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THE IMPORTANCE OF ECOSYSTEM SERVICES OF TREES IN SMALL FARMS OF BUIKWE DISTRICT (UGANDA).

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Ecosystem Services (ESs) are considered as those benefits from the ecosystems that provide wellbeing to humans. In the case of trees, they must be considered as ESs provided that they are recognized as key features of more sustainable agroecosystems. Despite the fact of its importance, the strategic management of tree attributes for ecosystem service provision is still not very well known. This management requires understanding about which tree species, not only natives, could provide a service and how to manage them in different contexts. For this, is relevant the interrelations each other and between them and the crops to avoid the negative effect of the competition for light, water and nutrients. Agriculture in Uganda accounts for 70% of employment, most of them are small farms and they correspond to one-quarter of GDP in the country. Therefore, it must be considered an essential sector for economic growth. This paper is about the study of models farming in Buikwe (Uganda), as an objective of a cooperation project. A group of 15 farmers are taking part; their small farms and the relationships with the environment are being observed. The focus is on the relevant role of trees.

Keywords: Ecosystem services; agroforestry; trees, farming.

LA IMPORTANCIA DE LOS SERVICIOS ECOSISTÉMICOS DE LOS ÁRBOLES EN LAS PEQUEÑAS FINCAS DEL DISTRITO DE BUIKWE (UGANDA).

Los Servicios Ecosistémicos (SE) son los que, proporcionados por los ecosistemas, brindan bienestar a los humanos. En el caso de los árboles, se consideran SE cuando proporcionan características clave en agroecosistemas sostenibles. A pesar de su importancia, la gestión estratégica de los beneficios proporcionados por los árboles entendidos como servicios ecosistémicos, aún no es muy conocida. Esta gestón requiere comprender qué especies de árboles, no solo los nativos, podrían ofrecer un servicio y cómo manejarlos en diferentes contextos. Para ello es fundamental conocer las interrelaciones entre ellos y los cultivos para evitar el efecto negativo de la competencia por la luz, el agua y los nutrientes. La agricultura en Uganda representa el 70% del empleo, la mayoría son pequeñas explotaciones y corresponden a una cuarta parte del PIB del país. Por tanto, debe considerarse un sector fundamental para el crecimiento económico. Este artículo trata sobre los modelos de agricultura en el distrito de Buikwe (Uganda), como objetivo de un proyecto de cooperación. En él participa un grupo de 15 agricultores; que se han prestado para que sus huertos sean estudiados, así como la relación con el medio ambiente. La atención se centra en el papel relevante de los árboles.

Palabras claves: Servicios ecosistémicos; agroforestería; agricultura.

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1. Introduction

Uganda has had over time very favourable conditions for the production of a wide variety of crops and livestock. However, now it has to face some challenges due to the depletion of resources and the climate change that cause the decrease of production. This context, together with the environmental degradation, the lack of skills and knowledge and the shortage of quality livestock get stuck the farmers in a level of poverty difficult to escape from.

For this reason, it is important to work on increasing the resilience of agroecological systems turning them into some sustainable and respectful ones with the environment.

This work takes part in a cooperation project in collaboration with a Ugandan NGO, in which small farms are been studied with the goal to improve productivity. The features are been studied are the soil, the quality of material, the traditional crop cycles and the effect of trees.

This paper is specifically focused on describing the presence of trees in a group of small farms, analysing the knowledge the farmers have about its importance with the final objective to promote their use to increase the resilience of the agrosystems and to mitigate the impact of climate change.

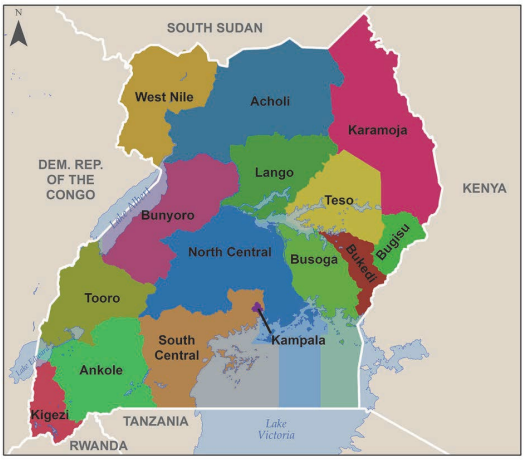
It is proposed the concept of Trees Ecosystem Services (TESs) in order to value, emphasize and disseminate the importance of trees in agroecological systems. The Ecosystem Services approach appeared in the 1980s and despite there is no exact definition of that, they can be considered as those benefits from the ecosystems that provide wellbeing to humans.

