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Biofuel Production and Its Impact on Global Food Security: A Review Article

Abdulrahman R. Mahmood*, Mohamad R. Abdullah, Husam S. Khalaf

Department of Chemistry, College of Education for Pure Science (Ibn Al-Haitham), University of Baghdad – Iraq

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Corresponding Author:
Abdulrahman R. Mahmood
abdulrahman.r.m@ihcoedu.uobaghdad.edu.iq

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Abstract

The aim of this study is to shed light on the importance of biofuels as an alternative to conventional energy, in addition to the importance of preserving agricultural crops, which are the main source of this fuel, to maintain food security, especially in developing countries. The increase in global oil prices, in addition to the fear of global warming, are among the main factors that draw the world's attention to searching for alternative sources of traditional energy, which are sustainable on the one hand, and on the other hand reduce carbon emissions. Therefore, the volume of global investment in renewable energy in general, and in liquid biofuels and biomass in particular, has increased. Global fears emerged that the excessive conversion of large farms suitable for growing food to energy production would threaten global food security. In the first ten years of the new millennium, biofuel production increased fivefold, and the largest increase in biofuel production was recorded in 2007-2008, coinciding with a sharp rise in food prices. Compared to the average food prices in the period 2002-2004, the average global prices of cereals, oils and fats traded were 2 to 2.5 times higher in 2008, this continuous increase in the use of food crops to produce biofuels has reflected on global food security. Accordingly, this review article will address previous studies on biofuel production; identify the theoretical framework for the concept of biofuels and its characteristics, and the relationship between biofuels and food security. In this study, we presented biofuels, which are considered one of the important categories in the field of renewable energy and its environmental and economic effects, as well as the experiences of some countries in its production, and the possibility of benefiting from the natural resources available for its production. We will discuss the scientific (chemical) principles of biofuel production.

1. Introduction

The risks of biofuel production on global food security are of many dimensions. Large farms to produce liquid biofuels, with their many inputs, may divert land and other resources such as water, away from food crops. In addition, these farms may be based on very good lands due to their abundant profitability, which reduces the availability of such agricultural land as food crops or subsistence crops [1]**.** Biofuels have a negative impact on global food security, as the biofuel industry in itself creates a small number of sustainable risks related to food production in terms of competition for water and land use and a good tendency to grow integrated ecological crops. Thus extending the productivity of the agricultural sector for human consumption in parallel with biofuel production. This production would reflect on local food prices and isolate local food prices from fluctuations in international prices [2]. Since ancient times, humans have known solid biofuels, such as dry trees and plant residues, to be used in making fires for cooking, lighting and heating purposes. As for biofuel in its liquid form, it has been used since the early days of the industry. The German car engine inventor Nicholas Otto designed his engine to run on ethanol. While the German inventor of the diesel engine "Rudolf Diesel" designed his engine to work with soybean oil, while the American "Henry Ford" designed his original model of his "T" type car, a car that was produced during the period 1903-1929 to work entirely on bioethanol [3]**.** Cars began to run on fuel extracted from petroleum materials after entering the stage of producing cheap oil extracted from the depths of the earth in America in Texas and Sylvania. With the signs of the Second World War, a number of countries began to look at biofuels as a substitute for imported oil with a volatile supply [4]. Therefore**,** Germany manufactured and sold a mixture of fermented gasoline and alcohol from Potatoes **[**5]. In Britain, the Distillery Company Limited "Decol" was able to mix ethyl alcohol with gasoline, and the “Asso” company in Cleveland marketed it. With the end of World War II, the supply of oil witnessed a steady increase in the world, and cheap Middle Eastern oil reduced the interest in biofuels, that is, the decline in the economic feasibility of producing energy from agricultural crops. However, the oil market witnessed unprecedented levels of rise, as the price of a barrel of crude oil reached more than 35 dollars a barrel during the period between the October War of 1973 and the global oil crisis in 1979[6]. With the beginning of the eighties and the decline in economic growth in the major industrial countries, the oil supply witnessed a glut. While the demand fell significantly, the price of oil fell to about 10 dollars a barrel in 1986 for crude oil. Likewise, interest in biofuel production has faded [7].With the escalation of the oil price crisis since the first half of 2008 and the price of a barrel of oil reaching more than 140 dollars a barrel, reaching about 90 dollars a barrel at the beginning of 2011, as well as the increasing environmental concerns about global warming, it prompted us to think again to enter the era of intensive production of biofuels As a result, the economic feasibility of biofuel production is high. Although periods of interest in biofuel production are linked to crises in the global oil market, the decline in prices is not likely to reduce global interest in biofuels, especially after the development of scientific research in this field and the arrival of more modern generations to produce biofuels, as well as the introduction of the concept of biofuels. Sustainable development of bio-energy and the dependence of a number of countries on biofuels as one of their renewable energy sources **[**8]**.**

