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Plant Oils in Nepal: A Potential Alternative Energy to Fossil Fuel

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Abstract

This paper describes the prospects and constraints for utilization of oil-bearing plant resources of the Himalaya as alternative sources of energy and its related activities in Nepal Himalaya in particular. While the world continues to rely on non-renewable fossil fuels, the prospects for alternative sources of energy from oil-bearing plant resources have not been fully explored. The possibility and scope of bio-fuel for the Least Developed Countries like Nepal is promising from both economic, as well as, environmental grounds. The main incentives for the development of bio-fuel are that it has both economic and environmental benefits over fossil fuels. It is biodegradable, locally regenerative, and non-toxic to the environment. It is a renewable energy produced from vegetable oil with characteristics similar to fossil fuel. Its proliferation can create employment and generate income for rural people reducing the population pressure in urban areas. Research and development on plant oils can significantly uplift the economic conditions of rural farmers while contributing to the national economy. There is good scope to improve the supply of edible and non-edible plant oils and for this, a number of steps can be suggested.

1. "Green Energy" plants can be introduced and promoted for cultivation in the traditional agro-forestry systems to improve the degraded situation of deforestation and energy supply in Nepal Himalaya by developing agro forestry on the farm lands of individual farm households, especially in the mid and high hill farming systems;
2. Nepal has been found with vast field of fixed and essential plant oil energy both under cultivated and natural conditions. These vast number of abundant non-conventional resources that still remain unexploited. More than 500 species of plant with oil-bearing fruits, seeds or nuts are found indigenously in Nepal and if explored more of the potential oil-bearing plant resources can be identified in marginal and uncultivated land where no efforts have made to collect and process these resources. For example; Jatropha curcas seeds;
3. In addition to being a diesel substitute, the plant oil can be used for cooking, which can help save the fuelwood and kerosene. These inedible plant oil can also be used for industrial purposes such as paint, varnish, soap manufacture, lubricant, dying, etc.;
4. Dumre-Bhansar of Tanahu district in Gandaki Zone and Arya Bhanjyang of Palpa district in Lumbini Zone of Western Development Region of Nepal have considerable number of Jatropha from where collection of enough seeds can be easily done. It is to be noted that the villagers are not collecting large amounts of Jatropha seeds and in coming years the collection of Jatropha seeds is likely to be far less than availability; and
5. Modern oil-extracting technologies, such as Sundhara Oil Expeller (SOE), that is better suited to conditions found in the rural areas of Nepal Himalaya may be introduced. Some sites are also using a large number of diesel engines for running rice mills and oil expellers.

Keywords: *Green Energy; Bio–fuel; Jatropha curcas; Sundhara Oil Expeller; Nepal Himalaya*

Introduction

Green energy

Today, access to sustainable energy is a key factor in sustainable poverty-oriented development activities and its programme. In future, availability of and access to energy will be influenced by:

1. Energy consumption is increasing primarily in the developed countries. It is estimated that energy use will double in developing countries in the next 20 years; and
2. The use of substitutes for fossil fuels is increasing, accelerated by rising oil prices.

The increase in the global market price of fossil fuels is a burden not only on individual household budgets, it is above all a burden on the budgets of many developing countries, amounting to as much as 10-30% of their gross domestic product. The economic and social impacts harbour a potential conflict that should not be underestimated. Moreover, higher prices of fossil fuel diminish the financial options for promoting future oriented energy programmes in rural areas. Renewable energy, particularly bio-fuels, is becoming increasingly important. Experts predict that today's petroleum based society will be transformed into a bio-energy-based society in this century. The environmental and social impacts of Green energy production vary depending on the contexts. Substitution of bio-fuels for fossil fuel will have positive impacts, primarily in relation to reduction of greenhouse gases and possibilities of re-cultivation of degraded areas. Provision of energy services to poor people in rural areas of Nepal is a particularly challenging and multifaceted task.

In connection with this, Nepal being the "International Center of Himalayan Biodiversity" has become homeland over 7,000 vascular plants, with similar variation existing in lower plants. Over 1500 medicinal plants have been identified and over 75 flowering plant species have been traditionally used as agricultural crops, grain legume crops, horticultural crops, industrial crops, etc. Most of their wild species still exist in the soil of Nepal Himalaya. Such vast natural plant resources are known as the "Green Energy" of Nepal Himalaya. The potential use of Green Energy, traditionally as well as scientifically is unlimited. These components of green energy are substitutes and alternative to many presently non-sustainable practices. Such components of "Green Energy" are cost effective, locally regenerative, environmentally friendly and economically sustainable in the Least Developing Countries (LDCs) like Nepal, where there is critical crisis of energy, economy and environment. The main component of "Green Energy" is plant oil energy of a fixed nature from the vast untapped natural resources of oil-bearing seeds and nuts of trees and plants–both edible and/or inedible oil for several purposes. As a cash crop, Green energy also represents a new source of agricultural income. Nepal Himalaya must explore and utilize such important natural resources more effectively so that the resource poor farmers and the poorest of the poor may benefit from such a vast untapped natural resources. How can "Green Energy" in the form of plant oil energy be provided to rural areas in ways that promote sustainable rural development, address poverty, protect the environment and conserve the nature through the research and development of "Green Energy" is the major question at the center of this paper focus.