It is worth mentioning that, despite the clear benefits that trees provide, the strategic management of tree attributes for ecosystem service provision is poorly understood. This management requires understanding about which tree species to include and how to manage them for different contexts, and also to know-how trees interact with the crops in order to avoid the negative effect of the competition for light, water and nutrients.

1.1. Uganda

Uganda is a landlocked country in Eastern Africa located at the equator. It has an area of over 240.00 km^2; the cultivated area is over 40%, 17% inland water, 11% is covered by swamp and 12% of forest (it was 24 % in 1990) and the remaining is mainly grassland.

Figure 1: Uganda Districts Map.



Source: Uganda Bureau of Statistics.

The country borders are South Sudan to the north, Kenya to the east, Tanzania and Rwanda to the south and the Democratic Republic of the Congo to the west.

The country can be subdivided into two major agro-ecological systems: the highly productive area referred to as the 'tall grass zone' of the south and southwest in the Lake Victoria crescent, associated with bimodal rainfall and perennial cropping; areas classified as difficult—the 'short–grass zone' where only annual crops may be cultivated (FAO, 2014).

1.2. Climate

Uganda has a warm tropical equatorial climate with small regional variations in annual temperature and humidity. Rainfall varies from 750 mm/year from the north to 1500mm/year. There are two rainy seasons in March-May and August-November without any pronounced dry season in between. Seasonal variability of precipitation causes specific problems as the country encompasses both humid and semi-arid areas. There are variations in the timing of the onset of seasons and in the amount of rainfall over the years.

The main annual temperature over most of the country is in the range of 18 °C to 35 °C, while the corresponding minimum range is 8° C to 23 °C.

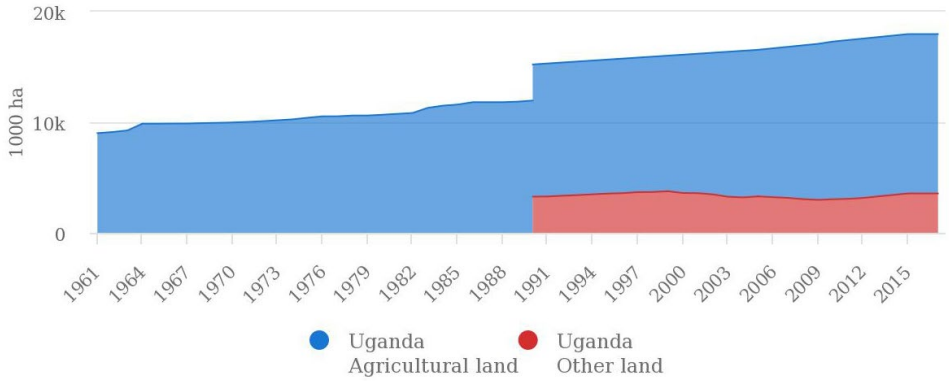
Relative humidity is high, ranging between 70 % and 100 % and the main monthly evaporation rates are between 125 and 200 mm (FAO, 2014).

1.3. Agriculture in Uganda

Agriculture accounts for 70% of employment, most of them are small farms and they corresponds to one-quarter of GDP in Uganda. 77% of people are women and 63% are young people (FAO, NPA, 2015). It should be considered a key sector for economic growth. The soils are generally fertile and the regular rainfall offers a huge agricultural potential.

The country covers a surface area of 241.550 Km^2, with more of 80 % of it, suitable for agriculture (FAO, 2018).

Figure 2: Uganda Land Use 1961-2017. FAOSTAT



Despite favourable natural resources for the production National agricultural output has grown at only the 2% per annum, between 2013 and 2018, when it was expected to the 3.3% as in similar countries (World Bank, 2018).

Most probably the effect of pests and climate change have played a harmful role; other possible explanations are the inability of the public institutions for promoting agricultural productivity at the level of small farms and an inefficient policy in agricultural public expenditures.

