry about not having enough food and the children seemed to benefit more from the kitchen gardens compared to the female.

The consumption of orange fruit, beans and peas, grains and other vegetables was significantly higher for children living in a household having a kitchen garden compared to those not having. For female the result showed that the consumption of nuts and seed was higher as well as the consumption of relief food. Both child and female ate fewer white roots and tubers and green leafy vegetables when having a kitchen garden. To do comparisons between the four areas in the Karamoja cluster may not be relevant due to their differences in lifestyles, climate and eating habits though it was a lot more people in Turkana that were worrying about not having food compared to the other sites.

The kitchen garden farming in West Pokot (Chepareria) showed that the local community had taken knowledge of the practice and household had started their kitchen gardens at home. From the 20 households that were visited during the study, 16 household had started their own kitchen gardens at their households. Some people had chosen to go from the original design and used other materials due to resource availability. The time for the study was too short to see the spread of knowledge further since they wanted to try the kitchen garden farming themselves before teaching and recommending it to others.

The experiment of testing human urine as a fertiliser showed only one clear positive effect on watermelon leaf in the urine treatment. This could be due to challenges with rainfall and too short time to finalize the experiment. The community members were positive about trying human urine as a fertiliser, as most of the people were willing to try the method, but it was important for them to see the experiment first. The knowledge and learning of fertiliser methods can and should be applied together with the sharing of kitchen garden practise, and as we can see from the interview part of the study that the community are already adapting the practice of half-moon shaped kitchen garden beds and are designing and adapting them to the abilities and opportunities they have.

6. Recommendations

Promotion of the kitchen garden technologies are important and have potential to reduce the worries of not having enough food, especially in Turkana County.

Human urine has a high potential in these areas of limited resources; however, it is important to have more experiments and trainings for people to see with their own eyes what the effects are before they consider practising the technique.

More time and resources are needed to follow up the knowledge spread from the ToT training and the results of the urine fertilisation experiment.

References

24-hour Dietary Recall (24HR) At a Glance | Dietary Assessment Primer (2024). https://dietassessmentprimer.cancer.gov/profiles/recall/ [2024-06-18]

AdeOluwa, O.O. & Cofie, O. (2012). Urine as an alternative fertilizer in agriculture: Effects in amaranths (Amaranthus caudatus) production. *Renewable Agriculture and Food Systems*, 27 (4), 287–294. https://doi.org/10.1017/S1742170511000512

Andersson, E. (2015). Turning waste into value: using human urine to enrich soils for sustainable food production in Uganda. *Journal of Cleaner Production*, 96, 290–298. https://doi.org/10.1016/j.jclepro.2014.01.070

Anno, E. & Ameripus, M. (2022). Effects of Internal and Cross-Border Resource-Based Conflicts on Livestock Market Performance in Pastoral Areas of Karamoja, Uganda, and Turkana, Kenya. *American Journal of Environmental and Resource Economics*, 7, 87–96. https://doi.org/10.11648/j.ajere.20220703.14

Bernard Ronald, Dulle, F. & Mtega, W. (2013). Understanding the knowledge sharing process among rural communities in Tanzania: A review of selected studies. *Knowledge Management & E-Learning: An International Journal*, 205–217. https://doi.org/10.34105/j.kmel.2013.05.014

Berrahmouni, N. & Parfondry, M. (2015). *Global guidelines for the restoration of degraded forests and landscapes in drylands - Building resilience and benefiting livelihoods*.

Biesalski, H.K. (2013). First International Conference on Hidden Hunger, Hohenheim, Stuttgart, Germany March 6 – 9, 2013. *Food Security*, 5 (3), 457–473. https://doi.org/10.1007/s12571-013-0267-7

Chepareria topographic map, elevation, terrain (2023). *Topographic maps*. https://en-gb.topographic-map.com/map-pnc14/Chepareria/ [2023-05-24]

Dong, S. (2016). Overview: Pastoralism in the World. I: Dong, S., Kassam, K.-A.S., Tourrand, J.F., & Boone, R.B. (red.) *Building Resilience of Human-Natural Systems of Pastoralism in the Developing World: Interdisciplinary Perspectives*. Springer International Publishing. 1–37. https://doi.org/10.1007/978-3-319-30732-9_1

