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Potential-Analysis of Biochar Systems for Improved Soil and Nutrient Management in Ethiopian Agriculture

EXECUTIVE SUMMARY

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Composition and layout: Tobias Seitz
Cover photo - village in Amharan highlands at dawn: Tobias Seitz

Executive summary

Soils are one of the most valuable resources on earth and are one of the most important foundation of food security. Particularly in tropical and subtropical Africa, soils are affected by degradation, which has a negative impact on agricultural production. The arable and pasture land of the Ethiopian highlands form the basis for the livelihood of a large part of the population, though being one of the most degraded areas in the world. More efforts must therefore be made to stop the progressive soil degradation and, where possible, to reverse it.

One way of rehabilitating degraded soils and improving soil and nutrient management is to apply biochar substrates. In order to document the potential of this process in Ethiopia, the Federal Institute for Geosciences and Natural Resources has commissioned a feasibility study by Biochar Europe UG on behalf of the German Federal Government and in cooperation with the Ethiopian partner, the Ethiopian Ministry of Agriculture and Natural Resources (MoANR). Within the scope of this study, the state of the research was shown and experiences on the production and use of biochar substrates in Ethiopia were evaluated. On this basis, potentials for the establishment of sustainable biochar systems were described.

Biochar is charred biomass produced under low-oxygen or oxygen-free conditions from organic residues (e.g. by-products from agriculture and food production). The production methods range from small, low-cost production units on a household scale (e.g. cooking stoves) to semi-industrial power plants, where biochar is produced as a by-product. It is important to use only contaminant-free raw materials and adequate certified production technologies for the production of biochar, to ensure the production of pollutant-free biochar substrates. These substrates consist of biochar mixed and composted with different materials such as green cuttings, compost, fermentation residues, manure and minerals. The substrates are then added to soils as high-quality organic fertilizer or soil conditioners.

Biochar substrates can have positive effects on numerous soil properties. Improved nutrient storage, leads to a reduced inorganic fertilizer demand. The water holding capacity of the soils can be increased and thus the drought susceptibility of the agricultural production can be reduced. As a result, biochar substrates can contribute to a more robust and sustainable production of crops in regions with degraded soils and inadequate water and fertilizer supplies. Furthermore, in Ethiopia the sustainable improvement of important soil properties (pH, KAK, carbon content, etc.) by biochar has been demonstrated in various scientific projects. Moreover, biochar is composed of particularly stable carbon compounds, which makes it an important contribution to carbon storage in soils and thus to climate mitigation.

For the success of biochar as a soil conditioner, it is important to consider the whole system from the available resources, the use of energy, the increase in production, the financial conditions, etc. Therefore the knowledge of the different local conditions is important for success. In terms of sustainable agricultural production, the greatest potential is for highly degraded and sandy soils with a low pH, low organic soil content, nutrient depletion and a high proportion of heavily weathered minerals. At the same time, the success also depends on the availability of biomass in the form of "real residues". This is biomass (e.g. crop residues, residues of food production), for which there are no alternative uses. The impact potential is also dependent on the agricultural crops, since field crops respond differently to soil improvement with biochar. In addition, for a maximum climate-friendly effect of biochar systems, it should be ensured that the energy generated during the production of biochar is used, e.g. for drying, heating or cooking.

Despite the range of scientific activities in Ethiopia (Figure 1), so far there have been only few attempts to implement biochar systems. Those who perform this pioneering work face considerable challenges. In addition to technical problems with the production processes and high investment costs

