Alternative Source of Green Energy for Marginalised Groups in Kenya: An SDG Agenda 2030 Requirement

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Abstract

The commonly used form of energy for cooking, heating or small-scale industries by most households in Kenya are firewood, charcoal, and fossil fuel at 93 per cent. This group of people seems to be marginalized since the use of this forms of energy attracts a lot of interest on public health, environment, and rural development. The problem here is that the sector is handled by the informal sector, thus, there is scarcity and uncertainty of wood energy data which could contribute to economy like green energy. Moreover, 18,000 deaths are experienced annually due to indoor air pollution from cooking and heating using wood and fossil fuel energy. This paper underscores the alternative source of green energy from water hyacinth in the form of charcoal briquette which is carbon free, there are two forms of biomass briquette, Carbonized and Non-carbonized, this study considers carbonized briquette where biomass undergoes pyrolysis the process of converting dried water hyacinth at 350 C-500 C in a finer fabricated biomass carbonizer mixed with binding agent to stick before it is pressed to form briquette. The study is secondary data (desktop) research, the method used to collect data was by use of existing research data. When the destructive water hyacinth is put under production of charcoal briquette which is green and carbon free energy it promotes SDG Agenda 2030 by reducing mortality rates among the marginalized due to indoor air pollution and creation of socio-economic empowerment among the young people through employment and enterprise growth.

***Keywords*: Hyacinth, Briquette, Eco-Charcoal, Biogas, Green Energy**

Introduction

Marginalized situation means a disadvantaged group of people who struggle in their social life and participation in accessing resources[1]. Alakhunova et al. (2015) argues that it is a process that denies some group or individuals from participating full in socio-economic and political life by the society. Marginalization could be social which relates to the human dimension or spatial marginalization relating to physical location and distance from the center (Gurung and Kollmair, 2005). Sanusi (2017) affirms that in terms of renewable energy sources, some group in the society is excluded from accessing renewable energy even though it might be within their disposal. This problem of energy marginalization remains common in African continent even with high capacity of renewable energy sources such as wind power, solar power, hydropower, and geothermal energy are available. The most commonly used sources of energy by the marginalized are wood energy, and fossil fuel energy.

Fossil fuel energy has been on use by man for many years, the recorded period of time that the form of energy was in high use goes back to the second half of the 18thC. during the Industrial Revolution in Great Britain[2]. A fossil fuel is a hydrocarbon that contains material naturally formed in Earth's surface from animal and plants remains which is extracted and burned as fuel. It comes in the forms of crude oil, natural gas and coal, it can also be burned directly to produce heat for cooking, powering engines, generating electricity, also production of kerosene gasoline and propane before burning. The origin of fossil fuel according to scientific research is the aerobic decomposition of buried dead organisms containing organic molecules created by photosynthesis it's conversion from these material to carbon fossils requires geological process for long period of time (Timmer, 2017). While burning wood or fossil fuel as a form of energy releases pollutants which leads to respiratory disorder, asthma, stroke, heart attack, and early death to the users who in this case happens to be the marginalized people[3].

Background

Since the time of industrial revolution, fossil fuel energy consumption has been on high increase as envisaged today. The most industrialized countries in the world consume more than 80 percent of the energy supplied by fossil fuel. Despite new deposits being discovered, it is difficult to estimate the amount of reserves remaining on earth due to consumption rates that keeps changing and also the development and

[1] https://link.springer.com/chapter/10.1007/978-3-030-24021-9_14
[2] https://www.britannica.com/science/fossil-fuel.
[3] https://www.google.com/search?q=impact+of+fossil+fuel+to+human&oq=impact+of+fossil+fuel+to+human&aqs=chrome..69i57.26602j0j7&sourceid=chrome&ie=UTF-8

advancement of technology like hydraulic fracturing (fracking), rotary and directional drilling. The technology involved in extraction of these minerals makes the cost to increase in addition to recoverable material such as light to medium oil becoming depleted. In the year 2018, air pollution resulting from fossil fuel was estimated to cost over US $ 2.9 trillion that's 3.3 per cent of global GDP[4].

