Chapter 10

The Integrated Biochar Industry for Indonesian Rural Area Households: Study Case on Forest Biomass and Carbon Sequestration

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A. Forest Biomass and Indonesia's Rural Area at a Glance

Biomass and carbon sequestration has excellent attention from forest managers and experts all over the world, and biomass and carbon estimation was the critical point to overcome future forest management (Dong et al., 2014; Jagodziński et al., 2018; Khan et al., 2018; Parresol, 2001; Zeng et al., 2017). Climate change effects on forestry are also essentials factors that need to acquire on a statistical basis (Lei et al., 2016; Schneider et al., 2018; Trautenmüller et al., 2021; Vaughn et al., 2021; Xiang et al., 2021; K. Xu et al., 2021; Zhang et al., 2020).

Biomass allometric models are essential methods to examine forests biomass and carbon modeling. Indonesia (Kusmana et al.,

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2018) has conducted biomass allometric models for *Sonneratia* spp. However, the allometric model for all tree species is still limited. Since climate change issues occur in all countries, forestry biomass estimation is essential to dealing with the zero carbon emission goals. Forest biomass has a huge potential to reduce carbon emissions and as a bio-energy source (Suntana et al., 2009). Many industries have established bio-energy-based products to address greenhouse gas (GHG) emissions such as bio-methanol, biochar, biofuels, bio-based chemical, and other bio products.

Biochar is the new solution worldwide, such as managing agriculture or forestry residue and climate change (Anand et al., 2022). Biochar is highly correlated with biomass and carbon sequestration. There are several ways to obtain sustainable raw materials. As a developing country, Indonesia must take a robust plan in the future because natural resources are fundamental for our necessities and industry sectors. Hence, in recent decades, many worse situations caught a terrible effect on the environment, such as the Lumpur Lapindo mining, forest fire in Sumatra, and deforestation in Kalimantan and Papua. Those problems were primarily reported because the roadmaps were not implemented using a scientific base. It showed us that the scientific base had not been well implemented in those several work/projects. Therefore, Penta helix's five actors (academics, business, community, government, and media) should take extra action to mainstream the scientific base rather than other issues.

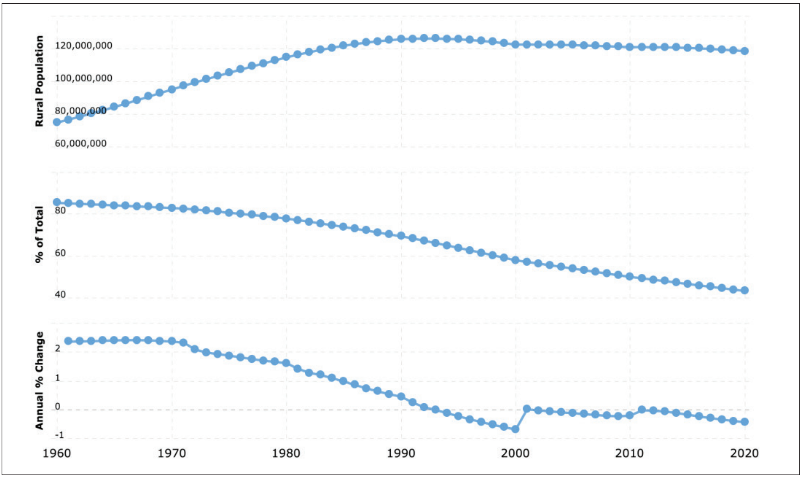
The Penta helix five actors led the people to pay attention to the current issues. Otherwise, the next generation will suffer from climate change's adverse effects. The most common problems are getting a job, earning a stable income, and having enough food and other necessities. Climate issues are still not popular because they are unrelated to their lives. However, for several locations in the region or their surroundings, something worse affected by climate change will make it easier to understand climate change, such as rising sea level, flooding, long dry season, changing rainy or sunny season, etc.

Before those disasters, it would be better for human beings to care for the earth's future.

