

Biodiesel Production Potential from Native Tehran Oil Crops Using GIS

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Abstract—One of the main factors in the field of alternative fuel economy is the primary raw materials. Importing raw materials and preparation conditions for cultivation of non-native species require high expenditures. Using native species can reduce the production cost. Therefore in this paper, for the first time a comprehensive study of indigenous Tehran oil plants is presented. Three indigenous non-edible species, rapeseed, cotton and barley were selected due to their feasibility of producing biodiesel. The purpose of this study is to propel relevant policies in the country towards greater use of domestic raw materials and known potentials. The potential for biodiesel production from plant sources, in this region was studied using GIS software. The present paper describes the zoning map and identifies the potential map of producing biodiesel from indigenous plant sources in Tehran province. According to the map, concentration of biodiesel production is in the central and western cities of province. This map shows that 116806.8665 hectares with the greatest potential to produce biodiesel. Also we calculated the potential of biodiesel production from introduced species, considering the yield per hectare and their oil content. The results show that the potential of biodiesel production for the three species of rapeseed, cotton and barley are respectively 98117.77, 58403.43, 83516.91 tons in Tehran province. Non-edible rapeseed having the highest production potential has been introduced as a superior indigenous species for the future investments in biodiesel production in Tehran province.

Keywords—biodiesel; indigenous oil plants; GIS; biodiesel production potential

I. INTRODUCTION

Endemic plant species, as a factor strategy to ensure environmental sustainability in agricultural programs, provide genes which are resistant to unfavorable environmental factors, disease and pest, are one of the most important national and natural assets. Biodiesel (biodiesel technically is termed as Fatty Acid Methyl Ester) is a clean diesel fuel from renewable natural resources such as vegetable oils and animal fats. Oil plants are one of the biodiesel production sources. This study is based on the evaluation of producing biodiesel as an alternative fuel from endemic oil plants. Because the performance of biodiesel in compression ignition engines is the same as diesel fuel, therefore, its use doesn't need engine modifications.

Using biodiesel in a conventional diesel engine can reduce unburned hydrocarbons, carbon monoxide and particulate matter. Also, due to its oxygen and complete combustion to CO₂, the proportions of carbon are reduced in the suspended particles. Sulfate present in the oil sector are absent due to the absence of sulfur in biodiesel. Thus, despite similar physical and chemical properties of biodiesel with conventional diesel, the exhaust output of the bio fuel has an advantage over conventional gasoline fuel. When the production of biodiesel started the process of transesterification (what we do to make biodiesel) was used to separate glycerine from oil. Glycerine was widely used in the cosmetic, food and explosive industries [1]. As petroleum fuels were plentiful and cheap, the main interest was on designing increasingly more sophisticated fuel injection systems [2]. Over the years, this meant that vehicles evolved to run thinner fossil diesels rather than thicker vegetable oils. Once the price of crude oil increased though, there was an incentive for research on alternative fuels. It was already pretty much accepted that unmodified vegetable oil was not suitable for modern injection systems. The transesterification process was pretty much old science and was used to reduce the viscosity of the oil; producing biodiesel [3, 4], so commercial process to turn waste cooking oil into biodiesel was developed [5]. In the 2000's when crude prices started rising, government subsidy of biofuel industries became common. This has given the industry the economic security needed to invest in biofuels. In Iran, researches around producing biofuels are performed since 1996, especially in case of biodiesel from different resources [6] as using native species can greatly reduce production cost. In Iran potential assessment of biodiesel production hasn't been studied yet. However, in the field of geothermal and wind power, production potential has been using GIS systems [7-9]. In this study, a GIS based approach is employed to investigate the biodiesel production potential based on native Tehran oil plants

II. RESEARCH METHODOLOGY

The sources of Iranian native plants have been investigated and native oil plants of Tehran province have been extracted to provide Tehran native oil plant statistics. Information related to the oil content of plants, vegetation and habitat conditions was

TABLE I. CLASSIFICATION OF MEASURES TO PRODUCE RAW MATERIALS FOR BIODIESEL PRODUCTION.

