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Original article

Bioenergy: a foundation to environmental sustainability in a changing global climate scenario

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ABSTRACT

Bioenergy has obvious advantages over conventional fossil fuels owing to its renewability and huge capacity, which has dominating role in shielding the energy security that can be a favourable alternative to the disruption of food, resources and the atmosphere. In order to maintain their immediate energy levels and restore the atmosphere, coal-based countries need alternative fuels. For example, wonder inclusion to renewable energy are biofuels derived from crop residues devoid of sacrificing on food production. Annually, about 65 million tonnes (or 280 million metric tonnes) of energy crop-based ethanol are generated, which itself is equal to China's present gasoline ethanol output (2 million tonnes per year). The adverse effects of bioenergy production can vary highly depending on biological sources, land locations and management practices. Replacing fossil fuels with biofuels can significantly reduce these harmful effects arising from various fossil fuels. Identifying crop growing areas, appropriate bioenergy cultivars and appropriate management practices will contribute to the rig environment and biochemical sustainable development. Improved farm management and landscape planning are valuable for ecological services. This paper discusses several biofuels induced patterns of land managements, and generations of biofuel resources practices, cultivation of bioenergy crops environmental implications, and prospective techniques for establishing ecologically friendly biomass energy programmes.

1. Introduction

Every time there is concern about access to biomass, the competition between different uses of biomass and the potential for bioenergy development. Majority estimates indicate that survival plays an essential role in a broad energy delivery system. World's half renewable energy consumption (including wind, water, solar and other combined renewable energy) is contributed by bioenergy (International Energy Agency, 2016; Leirpoll et al., 2021; Shorabeh et al., 2021) is depicted in Fig. 1. The term bioenergy has a definite impact on decarbonising of various zones, which include goods in transit, highway transportation, air travel and marine transport. The development of bioenergy is determined by its ability to extract large amounts of biomass (Umar et al., 2021). For the development of the bioenergy uninterrupted business of biomass will play significant task in future (Nwozor et al., 2021; Malode, et al., 2021). Biomass has a variety of feedstocks, including lignocellulosic biomass, agrochemical biomass and biowaste which comprise of various transformation methods such as, biochemical, chemical and thermos chemicals. These transformation procedures commonly depend on the availability of biomass and the liveliness requirements. Therefore, energy-induced

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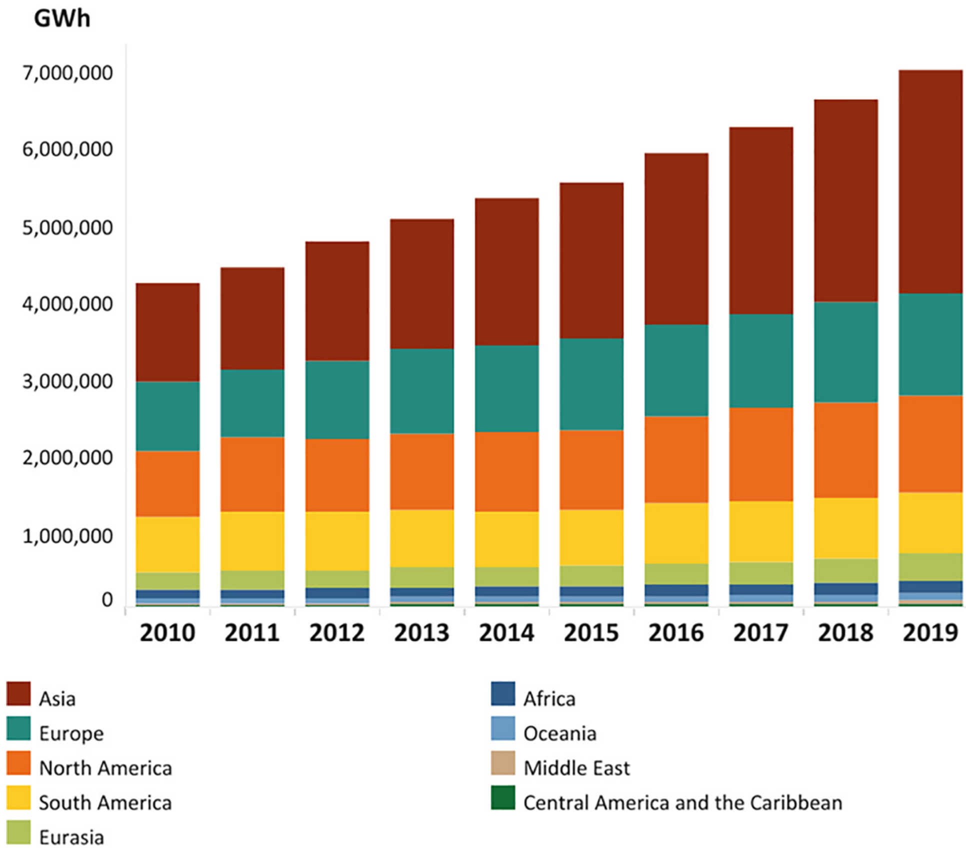

Fig. 1. Trends (2010–2019) in renewable energy by region Source: Data extracted from: (IRENA, 2020).

efficiency depends not only on the sources of biomass, but also on the technology involved in energy conversion. The life-based economy depends on the sustainability of the biomass. As long as carbon level will remain near to neutral greenhouse gases can be generated from biomass using low-energy inputs or high efficiency renewable energy (Bagheri et al., 2018; Purnell, 2019). Significant opportunities for biomass production include climate, energy goals and social, environmental, and economic benefits. It facilitates agricultural markets and promotes sustainable development in rural communities. With proper planning and management, biochemistry, food, ecosystems, water, health, and wellbeing provide many benefits. Future research in biofuels includes improving the net process efficiency of biofuels and developing economical automation for new biofuels. Though biomass is thought to be a renewable resource, however due to insufficient resources that are important for production, its use is limited. Due to the growing interest in bioeconomy, organic assets continue to evolve and become high added-value products. The target of the study is to describe the composition characteristics of the biomass products and the composition that determines the diverse biomass types and classifications. In addition, a comprehensive review of different biological resources around the world has focused on their several environmental impacts. Bioenergy is considered a robust renewable alternative to fossil fuels to achieve energy security, reduce global warming, and accelerate global population growth (Prasad et al., 2021). As per studies, it has been revealed that the different fuels can be used for biofuel production. Therefore, bioenergy is gaining increasing attention and is active in the energy use of land in relation to climate change (Jiang et al., 2012; Avagyan, 2021). As reported by World Energy Council and Research (Army et al., 2021) 14% of the world-wide energy use is biochemical in nature as shown in Fig. 1. [https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Regional-Trends].