Drylands Transform (2021). *2021*, 8

FAO (red.) (2009). *Livestock in the balance*. FAO. (The state of food and agriculture; 2009)

Goal 2: Zero Hunger (2020). *The Global Goals*. https://globalgoals.org/goals/2-zero-hunger/ [2023-10-11]

Goldstein, J. (2012). *Waste. The Oxford Handbook of the History of Consumption*. 2012. https://academic.oup.com/edited-volume/28183/chapter-abstract/213085898?redirectedFrom=fulltext [2024-03-07]

Groce, N., Challenger, E., Berman-Bieler, R., Farkas, A., Yilmaz, N., Schultink, W., Clark, D., Kaplan, C. & Kerac, M. (2014). Malnutrition and disability: unexplored opportunities for collaboration. *Paediatrics and*

International Child Health, 34 (4), 308–314. https://doi.org/10.1179/2046905514Y.0000000156
Hanson, J.W., Streissguth, A.P. & Smith, D.W. (1978). The effects of moderate alcohol consumption during pregnancy on fetal growth and morphogenesis. *The Journal of Pediatrics*, 92 (3), 457–460. https://doi.org/10.1016/S0022-3476(78)80449-1
Heinonen-Tanski, H. & van Wijk-Sijbesma, C. (2005). Human excreta for plant production. *Bioresource Technology*, 96 (4), 403–411. https://doi.org/10.1016/j.biortech.2003.10.036
Huang, J., Yu, H., Guan, X., Wang, G. & Guo, R. (2016). Accelerated dryland expansion under climate change. *Nature Climate Change*, 6 (2), 166–171. https://doi.org/10.1038/nclimate2837
Infant and young child feeding (2023). https://www.who.int/news-room/fact-sheets/detail/infant-and-young-child-feeding [2024-03-08]
IPC Global Platform (2022). https://www.ipcinfo.org/ipcinfo-website/alerts-archive/issue-47/en/ [2022-03-15]
IPC Global Platform (2023). . https://reliefweb.int/report/kenya/kenya-ipc-acute-food-insecurity-and-acute-malnutrition-analysis-february-june-2023-published-20-february-2023
Jönsson, H., Stintzing, A.R., Vinnerås, B. & Salomon, E. (2004). *Guidelines on the Use of Urine and Faeces in Crop Production*. (2). Stockholm Environment Institute.
Kenya – Geografi och klimat (2020). https://www.ui.se/landguiden/lander-och-omraden/afrika/kenya/geografi-och-klimat/ [2022-03-15]
Kenya: country data and statistics (2022). *Worlddata.info*. https://www.worlddata.info/africa/kenya/index.php [2023-02-13]
Levine, S. (2010). A food security analysis of Karamoja. *2010*,
Lowe, N.M. (2021). The global challenge of hidden hunger: perspectives from the field. *Proceedings of the Nutrition Society*, 80 (3), 283–289. https://doi.org/10.1017/S0029665121000902
Muggaga, C., Okello-Uma, I., Kaaya, A.N., Taylor, D., Ongeng, D. & Basil, M. (2023). Dietary intake and socio-economic predictors of inadequate energy and nutrient intake among women of childbearing age in Karamoja sub-region of Uganda. *Journal of Health, Population and Nutrition*, 42 (1), 12. https://doi.org/10.1186/s41043-023-00351-z
Mureithi, S. (2024). *Baseline and Follow-up Surveys Report: Pathways and Challenges towards a Transformation of Landscapes, Livestock and Livelihoods in Karamoja border region of Kenya and Uganda*. (Drylands Transform Research Project)
Murphy, L.L. (2008). AIDS and kitchen gardens: insights from a village in Western Kenya. *Population and Environment*, 29 (3), 133–161. https://doi.org/10.1007/s11111-008-0065-x
Nakalembe, C., Dempewolf, J. & Justice, C. (2017). Agricultural land use change in Karamoja Region, Uganda. *Land Use Policy*, 62, 2–12. https://doi.org/10.1016/j.landusepol.2016.11.029
Nyaga, M., Mureithi, S., Mwangi, A., Wegesa, J., Kawira, C., Letting, M. & Makokha, W. (2022). *Field Report: Training on Kitchen Gardening and Regenerative Agriculture at the Livestock Café site in Chepareria Ward, West Pokot County*
Nyberg, G., Knutsson, P., Ostwald, M., Öborn, I., Wredle, E., Otieno, D.J., Mureithi, S., Mwangi, P., Said, M.Y., Jirström, M., Grönvall, A., Wernersson, J., Svanlund, S., Saxer, L., Geutjes, L., Karmebäck, V., Wairore, J.N., Wambui, R., De Leeuw, J. & Malmer, A. (2015). Enclosures in West Pokot, Kenya: Transforming land, livestock and

livelihoods in drylands. *Pastoralism*, 5 (1), 25. https://doi.org/10.1186/s13570-015-0044-7