The increased use of fossil fuel in industries, construction and even transport sector increases the emission of the by-product of fossil fuel which carbon dioxide (CO_2) on the surface of the Earth's Atmosphere. Concentration of carbon dioxide in the Atmosphere has been fluctuating between 275 and 290 parts per million by volume (ppmy) of dry air between 1000 CE and the late 18th C. but increased to about 316 ppmy by 1959 and rose to 412 ppmy in 2018. Carbon dioxide is known by its character of absorbing infrared radiation such as net heat energy that is emitted from the surface of the Earth then reradiates it back to the surface[5]. This is a character of greenhouse gas therefore, increased supply of (CO_2) in the atmosphere contributes heavily on global warming as a human induced factor. Another potent greenhouse gas which is the chief constituent of natural gas is Methane (CH_4). Its concentration on Earth's surface rose from 722 part per billion (ppb) in 18th C. to about 1859 ppb by 2018[6]. Countering worries on the rising rates of greenhouse gas concentration in the atmosphere that leads to global warming, countries must seek to reduce their dependence on fossil fuels through development of alternative source of renewable energy such as geothermal, solar, wind, tidal, biofuel, and hydroelectric sources of energy with improved and mechanically efficient engines which may rely on these renewable energies[7].

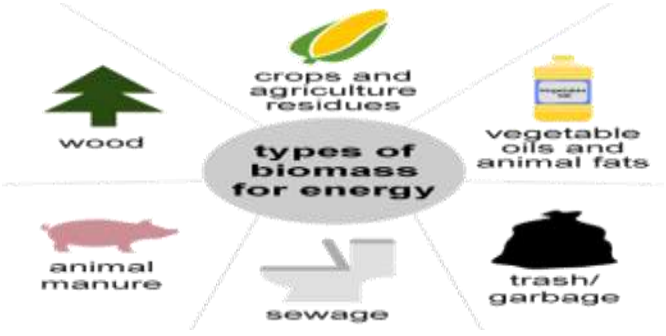
Based on this background, this paper underscores the use of alternative green energy that is affordable by the marginalized group of people whose source of income is not only below average, but also unstable. For many years, wood has been extensively used as a source of energy in developing countries which has led to depletion of forest cover hence, posing environmental threats and health hazards to living organisms[8]. In Kenya, wood fuel is the major form of biomass energy that contributes to over 70% of the National energy demand; while over 93 per cent of rural households are using wood as a source of fuel either as charcoal or firewood (Githiomi, 2016). The consumption levels of charcoal in urban areas alone rates between 1.6 and 2.4 million tons annually with a per capita of 156 kg. and 152 kg for urban and rural areas[9].

[4] https://web.archive.org/web/20200406173555/https://energyandcleanair.org/wp/wp-content/uploads/2020/02/Cost-of-fossil-fuels-briefing.pdf.
[5] https://www.clientearth.org/latest/latest-updates/stories/the-human-impact-of-fossil-fuels/
[6] https://www.sciencelearn.org.nz/resources/1636-energy-sources-through-time-timeline.
[7] https://humanjourney.us/economics-renewable-energy-u-s/?gclid=CjwKCAjww8mWBhABEiwAl6-2RfdciFYR0Qz6KncvjhOSCRSqNDSo7TJ-9Kso6f7X92IJ5adsLf-COBoCG0sQAvD_BwE
[8] https://doi.org/10.1371/journal.pone.0207135.
[9] https://www.researchgate.net/figure/Charcoal-consumption-in-Kenya_tbl2_260162166