The tropical rainforest has a tremendous amount of biomass compared to other forest types. Because tropical rain forest above and belowground saves many biomasses; stem, branch, foliage, root, and the forest litter. On the other hand, crop waste can also be used in the biochar industry. Bio-charcoal is the known name of biochar. The biomass was processed by pyrolysis, torrefaction, gasification, and carbonization through thermochemical conversion in the partial air supply. Syngas and biochar are known carbonization products (Anand et al., 2022).

In this chapter, we have examined the potential of forest biomass as a biochar industry main source. However, theoretically all carbonic materials can be used for biochar production. Such as household waste, crop residues, sewage sludge, forest residues, algal biomass, and animal litter. In addition, the biochar industries have to highlight the main physical & chemical properties, i.e., cellulose, hemicellulose, lignin, moisture content, and inorganic substances. We projected trees as the biochar raw materials and forest waste/litter, bamboo, shrub, and other vegetation as potential sources for the raw materials. For example, China is the most bamboo producer in the world, and bamboo waste can be made as biochar at a low cost. The annual increase in bamboo biomass is 10–30% compared with tree biomass of 2–5%. It means bamboo timber production in the same area is estimated to be 20 times more than trees (T. Xu et al., 2012).

Rural population refers to people living in rural areas defined by the Indonesia Central Bureau of Statistics (Badan Pusat Statistik); it was calculated as the difference between the total population and urban population. Indonesia rural population for 2017 was 119,995,396, a 0.29% decline from 2016. Based on the statistical data, the rural population from 1960–2022 declined yearly, including annual % change and % of the total population (Figure 10.1). The situation does not only happen in Indonesia but also worldwide. However, some countries still have high numbers of rural population, such as Austria,

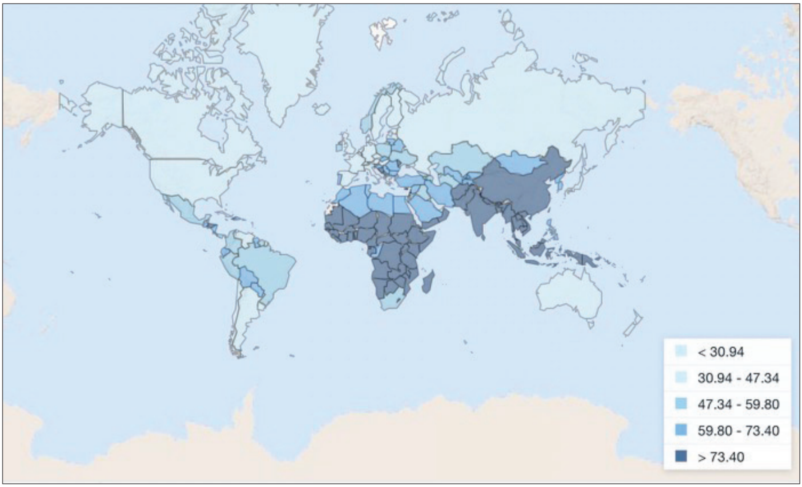


Sources: World Bank (2020)

Figure 10.1 Indonesia Rural Population 1960–2022

Barbados, Guyana, Samoa, and Tajikistan. Furthermore, an aggregated value for high-income, low and middle-income, low-income, lower-middle-income, middle-income, and upper-middle-income countries showed that the number of rural populations declined year by year. Based on the World Bank (2020), the world's rural population (% of the total population) in 1960 was 66.38%, and the latest data in 2020 was 43.84%.

In 1960, the rural population in Indonesia (Figure 10.2), China, and Africa were almost similar. More than 73.40% of people live in rural areas. Based on the history of Indonesia, during the President Suharto regime (1967–1998), urbanization significantly increased. The government also established policies to control the population in Java Island, the most populated island in Indonesia, such as transmigration program and rural area development. In the beginning, the program successfully impacted the Java Island population. However, the government did not regulate the details aspect livelihood aspects, natural resources, market, or transportation. Therefore, some locations