2. Sources of bioenergy waste

2.1. Agricultural Aspects

Huge amounts of harvested crop waste are created in agriculture production. Wheat, rice, vegetables, fruits, and other crops produce lots of leftovers, which are necessary for the yearly conversion of biomass. As a result, agricultural biomass considerably improves the generation of sustainable energy for industry and home processes (Kumar et al., 2015). Leftover biomass from agricultural and forest residues may be divided into two categories: (1) plant pieces that are left in the field, and (2) plant components that are lost due to processing processes. Previously, though, all forms of leftovers were not used for biomass. Biomass wastes can now be utilised for a variety of applications, including biofuels (biogas/bioethanol), energy generation, and fodder, all of which benefit a country's economic prosperity (Mata et al., 2010; Giwa et al., 2017). Fruit plants, especially drupes, have endocarp tissues in horticulture. The endocarp of a drupe fruit is the hard, unpalatable component of the fruit, while the mesocarp is the palatable section. The woody biomass of the drupe endocarp is the main source of lignin, accounting for almost half of the total (Welker et al., 2015; Mohammed et al., 2018). As a biofuel, lignin has a higher power density than cellulose. In horticulture, lignin plays an important role in energy generation by using the endocarp of fruits (Li et al., 2018; Sharma et al., 2021; Wani et al., 2018).

2.2. Industrial Aspects

In industry, microbes can be employed to produce biomass. Especially yeast, which is employed as a biocatalyst in bakeries, lactic acid (used as a starting culture in dairy product manufacture), breweries, probiotics, aquaculture, as well as livestock feed production (Karim et al., 2020). Fermentation may be utilised to produce biomass on a big scale utilising low-cost substrates and products. Soya bean meal, sugar cane molasses, and other industry wastes are among the cost-effective substrates (Nigam and Singh, 2011). In the industry, solid biomass is desired. Implementations also employ liquid waste and biogas, but solid biomass has become more essential in the last seven years. In other countries, 80 percent of global biomass is used in some capacity in industry. Most of the biomass used in business comes from American woods, especially black liquor (Amidon et al., 2008; Dominguez et al., 2020). In Sweden, biomass was used by 41% of industries in 2010. The wood processing industry, in particular, makes extensive use of wood-based biomass, accounting for 45% of total industrial electricity consumption in 2010.

2.3. Domestic food waste and considerations

Increasing waste materials cause energy loss, risk to the human health and the environment (Panwar et al., 2011; Sridhar et al., 2021). The biological waste, especially food waste, makes up the majority of municipal solid waste (MSW) (Ionescu et al., 2013; Ferrao et al., 2014). The European Union's objective of finding a viable supply for the "Recycling Society" might be a superior resource for reducing waste output. Biological waste, especially food waste, makes up the majority of MSW (European Union 2009; Mazivila 2018). As a result of the rising population, food consumption has grown, and waste output (i.e., food waste) is predicted to expand significantly. The Waste Framework Directive regulates food waste largely at the EU leve (Kupper et al., 2014; Garske et al., 2020). As a result, it is clear that more effective and alternative techniques of dealing with biodegradable waste produced in households are needed (Kirkman and Voulvoulis 2017; Kakadellis and Harris 2020). Domestic composting and anaerobic digestion are two techniques that are both well-known, widely dispersed, and compact. Nonetheless, it frequently fails and cause more problems than they resolve, such as odours and GHG emissions (Kiyasudeen et al., 2016; Peng and Pivato 2019). Around 23% of the 4.8 million tonnes of MSW produced each year is reused (mainly packaging debris), while the remaining 77% is disposed of without sufficient treatment. Due to a lack of new creative initiatives, the percentage of waste produced is likely to continue to rise, posing serious environmental concerns in the near future.

3. Bioenergy research overview

Bioenergy has a bright future as a source of energy for the world. The calculated the worldwide future of biofuels from lignocellulosic and food crops in 2070 based on expected changes in land usage and technological advancements (Deng et al., 2015; Malik et al., 2018). Despite the fact that their research included all nations on the globe, only 55 countries were regarded as relevant due to abundant biomass resources, and the others were labelled "Rest of the World". By 2070, China and the United States are expected to have the biggest Lignocelluloses as well as food plants, respectively, have biofuel potentials. With the price of fossil fuels rising, bioenergy may be a viable alternative. However, uncontrolled and haphazard bioenergy production might be damaging (Cherubini and Stromman 2011; Ayub et al., 2021). The conflict between fuel and food is a big challenge with biofuel production. The competition can be resolved to some extent by combining biofuel production with food production. However, by enhancing land use efficiency, bioenergy output might be boosted with low impact on food security. For example, providing financial help with feedstock on a limited basis producers to enhance agricultural profitability might boost biofuel production efficiency without affecting food supply. Another way to increase productivity of the land is being set aside for bioenergy development and implement a dual strategy of cropping, such as Lucerne or grassy patches should be planted between varieties of poplar for both fuel and feed. Cultivating local crops for biofuel in deficient soils regions, that have fewer conducive to successful processing of foods, could also help boost bioenergy production without jeopardising agricultural production. Biofuels made from lignocellulosic materials such as rye (Secale cereale), oat (Avena sativa), straw, maize stover and wheat (Triticum aestivum) are some of the other grains that can help to solve concerns about fuel and food (Talebnia et al., 2010; Gasparatos et al., 2015; De Corato et al., 2018; Islam et al., 2020).

Table 1 shows the bioenergy feedstocks from important agricultural and forest products. The generation of biofuel feedstocks can have a significant impact on carbon in the soil, such as in poor soils it varies between 0.6 and 3.0 Mg C/ha/year capacity to absorb carbon. Beside from the fuel versus food struggle, biofuel feedstock development has the potential to have a considerable influence on the water footprint (Jha and Schmidt, 2021; Babin et al., 2021). Increased biofuel production means more agricultural activities, such as fertiliser application treatments with tillage, which worsens surface and groundwater quality. In the Gulf of Mexico, corn is the dominant biofuel resources, using the largest fertiliser application rates, more land covered and vulnerability to erosion, and the maximum nutrient discharge to aquatic bodies (Dale et al., 2010; Ortiz-Reyes and Anex, 2020; Haque, 2021). Fig. 2 shows the sources and feedstocks in processing biofuels and other end use application.