2. Definition of biofuel

Biofuel is defined as: “energy derived from living organisms, whether plant or animal, and it is one of the most important sources of renewable energy, unlike other natural resources such as oil, coal, and all types of fossil fuels and nuclear fuels”. Biomass-based fuels can be divided into**:**

A: Solid Biofuels

It is seen as a traditional biofuel. It is obtained from trees in the form of timber or agricultural waste to be used for purposes such as cooking, heating and lighting. This type has spread since antiquity, especially in rural and remote areas scattered in poor and developing countries in Latin America and Africa [9].

B: Gaseous Biofuels

It is one of the types of biofuels in gaseous form, which is produced from the decomposition of organic materials in animal and plant waste, which results in methane gas to the extent that it can be collected and benefited from as an alternative energy for conventional energy and used in various fields such as electricity generation or as an alternative to natural gas, for cooking and heating purposes [10].

C: Liquid Biofuels

It is one of the types of biofuels that sparked a global controversy and entered the era of intensive production of biofuels worldwide. Through it, talk emerged about global food security, and the International Energy Agency predicted that biofuels will provide about 27% of the fuel used in the transportation process by 2050[11]. Liquid biofuels are divided into:

1) Biodiesel

It is produced from • Rapeseed (EU countries) • Soybeans (US - Brazil - Argentina - EU countries) • Palm oil (Malaysia - Indonesia) • Jatropha and Carnia (Germany and India) • Castor oil seeds and cottonseed (Senegal) and West African countries - Ethiopia [12].

2) Bio Ethanol

It is produced from: Sugar cane (Brazil - Australia - China - Colombia - Ethiopia - India - Thailand - South Africa). • Sugar beet (European Union countries). • Sweet and sorghum (USA - China). • Cassava (Thailand - China - Tanzania - Uganda). | • Plant waste (forest waste (Canada) - wood processing waste and waste Agricultural - fodder corn plants - remnants of sugar cane factories (different countries) - rice husk (Thailand, Indonesia and the Philippines) [13].

3. Biofuel Production Methods

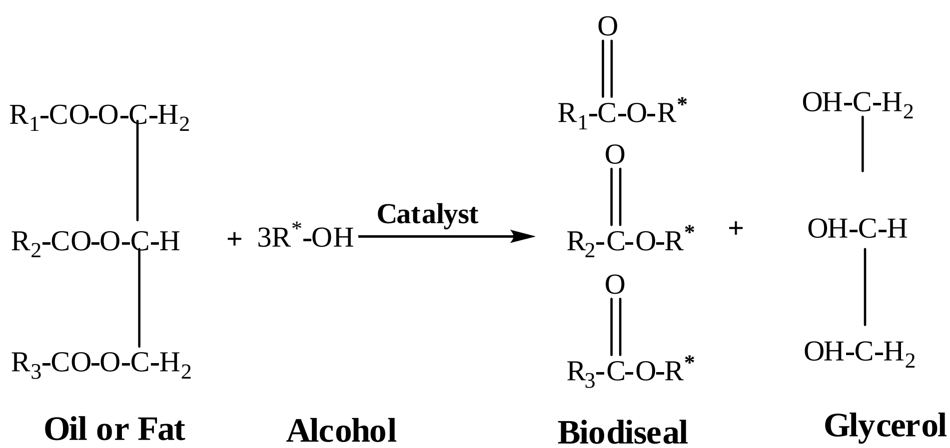
There are four ways to convert biomass into energy:

A: **Burning** woody biomass to produce heat and use it for cooking, heating and generating Electricity.