| Measures | Classes | Classes Range | Classes Name |
|-------------------------|---------|---------------|-------------------|
| annual rainfall (mm) | 1 | 0-150 | Inappropriate |
| | 2 | 150-350 | Relatively Poor |
| | 3 | 350-550 | Medium |
| | 4 | 550-750 | Modest |
| | 5 | 750< | Appropriate |
| annual temperature (°C) | 1 | <10 | Inappropriate |
| | 2 | 10-12 | Relatively Poor |
| | 3 | 12-14 | Medium |
| | 4 | 14-16 | Modest |
| | 5 | 16-18 | Appropriate |
| soil texture | 1 | - | Heavy |
| | 2 | - | Medium |
| | 3 | - | Light |
| | 4 | - | Macro |
| | 5 | - | Land without Soil |
| soil salinity | 1 | - | Low |
| | 2 | - | Medium |
| | 3 | - | High |
| | 4 | - | Quite a lot |
| | 5 | - | Land without Soil |

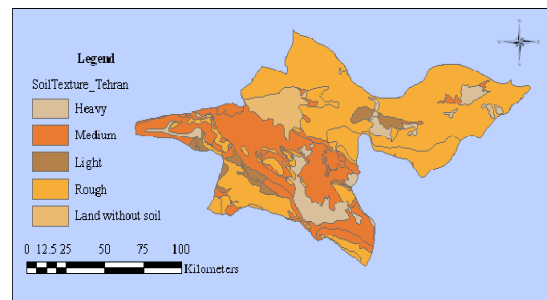


Fig. 7. Soil salinity levels

Some non-proliferation and dispersion endemic species have remained in the same small origin area. Tehran province has a diverse cover based on climate and other geographical conditions. Oil plants of Tehran are introduced in Table II. After identification of indigenous oil resource plants, levels of the products cultivation and their growth area were examined. Plants with low oil content (below 20%oil content in seed or 10% in residue germ) or plants directly used as food and edible oil have been abandoned. In order to produce biodiesel, only three non-edible plants were looked upon: rapeseed, cotton and barley bran due to their compatible growing conditions with Tehran climate, high oil content, yield per hectare and not applicant as nuts or major edible. Non-edible rapeseed (*Brassica carinata*) is an oilseed crop with 30 to 50 percent oil content [12]. In this study, its industry variety was considered which isn't edible. Cotton (*Gossypium Sp.*) with 25 to 30 percent of oil content is among the oilseed crops [13]. The fiber of this plant is used for industrial production. Cotton oil seeds can be used to produce biodiesel.

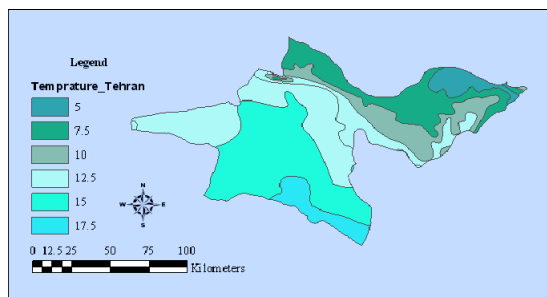


Fig. 4. Average annual precipitation levels

Barley (*Avena Sativa*) is a kind of cereal that its shell and bran contains significant amounts of oil (11% oil in residue germ) [14]. More cultivation of this plant in addition to increasing domestic production can provide large amounts of raw materials to produce biodiesel. Suitable areas for cultivation of these plants in province were looked for. Since the above mentioned plants need low water requirements, therefore, the average of annual rainfall of above 300 mm was selected as appropriate rain class (Figure 8). Base temperature for Canola, cotton and bully is respectively 5 °C, 12- 15 °C and 11 °C. Since the lowest temperature that all the three plants have the ability to grow is 12 °C therefore classes with (12-14 °C), (14-16 °C) and (16-18 °C) were selected as the suitable temperature class (Figure 9). As mentioned earlier, the most suitable areas for cultivation are the ones with medium texture soil and low salinity. Thus, as shown in Table I, only class 2 of soil texture and class 1 of the soil salinity were selected as the suitable layers (Figures 10 and 11).