R Core Team (2023). *R: A language and environment for statistical computing* [R Foundation for Statistical Computing]. https://www.R-project.org/

Raghuram, N. & Jangam, A. (2015). *Nitrogen and Stress | SpringerLink*. https://link.springer.com/chapter/10.1007/978-1-4939-2540-7_12 [2024-03-12]

Richert, A., Gensch, R., Jönsson, H., Stenström, T.-A. & Dagerskog, L. (2010). *Practical Guidance on the Use of Urine in Crop Production*. Stockholm Environment Institute.

Sarigul, N., Korkmaz, F. & Kurultak, İ. (2019). A New Artificial Urine Protocol to Better Imitate Human Urine. *Scientific Reports*, 9, 20159. https://doi.org/10.1038/s41598-019-56693-4

Schreinemachers, P., Patalagsa, M.A., Islam, Md.R., Uddin, Md.N., Ahmad, S., Biswas, S.C., Ahmed, Md.T., Yang, R.-Y., Hanson, P., Begum, S. & Takagi, C. (2015). The effect of women's home gardens on vegetable production and consumption in Bangladesh. *Food Security*, 7 (1), 97–107. https://doi.org/10.1007/s12571-014-0408-7

Schönning, C. (2002). EVALUATION OF MICROBIAL HEALTH RISKS ASSOCIATED WITH THE REUSE OF SOURCE-SEPARATED HUMAN URINE.

Semalulu, O., Azuba, M., Makhosi, P. & Lwasa, S. (2011). Potential for Reuse of Human Urine in Peri-urban Farming. Bationo, A., Waswa, B., Okeyo, J.M., Maina, F., & Kihara, J.M. (red.), Dordrecht, 2011. 651–660. Springer Netherlands. https://doi.org/10.1007/978-90-481-2543-2_66

Sharma, G., Barney, J.N., Westwood, J.H. & Haak, D.C. (2021). Into the weeds: new insights in plant stress. *Trends in Plant Science*, 26 (10), 1050–1060. https://doi.org/10.1016/j.tplants.2021.06.003

Stanley, M. & Prof Siraje, K. (2020). *Effect of Human Urine as a Fertilizer for Vegetable Growing in Kitemu Zone, Wakiso District, Uganda*.

Thapa, S. & Stewart, B. (2016). Dryland Farming: Concept, Origin and Brief History. 3–29.

UNFPA. Leaving no one behind in Karamoja (2018). https://uganda.unfpa.org/sites/default/files/pub-pdf/Issue%20Brief%207.%20Leaving%20no%20one%20behind%20in%20Karamoja.pdf

Waithaka, M.M., Thornton, P.K., Shepherd, K.D. & Ndiwa, N.N. (2007). Factors affecting the use of fertilizers and manure by smallholders: the case of Vihiga, western Kenya. *Nutrient Cycling in Agroecosystems*, 78 (3), 211–224. https://doi.org/10.1007/s10705-006-9087-x

Wang, Y., Wang, J., Guo, S., Tian, S., Zhang, J., Ren, Y., Li, M., Gong, G., Zhang, H. & Xu, Y. (2021). CRISPR/Cas9-mediated mutagenesis of ClBG1 decreased seed size and promoted seed germination in watermelon. *Horticulture Research*, 8, 70. https://doi.org/10.1038/s41438-021-00506-1

West Pokot, KE Climate Zone, Monthly Weather Averages and Historical Data (2022). https://tcktcktck.org/kenya/west-pokot [2023-05-24]

Winblad, U. (2004). *Ecological Sanitation*. EcoSanRes Programme.