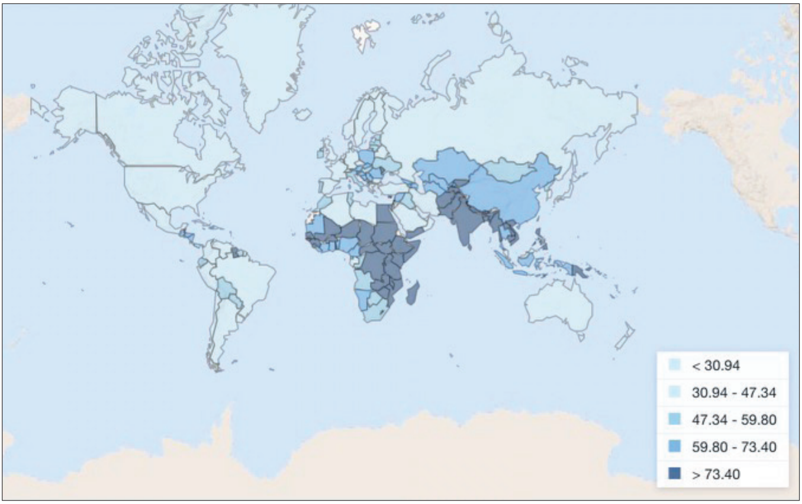


Sources: World Bank (2020)

Figure 10.2 Rural Population (% of the Total Population) in 1960

for transmigration program were misleading, and other problems were caused by the continuous number of people's arrival. Not only affect the natural resources, but some social conflict between the local society and newcomers became the most treacherous issue.

The Indonesian government must learn from those situations to implement a new regulation. Predicting the future is a more appropriate way to deal with future uncertainty. The scientific method is the key to deal with several complex problems. Therefore, the researcher should encourage the government to ensure that the to implement more accurate policies. As a democratic country, Indonesia must educate the people to be more concerned about the regulations. That means the government and the people are working together. Since the technology era has been growing faster for several decades, it will challenge the Indonesian government. If the regulation does not impact the people's participation in the policy, it will be hard to hook them into government plans in several decades.



Sources: World Bank (2020)

Figure 10.3 Rural Population (% of the Total Population) in 2020

As the fourth largest populated country (after China, India, and the USA), Indonesia has many potentials human resources; however, the human resources should be ensured enough quality to face the post-modern industry. The urban population grew yearly, which means the demand for food, electricity, water, transportation, and other bases increased. Compared with recent decades, some rural areas are changing into urban areas. These situations indicated that the people living in rural areas should prepare to be more independent as families and individuals. Because if the government did not have the option to keep rural areas with the program, rural society would still live in the owned system.

Regarding the demands of rural households, energy power has become essential, such as for for cooking, telecommunications, small industries, etc. To deal with that demand, the rural government should make an initiative. As an abundant resource, biomass has the potential to process into biochar. Usually, the rural area society is also familiar with biomass because, as a traditional method, the rural area society uses biomass for cooking. In subsequent decades, clean energy and technology are required to complete the IPCC requirement. Therefore, the rural area biomass sources can be processed into biochar through implemented technologies.

B. The Integrated Biochar Industry

1. Forest inventory and quantification

In recent decades, Indonesia had some regulations about forest quantification. However, not all forest areas have been measured. The problem is due to the accessibility, funding, and regulation. According to the IPCC and COP 26 at Glasgow, the Indonesia Minister of Environment and Forestry said that Forest and Land Use (FoLU) are the keys to Indonesia's sustainable forest management. However, the Indonesian government still has many tenurial conflicts and problems. Therefore, Indonesia must have deal with the tenurial issues in the following decades and should have an accurate number of Indonesia's forest cover, biomass, and other natural resources. To deal with carbon sequestration issues, forest biomass and carbon measurement have become significant issues to overcome.