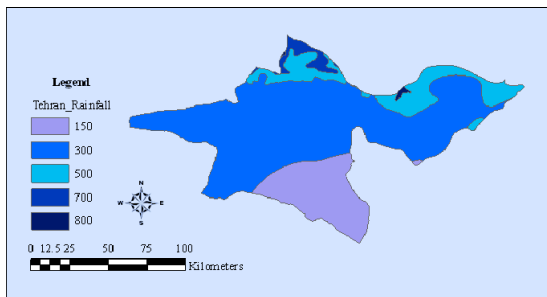


Fig. 5. Average annual temperature levels.

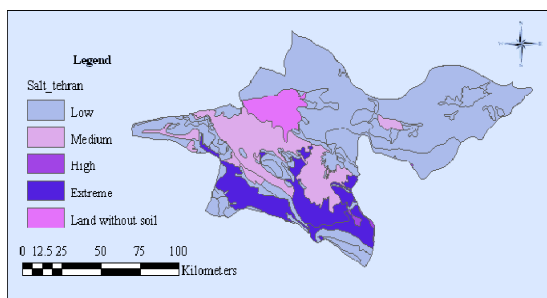


Fig. 6. Soil texture levels.

After provision of the favorable region maps to produce biodiesel raw material in Tehran province, four maps were obtained and overlaid and finally the feasibility map of producing biodiesel from oil plants in this province was presented (Figure 12). Considering the map, concentration of biodiesel production is in the central and western cities of province. Also this map shows that 116806.86 hectares of land have the greatest potential to produce biodiesel.

TABLE II. OIL PLANTS OF TEHRAN PROVINCE.

| Common name | Scientific name | Family | Oil content | Oil organ |
|---------------|-------------------------|---------------|-------------|-----------|
| Walnut | Juglans regia | Juglandaceae | 60 | seed |
| Hazelnut | Corylus Columna L. | Cupuliferae | 55 | seed |
| Pistachio | Pistacia vera L. | Anacardiaceae | 54 | seed |
| Sunflower | Heliantus annus | Compositae | 45 | seed |
| Rapeseed | Brassica.napus.oleifera | Cruciferae | 30-54 | seed |
| Almond | Prunus communis | Rosaceae | 50 | seed |
| Soybean | Glycin max | Fabaceae | 57 | seed |
| Apricot | Prunus armeniaca | Rosaceae | 40-50 | seed |
| Prune | Prunus domestica | Rosaceae | 35 | seed |
| Tomato | Solanum lycopersicum | Solanaceae | 35 | seed |
| Cotton | Gossypium Sp. | Malvaceae | 20 | seed |
| Chickpea | Cicer arietinum | Leguminoseae | 5 | seed |
| Wheat | Triticum | Poaceae | 2 | germ |
| Sea buckthorn | Hippophae rhamnoides | Elaeagnaceae | 3-5 | fruit |
| | | | 8-18 | seed |
| Apple | Calocarpum mamossum | Rosaceae | 27.5-28 | seed |
| Grape | Vitis vinifera | Vitaceae | 12 | seed |
| Oat | Avena Sativa | poaceae | 11 | bran |

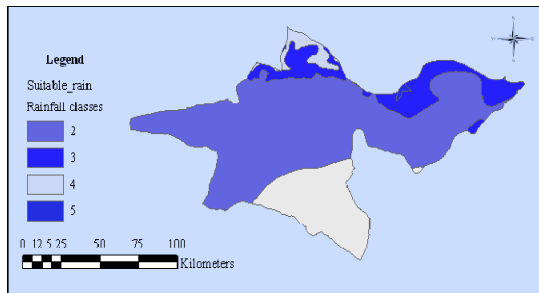


Fig. 8. Suitable class of precipitation.

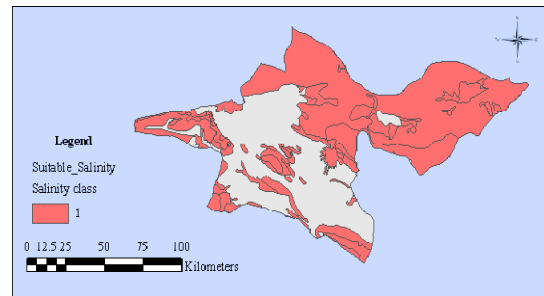


Fig. 11. Suitable class of soil salinity.

