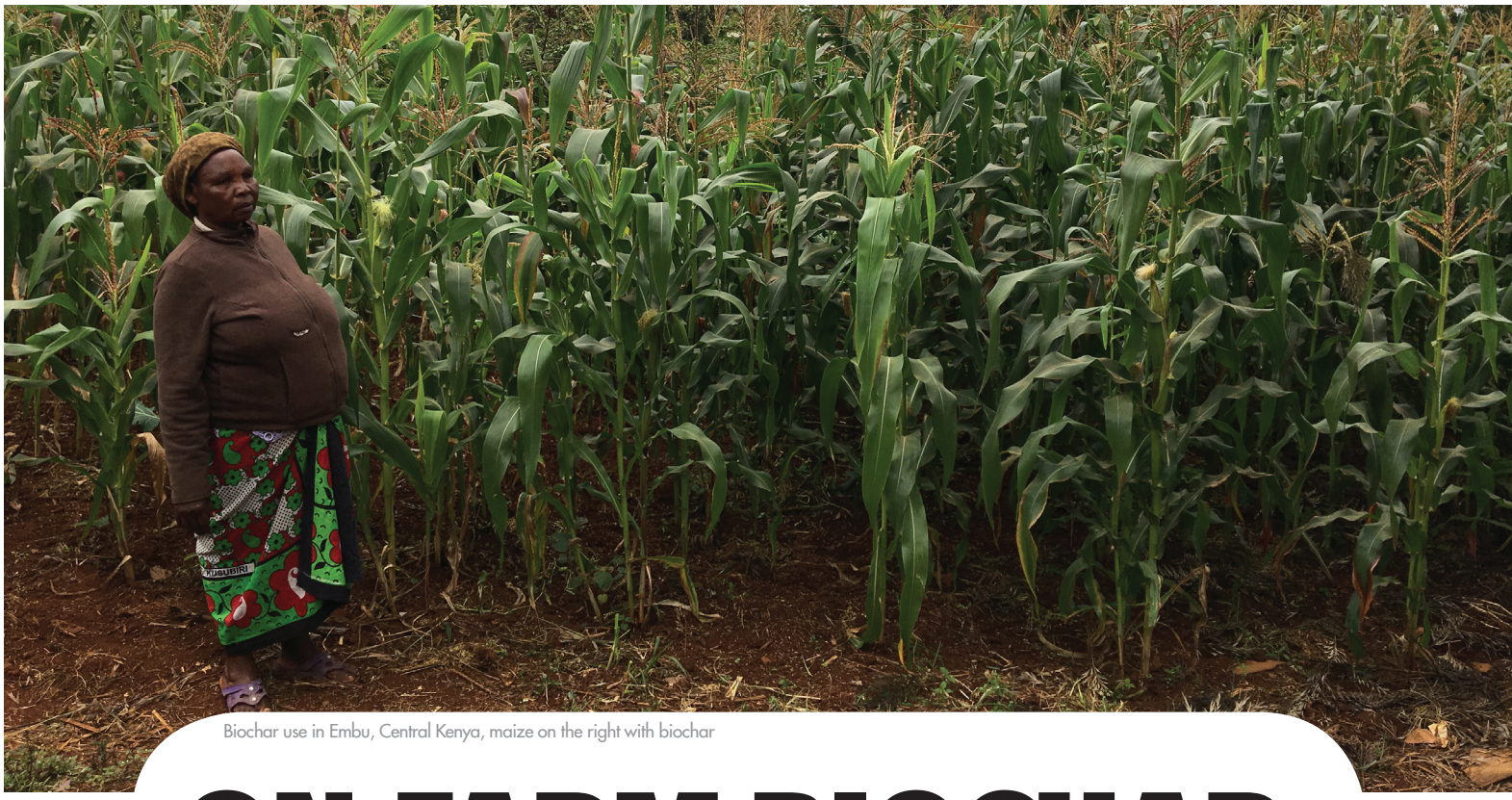


Biochar use in Embu, Central Kenya, maize on the right with biochar

ON-FARM BIOCHAR-WOODFUEL SYSTEMS IN RURAL KENYA

SOME LESSONS FROM A CASE STUDY

BY JAMES KINYUA GITAU, CECILIA SUNDBERG, RUTH MENDUM AND MARY NJENGA
ALL PHOTOS FROM THE AUTHORS

INTRODUCTION

Firewood and charcoal are the most commonly used fuels for cooking in Sub-Saharan Africa as they are relied on by over 90% of the population (IEA, 2006). Mostly, these fuels are unsustainably and inefficiently produced and consumed leading to negative environmental and health impacts. Past efforts to replace the open fires with more efficient stoves have been unsuccessful because new devices fail to meet the users' cooking needs. The gasifier is a recent innovation gaining attention as a cooking stove in developing countries (Torres-Rojas *et al.*, 2011). This article is based on a case study from a biochar-bioenergy project where 150 smallholder farmers from Embu, Kwale and Siaya Counties were given Top Lit UpDraft (TLUD) gasifier cookstoves. These were branded as "GASTOV" from the Kenya Industrial Research and Development Institute (KIRDI) and provided for free after training on their use. The households were interviewed after three months of using the stove and thereafter participatory cooking tests were conducted whereby 25 randomly selected households in each of the sites cooked with the gasifier and five repeated the test with a three-stone open fire for comparison.