In 2015, the UN Climate Change COP 21 conference was described by the world front runners for Global Climate Change Agreement, aiming at neutralising global GHG emissions. Compared with pre-industrial times, capturing global warming below 2 °C (Robbins 2016). Unlike change in climate, the European Union passed the Energy and Climate Act system that set three main targets for 2030: to reduce the greenhouse gas emission (GHG) by less than 40% from 1990 levels, to reduce the apportion of renewable energy not less than 27% and to increase energy productivity by at least 27% (EC, 2014). Biomass-based energy will play a key role in meeting these ambitious targets, with woody biomass accounting for 44% of total renewable energy output in the European Union (EU) Member States in 2014 (Berndes et al., 2016). The Environment and Energy System (2014) is culmination of the political process that began with Green Paper (1996) and aims at enhancing the energy mix including some proportion of renewable energy sources. Bioenergy is characterised from a technical point of view as biodegradation energy, where biomass can be directly used as combustible or converted into gases and liquids (IEA 2016). The term bioenergy is derived from the organic/biological materials like plants, crops and other waste, and is considered to be specific main modules of the EU Sustainable Growth Innovation: Bioeconomy for Europe strategy (EC, 2012; Yang et al., 2021). Bioenergy has been accounted for 60% of Europe's sustainable energy in its entirety (European Biomass Association, 2013) and its significance has improved in response to the EU countries' assurance that 27% of total energy consumption will be delivered by renewable energy by 2030 (Nikodinoska et al., 2015). Fig. 3 shows the installed capacity transformed directly burned for heating or power generation from Biomass such as liquid biofuels, renewable municipal waste, biogas, and solid biofuels.

Table 1
Bioenergy feedstocks include important agricultural and forest products.

Primary Bioresources from agricultural lands					Resources from timber lands/Wood residues		
Energy crops				Crop residues	Timber		Biomass
					Saw timber	Pulp wood and other round wood	
Herbaceous		Woody					
Perennial	Annual	Coppice	Non coppice		Logging residues		Whole tree biomass
Switch grass	Biomass Sorghum	Willow	Poplar	Corn Stover			
Miscanthus		*Eucalyptus*	Pine	Wheat straw			
Energy Cane				Barley straw			
				Sorghum straw			

* According to the Cambridge Dictionary, a coppice is a densely planted forest where the trees are chopped down on a regular basis to supply wood. Based on U.S. Billion Ton Report (2016): Pushing Domestic Resources for a Vibrant Bio-Economy (J. Kristen, R.Efroymson, M. Langholtz, 2016.

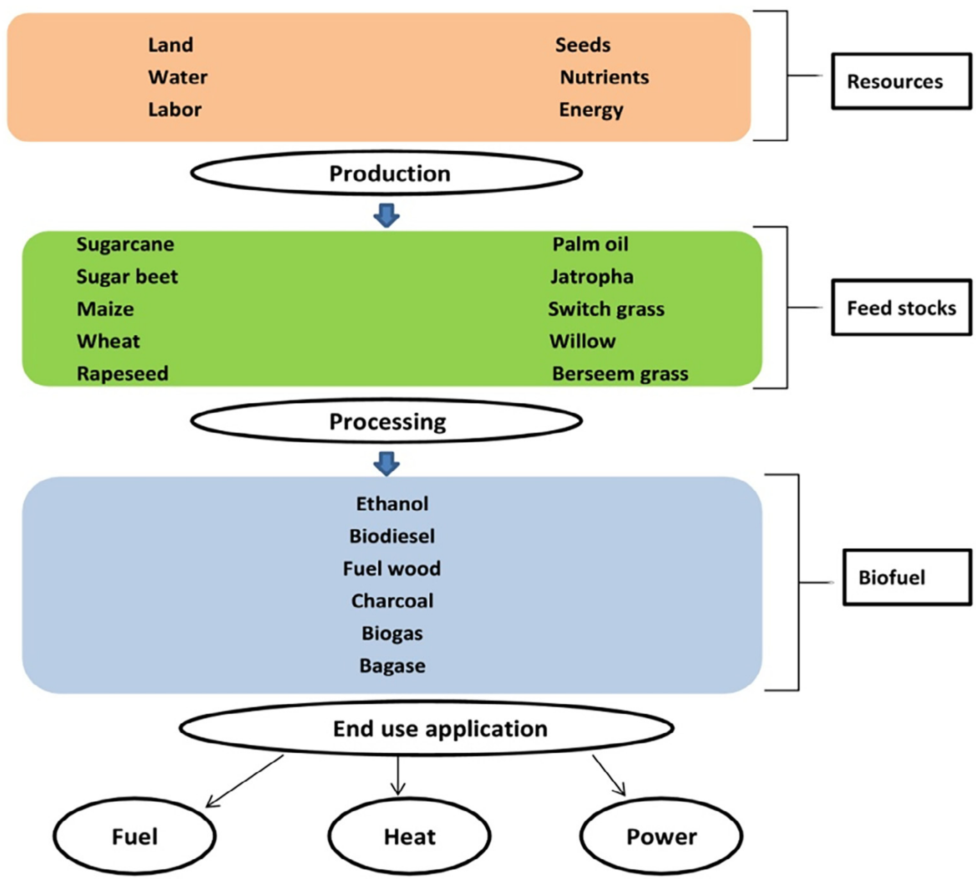

Fig. 2. Flowchart depicting the sources and feedstocks in processing biofuels and other end use application.

4. Impact of bioenergy on environmental issues

4.1. Water quality and quantity

Water supply and quality are affected by bio-production systems. Different crops have different water use capacity and depending on its different systems use underground water and surface water as a source for irrigation. An important water quality concern in growing bioenergy crops is nutrient contamination triggered by outside runoff and groundwater aggression. Nitrate is the utmost cause of mineral effluence. As per the EPA (2011) notes, corn/maize has complex fertilizer consumption and lower nutritional productivity than other bioenergy crops. The different impacts of bioenergy production on both quantity and quality of water depend primarily on the use of water and land conversion of bioenergy crops. For example, a first-generation biofuel promoted by EISA (Energy Freedom and Conservation Act, 2017), which is estimated to create potential pressure at local and regional standards, may be considered a widespread expansion in production of maize ethanol in the US (Gasparatos et al. 2011; Zhou et al. 2015; Hoekman et al., 2018). In comparison to other crops, such as wheat and soybeans, maize needs more water because more water is absorbed at each stage of development (Wu et al, 2018). Therefore, the high frequency of maize planting in the circulation of maize and soybeans or the continuous return of maize would give more nitrate to the waterways and reduce the percentage of soil nitrogen (Wu and Liu, 2012; Wu et al., 2014). There are, however, significant remunerations in the change from arable to perennials in land use. Compared to conventional cotton cropping systems, 30 to 40% total loss in nitrogen is eliminated individually by growing perennial grasses (Chen et al., 2017). Furthermore, almost no pesticides are required to grow perennial grasses that can help improve the quality of water (Hackman et al., 2018). Normally more water is required for bioenergy-suitable crops than the