Biomass Energy Conversion

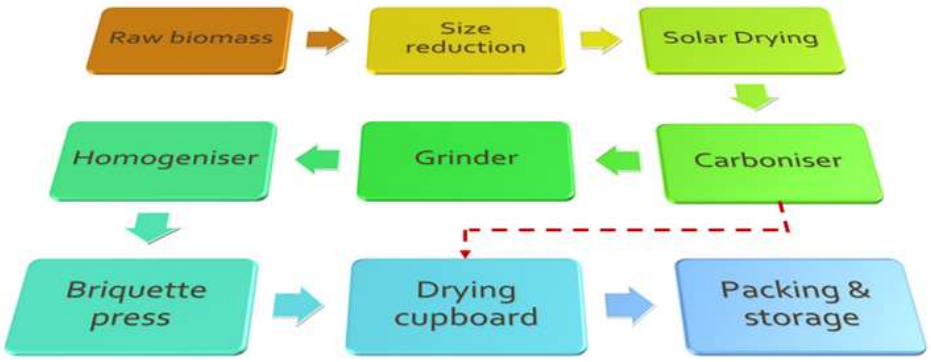
Plants and animal products forms biomass which is renewable organic material used as alternative fuel for cooking, heating, transport, and even for generating electricity. The use of this form of energy helps reduce emission of (CO_2) from fossil fuel. In 2021 for instance, about 5 quadrillion British thermal (Btu) and 5 per cent of the total primary energy use in the USA was provided by biomass[10]. Some of the major sources of biomass are wood and wood processing wastes, agricultural crops and waste materials such as sugarcane, soybeans, corn, wood plants, algae, crops and food processing residues which produce biofuels (Kunatsa and Mufundirwa, 2015). Other sources include biogenic materials such as paper, cotton and wool products, wood wastes, and food stuffs. Animal and human wastes are also used in producing renewable natural gas/biogas (Zupancic and Grilc, 2018).

Different processes are used in converting biomass into energy, the most common is direct combustion or burning biomass to produce heat as useful energy, others include thermochemical conversion to produce solid, gaseous and liquid fuels, chemical conversion to produce liquid fuels, and biological conversion to produce liquid and gaseous fuel (Njogu et al, 2015). Conversion of biomass through thermochemical involves a process known as gasification and pyrolysis where feedstock of decomposed biomass material is heated in a closed, pressurized vessel (gassifier) at high temperatures. Biomass can also be fermented and be converted into ethanol and anaerobic digestion which produces renewable natural gas biogas/bio methane (Langeland and Cherry, 2018). Well treated renewable natural gas has same use as fossil fuel natural gas. Naturally, biogas is a lighter gas than air with ignition temperature of amounting to 700˚C while diesel oil 350˚C; petrol and propane about 500˚C). The temperature of the flame is about 870˚C. Biogas consists of about 60 per cent methane (CH_4) and 40 per cent carbon dioxide (CO_2) (Njogu et al, 2015).



(Fig. 1). Source: U.S. Energy Information Administration

[10] https://www.eia.gov/energyexplained/biomass/



(Fig.2): Process of conversion of water hyacinth to briquette. Source: HiGi

Biomass Energy from Water Hyacinth (Briquettes/Eco-Charcoal)

Water hyacinth, scientific name (Eichhornia crassipes or Pontederia crassipes) is an aquatic free-floating perennial aquatic plant (or hydrophyte) native to tropical and sub-tropical South America (Almoustapha, et al, 2016). It is one of the plants that multiplies very fast it reproduces primarily by way of stolons or runners each plant can produce so many seeds that can remain viable for over 28 years and in a day, they can grow between 2-5 meters[11]. The plant as its dubbed by scientists the world's worst aquatic weed could have been introduced in Africa in early 1900s (Rezania et al, 2016). In East Africa it could have arrived with Belgian colonists in Rwanda who loved the purple flowers and glossy leaves floating in garden ponds. In 1980s the plant slipped out of Rwanda through river Kagera downstream to Lake Victoria[12]. Due to favorable environment in the lake, the plant started gobbling up any open space in the lake thus becoming more hazardous to marine life but habitat to mosquitoes ***(Fig.3***).

In early 1980s researchers started exploring the potential biofuel of the plant and learnt that about 4 kg of the dried products was able to produce enough energy. Academicians in Nigeria in the year 2014 discovered that by mixing the water hyacinth products with sanitized chicken manure they could harvest gas. Some years later, researchers in Kenyan confirmed the study undertaken in Nigeria and their achievement by which mixing animal dung with weed could produce gas. Scientists in India took much interest in the study and tried to work on it for more products including mixing with cannabis sativa in the absence of cow dung (Yong, 2015).

[11] https://en.wikipedia.org/wiki/Pontederia_crassipes
[12] https://www.theguardian.com/global-development/2019/aug/27/kenya-water-hyacinth-wonder-source-biofuel

(Fig. 3). Water Hyacinth covering Lake Victoria.