HOW THE GASIFIER WORKS

The chopped fuel is arranged in a fuel canister and ignited at the top while outside the kitchen, and moved inside when the fuel catches the fire well enough to reduce smoke. The canister is then returned into the insulated casing and a combustion chamber is placed on top (see photo). Through burning biomass under limited air supply, energy rich gases are produced and burn at 700°C to

1000˚C, generating heat used to cook. When the flame goes off, the biomass has converted into charcoal which can either be harvested or left to burn to provide heat for continued cooking. When fuel turns into charcoal before food is ready, it is harvested and the canister is reloaded with fresh fuel, lit and cooking is continued.

USE OF THE NEW STOVE BY HOUSEHOLDS AND BENEFITS

After 3 months, 86%, 96% and 100% of the households were using the gasifier at Embu, Kwale and Siaya respectively with 58%, 42% and 86% using it often (3-5 days per week). The benefits of gasifier liked by Kwale households, include a reduction in fuel used, less generation of smoke, and the production of charcoal. These were the most common which indicates that cooks are concerned about fuel sourcing, smoke reduction and charcoal production which is a form of fuel poverty alleviation (Gitau *et al.*, 2019a) (Figure 1).

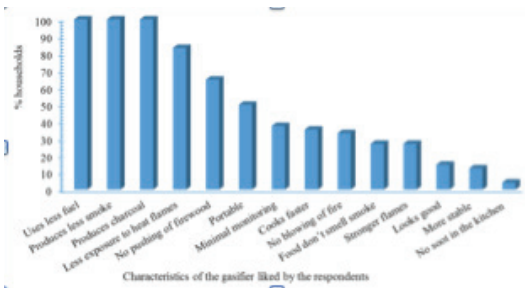


Figure 1: Benefits of gasifier use according to household survey after 3 months of stove use

SOURCING BIOMASS FOR COOKING AND BIOCHAR

Households mainly used firewood while cooking with the gasifier. The main source of firewood used by households is on-farm (Figure 2). Firewood collection off-farm is a difficult task which is time consuming, limiting time available to engage in productive activities.

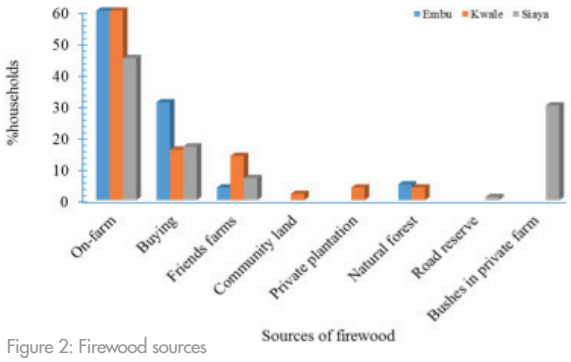
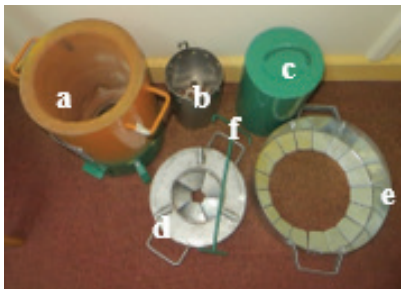


Figure 2: Firewood sources

Biochar application



'GASTOV' parts: (a) An insulated casing with a 5.5 cm x 4.5 cm air inlet with a door (damper) that can be regulated at half or full height at the bottom, (b) a 19 cm high fuel canister in the middle, (c) a charcoal cover (snuffer) used to cool the charcoal by cutting off oxygen, (d) a 6 cm high gas combustion chamber on top as the main burner, fitted with a skirting (e) to hold the pot in position and protect flames from wind and (f) a canister holder

PRODUCING BIOCHAR WHILE COOKING

Charcoal is harvested and cooled using the charcoal cover (snuffer) that cuts off oxygen and stops burning. Households were requested to store the charcoal they produced for use as biochar for soil improvement in participatory farm trials. However, some of the charcoal was put into other uses (Figure 3), an indication that energy poverty alleviation is of importance to these households. Households produced 193g of charcoal per cooking on average.