B: **Fermentation** of sugars, such as (sugar cane or sugar beet), or starches such as (corn) to convert to bioethanol. The production process of bioethanol starts with milling, where the plant crops are grinded and then sieved. After that, water and alpha amylase is added as a catalyst at 150°C, and then the mixture is subjected to sudden cooling to kill the bacteria. In fermentation process, glyco amylase is added until the mixture is brewed. Alcohol is extracted from the liquid completely. Finally, the filtration process is carried out where the water is completely extracted from the ethyl alcohol to keep the bioethanol pure [14].

$$\underset{\textbf{Glugose}}{C_6H_{12}O_6} \xrightarrow[\text{Glyco-Amylase}]{\text{Alpha-Amylase}} \underset{\textbf{Bioethanol}}{2C_2H_5OH} + \underset{\textbf{Carbon dioxide}}{2CO_2}$$

C: **Esterification** of vegetable oils such as (rapeseed, sunflower, palm or bean oils). (Soybean) to convert to biodiesel. Oils extracted from plant sources such as jatropha oil, castor oil, animal fats or cooking oils are no longer suitable for cooking. These oils interact with alcohol in presence of a catalyst such as sodium hydroxide, produce biodiesel. Biodiesel is an alternative fuel for traditional fuel and environmentally friendly fuels [15]. Chemical reaction called esterification as below:



4. Generations of Biofuels

First Generation

Ethanol and biodiesel are produced from food crops, in addition to vegetable oils, bio-alcohol, biogas, industrial gas and solid biofuels.

Second Generation

In the production of biofuels, this generation depends on bio-agricultural waste, which is typical of cellulosic materials, which include bio-energy crops, such as rice straw, bagasse, stalks and husks, in addition to the by-products of the agricultural process.

Third Generation

This generation is considered one of the most recent generations for biofuel production, which in its production of biofuels depends on converting oil-rich algae into bioenergy, and is distinguished from previous generations by its high productivity and not harming the environment or its natural resources.

Fourth Generation

The fourth generation in biofuel production depends on making a change in the genome of a microorganism, and it depends mainly on a type of bacteria. It is called Mycoplasma Laboratorium, with this change, bacteria will be able to produce biofuels from carbon dioxide, and this generation will be the latest global trends for biofuel production [17].

5. Characteristics of Biofuel Production

The process of replacing liquid biofuels with fossil fuels has a number of potential benefits. The most important one is to view it as a sustainable source of energy in contrast to depleting fossil fuels, and thus the theory that the inputs to biofuel production can be produced and used indefinitely [18]. There is a huge potential, especially for the second and third generation, to reduce greenhouse gases and carbon emissions. Moreover, it results from the use of marginal lands, and thus there are a number of potential economic impacts, namely:

1. Biofuels are produced locally, and this is beneficial in reducing dependence on the consumption of imported fossil fuels, and then the economy becomes less vulnerable to the negative effects of interruption.

2. Reducing dependence on imported petroleum products, which is likely to improve the balance of payments in favor of developing countries that have a comparative advantage in biofuel production. To use the available foreign exchange earnings in economic development processes.

3. Creating more jobs in developing countries, which suffer from low employment rates and linking the primary economy with the industrial economy [19].

6. Reasons for Turning to Biofuel Production

The global interest in liquid biofuels extracted from biomass increased in the first decade of the twenty-first century, as a group of factors combined and led to the preoccupation of global thought in this field, the most important of which are the high oil prices and concerns about future energy security, as well as the environmental threats resulting from the use of fossil energy which is the main source of carbon dioxide emissions [20]. There are many reasons that led countries to move towards producing biofuels as an alternative to traditional fossil fuels, such as:

1. Protecting the Environment from Carbon Pollution

There has been much talk about the costs borne by developing and developed countries alike as a result of environmental pollution and the global risks of climate change, global warming and the melting of polar ice resulting from the heavy use of oil and its fuels. The burning of petroleum, oil, and natural gas, and the release of carbon dioxide that it causes, has caused an increase in the Earth's temperature in what is known as global warming. On the contrary, the production of biofuels, in theory, means growing a tree that absorbs carbon dioxide (CO_2) from the air and water (H_2O) from the soil and uses rays of radiation .The sun converts carbon, hydrogen and oxygen into sugars or starches from which biofuels can be produced [21].