Source: Photograph: Dan Kei/AP; Lake Victoria, Kisumu, Kenya

In the year 2018, technology was discovered to reduce use of firewood and depend on biogas for cooking. A machine known as 'digester' was introduced, it could be fed by the weed and cow dung and left to ferment for about 20-30 days to give off gas that is piped for domestic use (Sudhakar et al, 2015). This technology is able to service about 60 per cent of the population around the beach popularly known as Dunga Beach on the shores of Lake Victoria[13] (***Fig.4***).

(Fig.4): Biogas from water hyacinth in Dunga, Kisumu.

***Source: Photograph: Kirill Nikitin/Alamy*.**

Water hyacinth or the 'weed' has much impact on the lives of both marine animals and human being however, there is some positive benefits that man can achieve out of its use. As indicated the weed can be used to harvest green energy with little or even no air pollution otherwise produced by use of fire wood by people living in rural or informal urban areas. According to World Health Organization report (WHO, 2019) about 4.2 million people die global every year, 80 per cent of this deaths is found in Sub-Sahara Africa and is caused by use of solid fuels like charcoal and wood for cooking and over 18,000 deaths are experienced in Kenya annually from conditions that are linked to indoor air pollution majorly caused by cooking or

[13] https://bhekisisa.org/

heating[14]. Solid fuels like fire wood and charcoal are commonly used in Kenya both in urban and rural areas for cooking and heating[15].

The briquettes/eco-charcoal just like fermented water hyacinth mixed with dung to produce gas by a digester machine as used by the people of Dunga beach is environmentally friendly biogas. This kind of biogas is a Minimum Viable Product (MVP) that can replace the use of firewood and charcoal hence reduce (CO_2) that is harmful to human health in areas of low-income earners. A study Rahman, (2018) indicates that the testing and analysis of MVP through burning shows huge improvement in released smoke unlike the firewood, eco-charcoals are smokeless (***fig.5).***

(Fig.4): Eco-charcoal/Briquettes from water hyacinth

Statement Problem

The usage of wood as a source of energy is commonly handled by informal sector, hence, there is scarcity and uncertainty of data concerning wood energy use which could contribute to economy like green energy. On the other hand, carbon dioxide (CO_2) and Methane (CH_4) are greenhouse gases contributing heavily to climate change. CO_2 being a hazardous gas concentrates in the atmosphere making it unsafe for human and animals breathing. CO_2 is characterized by absorbing infrared radiation like net heat energy emitted from the surface of the earth and reradiated back to the surface, this is a greenhouse gas character which when its supply increases in the atmosphere it contributes heavily on global warming as a human induced factor. Another potent greenhouse gas which is the chief constituent of natural gas is Methane (CH_4), its concentration on Earth's surface rose from 722 part per billion (ppb) in 18th C. to about 1859 ppb by 2018. Thus, high use of wood fuel in Kenya like any other developing country leads to many factors that are environmental and health hazards to the bigger population with no means to afford green energy. As indicated, in Kenya alone over 18,000 deaths are experienced annually due to indoor air pollution from

[14] https://www.who.int/health-topics/air-pollution#tab=tab_1
[15] http://documents.worldbank.org/curated/en/164241468178757464/pdf/98664-REVISED-WP-P146621-PUBLIC-Box393185B.pdf.

cooking and heating using wood and fossil fuel energy. Therefore, eco-charcoal due to its being carbon free can be an alternative to the marginalized groups in society by reducing high number of deaths experienced annually from this groups in society **(Fig.4)** shows a smokeless eco-charcoal as compared to (**Fig.5**) commonly used in Kenya.

(Fig.5) Source: HiGi The National Energy University (2018)

(Fig.6) commonly used firewood cooking in Kenya.

Objective

Generally, the study is geared towards enhancing accessibility of green and affordable energy by the marginalized and promoting achievement of SDG Agenda 2030.