The Himalaya

Himalayas, also Himalaya (Sanskrit for "abode of snow"), mountain system in Asia, forming a broad continuous arc for nearly 2600 km along the northern fringes of the Indian subcontinent, from the bend of Brahmaputra River in the east to the Indus River in the northwest. The Himalayas range, averaging 320 to 400 km in width, rises sharply from the Gangetic Plain to the Tibetan Plateau in the north. The Himalayan region is the largest, highest, and most populous mountain chain in the world. More than 40 million people inhabit the Himalayas. Generally, Hindus of Indian heritage are dominant in the Sub-Himalayas and the Middle Himalayan valleys from eastern Kashmir to Nepal. To the north, Tibetan Buddhists inhabit the Great Himalayas from northeast India to Ladakh. Himalayan region is one of the world's richest ecosystems in terms of biological diversity. Extreme variations in altitude, aspect, geology and soils over the short distances have resulted to form a region with a wealth of natural ecosystems. The Himalayas are home to hundreds of endemic plant species and some of the world's rare wildlife species. These rich biological resources traditionally have served as the foundation for the economic and cultural life of the mountain people. Such biodiversity creates a stable environment, which has been sustained since long back. Conservation of bio-diversity is one of the important global responsibilities of mankind to ensure its safe future. Biodiversity has, consequently, become a growing concern of central significance to all sectors of society. As a result, in the instruments adopted at the

United Nations Conference on Environment and Development (UNCED 1992), Chapter 13 of Agenda 21, mountains are defined as: "important sources of biological diversity" and "storehouses of biological diversity and endangered species". The great wealth of biological diversity is due to the wide variety of environments existing in the mountains, particularly in the Himalayas.

Nepal Himalaya: The International center of Himalayan biodiversity [1]

Nepal Himalaya, is situated in the Central Himalaya between the arid Tibetan plateau of China in the north and India in the east, south and west, is a small mountainous country with an area 147,181 km^2 lying in between 26°22' to 30°27'N and 80°4' to 88°12'E. The average length of the country is 885 km with a mean of 193 km north–south. About 86% of total land area is covered by hills and high mountains and remaining 14% by flat lands of the Terai (< 300 m in elevation). The altitude varies from 60 m above the sea level in the Terai to 8,848 m. the Mount Everest (Sagarmatha), which is the highest peak in the world. In the bio-geoclimatic map of the world, Nepal lies within both the Palaearctic and the Indo-Himalayan Realms at the crossroads of south-east Asian, north-east Asian (Chinese) and Mediterranean tracts. Nepal's northern parts, consisting of mixed high mountains and highland ecosystems with complex zonations, lie within the Palaearctic Realm, the tropical, deciduous and monsoon forests and croplands of the southern Terai plains fall within the Indo-Himalayan Realm. The Palaearctic component is more interesting by dint of its complex zonations showing a high level of biological diversity. Prater (1928) divided the Country of Nepal into three zoo-geographical zones-Indian, Himalayan and Palaearctic. The Palaearctic zone, of Nepal is further subdivided three sub-zones, namely the Mediterranean, West Chinese and Indo-Chinese sub-regions. Around 80% of the annual rainfall occurs during the monsoon between June and September, the remainder falling in the winter months between October and April.

At the ecosystem level, Nepal presents great diversity in its land and water ecosystems. It ranges from dense tropical monsoon forests of the Terai in the South, with rich paddy fields and warm waters to deciduous broadleaved forests of the sub-tropical and temperate middle regions to the sub-alpine and alpine pastures and snow covered Himalayan peaks with many cold streams, glaciers and lakes in the north. Phytologists have divided Nepal into three vegetation zones: Eastern, Central and Western. Nepal is considered the meeting place of eastern and western Himalayan flora and fauna. Nepal's southern part, with the monsoon tropical croplands and forests, is cool during the winter but the rivers do not freeze. In the high mountains and plateaus, with many dry valleys, no trees grow at all; the vegetation is much related to that of other European, Asian and North African mountains. The sparse deserts have many species similar to those found in the Mediterranean and the Middle East countries. The middle valleys, having been isolated by the mountains for a long time, have their own characteristic and endemic species of plants and animals. A total of 118 ecosystems with 75 vegetation types and 35 forest types have been identified in different physiographic zones in these realms. Out of this, 38 types of ecosystems are represented in protected areas network alone (national parks, wildlife reserves and conservation areas). Estimates on the number of plant and animal species vary, but there are over 6,500 species of flowering plants; over 1,500 fungi species; and over 350 species of lichen. About 370 species of flowering plants are considered endemic to Nepal and about 1500 species are known to possess medicinal properties. There are over 200 species of aromatic plants (sources of essential plant oil), and at least 500 species of plant oil in Nepal. Similar variation exists in fungi including edible and non-edible mushrooms. Variation in animal science is not less. Nepal has at least 16 local races (ethnic groups) of about 25 million human population some of whom are still in semi wild stage. One of the main reasons for existing such wide biodiversity within such tiny country is because of its extreme variation in its physiotopography. Subtropical, temperate, alpine, tundra and arctic vegetation types exist in relatively close proximity. Thus, Nepal can be called as the "International Center of Himalayan Biodiversity".