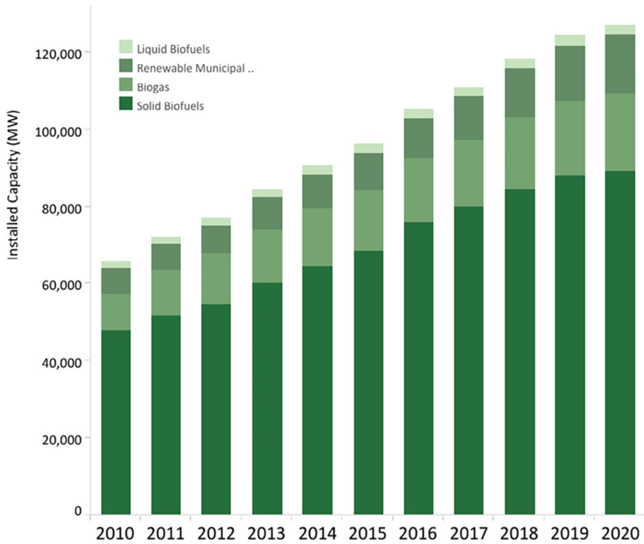

Fig. 3. From the year 2010, Installed capacity transformed from heating or power generation from Biomass has significant potential (Liquid biofuels, renewable municipal waste, biogas, and solid biofuels). Source: Data extracted from: (IRENA, 2020).

natural plants/ crops for their rapid development. Some of the live crops compete with food crops like sugarcane. According to (Sivan, 2006) harvesting remainders, growing crops devoid of undergrowth as well as establishing plant types that forgo yield adequate quantities could decrease the capacity of rain to intrude the topsoil and fill up groundwater sources, causing water difficulties on top of consumption. Authors reported that the extensive bioenergy crop planting would increase evapotranspiration (ET) rate while decreasing the annual surface water and water harvesting in the world's leading maize production regions (Kim et al., 2013). Similar findings were reported by (Wu and Liu, 2012, Guo et al., 2018). These findings also estimate that at the watershed scale, the transformation of land to bioenergy crops may cause a decrease in water supplies.

Several regions reported not only reduction in water flow but also leads to nutrient loss using the 'Soil and Water Assessment Tool (SWAT)' (Guo et al., 2018; Bano et al., 2018). In addition, the water flow problems can be reduced by suitable crop species assortment and proper supervision (for e.g., crop rate, irrigation, adequate fertilization, and filtration pits) (Wu and Liu, 2012; Qin et al., 2018), signifying opportunity of stability among bioenergy fabrication and water resource fortification.

4.2. Quality and fertility of the soil

Land despoliation is a serious global issue and is an important component of biomass production as erosion reduces soil standard and potency of various ecological communities. Some of the bioenergy fabrications methods use and reinstate stained land while as others add to the land degradation. Therefore, in many cases, bioenergy production changes the soil quality with regard to carbon and nutrients and also affecting the risk of soil erosion. As a result, biomass crops pose a specific dare to enhance management of the soil, as the substance is fully pruned and there are little organic matter/plant nutrients for protecting soil. In various rural areas of the underdeveloped countries that rely mostly on the recycling of crop wastes and fertilizers instead of using external inputs of soil management, biomass leads to a rapid reduction of soil fertility. Bioenergy reduces the yield potential of crop plants, although there is always a need for maintaining the soil organic matter by the addition of adequate plant material to the soil. In many cases, farmers can reduce the risk of malnutrition by decomposing tree branches and foliage on the farm. The nutrients available in the feed can be obtained in the form of slag or ash from the alternative facilities and can be converted into suitable materials in the field without putting on land and hence the technique is accessible for various bioenergy systems. Moreover, nutritional importance of the ash or slag is less than optimal. There are three main methods of soil degredation: (i) maize acreage, (ii) residue removal, (iii) change in land use. Soil retention can have serious negative effects, as demand for ethanol is increasing and the planting area is reduced to an acre of corn. If corn crop is grown on these lands, the benefits of various conservation measures in maintaining the soil will be further reduced, and moreover the cultivation of the existing maize crops with suitable agricultural operations will reduce the soil erosion (Hackman et al., 2018). According to Blanco-Conkey and Wortmann, (2017) the air and water erosion occur in residual crop residues on the soil surface. Therefore, harvesting crop residues increases the risk of erosion because of the minimal physical slope of the soil surface leading to the nutrient and SOC losses (Environmental Protection Act, 2011; Lal, 2005). Soil erosion is induced to remove excess residues, using regulative measures like using direct input of organic matter along with additional conservative approach (Cibin et al., 2016). In addition, soil or shelter soil can be enhanced from land use alternative erosions. For example, soil and water loss is increased by the conversion of forests to perennial biochemical intermediates while as switching from the grain crop to perennial grass has an uplifting effect on water and soil security (Liu et al., 2012). Perennial grass, especially grass will reduce residual yields in stream runoff and soil erosion thereby increases water and infiltration use despite of weather conditions. Certain regions such as the Chinese Lotus Plateau, sustainable land and water conservation are more favourable as compared to cropland (Brown et al. 2000). Therefore, corn crops ethanol seems to have a better potential over grass grown in erosion-prone areas.

4.3. Biodiversity and soil organic carbon

Biodiversity is an important annunciator of food augmentation and environmental functions (Qin et al., 2018). The influence of biomass yield on biodiversity rests on the early land utilization state, biochemical yield set-up and the natural organization (Immerzeel et al., 2014; Sangeet and Kumar, 2020). Change in land utilization is the significant feature affecting biotic capacity of soil through undeviating changes in land utilization conditions and yield management, which is related to the type of plant and the planting area. For example, substituting pastures by various biofuel plants can increase regional produce efficiency and help sustain environmental performance due to changes in yielding times (Sang and Zhu, 2011; Korea et al., 2017). Also, several researchers have stressed that increasing temperatures have little undesirable effect on diverseness of life as compared to yearly crops, because perpetual agriculture provides quite reliable habitat for wildlife (Rowe et al., 2009; Werling et al., 2013). Furthermore, landscape designs are improved by marginal landscape or power plants with low productivity and administrative exercises may help in reducing biodiversity in places, even though it needs additional research (Sang and Zhu, 2011; Manning et al., 2015; Wani et al., 2018). Since Soil Organic Carbon (SOC) is major annunciator therefore soil status and large content of SOCs helps in soil water retention, soil biodiversity and crop productivity. Biochemical yield affects Soil Organic Carbon in three main ways - residual disposal, cultivation and change in land utilization. So, the debris collected from decayed plants return to the crop first which can directly increase SOC losses because of low carbon input (Hoekman et al., 2018).