Specifically.

i. To reduce mortality rates among the marginalized in society by providing green energy which is carbon free (SDG.7).
ii. To promote socio-economic situation of the youth in Kenya through capacity building and creation of job opportunities and sustainable lives (SDG.8)

iii. To train and empower youths with vocational skills and capacity for marketability and adopt technology (SDG.9)

Empirical Review

In 2014 a study carried out entitled "*Smoke-The Killer in the Kitchen*"[16] indicates that globally, more than half of humanity are condemned by poverty to cook with solid fuels. The smoke emitted from the wood fuel in homes is fourth greatest risk factor for death and diseases in developing countries although it is neglected. Sad enough our mothers/women and children are mostly at risk from the killer in the kitchen since they spend much of their time cooking for the families. Reducing this indoor air pollution in developing world contributes significantly to reduced mortality rates[17]. In the year 2021, over 2.4 billion people around the globe still depend on inefficient and polluting cooking or heating systems.

Still the bigger population of Kenyan citizen is the young people (15-35 years) making over 62 per cent of the population. The analysis of their socio-economic situation both male and female indicates that due to various socio-cultural factors, they do not benefit from fruits of economic growth hence, impacting their economic situation in a deterioration manner leaving many in their different groups in adverse situation. The most affected groups include and not limited to those not employed or even unemployable, Rural youth, those out of school and the school dropouts, drug addicts, those living with HIV/AIDS, victims of sexual abuse and commercial sex workers, those with disabilities and pregnant girls. These are the groups most affected with poverty due to high rates of unemployment, exclusion and low investment in youth development projects and education that has to be addressed urgently.

Methodology

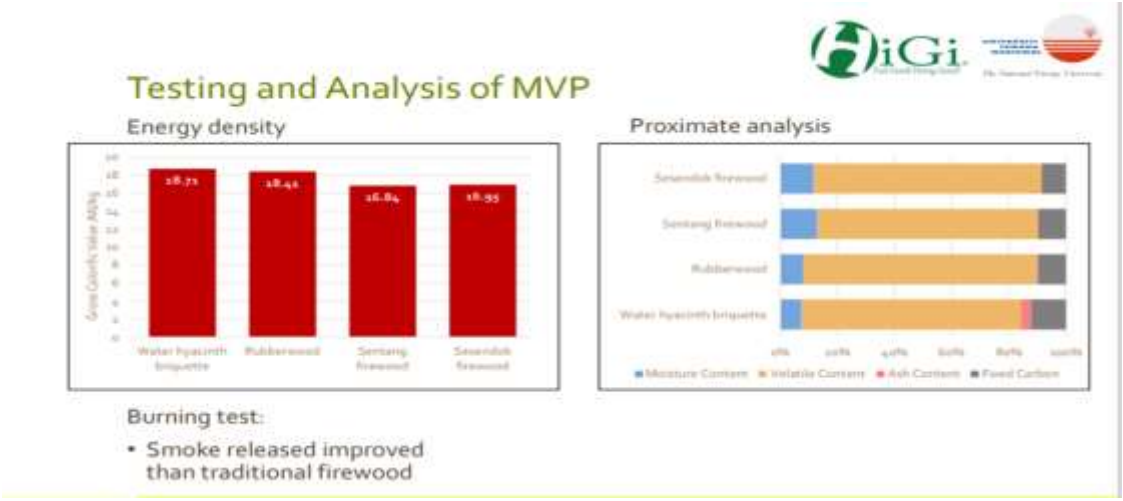
Data collection is the process of collecting information from relevant sources in answering research problems, testing hypotheses, and evaluating the outcome. Generally, there are two types of data collection; Primary and Secondary data (Naveen & Sivapullaiah, 2020). Primary data is collected with the help of survey and interview while secondary data is collected with the help of previously published papers, reports, case studies. This is a secondary data collected (desktop study) where data was collected through the use of existing information.

[16] https://www.co2balance.com/smoke-the-killer-in-the-kitchen/.
[17] https://www.google.com/search?q=smoke+from+charcoal+burning+stove&sxsrf=ALiCzsbSmBQc5IySDv-sGGqiHSOUFyTJaQ:1659081848058&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjdr9PB0Z35AhUN76QKHT3YDbcQ_AUoAXoECAEQAw&biw=1366&bih=624&dpr=1#imgrc=ZJi17FAsXpnewM.