Wohlsager, S., Clemens, J., Nguyet, P., Rechenburg, A. & Arnold, U. (2010). Urine - A Valuable Fertilizer with Low Risk after Storage in the Tropics. *Water environment research : a research publication of the Water Environment Federation*, 82, 840–7. https://doi.org/10.2307/27870384

World Bank Climate Change Knowledge Portal (2021). https://climateknowledgeportal.worldbank.org/ [2022-03-15]

Xiong, D., Chen, J., Yu, T., Gao, W., Ling, X., Li, Y., Peng, S. & Huang, J. (2015). SPAD-based leaf nitrogen estimation is impacted by environmental factors and crop leaf characteristics. *Scientific Reports*, 5, 13389. https://doi.org/10.1038/srep13389

Kunskapsspridning om betydelsen av köksträdgårdar i Kenyas torrområden -inklusive ett gödningsexperiment med humanurin

Torrmarksområden täcker nästan hälften av jordens landyta och är hem till en tredjedel av världens befolkning (2 miljoner människor). Fattigdom, matosäkerhet som utlöses av markförstöring och instabilt klimat är inte ovanligt och leder till undernäring och andra hälsoriskfaktorer bland befolkningen och djuren. Populationer som lever i torrmarksområden har länge sysselsatt sig som boskapsskötare (pastoralister), men med ökad befolkningsmängd, konflikter och ett mer intensivt jordbruk har allt fler människor behövt hitta alternativ till traditionella levnadsätt och försörjningsmöjligheter.

Stora delar av befolkningen i dessa områden upplever undernäring baserat på bristande variation i kosten, jordbruket är fokuserat på basvaror som till exempel durra, hirs, solrosor och majs. Perioder med torka och översvämningar stör dock fälten mer än vad de borde på grund av jordarnas instabila egenskaper som kommer av monokultur och hård betning av djuren.

I uppsatsen redovisas en undersökning om köksträdgårdar kan bidra till en kost som gav en större bredd i näringsintag genom att konsumera fler olika typer av grönsaker, samt om oron över att inte ha tillgång till mat minskas av att ha en köksträdgård. Vidare så har jag undersökt utvecklingen och spridningen av köksträdgårdsodling och design efter en kurs som lokal befolkningen i Chepareria kunde delta i. Baserat på denna kurs i att anlägga och sköta en köksträdgård gjordes ett uringödslingsförsök, bevattning med vad som på svenska kallas guldvatten.

Resultaten visade på en minskad oro för de hushåll som hade en köksträdgård. För de människor som deltagit i kursen om köksträdgårdsodling fanns ett utbrett användande, dock fanns inte tiden till för att undersöka hur kunskapen spred sig vidare från dessa personer. Tiden för uringödsling försöket var även den lite kort pga att regnperioden startade senare än beräknat. Vattenmelon var den grönsak som visade att metoden kan ge ett näringstillskott till växterna.

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Appendix 1

Base for the Semi-structured interviews.

Name?
Gener?
Village?
What is a kitchen garden for you?
Trained by the drylands transform team?
Started a kitchen garden at home?
Numbers of halfmoons 2022?
Numbers of halfmoons 2023?
Total amount of halfmoons?
Material used to fill the sunken beds in the halfmoons?
What did you plant in the halfmoons?
What was the hardest with building/digging the halfmoons?
What worked better than you thought?
Improve for next season?
Do you eat more vegetables when you can provide it for yourself?
Did you get any surplus? What do you do with the residue?
What do you fertilize with?
Are you willing to try to fertilize with Goldwater?
How many people have you train?
Plan to train people?

Appendix 2

The 24h Recall questions

- Any vegetables or roots that are orange-coloured inside (like sweet potato, pumpkin, carrot and orange maize)
- Any white roots and tubers or plantains/bananas (like Irish potatoes, yams, cassava, white fleshed sweet potato)
- Any dark green leafy vegetables (sweet potato leaves, cassava leaves, Rape, Amaranth, pumpkin leaves, masuku, gradanilla and yellow peaches)
- Any beans and peas (fresh or dried beans, soybean, lentils)
- Any foods made from grains (like maize, rice, wheat, sorghum, millet, noodles, bread, porridge)
- Any nuts or seeds (groundnuts, whole or "butter" sunflower seeds)
- Any other vegetables (Eggplant, Okra, Tomatoes, Cucumber)
- Any other fruits (avocado, pineapple, chipwete, guava, masau, malambe, bwemba, jambalua, white peaches, strawberries, and coconut)
- Any fruits that are dark yellow or orange inside (ripe mango, ripe papaya, passion fruit)
- Relief food (free of charge, provided by government or other organisations)
- Foods from supplementary programme (WHO/UNICEF/WFP) for undernourished children