However, Soil Organic Carbon (SOC) risks maintaining partially suitable residues by eliminating excess organic matter residues and inputs (e.g., fertilizer use) (Robertson et al., 2014: Sheehan et al., 2014; Wu *et al.,* 2015). Control). Plant residues are the major source of biochar production, using crop residues with suitable technology to generate huge amount of biochar with available crop residues. Using bioassay can help in enhancing efficiency in carbon sinks in agriculture, as it not only collects SOC but also absorbs mineral carbon (i.e., CO) into the air (Li *et al*., 2017). Another reason for the loss of Soil Organic Carbon is control practice and land disruption. E.g., Trivink *et al*., (2015) replicated the effects of cultivation methods using biochemical models on SOC and found that cultivation always causes SOC losses. Similarly, field tests have shown that interference (e.g., cultivation techniques) can greatly reduce SOC (Cheng, 2009: Yang et al., 2015; Warren Raffa et al., 2015). Furthermore, land change is too a significant feature for SOC change. Bioenergy-based on change in utilization of land always signifies the transition from yield to perennial grass or marginal crop growing bioenergy crops having a good impact on SOC change. Latest research suggests that the accumulation of mendonas in the fruit ranges from 0.42 to 3.8 mg/ha with carbon (McCalmont et al., 2017). Further, bioaccumulation is essential for development of the organic carbon in the soil since it absorbs CO_2 from the air and protects agricultural soil carbon sinks and air quality (e.g. methane, nitrogen oxide, and PM2.5 (Borsham et al., 2017; Ajibade et al., 2021). Identify plant types and management activities in consideration of P. bouquet areas. To summarize (Borschem et al., 2017), briefly consider the area's most suitable for the development of bioenergy, plant types and activities of management: biodiversity and carbon sequestration.

Biofuel feedstocks which replaced environments, including such forests, marshes, or natural meadows, have been shown to be detrimental to biodiversity (Webb and Coates, 2012; Arneth et al., 2021). A few of the key avenues for biodiversity loss is habitat destruction owing to the alteration of these natural areas for biofuel feedstock production. Another key avenue is the degradation of agrobiodiversity in the shape of crop genetic homogeneity owing with changes in land use and development on croplands. Grasses utilised as biofeedstocks, sugarcane an example has poor genetic homogeneity, making them more vulnerable to novel pests and diseases than feedstocks with such a significant level of genetic variation, including such Jatropha. Furthermore, land intensification motivated by market incentives may result in biodiversity loss. Excess supply for biofuel in Brazil, for example, resulted in higher commodities prices and agricultural growth, endangering regions with diverse bird species (Hill et al., 2006; Ale et al., 2019). Biofuel production, on the different hand, can have a beneficial impact on biodiversity where deteriorated or marginal areas are regenerated for the production of biofeedstocks such perennial mixed species (Webb and Coates, 2012; Panchuk et al., 2020). As contrasted to compared to corn and soybean, (Tilman et al. 2006) discovered a wild grassland with great variety and little inputs perennial combinations provide such a variety function provided by ecosystems includes animal Carbon sequestration, habitat, and water infiltration. Overall, in order to build sustainable biofuel production systems, it is necessary to enhance positively benefits and reduce adverse implications of biofuel production and consumption on biodiversity (Fig. 4).

4.4. Climate change mitigation potential

Minimization of greenhouse gas (GHG) mission, the main term linked to biochemical yield is GHG emission reduction. Due to its large size and multiple genesis mechanisms, CO_2 and N_2O are two major GHGs (Dunn et al., 2013; Qin et al., 2016). Conceptually, the total CO_2 emission is much lower than that of used oils due to unmediated use of bio- CO_2, as has been shown in various research studies (Wang et al., 2012; Dunn et al., 2013; Fu et al., 2014). It has been estimated that the overall potential production of switchgrass instead of fossil fuels on the margin ground would minimize emission by 29 mt of CO_2– eq f yr Liu et al., (2017). From the experimental results, it was concluded that the use of ethanol in ethanol per mega joule (MJ) energy for transport would reduce 40–85 percent of GHG emissions in the United States, although the reduction in GHG is different. Different feeds differ substantially in inventories. However, there are also significant concerns about the mediated effects of biochemical yield on CO_2 emissions (Singer et al., 2008; Dunn et al., 2013) and also the disruption of CO_2 ejection caused by changes in land use (Hill et al., 2006).

Hams et al., (2015) found in the latest study of potential biofuel effects that the shift from agriculture to bioenergy crops of the second generation could marginally reduce CO_2 emissions and that the transformation from the local grasslands of first-generation bioenergy crops and limited rotation cap lands would lead to increased CO_2 emissions. From now on, when speculating about reducing CO_2 emissions, it is important to understand various potential bioenergy crops and control practices. Like CO_2, N_2O (298 times CO_2) also has a role to play in global warming, and this gas provides the largest amount of agricultural output (Williams et al., 2010). Changes in land use are the main contributing factor influencing N_2O emissions, such as CO_2 emissions. The effect of shifting SRC and perennial grass from agriculture to $N_2O - 0.2$ tons/ha was summarized by Harris et al., (2015), but with a small increase in NDA emissions from land transition front grasslands to SRC Ken. In addition, (Liu et al., 2011; Rani et al., 2021) stressed instead of fossil fuels that the use of marginal land-derived biomass for energy has a constructive effect on national GHS emissions on the climate. Nevertheless, ethanol demand-driven maize expansion stimulates N_2O release. Corn needs more fertilizer than any other crop, especially nitrogen fertilizer, which is the basis of the process of soil degradation and thus increases N_2O emissions directly. Thus, in reducing N_2O emissions, proper selection of bioenergy plant varieties and planting sites is essential.

With its ineffective use of land and possible interference with the other land use pattern, bioenergy plays an important part in most long-term enhancing sustainability for main three reasons. First, despite intermittent energy sources, bioenergy can fulfil baseload electrical energy demands, a feature that is expected to become essential as current thermal capacity dependent on fossil fuels is being phased out. Second, large fuels are required for uses in transportation and aircraft, and biofuels can satisfy this need at a cheap cost. Finally, BECCS has the potential to be a carbon-negative energy source. Basic investments in public and private research and development (R&D) are required, which are normally made through public funds or specialist industries. Data regarding R&D) financing of selected energy technologies were gathered from the International Energy Agency (IEA, 2021) as represented in Fig. 5.