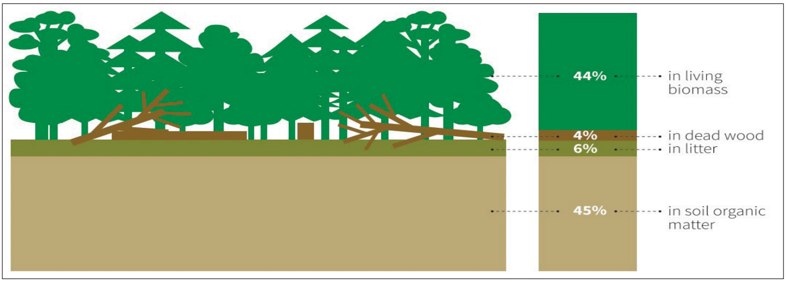
As the government and the people aim, the forests should contribute to the economy. Hence, the forests have become the object of people's economic growth. Such as the social forestry program (Sahide et al., 2020), simplified, gives people access to use the forest land. Besides, the program also does not guarantee a positive contribution to sustainable forest development because some evidence shows that the access only gives the land certificate, however, how those people use the land is not controlled by the government. Thus, there is no guarantee that the forest area will be kept in the function or changed into another function. This program, is a short mission without measuring for its long-term effect. To address this problem, the government and the academicians should have comprehensive planning and guidance, then duplicate it into society. Because Indonesia consists of many islands, one guidance is not enough to implement. Adaptation to the local characteristics is appropriate.

Accurate forest inventories, quantification, and estimation can improve the action to address climate change and develop sustainable forest management. In China, forest inventories have been quantified from 1977 to 2013 (Zhao et al., 2019). The program obtained the average biomass carbon sink, the biomass carbon stocks, and the biomass carbon density. This program's result could help validate and calibrate simulation model results and comprehensively investigate forest carbon budgets. Indonesia should have that kind of forest inventory to ensure that the program and planning are well-implemented.

2. Forest mapping

The proportions of carbon stock in forest carbon pools are: living biomass (44%), deadwood (4%), litter (6%), and soil organic matter (45%) (FAO, 2020). After the soil organic matter, living biomass is the largest forest carbon pool (Figure 10.4). The national commitments to reducing forest emissions in Indonesia are still ineffective (Meehan et al., 2019). The government is not seriously putting local and smallholder farmers together. However, the government always said that they have already collaborated with the local and smallholder farmers. Indonesia also has extensive tropical peatlands, and the smallholder farmers are essential in preventing forest fires, protecting the forests, and restoring the degraded peatlands (Merten et al., 2021). Indonesia reduced emissions target to NDCs is affected by some highlights emission sources: illegal land clearing, illegal logging, and forest fires (Tacconi & Muttaqin, 2019). Therefore, forest mapping in a new paradigm is pertinent to all elements needed to be targeted. Indonesia forests as tropical rain forests should be more effective in developing into a higher stage.

The forest mapping does not merely belong to the log potentials; the carbon stock is now more fundamental. The larger to smaller proportions are in soil organic matter, living biomass, deadwood, and litter (Figure 10.4). Furthermore, the forest carbon pools can also



Sources: FAO (2020)

Figure 10.4 The Proportion of Carbon Stock in Forest Carbon Pools, 2020

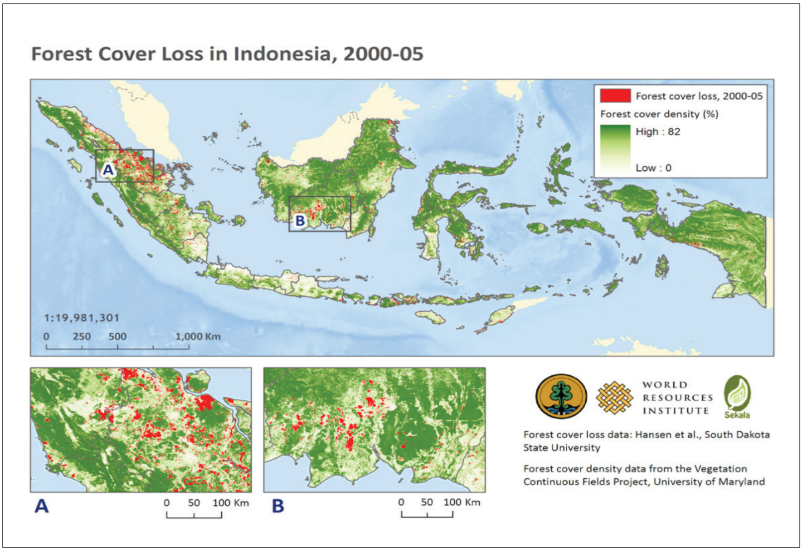
process onto biochar if sustainability management is implemented in all industrial processes. Besides, biochar is the key to increase nutrient content (Zhou et al., 2021). As an agricultural country, Indonesia has many farmers living closer to forests. Building the forest sustainable management mapping simultaneously with the biochar industry could be double robust to achieving a sustainable forest management plan for further decades.