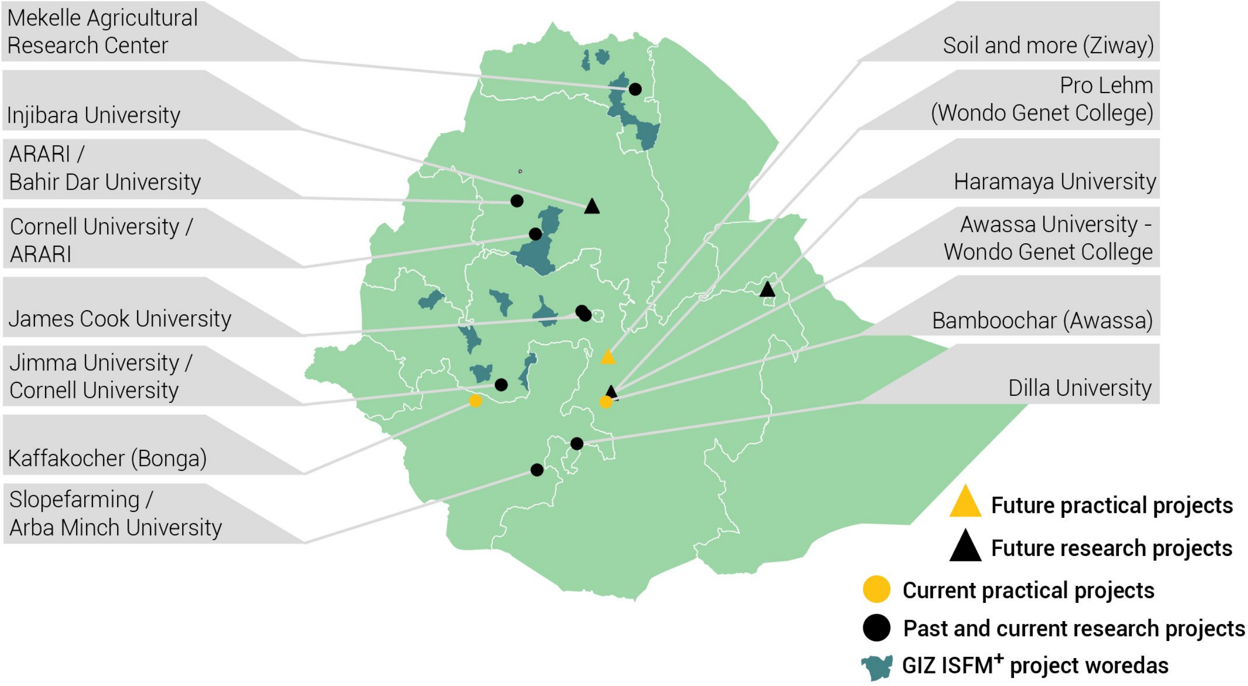

Figure 1. Compilation of biochar activities in Ethiopia

in large plants, there is a lack of information as well as national guidelines and standards.

In Ethiopia, there is significant potential for the establishment of biochar systems. Several biomass resources, which are currently not used, are available for the production of biochar substrates (Table 1). In addition, there is great political and scientific interest to bring this technology into application.

Three intervention levels are recommended on the basis of the existing framework. The first approach involves the local level and focuses on the use of crop residues such as corn cobs or coffee husks in small pyrolysis units as small cooking stoves used by farmers. The second approach takes into account the regional level, in which small to medium pyrolysis plants are used, for example for large kitchens or tanneries. The third approach, finally, refers to the supra-regional level and involves large pyrolysis plants which, for example, could process rose rootstocks from flower farms. On this basis, two priority regions have been identified, in which an improvement of soil properties by adding biochar substrates can be expected and in which the basic prerequisites for the sustainable establishment of biochar systems are given.

As the first potential pilot area with a local approach, the project area of the Integrated Soil Fertility Management (ISFM+) project of the GIZ (Figure 1) is recommended as it has already gained important experience in small pyrolysis stoves. The biochar system can be combined with other soil improvement measures of the ISFM+ project (compost, manure, inorganic fertilizer). As a sustainable raw material and fuel, Oromia offers coffee husks for these cooking stoves in some areas (figure 2). An analysis of soil properties has shown

Table 1 . Selected feedstock potentials in Ethiopia on an annual basis ([1] *P. juliflora* reflects the feedstock potential of a total eradication)

Feedstock source	Feedstock potential [kilotonnes per year]
Houshold waste	high variation
Coffee husks	403
Flower waste	140
Sugar cane	3,148 – 4,206
P. juliflora [1]	9,198 – 9,975
Sesame	236
Animal bones	192 – 330
Human feaces	75 (only Addis Abeba)