4.5. Carbon sequestration

Specialists agree that bioenergy from forests has a detrimental effect on carbon sequestration (Babin et al., 2021; Di Sacco et al., 2021). Via the biogeochemical cycle, prolonged decomposition of deadwood and wood residues is released into the carbon atmosphere within a short period. Our findings indicate differences between decision-makers and educators/researchers. Clear cutting of copies has an affirmative impact on the carbon sequencing for the first party. But it also impacts scholars and educators negatively. The 'official notion' refers to the mentality of public managers, forest managers, and policymakers who aim to use forest biology as a sustainable resource to combat climate change. Some

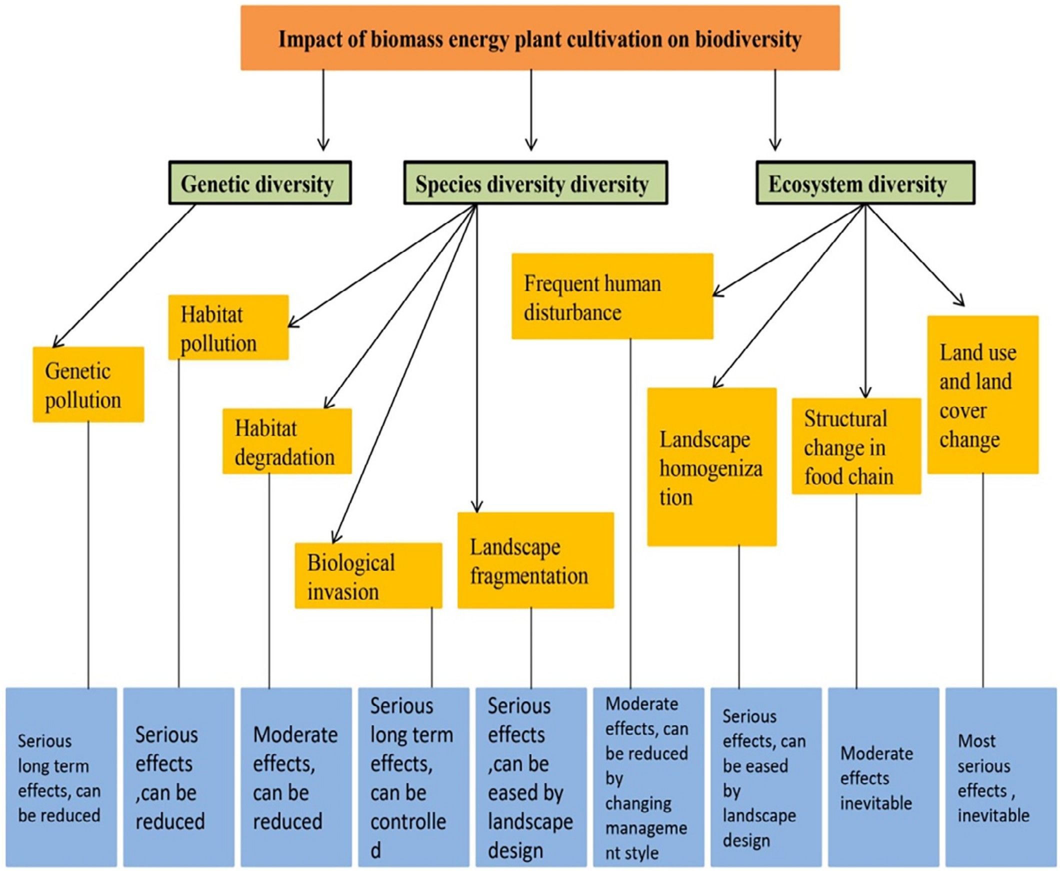

Fig. 4. Impacts of biomass energy plant cultivation on biodiversity (Reproduced from Liu et al., 2014).

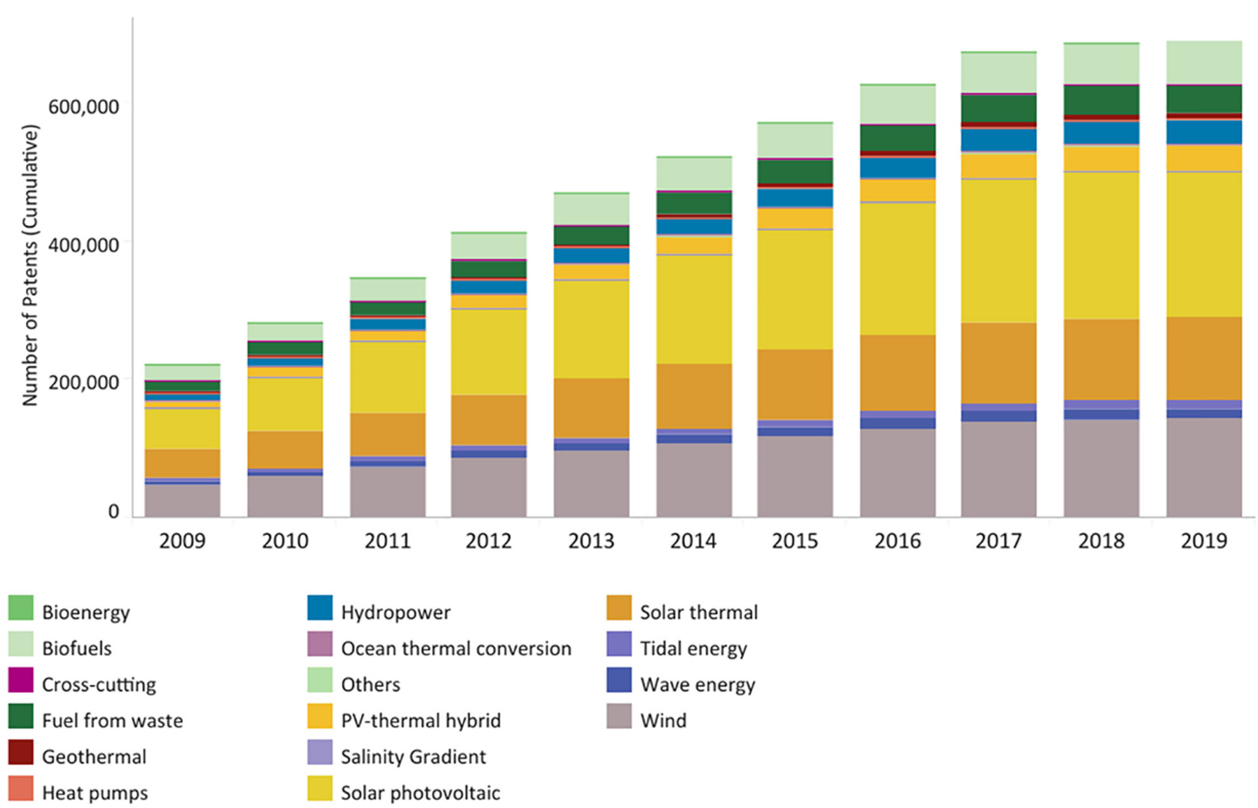

Fig. 5. Number of patents filed for renewable energy technologies worldwide. Source IRENA INSPIRE (www.irena.org/inspire) based on data from EPO PATSTAT and climate change mitigation technologies (2009–2019).

researchers indicate that the effect of climate bioenergy plays an important role in the international debate and use of the forest biomass as the source of energy increases the global warming while as others may play a role in reducing forest biomass. The study's aims and the methodological methods implemented (Berndes et al., 2016). Land biogeography is, in particular, an important part of forest management and energy industry systems. As opposed to fossil fuel substitutes, forest biomass has a substantial reduction in GHG emissions. This approach allows forest resources to be more effective in mitigating climate change, given the widespread effects of bioenergy production in forests, especially in carbon ponds (McKenney et al., 2011; Nave et al., 2021). Bioenergy is part of a solution to pollution from stumps and roots. However, the quantity contained in dead organic matter is decreased by applying this source to biology. There is also a fascinating tradeoff between the use as a stump of bioenergy and the addition of it to a reservoir of deceased organic matter. Since the stump decays with time, the issue has a significant temporal dimension (Melin et al., 2010).