3. Smart Forestry Station (SFS) Initiatives

The Indonesian government has implemented the social forestry policy since 2014. Some experts argue that the social forestry policy goes to populist ideals, which means the boom expansion should be anticipated with several plans. The social forestry area increased from 653.311 ha in 2014 to 3.369.583 ha in 2019. Regarding the national goals that promote sustainability and social justice, management and monitoring system practices are the crucial management systems. The one map policy, digital data, and other relevant technology implementations have to promote to deal with the global industries.

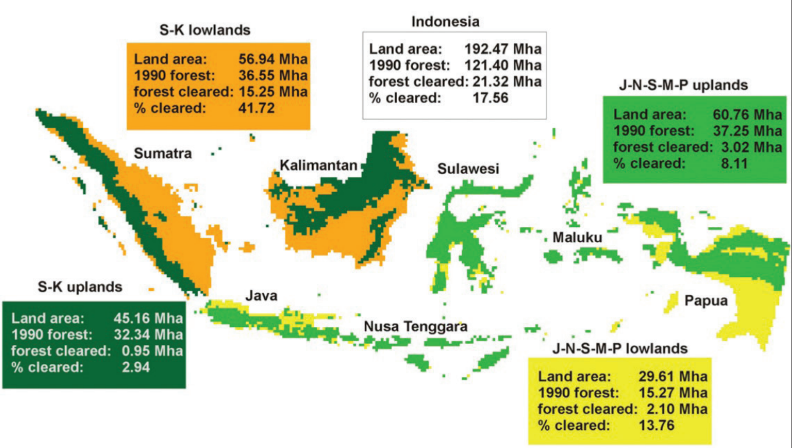
Smart Forestry Station (SFS) initiatives are the idea needed to implement in this stage. Smart means the input, process, and outputs should use in the smart way, not only in technology but also the people's mindsets. The SFS integrated with previous enterprises, such as Perum Perhutani Group (Indonesia Forestry Enterprises Holding Group). Because in many ways, people are suitable with the usual system (business as usual), transformation and adaptation need takes time to implement. For example, a study proposed by Vicol et al. (2018) showed that key individual positions are essential to influence the social community. It would be better to build the infrastructures rapidly during the process. Therefore, social modal, social-economic engineering, and funding are fundamental requirements.

SFS is also essential for mitigating forest loss in Indonesia, such as providing real-time data and coordination between ecoregion, province, and island. As an country, Indonesia must coordinate rapidly to ensure the forest's real-time spatial condition on each island. From 2000–2005, dramatic forest clearing rates dropped last century (Figure 10.5). Moreover, Sumatra Island and Kalimantan Island are significant levels of forest clearing (Figure 10.6). The political and economic factors were highly related to forest clearing (Hansen et al., 2009). Therefore, the objective of SFS was to improve the forest management



Sources: World Resources Institute (2010)

Figure 10.5 Forest Cover Loss in Indonesia, 2000–2005



Private and civil society interests with the information needed to improve forest management. The forest clearing rate in Indonesia is among the highest reported by the United Nations Food and Agriculture Organization (FAO)

Source: Hansen et al. (2009)

Figure 10.6 Estimates of National and Sub-National Forest Extent and Loss

system, improve the socio-econometric, biodiversity conservation efforts, hydrological management, climate change mitigation, and forest biomass-carbon modeling efforts.

The SFS functions are to ensure the forestry bureau at a province level, even up to the rural level stay on track, and follow the national development targets. The SFS official office should close with the forestry bureau, but being independent in the monitoring function. A sustainable forestry management system must be achieved through innovative technology and competent personnel. The local younger people are also the keys to a better understanding of local society and forestry development. Moreover, a very ambitious team, transparency systems, objective goals, and aggressive path reflect the SFS role.