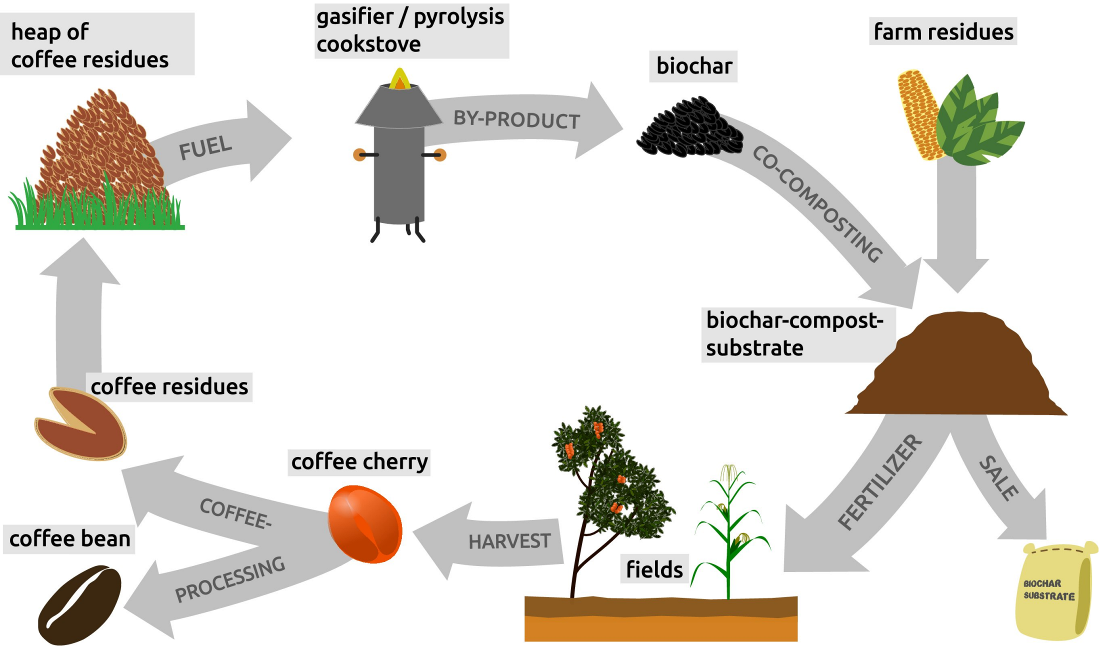

Figure 2. Model of a small-scale biochar system based on coffee residues as feedstock

that the soils in Oromia and Amhara are better suited for the application of biochar substrates than those in Tigray.

The second approach encloses the area of rose farms south and southwest of Addis Abeba. The woody remains of the production of cut roses (rootstocks) can be used as a raw material for a large pyrolysis plant. The resulting biochar can then be co-composted with the fresh rose biomass (Figure 3). There is already a business model from Soil and More Ethiopia for this value chain. The resulting heat energy can be used with the help of so-called absorption chillers to supply rose cooling stores, thus replacing the current energy source.

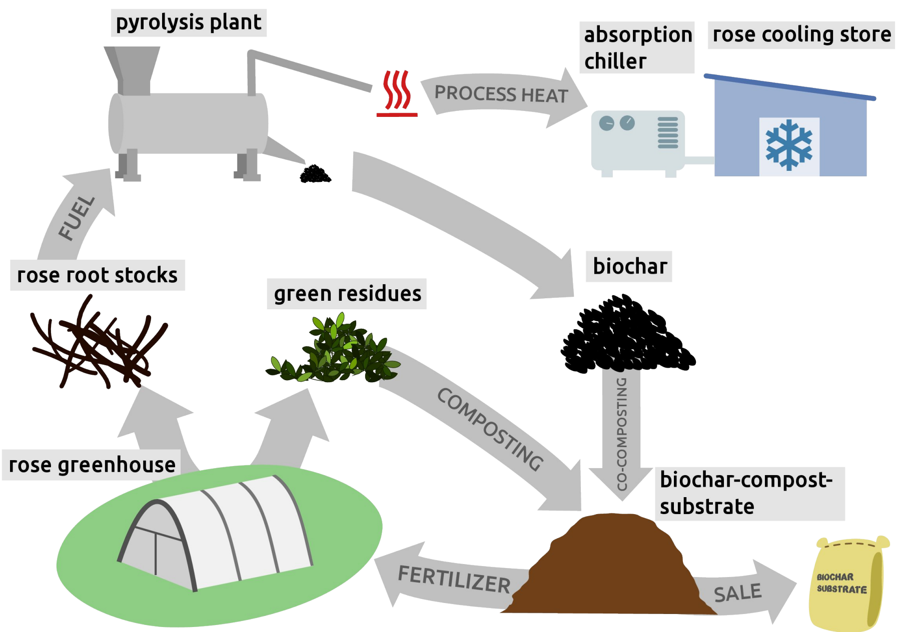

Figure 3. Model of a large-scale biochar system based on flower residues.