In addition, the lack of knowledge is a gap for the companies willing to sell the agrochemical products and all of this contributes to the land and water degradation in the absence of adequate on-farm investments.

1.4. Problems of agriculture in Uganda

Uganda based main industry in agriculture. In the colony times, new crops such as maize, wheat, tea and coffee were introduced. African farmers followed the new guidelines in the first half of the 19th century thinking that it was progressing and consequently, leaving aside the indigenous practices. Only in the second half of the 19th century, they experienced some improvements.

Currently, the low level of farmer's education results often in ineffective agricultural practices. The lack of modernisation, the old farming tools and the inefficient transport to distribute the products create a non-easy scenery for the farmers.

Due to the good production results in the past, and the small size of farms, the people didn't feel the need to establish themselves in networks, like it has been happening in South America, and most of them have been working isolated. Moreover, lack of knowledge promoted that the local people have been employed in bigger farms with very low salaries, suffering the difficulty to get loans for their own businesses.

At this moment, can be said the modernization of Uganda agriculture requires a change to increase the allocation of resources to enhance small-scale farming, agricultural research and training of farmers in new production methods environmentally sustainable.

1.5. The importance of Agroforestry

The combination of trees and agriculture is an ancient practice that farmers have practised over the ages and around the world. King, in the History of the Agroforestry (1987) explained that in Europe, until the Middle Ages, it was the general custom to clear the degraded forest, burn the remains, cultivate food crops in rotations on the cleared area and plant or sow trees before, along with, or after sowing agricultural crops. This farming system is no longer popular in Europe, which moved into intensive farming in the last decades, but it was widely practised in Finland in the last century and in Germany up to the 1920s.

In tropical America farmers have simulated forest conditions to obtain the beneficial effects of the forest ecosystem using the same structure with big trees (papaya), medium plants (banana trees, citrus), small plants (coffee, cacao) and cover plants (pumpkin). There has been a lot of examples in the past, however, the ultimate objective of these practices was not tree production but food production.

Agroforestry was formally outlined in the early 20th century by the American economic geographer J. Russell Smith in his book “Tree Crops: A Permanent Agriculture” (1929). Smith proposed the use of trees as a solution to decrease the erosion of sloping lands. However, his contributions were not considered during the Green Revolution of the 1960s and the subsequent intensive farming systems development approach of the early 1970s. Those endeavours failed to take into consideration the needs of small-scale resource-limited farmers in the tropical areas, such as timber and non-timber products derived from trees, including food, fuel, fodder, building materials, medicine and income, as well as the ecosystem sustainability that trees maintain.

Products got from the trees include fuelwood, livestock fodder, food, fruit, poles, timber and medicines.

Agroforestry services include erosion control, soil fertility replenishment, improved nutrient and hydrological cycles, boundary delineation and additionally, poverty reduction as well as enhanced food security, household nutrition, watershed stability, biodiversity, and carbon print control (Sánchez, 2000).

Figure 3. Above Agroforestry farm.
Below Nursery in a farm with very low presence of trees

The concept of Tree Ecosystem Services reinforces and more clearly identifies the benefits of trees that are already defined in agroforestry. In the case of small farms in tropical countries, it acquires great relevance since they contribute to the improvement of the qualities of the environment, which in the long-run has an effect on an improvement in production.

2. Methodology

The main goal of the project of which this paper is part is to promote sustainable practices of the small family lands and to improve productivity. For that are being studied the agrosystems and encouraging to establish a network of collaborators to disseminate good practices and share their knowledge.

The Local NGO, Kitega CC, takes a relevant role in order to gather farmers, facilitating the network of contacts, as well as the translation that has been necessary most of the time, to make possible the communication with the farmers.

A total of 17 farmers are involved in an initial group, that will be responsible for the transmit the knowledge to the rest of the community. There is an engagement to transmit from this community to others 19 that are all under a bigger community project.

The methodology is based on meetings, visits and interviews with farmers in the area of Kitega that are offering the farms to study and recognize the models of family agriculture as well as the interaction between environment and crops. Due to pandemic context monitoring is taking

place thanks to ICT with the collaboration of the local team who is organizing meetings and regular visit to the farmers and reporting regularly through forms, WhatsApp's messages, video calls and emails.