R-Result in written form

Orange vegetables and tubers
Female: Positive coefficient of 0.18 in Moroto and Napak. Not statistically significant.
Child: Negative coefficient of -0.28 In Moroto and Napak. Statistically significant ***. Indicates an decrease in consumption of orange vegetables and tubers.

White roots and tubers:
Female: Negative coefficient of -0.99. Statistically significant ***. Indicates an decrease in consumption of white root and tubers.
Child: Negative coefficient of -0.98. statistically significant *** indicates an decrease in consumption of white roots and tubers.

Dark green leafy vegetables
Female: Negative coefficient of -0.37. Statistically significant *, indicate a small decrease in consumption of dark green leafy vegetables.
Child: Negative coefficient of -0.25. statistically significant *. indicate a small decrease in consumption of green leafy vegetables.

Orange fruit
female: Negative coefficient of -0.32, But is not statistically significant. (.)
Child: Positive coefficient of 0.32, statistically significance of **, indicate an increase in consumption of orange fruit.

Other vegetables
Female: Positive coefficient of 0.06, not statistically significant
Child: Positive coefficient of 0.58. Statistically significant, indicates an increase in consumption of other vegetables.

Other fruit
Female: negative coefficient -0.28. Not statistically significant.
Child: Coefficient of 0.00, and is statistically significant

Beans and peas
Female: Positive coefficient 0.32. Not Statisticallt significans. Increased consumption of beans and peas.
Child: Positive coefficient of 0.35. Statistically significant * increased consumption of beans and peas.

Grains
Female: Negative coefficient of -0.24. Not statistically significant.
Child: Positive coefficient of 0.37. Statistically significant, indicates an increase of consumption of grains.

Nuts and Seed
Female: positive coefficient of 0.10. Statistically significant *.

Child: Negative coefficient of -0.09. Not statistically significant.

Location (study sites) and intake of the different vegetables

Orange vegetables and tubers
Female: negative coefficients on all sites. There is a significant of ***
Child: negative coefficients on all sites. There is a significant of *** indicates a decrease in consumption.

White roots and tubers
Female: Negative coefficients on Moroto and turkana, positive in Napak, Statistically significance of ***
Child: Negative coefficients on Moroto and turkana, positive in Napak, Statistically significance of ***

Dark green leafy vegetables:
Female: Negative coefficient on the sites, statistically significance of ***
Child; Negative coefficients on Moroto and Turkana, positive in Napak, not statistically significant**.**

Orange fruit:
Female: Negative coefficients on the sites Moroto and Napak, and positive coefficients on turkana, statistically significant of ***
Child: Negative coefficients on Napak and positive in Moroto and turkana, statistically significance of ***

Beans and peas
Female: Negative coefficients on the sites Moroto and Napak, and positive coefficients on turkana, statistically significant of ***
Child: Negative coefficients on the sites Moroto and Napak, and positive coefficients on turkana, statistically significant of ***

Grains
Female: Negative coefficients on the sites Moroto and Napak, and positive coefficients on turkana, statistically significant of ***
Child: Negative coefficients in Napak and positive in Moroto and turkana statistically significance of ***

Nuts and seeds
Female: Coefficients positive in all sites. statistically significance of ***
Child Negative coefficient in Turkana, Moroto and Napak positive. Statistically significant of ***

Other vegetables
Female: Negative coefficients in all sites. Statistically significance of ***
Child: Negative coefficients in all sites. Statistically significance of *

Other fruits

Female: Negative coefficients in all sites. Statistically significance of ***
Child: Negative coefficients in all sites. Statistically significance of **

Relief food
Female: positive coefficients on all sites, statistically significance of ***
Child: positive coefficients on all sites, statistically significance of ***

Supplementary feeding programme
Female: positive coefficients on all sites, statistically significance of ***
Child: positive coefficients on all sites, statistically significance of ***

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