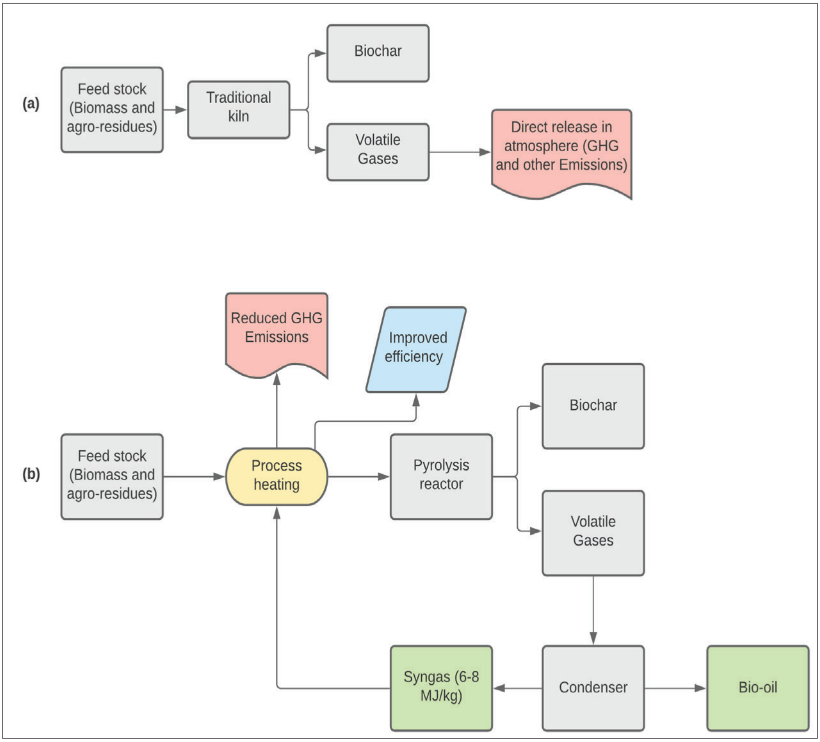
4. Biochar Industry

The previous study examined forest biomass as source of bio methanol (Kim, 2019; Sahoo et al., 2022; Suntana et al., 2009). However, Indonesia does not have many experiences using bio methanol in a large amount. From 2004 to 2005, rural and urban low-income Indonesian communities implemented energy conversion from kerosene into natural gases during the first SBY Presidency era. Before, many low-income communities depended on kerosene as their household's energy supplies. Since the energy conversion, 3 kg gas tube, including the gas stove and the pipe, has been distributed nationally. This program has been successfully implemented; however, several problems still appear, such as the subsidiary from the government was not implemented in the target communities.

Biochar has received greater attention from researchers since it has multiple functions, such as the color can indicate and predict biochar's properties (Fan et al., 2021). Biochar also can remove organic and inorganic contaminants from soil and water, even heavy metals (Kumar & Bhattacharya, 2021). The biochar industry using renewable resources can be the strategic solution to deal with environmental, livelihood, and economic growth. Indonesia, as a tropical country, has abundant biomass sources. As an Indonesian neighbor, Malaysia almost has a similar climate and resources in terrestrial areas (i.e., tropical rainforest, agriculture, and palm oil plantations). A study in Malaysia proposed by Kong et al. (2014) pointed out that producing biochar from oil palm has challenges, such as economic, logistical/transportation, and market acceptance. Acting as a carbon sink, while oil palm biomass is processed into biochar, an innovative integrated economic system was needed (Kong et al., 2014). Besides, biochar is also helpful for waste sludge reclamation. (Sun et al., 2021).

This chapter describes forest biomass in a different management unit in detail. However, other biomass resources such as agriculture/crop residues, and palm oil industry residues, also have the potential for the biochar industry. This chapter examined the key management of the biochar industry to help rural communities gain equitable energy. Nowadays, many rural communities use wood combustion, and even wood cooking stoves are not suitable for healthy living for the whole family, especially women and children.