4.6. Socio-economic impact of bio energy production

In order to recognize the advantages and downsides of bioenergy when they occur, as well as to minimize unfavorable results, an early assessment of the implications is required. A few of the socio-economic effect subcategories for Bioenergy include job creation, income, food security, macroeconomic growth, rural economic boom, available energy, commercial viability, land rights, working conditions, public acceptance, and community benefits (Brinkman et al., 2019). Therefore, the two most critical concerns involving biomass utilization for energy production are likely to be local job creation and economic advantages Table 2.

Bioenergy's many effects cannot be summed up in a single numerical figure. As a result, numerous indicators are used to represent each possible socio-economic impact, accounting for the many elements of every socio-economic impact (Bell and Morse, 2008; Zahraee et al., 2020). Obtaining consensus on the clear signals of probable socioeconomic impacts can aid in the transmission of sustainability criteria and quantification of agreement (Markevius et al., 2010; Heckwolf et al., 2021). It will increase the whole bioenergy's long-term viability (Lewandowski and Faaij, 2006; Xu et al., 2020). Table 3 shows the four categories of indicators that have been chosen.

Table 2
Bioenergy production elements and its benefits (Domac et al., 2005).

Key elements	Benefit
Social Aspects	• Improved living standard - Atmosphere - Health - Training • Social consistency and constancy - Movement effects (alleviating rural removal) - Provincial progress • Rural modification
Macro level	• Security of Supply/Risk Diversification • Condensed Area Trade Balance • Export Potential
Supply side	• Augmented Production • Boosted Effectiveness • Labor and Inhabitants Flexibility (induced effects) • Improved Organization
Demand side	• Employment • Income and Wealth Creation • Induced Investment • Support of Related Industries

5. Evaluate the impact of environmental life cycle bioenergy production

Life Cycle Assessment (LCA) is a comprehensive way to determine the environmental impacts with extracting raw materials from all stages of an object's life (i.e., processing, distribution, use and end of life). The method used by Pennington et al., 2004. LCA has been used to examine the environmental benefits and risks of biodiversity across globe (Poshiro et al., 2016; Cherubini and Stroman, 2021; Dias et al., 2017: Homosen et al., 2017), especially GHG Storage and SOC Ordering. Acute to the severe impacts on environment by nurturing of permanent energy crops has been assessed and it has also been found that significant GHG emissions from fossil-C to fossil-C were significantly lower than those with permanent cultivation crops Fazio and Monti (2011). In addition, perennial grass can help reduce N_2O emissions (40 to 50% less ejections than fossil fuels). The LCA results that is glowing perennial grasses in fringe lands and using it for heat and electricity production leads to significant savings of greenhouse gases despite shortcomings, up to 13 T CO_2 eq./yr Schmidt et al., 2015. Escobar et al., 2017 stated that planting switchgrass significantly reduces GHG emissions in the Mediterranean Sea of Spain, where electricity generation is targeted. According to Kin et al., 2018, replacing fossil fuels with biofuels greatly reduced air pollution (e.g., particulate matter) in China. Somme et al., (2017) reported that rice grass power generation produced higher GHG emission reductions than conventional methods in India. According to Tonini et al., (2016), the agricultural residues from which biofuel is produced without incorporating changes in land utilization is a better way to reduce emission from a life cycle perspective. Whereas willow agriculture and alfalfa can release soil organic carbon as biomass feedstock, resulting in a low carbon hoofprints (Barajuli et al., 2017). The cultivation of bioenergy crops like mantanthus is considered an excellent CO_2 sink in the United Kingdom (McLemont et al., 2017),

Table 3
Key socio-economic indicators of sustainable development.

Classes	Impact	Quantitative indicators
Basic needs	Essential amenities are more easily accessible.	a huge population that is easy to reach (culinary fuel, pumped water, electric lighting, milling etc.),
Income generating opportunities	Employment generation	Higher proportion of big and small-scale firms, resulting in much more jobs for youths, as well as increased income recycling and platforms (markets) for local agriculture and non-products.
Gender	Has an impact on labour, power, and financial availability.	Availability use of bioenergy production projects, capacity to make decisions both within and outside of bioenergy projects
Land tenure and land use competition	Changes in land ownership patterns, altered access to public land assets, and the integration of local and macroeconomic struggles with those other land uses are all factors to consider.	Amalgamation or dispersion of landholdings, denationalization, pricing implications of land transferred on alternative goods, and concurrent land uses

demonstrating that biochemical production is an excellent option for entrapping more carbon in the soil. Thus, it can be concluded that the production of bioenergy is favorable for the relief of GHG emissions and SOC line. However, there are not sufficient reports on other environmental problems, as in case of water shortages and its quality, based on the LCA. Water scarcity and water quality dynamics in the life cycle of bioenergy crops are such that the impact of bioenergy production on such issues varies by biome types, land resources and management practices. To determine environmental costs in biodiversity, future studies should be extended to more ecological areas using the LCA.

6. Global impact of bioenergy

In order to preserve our village lands, it is of great importance to the planet to generate bioenergy, reduce carbon emissions and replace conventional fossil fuels. Indeed, because it accounts for one-fifth of the world's population, China has a great deal of potential for biochemical growth. China has about 130 million hectares (mha) of agricultural land, producing over 600 million tons (MT) crop residue, and is one of the world's largest agricultural countries (Jiang et al., 2012; Liu et al., 2012). On the other hand, Sang and Zhu (2011) stated that approximately 200 mount harvest residues had been burned with little conversion performance, and more than 100 mounts has been burned openly in fields leading to excess carbon emissions without proper management. The biochemical size is large and energy consumption is very normal if residues are highly productive. Biochar is also essential for the use of residues in the production of natural carbon in the loam. In China, the bioengineering industry, particularly the bioethanol industry had rapidly stretched over during the last decade (Sang et al., 2011; Qin et al., 2017). Since 2012, fuel ethanol has reached over 1.5 million metric tons (MT) (i.e., 1.9 billion liters or 1.9 billion bpd) each year, making China the third largest source of biomass in the world, with the main fodder being food grains (mainly maize and wheat) (Sang and Zhu, 2011, USDA, 2014). However, China, lags behind the two major producers, Brazil and the United States, with China's overall fuel ethanol production being 10% in Brazil and 4% in the United States (USDA, 2014) shown in Fig. 6.