2. Agricultural and Rural Development in Developing Countries

Biofuels represent a promising element in the agricultural development of remote rural areas scattered in developing countries that lack job opportunities, as the cultivation of biofuel production crops provides direct job opportunities through working in agricultural fields, as well as providing job opportunities through manufacturing, transportation and distribution of raw materials and produced fuel [22].

3. Achieving Energy Security

There has been a continuous increase in the world's population since the second half of the twentieth century, which led to a significant increase in the consumption of conventional energy with a growth rate of 5.6% in 2010, the largest growth rate in nearly 40 years. Despite the stable growth of global energy consumption in 2015 and the decline in the consumption of coal, the main source of carbon emissions, energy security remains a problem facing the international community in general [23].

7. The Concept of Food Security and Its Dimensions

During the Second World War, the international community established a specialized organization concerned with global food security called the Food and Agriculture Organization (FAO), and the founding document or constitution of the organization included seeking to achieve a set of goals, the most important of which are: raising the standards of nutrition and living, improving the conditions of the rural population, and ensuring the liberation of humanity from hunger [24]. The global food crises that the international community has been exposed to have contributed to shaping the features of the concept of food security, and accordingly the globally agreed concept of food security revolves around the concept that the FAO has settled on, as food security is defined as "food security is achieved when all people, at all times, have the physical, social and economic means to have access to sufficient and enriched food to meet their nutritional needs in accordance with their dietary preferences for an active and healthy life" [25].According to this definition of food security, the main dimensions of achieving food security can be identified, which lie in:

1. **Availability**: It represents the supply side, and is measured by the ability of the state society to provide adequate supplies of food for its inhabitants, whether from their local production or from foreign markets.
2. **Accessibility**: It is represented on the demand side, and is measured by the power of all individuals in the community manage their food needs according to their financial capabilities.
3. **Safety:** The considerations related to quality and specifications ensure safety food.
4. **Stability:** It is represented in the sustainability and communication of the previous three dimensions (availability and the ability to obtain it and safety) across different time periods without exposure to fluctuations or crises, in accordance with the relevant policies, programs and measures [26].

8. The Relationship between Food Security and Biofuel Production

Economists and environmental experts have divided opinions between two factions since the start of biofuel production. The first group believes that biofuel production is the ideal solution to the problem of climate change and the gradual start of the transition towards environmentally friendly energy sources, not only by reducing carbon emission rates from the combustion of fossil fuels, but also by absorbing carbon units through photosynthesis processes in which the plant absorbs the second carbon dioxide, and that providing energy from renewable sources will contribute to reducing dependence on importing traditional energy and providing foreign exchange and then using it to develop the agricultural sector and provide more job opportunities [27].

While the second group believes that biofuel production means abandoning food security, and comparing food security on the one hand and energy security on the other, the implication of this is that the intensity of biofuel production based on food crops will negatively affect the surplus of those crops allocated to the poorest and most vulnerable classes needy [28]. On the other hand, profitability may push agricultural producers to produce biofuel crops at the expense of food crops, which will have a negative impact on the increase in the number of poor people on the one hand and the proportion of hunger in the world on the other. However, what is proven is that biofuel production continues to flourish, and its production is expected to double, and this pushes towards the adoption of new generations of biofuel production that can harmonize the requirements of food security and energy security alike [29].

9. Global Production of Biofuels

Since 1980, the production of biofuels has been constantly increasing, and this production has witnessed a great boom since the beginning of the new millennium. The volume of production increased from about 841 thousand barrels per day in 2006 to 2307 thousand barrels per day in 2016. Table (1) [30]. There is an upward trend of production. At the detailed level, biodiesel production has increased by 5 times in a decade, while bioethanol has increased by 2.5 times during the same period, but bioethanol production continues to dominate production globally in terms of production volume [31].

Table (1): The development of biofuel production globally from (2006-2016) [32].