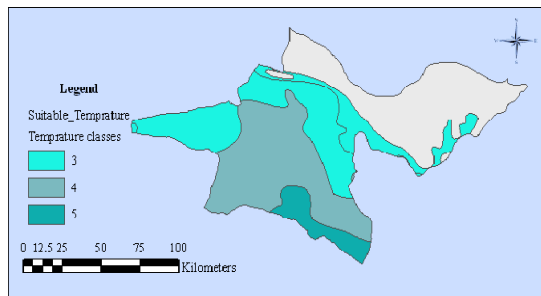


Fig. 9. Suitable class of temperature

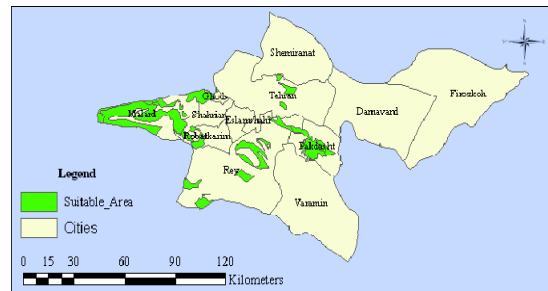


Fig. 12. Feasibility map of biodiesel production in Tehran

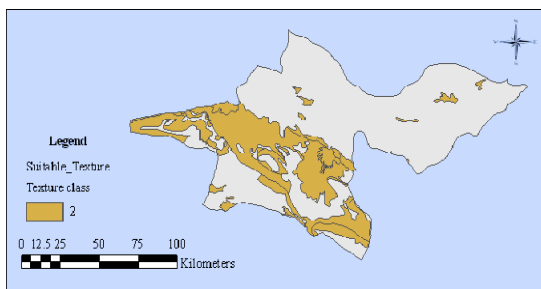


Fig. 10. Suitable class of soil texture

TABLE III. SUITABLE OIL PRODUCING PLANTS FOR TEHRAN PROVINCE

| Plant | Canola | Cotton | Barley |
|--------------------------------------|----------|----------|----------|
| Yield (tn/Ha) | 2.1 | 2.5 | 6.5 |
| Oil content (%) | 40 | 20 | 11 |
| Biodiesel production (tn/he) | 0.84 | 0.5 | 0.715 |
| Biodiesel production In Tehran (ton) | 98117.77 | 58403.43 | 83516.91 |

IV. CONCLUSION

One of the main factors in the alternative fuel economy is feedstock. The importing of raw materials and the preparation conditions for the cultivation of non-native species require high expenditure. Therefore, using native species can greatly reduce biodiesel production cost. The purpose of this study is to propel relevant policies in Iran towards greater use of domestic raw materials and known potentials. The results of this study are as follows:

- This study was the first time that native oil plants of Tehran province and their oil content with suitable growth conditions was presented.
- Three non-edible species namely rapeseed, cotton and barley were selected due to their feasibility of producing biodiesel.
- After a survey of indigenous oil plant species of Tehran province, the potential for biodiesel production from plant sources, in this region has been studied using GIS software.
- The present paper describes the country zoning map and identifies the potential feasibility map of producing biodiesel from indigenous plant sources in Tehran province.
- Considering the selected map, concentrating of biodiesel potential production is in the central and western cities of province.
- The selected map shows 116806.86 hectares of land with the greatest potential to produce biodiesel.
- Potential of biodiesel production from introduced species, considering to the yield per hectare and their oil content, was calculated. The results show the potential of biodiesel production for the three species canola, cotton and barley are respectively 98117.77, 58403.43, 83516.91 tons in Tehran province.
- Canola, with the highest production potential of 0.84 ton per hectare is introduced as a superior species for future investments in biodiesel production in Tehran province.

This map can also affect policy of the agricultural sector. Investing in the cultivation of biodiesel plants in these areas has the lowest risk of environmental damage and the highest efficiency potential especially if government support is directed towards biodiesel production.

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