Production of biofuels is projected to fall to the 2020 goal set by the 12th Five Year Plan and the National Commission for Develop-

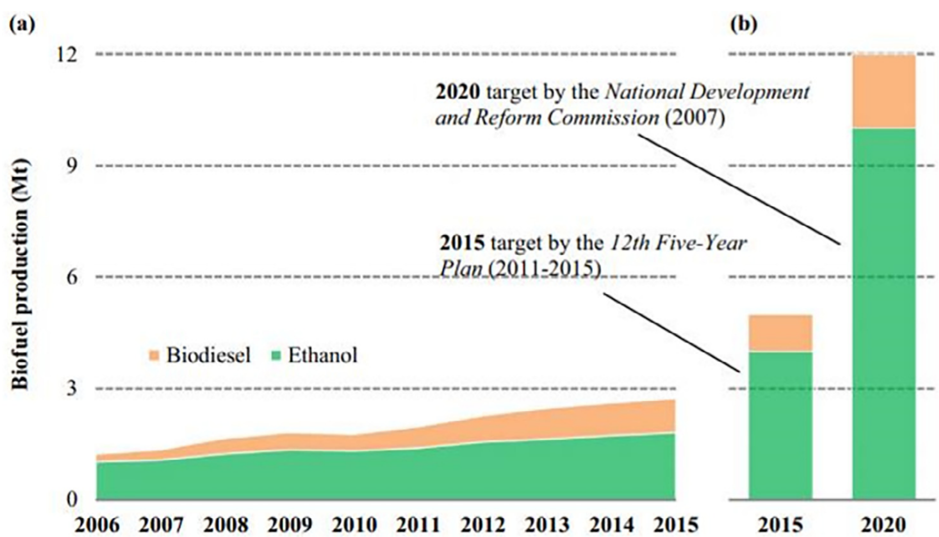

Fig. 6. The 12th Five-Year Plan's biofuel production objectives and the National Development and Reform Commission's 2020 aim (NDRC, 2007).

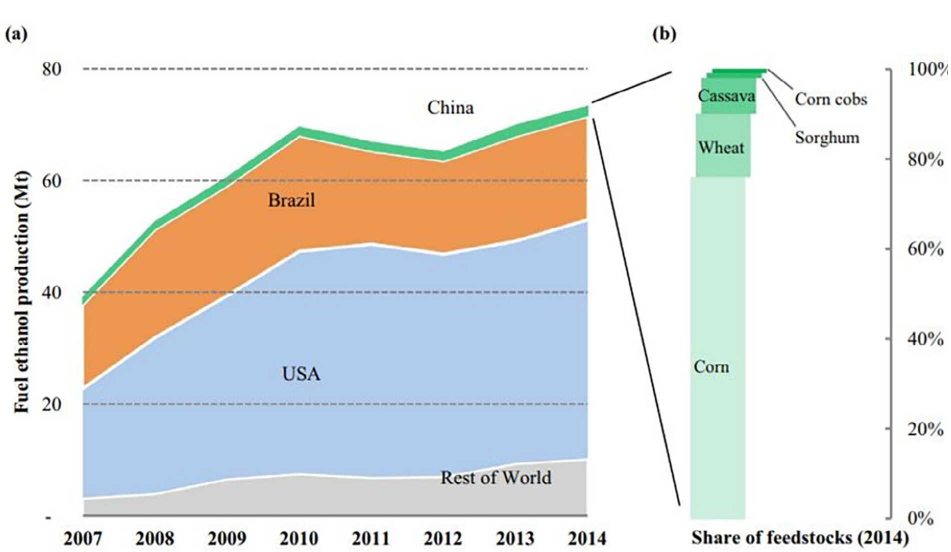

Fig. 7. Ethanol Fuel production in different countries and biofuel feedstock from different crop. (NDRC, 2007).

ment and Reform (NDRC), primarily due to supply and management constraints. China is very concerned about the production of food and the use of croplands to ensure food safety. It is hoped that biofuel development will not interfere with land-based food crops and that food grains, oil and sugar will be sacrificed. Ethanol has traditionally been produced primarily from corn and wheat grains in China. In 2014, 90% of ethanol is made from wheat and maize, while as the rest depends on newly introduced tapioca, sweet sorbet, and maize tiles (USDA, 2014). Intermediate biofuels are mainly focused on crops like cassava, sweet sorbet (ethanol), cotton and jatropha, according to the NDRC's Renewable Energy Production Program (NDRC, 2007) as presented in Fig. 6. Yet cellulosic biofuels should be introduced in the long run. The NDRC's 12th Five-Year Strategy, for example, emphasized the significance of the cellulosic biofuels and the potential for ethanol to be used with agricultural and forest waste (NDRC, 2013) as represented in Figs. 6 and 7.

The removal of wood residues during logging in hilly forests have a negative effect on the biodiversity, soil erosion, carbon sequestration, and water quality, as well as a positive impact on recreational activities and natural aesthetics. Agricultural and hydrological problems are mostly the major concerns of biochemical development in China. Since China accounts for 22% of the world's population, which is only 7% of the world's agricultural land, it must be agreed that it is a permanent thing to grow food (Zhang et al., 2015). The crops that can be used to grow bioenergy crops in China are few (Sang and Zhu, 2011; Mellor et al 2021). Therefore, while planning biochemical production (i.e., not to compromise on biochemical development) the food production should be a national priority (Qin et al., 2017).

7. Conclusion

Owing to large size as well as renewable nature of conventional fossil fuels, there are obvious benefits to bioenergy and play an important role in protecting global energy security. However, it is important to consider resources and environment costs when implementing biomass production. Based on some published results, we have drawn our analysis on the environmental consequences of the bioenergy development and also suggests that bioengineering has not yet received much attention despite growing trends. Apart from biochemical and water problems, less attention has been given to soil erosion. Biofuel production actually has an adverse impact on environment, soil degradation, plant varieties, land resources and management practices.

Bioenergy production offers a great potential to diversified systems of agricultural production while reducing GHG emissions and achieving fossil-fuel freedom and helps to mitigate the climate change threats which is the major concern nowadays. The implications of biofuel feedstocks vary greatly depending on the kind systems for biofuel production, conversion technologies, and biophysical research parameters of the land region. Therefore, bioenergy production methods have clear and immediate impacts on a local land, air and water resources. Hence, a substantial shift in agricultural output in one place might have an indirect influence on production systems somewhere else in the globe.

In future steps of the study, use of integrated sustainable modern agricultural manufacturing systems models will improved soil functions, land appropriateness, food and energy shortages in the area. However, many sustainability indicators and methods are required to develop ecologically sustainable multifunctional bioenergy production systems. In addition, policy makers (forest managers and planners, local, institutional, private enterprise, scientists and consultants) should encourage in maintaining ecologically balance, in adopting alternative management methods.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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