Production / Year	Bioethanol	Biodiesel	Total-1000 barrel/day
2006	716	125	841
2007	925	179	1104
2008	1,215	262	1477
2009	1,290	314	1604
2010	1,479	357	1836
2011	1,455	426	1881
2012	1,490	467	1957
2013	1,582	529	2111
2014	1,663	571	2234
2015	1,737	526	2263
2016	1,721	586	2307

10. The Ratio of Biofuel Production to Renewable Energy

A number of countries in the world have adopted different strategies for the production of biofuels based on their strength to support the industry and provide a favorable environment, and the result of this was that the percentage of biofuel production increased as the percentage of renewable energy consumption Table (2), especially between 2007-2008, when it reached [33]. The volume of bioenergy production accounted for about 38% of the global consumption of renewable energy products, and then began to decline until it reached about 20.5%, and this decline can be explained by the link between the economic feasibility of biofuel production with fossil fuel prices, and the decline in fossil fuel prices reduces the economic feasibility of biofuel production. The decline in prices since 2011-2012 had a significant impact on the decline in the consumption of biofuels compared to the consumption of fossil fuels, as was previously mentioned [34].

Table (2): The ratio of biofuel production to global renewable energy consumption [35].

Year	Renewable Energy	Biofuel	Production of biofuels to the consumption of renewable energy
2006	93.9	25.7	27%
2007	107.8	34.7	32%
2008	123.9	46.5	38%
2009	144.2	51.9	36%
2010	169.9	59.6	35%
2011	203.6	61.2	30%
2012	238.5	62.3	26%
2013	281.1	67.3	24%
2014	316.6	74.2	23%
2015	364.9	74.8	21%
2016	417.4	81.4	20%

11. Global Investment in the Biofuel Industry

As we show in Table (3), the volume of international investments directed to renewable energy in general and the biofuel industry in particular increased, and investments directed to the biofuel industry ranked second, with an investment rate of 26%, thus ranking second after wind energy, for which investments directed globally were estimated about 38% in 2006 [36]. The heavy investment in renewable energy comes to the unprecedented rises in global oil prices, and what the Middle East and the OPEC countries - the largest producers of crude oil in the world are witnessing - are witnessing many political and security turmoil [37].

Table (3): The global investment in renewable energy during the period (2006-2016)-Billion/**$** [38].

Investment / Year	Total Investment	Investing in Biofuels	Investing in Biomass
2006	112	28.2	11.9
2007	154	28.3	16.2
2008	182.2	18.5	17.1
2009	178.7	10.4	14.7
2010	239.2	10.1	15.7
2011	278.5	10.3	18
2012	257.3	7.2	13.5
2013	234	5.7	10.5
2014	273.9	4.7	10.4
2015	285.9	3.1	6
2016	274.5	2.1	7.3

12. Recommendations

1. It is necessary to work and coordinate between national authorities in each country with international organizations and energy and environment research centers, to develop economic feasibility studies and conduct a comprehensive study on the reality of alternative energy, especially biomass energy, and the potential direction in this field to revive the environment and save it from desertification, in addition to the desired economic effects from it.

2. Motivating the ministries of agriculture in developing countries, especially, to prepare a study on how to grow economically feasible plants, especially Jatropha shrub and palms, due to the characteristics these plants have that do not require large resources to grow and reduce the phenomenon of desertification, in addition to the abundance of oil production used in the production of biofuels.

3. Urging international bodies to assist developing countries and support them with money and expertise to reclaim land and cultivate plants that can be used in the biofuel industry.

13. Conclusions

Biofuels are of great importance as a source of renewable energy in both developed and developing countries, in order to achieve several goals, the most important of which are: Finding a renewable energy resource in order to achieve energy security and to get rid of the fluctuations in fossil oil prices in the international market. As well as reducing the pollution caused by the excessive use of fossil fuels and the property of coal. The relationship between food security and biofuel production has two trends. The first trend sees the production of biofuels as the ideal solution to the problem of climate change, and the gradual start of the transition towards environmentally friendly energy sources. While the second trend sees that biofuel production means abandoning food security, comparing food security on the one hand, and energy security on the other, the implication of this is that the intensity of biofuel production based on food crops will negatively affect the surplus of those crops allocated to the poorest classes and the neediest. The relationship between food security and biofuel production appears to be a controversial one, as it is undoubtedly a negative relationship in light of the use of food crops to produce biofuels. Here, the trade-off will be between what feeds humans and what feeds the engine of the car, which is an unfair trade-off. However, the development of generations of biofuel production gives hope that the world will continue to depend on it in the future. It is confirmed that biofuel production continues to flourish and its production is expected to double, and this pushes towards the adoption of new generations of biofuel production that can harmonize between food security and energy security alike.

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