Interventions

Despite the destructive nature of water hyacinth in reducing biodiversity, displacing marine species, damage of hydroelectric system, block water sources hence, flooding, and affect water quality when not controlled; this weed can offer varied solutions. It has also been noted that the weed (water hyacinth) apart from being responsible for health problems and environmental issues, it can be useful in soil amendment after composing, removal of heavy metals from aquatic system, and as a source of green energy either as biogas through aerobic/anaerobic digester technology (***fig.3***) due to its content of 46-53 per cent CH_4 as discussed above or in form of conversion of the plant into charcoal dust through pyrolysis to produce locally needed source of fuel (Rezania, et al, 2016). The process involves mixing charcoal dust with molasses a by-product of the sugarcane industry. Molasses serves as a binder; one ton of briquettes needs about 20-25% per cent molasses. Briquettes bound by molasses burn well but may produce unpleasant smell during combustion. Instead, thermal treatment 'curing' can be applied before using the briquette. Thermal waste treatment is the heating processes aimed at treating waste materials.

The waste management process reduces waste volume, convert waste into harmless materials, hence, utilize the energy hidden within waste as heat, steam, electrical power, or combustible material. The charcoal undergoes a process known as briquetting to improve its quality and also increase its strength which makes it more durable while handling and storage (Kunatsa and Mufundirwa, 2015). A part from the weed replacing firewood and reducing deforestation, its removal from water creates breathing space for marine life additionally, the briquettes are CO_2 free thus reducing mortality rates caused by indoor air pollution at the same time reducing the effect of global warming as temperatures are kept moderate due to reduced emission of CO_2 a greenhouse gas.



(Fig.7): Showing amount of smoke released when burning. Source; Higi

Expected Results

This study is anchored on Seven SDG goals as part of agenda 2030 among them, goal number 7 being key and as the focus of the study.

Goal.7 "Ensure access to affordable, reliable, sustainable, and modern energy for all". In achieving global climate goals, efficiency and sustained green energy projects need to be speeded up. In developing countries such as Kenya, electrification programs are faced with some challenges including high cost of production which is to be passed to poor consumers. International financial flows to developing countries for renewable energy has continuously declined from $24.7billions (2017), $14.3billions (2018), $10.9billions (2019). Innovation helps create an environment that is habitable and supports human life, green energy is the way to go in the modern world therefore, eco-charcoal becomes useful for people with little income since they are affordable and portable to any part that they are needed without much breakage.

Goal.3 "Ensure healthy lives and promote well-being for all at all ages" having learned about how harmful CO_2 gas is on human life promotion of health lives through alternative sources of energy such as eco-charcoal is significant to the society. Since CO_2 contributes to high rates of death eco-charcoal is solution to this problem as the mortality rates are reduced.

Goal.13 "Take urgent action to combating climate change and its impacts" in the year 2021, emission of CO_2 increased to 6 per cent which is highest levels in the global temperatures, more extreme weather charts are being experienced, scientific studies indicate that different temperature affects Coral reefs. These happens at a time when climate finances have fallen significantly. When we reduce the CO_2 emission, we

reduce whose character is greenhouse gas then we reduce the contamination of Ocean temperatures to moderate levels enhancing marine lives.

Goal.14 "Conserve and sustainably use the Oceans, Seas, and Marine resources for sustainable development". Oceans absorbs up to ¼ of the global annual CO_2 emissions, by the year 2021, over 17 Million metric tons of plastic are said to have entered and are chocking Oceans. All these activities end up increasing acidification which is threatening marine life and limiting the Oceans capacity to moderate climate change. The alternative use of eco-charcoal helps in conserving the marine life as it involves removing the weed that is chocking the surface of water and creating habitation space for marine life which had otherwise been reduced by overgrown weed.

Goal.11 "Make cities and human settlement inclusive, safe, resilient and sustainable" according the report by WHO nearly 99 per cent of the world's urban population breath polluted air. In Sub-Sahara Africa, less than 1/3 of city dwellers have convenient access to public transport. With no one left behind, achievement of this goal requires an intensified focus not only on 1 billion informal urban dwellers but also the majority leaving in rural areas more so in developing countries. The briquettes are CO_2 free thus the risks of indoor air pollution is reduced significantly reducing the mortality rates.