To get the information of the farms, a model of the survey has been defined and staff from the NGO have been trained to make interviews with the farmers. The survey collects information regarding the crops and their problems, products that farms apply, agricultural practices, and regarding this paper the inventory of trees and specific questioner about what the farmers know about them.

This work is based on a recent study showed that Ugandan farmers recognized the importance of trees when identifying Ecosystem Services (Bukomeko, 2019). Some of the most multipurpose trees identified by the farmers were: *Albizia coriaria, Ficus natalensis*, and the less: *Annona muricata*, and *Grevillea robusta* for the coffee plantations.

However, the lack of enough researches doesn't allow to evaluate how the contribution of the ecosystem services derived from forests to agricultural systems is, but it is possible to affirm that there is a contribution of trees to food production at the farm-scale and that with the appropriate and contextualized natural resource management strategy, yields can be maintained or enhanced comparable to intensive monoculture.

Further evidence is required in order to illustrate the potential local social and environmental benefits that can be achieved through both conserving trees within the landscape and incorporating them within food production systems (Reed, 2017) and these pieces of evidence can be got by sharing the knowledge with the farmers, as one of the principles of the agroecology.

The following list represents the Tree Ecosystem Services based on Bukomeko proposal provided by the main species that were found in the gardens of the interviewed. ES's are many, but these are a good representation in the context of this project.

- Leaf litter provision: trees that drop a lot of litter contribute to increasing the organic matter.
- Firewood provision: some trees provide better firewood.
- Food provision: some trees have edible parts.
- Tree growth rate: some trees grow faster.
- Medicinal: many trees have medicinal properties, and this knowledge is transmitted with the generations.
- Tree leaf decomposition: some tree-leaves decompose fast that also contributes to the organic matter.
- Provision of quality shade: some trees have better shade for crops that grow better on the shadow.
- Soil moisture: the influence of trees preserves the moisture of the soil by providing shade and creating natural mulching with leaves.
- Temperature: The effect of the trees allows mitigating the effect of the temperature, both high and low.
- Timber provision: some trees provide better timber.
- Weeds control: some trees suppress weed growth.
- Yield increase: some trees are associated with increased crops yield.

The interview questionnaire that has been used with the farmers to know more about the way they cultivate includes the following inquiries related to trees:

- Estimated number of trees.
- Estimated surface covered by trees.
- Estimated number of each species of trees.
- Type of species of trees on the farms.
- Main function of trees for the interviewed.

3. Results

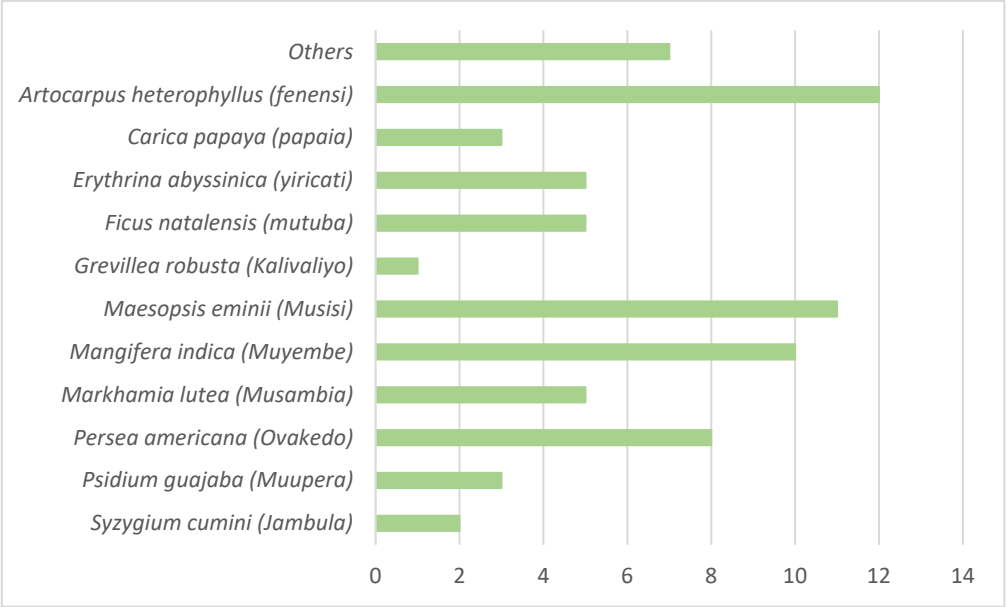
The trees that have been observed in the area provide the Ecosystem Services of the following table:

Figure 4. Ecosystem Services (ESs) of the trees observed in the community

	Litter provision	Firewood	Food	Growth rate	Medicinal	Leaf decomposition	Shade Quality	Soil moisture	Temperature	Timber	Weed control	Yield
*Albizzia coriaria**												
*Artocarpus heterophyllus***												
*Carica papaya***												
*Combretum collinum**												
*Erythrina abyssinica**												
*Eucaliptus sp.****												
*Ficus natalensis**												
*Grevillea robusta****												
*Maesopsis eminii**												
*Mangifera indica***												
*Markhamia lutea**												
*Persea americana***												
*Psidium guajaba***												
*Syzygium cumini***												

*Indigenous tree
**Naturalized tree
***Exotic tree

Figure 5. Presence of main species of trees in the farms (Latin name/local name)



To the question about the tree's function, the answers of the farmers were:

Table 1.

Trees functions	
Shade	6
Firewood	3
Fruits (food)	5
Medicine	1
Fencing	1
Wind protection	2
Fertility	1

The results of the interviews with the farmers concerning ecosystem services can be summarized that farmers understand that trees are important but not with all the potential and services they can provide. Of the twelve ESs that trees provide in this context, they have only been able to identify seven.

It should be noted how they do not perceive the value with the improvement of the soil in terms of structure and contribution of organic matter, provided by the decomposing leaves and litter. Very few of them can value the protection that trees offer from harsh weather conditions. In fact, only one of them insisted on the importance of trees for his crops in sense of protection.

In general, they consider shade as more important than fruit production. However, it is easily observable how the species most frequent are those that are fruit suppliers: *Artocarpus heterophyllous* (Jack fruit), *Mangifera indica* (mango), *Persea americana* (avocado).

It can be highlighted that indigenous trees don't have a special presence even though some of them as *Ficus natalensis* can provide important services and that it is significant in the Ugandan culture. Regarding this tree, there is a cultural issue with land tenure. The *Ficus natalensis* tree means, at the household level, ownership of land. For this reason, until very

recently, a woman could not plant ficus. This taboo is disappearing but it is still pervasive in some areas.

Regarding the medicine, only one farmer was able to think in that service, although there is a long tradition of medicine from plants in the country. Probably this is an ancestor tradition that runs the risk to be lost slowly.

After the interviews with the primary group, once having identified main trees and reviewed the bibliography regarding the Tree Ecosystem Services, it has been recommended to improve and reinforce the knowledge about the benefits of the trees further local people have, as a good agroecological practice. This will be made by designing appropriate materials for the farmers to understand that value.

4. Conclusions

The impact of intensive agriculture on the environment together with the increase in human population and climate change in rural areas is a challenge to face and is key to improving sustainability and meeting the needs of households whose livelihoods depend mainly on natural resources.

In many African countries, including Uganda, subsistence farming is not only about food production but is a way of life for those who can sell surpluses. However, in these countries with mainly agrarian economies, subsistence agriculture is increasingly being replaced by industrial agriculture with the push of governments trying to increase GDP with the contribution of the farming sector. But unfortunately, this does not guarantee food sovereignty and not even basic food provision.

Since there are still a lot of Ugandan smallholders living in poverty, investing in material, infrastructure or knowledge is not always possible for them. But there are technics responsible for the environment that can provide them better quality for their farms.

Quality professional training could contribute in a general way to teach to understand agrosystems in a global way and their implication with nature. For this, it is necessary to pass on knowledge about the environment and encourage farmers to discover the relationships between climate, trees, soil, crops and pests.

Finally, it must be highlighted that both agroecological and agroforestry models are very convenient to be promoted there and can only be done with the participation of local leaders. Communicating the concept of ESs and the benefits of trees can help farmers to make more conscious decisions and planting them more convenient, to get the goal to make agroecological systems more resilient. Encouraging these families to move into these models would help improve their lives.

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