Any renewable biological material can be used directly as a fuel, neither converted to another fuel or energy product; it is known as a feedstock. Good quality biochar also comes from a good quality of the feedstock. Biochar can also be divided into traditional and modern production systems, the schematic diagram shown in Figure10.7 (a) & (b), respectively. This chapter uses forest biomass residual processes in both traditional and modern systems. Although the modern systems are more appropriate than traditional ones, rural society must learn to simplify using biochar in the first stage. At the same time, the modern site has to build and make access to the local/rural society.



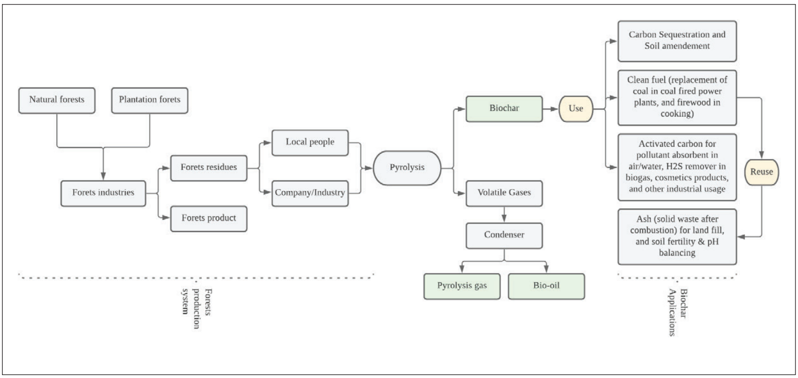
Source: Adapted from Anand et al. (2022)

Figure 10.7 (a) Traditional and (b) Modern Biochar Production System

The forestry production system comes from forest plantation and natural forest. Usually, the industry only accepts some parts, such as stems in specific diameters. Therefore, we can still use the branch, foliage, and root. The society can collect the forest biomass residues and work on the management. Thus, the biochar industry can create new job opportunities for rural people. In comparison, we reduce household carbon emissions and forest degradation through sustainable forest management.

5. The sustainable rural areas households

Rural population refers to people living in rural and maintaining the rural area. The stability number is also a fundamental issue the government needs to address. Rural areas have more flexible lifestyles as the buffer for the urban area because not all the economic systems are formal, such as farming, fishing, and rural livelihood, which do not need a more formal manner. Therefore, no high-risk damage will happen for those rural areas households as long as the family has access to the land, equipment, seeds, market, and other agriculture chain systems. Besides, in recent decades the modern economy and



Source: Adapted from Anand et al. (2022)

Figure 10.8 Forests Residue to Biochar Production and Application System the internet have already changed rural areas. That means sustainable rural areas and households must also be connected with the urban area.

There are two types of forest resources in typical forests: natural and plantation forests. Forest products also have residuals from this forest residue; the local people, companies, and industry can manage and produce biochar through pyrolysis. The standard products from pyrolysis are biochar, bio-oil, and pyrolysis gas. Moreover, biochar has functions like carbon sequestration and soil alteration, clean fuel, activated carbon for pollutant absorbent in air/water, ash for landfill, soil fertility, and pH balancing (Figure 10.8).

The biochar industry in rural areas needs to address rural economic growth, improve the government system, provide clean energy, enhance the small industry, and provide the supply chain for urban areas. Besides, the urban area needs to maintain a complex government system. In addition to reducing the urban area carbon emission, the comprehensive methods; technology solutions for e-governance order fulfillment. There are many ways to reduce carbon emissions. However, the implementation needs a strong government, private sectors, and social commitment. For example, due to reducing, a China study addresses climate change and promotes a low-carbon emissions (Wang et al., 2016). Therefore, a robust action plan was to examine sustainable rural areas households.

C. Conclusions

The integrated biochar industry for Indonesian rural area households has the potential to achieve the Nationally Determined Contributions (NDCs) implementation targets according to the Paris Agreement. Forest biomass and carbon sequestration also need to address through a comprehensive forest inventory and quantification, forest mapping, Smart Forestry Station (SFS) initiatives implementation, establishing biochar industry, and maintaining the sustainability of rural area households. Further study in the biochar industry and carbon emission estimation was needed.

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