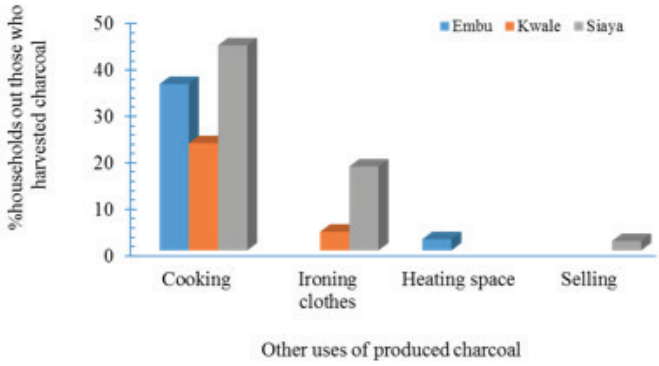


Figure 3: Other uses of charcoal produced by gasifier

BENEFITS ON BIOCHAR-WOODFUEL SYSTEMS

When charcoal is applied to the soil (Photo 2), it is referred to as biochar (Jeffery *et al.*, 2017). Biochar increases yields since it retains moisture and nutrients in the soil making it available to the crops for a longer period. For instance, after applying biochar to maize and kale plots at Kwale and Embu during the long and short rains of 2017 respectively, maize yield increased from 0.9 Mg ha-1 in the control plot to 4.4 Mg[1] on average while kale increased by 33% (Sundberg *et al.*, 2020). Biochar performed better when used in combination with fertilizer or manure. Increased yields mean reduced need to buy food and additional income.

Biochar hold nutrients for longer hence reduces amount of fertilizer and manure used. The gasifier uses less fuel than a three-stone open fire by 41% and 28% when char is considered as fuel and not fuel respectively, hence reducing the women's workload and associated risks.

Compared to a three-stone open fire, the gasifier reduced the concentration in the kitchen of CO, CO2 and PM2.5 by 73%, 30% and 90% respectively (Gitau *et al.*, forthcoming, Gitau *et al.*, 2019c). This in-turn reduces associated health problems such as respiratory diseases.

CLIMATE IMPACT OF BIOCHAR-WOODFUEL SYSTEMS

Biochar application to the soil helps to sequester carbon for a long period and leads to increased growth of above-ground biomass which acts as carbon sinks.

Stove users appreciated the gasifier's benefits either as an efficient way to cook or because biochar helps crops. Therefore, using the gasifier frequently reduces greenhouse gases emission and contributes to climate change mitigation.

CHALLENGES EXPERIENCED WITH GASIFIER USE

The gasifier users experienced challenges when using the stove (Figure 4) which should be addressed for better adoption. Within the project, cookstove users were issued with a second canister, to ease the changeover of fuel, a challenge identified during the study.

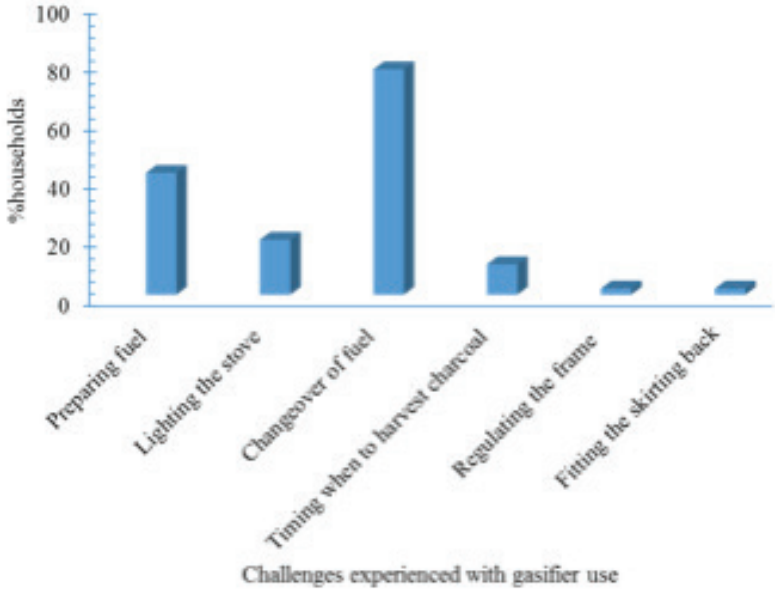


Figure 4: Challenges experienced with gasifier after 3 months of stove use by Kwale households

TAKE HOME MESSAGES

• The gasifier is a great and cleaner cooking option as it saves fuel, smokes less and produces charcoal as a by-product which is used for either cooking or as biochar which improves crop yields.

• Fuel preparation, lighting and reloading fuel were found to be challenging and need to be addressed for enhanced adoption.

• To effectively meet the users' needs, there is need for improvement of the GASTOV design; for example to allow continuous feeding of fuel, or provision of a tool for ease of cutting wood into small pieces.

• Stove users should dry the fuel well for ease of lighting as well as reduced smoke and fuel consumption. To reduce smoke in the kitchen the stove should be lit outside.

• Stove users should be involved in designing and development of the stoves to ensure that their needs and preferences are taken care of.

The writers are (i) Consultant, Bioenergy Researcher, World Agroforestry (ICRAF), (ii) Associate Professor, Swedish University of Agricultural Sciences (SLU) and KTH Royal Institute of Technology, (iii) Research Scientist, Bioenergy, Associate Director of Gender Initiatives, Office of International Programs, College of Agricultural Sciences, and (iv) Assistant Professor of Research, Penn State University and World Agroforestry (ICRAF) and Visiting Lecturer Wangari Maathai Institute for Peace and Environmental Studies, University of Nairobi.

Corresponding email: jameskinyuagitau@gmail.com

Project website: *www.biochar.abe.kth.se*

One Mg = 1 Mega gram or 1,000 kg which is one tonne