Goal.9 "Build resilient infrastructure, promote inclusive and sustainable industrialization and forest innovation". Most of the Small-Scale Industries in Developing countries lack access to financial support for recovery hence, they are left out in manufacturing growth. This limits employment capacity thus creating high rates of unemployed even though skilled and educated young people in Sub-Sahara African countries such as Kenya with over 60 per cent of population being young.

Goal. 15. "Protect, restore and promote sustainable use of terrestrial ecosystem sustainably manage forests, combat desertification, halt and reverse land degradation and biodiversity". Apart from 90 per cent of global deforestation due to agriculture expansion, wood for energy is also key this leads to over 10 Million hectares of forests being destroyed annually, interestingly over 40,000 tree species are at risk of extinction decades to come. If this project funded to a maximum, it increases the production level and the products reaches the market at the right time ending the use of firewood by rural and informal urban dwellers. This helps in restoring ecosystem and biodiversity.

Goal.1 "Reduce poverty in all its forms everywhere" rising of inflation and impacts of war apart from Ukraine tend to derail progress. Currently, the number of people leaving in extreme poverty by the year 2022 is projected to be between 657-676 Million. Such can be attributed to high rates of unemployment more so in developing countries of Sub-Sahara Africa Kenya not being left out since her largest population

(60%) is made of young people majority not employed. As we talk about employment the project has the capacity to employ at least a few people to help in the production processes and marketing. Goal number 8 cannot be neglected since specific objective number 2 of creation of opportunity fosters economic growth.

The intention of the SDG Agenda 2030 is that all humans around the world including the marginalized who make the big per centage of the people should lead a healthier life, not exposed to lethal levels of dangerous gases as embedded in different sustainable development goals. Our contribution is through creation of public awareness about the risks of greenhouse gases from our chimneys followed by replacing the commonly used form of energy (firewood and fossil fuel) with green/cleaner energy like petroleum gas or biogas. However, since the majority are socio-economically marginalized unable afford cleaner energy yet, their hope is not lost. These homes can reduce exposure to indoor air pollution by adopting the use of eco-friendly charcoal/briquettes which have been scientifically proved to be CO_2 free (**fig.7**). the manufacture of the briquette is an intention to solve problems of the socio-economically marginalized who can't afford expensive modern form of green energy at the same time managing the water hyacinth from destroying the marine life but turning it into environmentally friendly energy at the same time reducing the pressure of cutting down trees for energy use but enhancing clean environment and pollution free.

Conclusion

Indoor air pollution which contributes to high rates of mortality among the marginalized can be reduced by alternative green energy such as eco-charcoal from water hyacinth unlike the commonly used especially in developing world. The attainment of SDG agenda 2030 needs collaboration and embracing of technology at all levels to reduce challenges facing the society. At the same time, job creation especially for the young people becomes a cornerstone for prosperity and development in society. Establishment of such projects is a form of emerging micro small and medium enterprises (MSMEs) which is attributed to transformative growth and economic development reducing poverty rates among people[18]. According to ILO report (2017) global youth employment quality was a concern while the unemployment level was high. To UNESCO youth are person between ages of 15-24 years without prejudice to other definitions by member states[19], while African youth charter just like Kenya, youth is every person between 15-35 years. Employment among youth is a global challenge, thus many are focusing on entrepreneurship as a component of youth in labor market. Therefore, supporting these new youth-led enterprises and enterprise growth will enhance employment through creation of new jobs, skills and experience.

[18] https://entrepreneur-sme.asia/entrepreneurship/asean-sme/laos-sme-opportunities/.
[19] http://www.unesco.org/new/en/social-and-human-sciences/themes/youth/youth-definition/.

Since the SDG goals intersect with these enterprises by the youth, this is part of their contribution towards achievement of SDG 2030[20]. The enterprises are directly linked to goal's (1) reduce poverty, (5) gender equality, (8) decent work and economic growth and (10) reduced inequalities. Therefore, recognizing the diversity of economy such as informal sector and expansion of entrepreneurial activities more so in low income context facilitates the creation and enhancement of youth employment. Supporting and promoting youth enterprises through vocational courses and training, financial support, encouraging tailored local material, youth-led business development services and facilitating exchange and technology innovation and mentorship programs will spur development and help reduce inequality among the youth.

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