Plant oils in Nepal Nimalaya

About 30 plant species have been utilized commercially for oil extraction in the world and half of these species provide more than 75% of the total world's vegetable oil supply (Singh & Singh 1991 and Jayaswal 1995). The Asia and Pacific regions consists of 30 countries. This region accounts for 56.1% of the world's population, 72.7% of the world's farming households and 31.4% of the world's agricultural land. Oilseed accounts for 13% of the total cropped area and are considered second most important commodity after cereals (RAPA, FAO, 1993 and Jayaswal 1995) [2-4].

Nepal's conventional oil crop is rapeseed-mustard which is grown in 1,65,560 ha. of land with total production of 98130 mt. On an average, 38% oil recovery is obtained although this rate is low due to inefficient oil mills in rural areas and losses during milling. With the above rate 37289 mt. Of rapeseed oil is produced annually within the country. Besides traditional crop of rapeseed, very little area coverage has been on niger, sesame and groundnut, etc. In hilly areas some portion of their daily oil requirements is met by niger oil (*Guizotia abbysinica*) and bassia fat (*Madhuca butyracea*). So altogether the domestic supply will not be more than 2.0 kg/capita/year. To substitute the requirement of oils and fats, Nepal imported various kinds of edible oil from different countries. Major imports are soybean oil, rapeseed oil, palm oil, and corn oil. Soybean, rapeseed and corn have been the traditional crops of Nepal and there is every possibility to increase the present production and productivity to decrease the oil imports. Hence, research and development is needed for varieties of edible plant oils like maize and soybean with higher oil content.

Until 1969/70, Nepal was vegetable oil exporting country, but from 1978 the surplus became non-existent. The country became importer in the interim though the imports remained small and fluctuating. However, by 1090/91 the country paid about NRs. 199 million towards import of both edible and inedible vegetable oil. Regarding fossil fuel as well the import bill was about NRs. 411 million in 1992/93. Import of both the items is rising. Under these circumstances, the country has to look for ways of reducing consumption but by encouraging import substitution[5,6].

With the idea of import substitution for imported mineral fuel 5 plant species were identified as potential candidates for further study [7]. These plants were Prinsepia utilis for high hills and mid-hills, *Jatropha curcas* for inner valley and lower hills, *Ricinus communis* and *Xanthium stromarium* both for the Terai and mid-hills. Though *Canabis sativa* turned out to be one of the cheapest source of plant oil, the plant leaves are used for making illegal narcotic products and implicitly deciding on encouraging it is beyond the scope of this study. Among these 5 species, some work was carried out on *Jatropha curcas* to study it further as a substitute for diesel. Such a direction was taken simply because similar work carried out elsewhere indicated its potentialities.

Relative abundance of the species in most parts of the country, non-competing existence with food crops, ease of oil expulsion and availability of diesel engines suitable for substitution with small modifications were some the important reasons for selecting *Jatropha curcas* for further study. Questions such as how popular is *Jatropha* plantation among farmers, what is its use, whether there is a conflict between *Jatropha* and other crops in labour requirement, share of income received by the households from *Jatropha* are taken. Based on the cost incurred by the project for seed collection, transportation, processing and distribution, substitution diesel by *Jatropha* oil has been assessed and recommendations are made for further research and development of plant oils as an alternative to fossil fuel in Nepal[8].

Objectives

The main objective of this study is to gather socio-economic data, and listing oil-bearing plant resources on the basis of farmers' experiences and secondary information from the seed collection areas for the utilization of available unused wild plant resources. This is supplemented by general information on the main occupation of the respondents, their average land holding, percentage of farmers growing *Jatropha* and purpose of planting, composition of household energy use as income potentials from *Jatropha* more specifically the objectives of the field study are as follows:

1. To examine the prospects and constraints of oil-bearing plant resources including physic nut (*Jatropha curcas*) in Nepalese farming systems.
2. To find out the percentage of farmers growing *Jatropha* and purpose of growing.
3. To find if there are conflicts between normal agricultural activities and *Jatropha* cultivation.
4. To estimate the income from *Jatropha* seed.
5. To explore the possibilities of plant oil energy as an alternative to fossil fuel (Diesel) in Nepal Himalaya.
6. To assess the Sundhara Plant Oil Expeller in Nepal Himalaya [9].

7. To make recommendations for further research and development work in plant oil energy also called as "Green Energy" in Nepal Himalaya [10].

Methodology

The approach for the fulfilment of the objectives was to identify and review available literatures and visit the field to assess the extent of the availability of the oil-bearing plant resources selected from the seed collection and field-visit areas. Field visit areas were Lamjung, Tanahu, Kaski, Syangja, Palpa, Gulmi, Arghakhanchi, Rupandehi, Kapilbastu districts in the Western Development Region and Chitwan, Makawanpur and Dhading districts in the Central Development Region of Nepal in between 1995 and 1997. However, *Jatropha* seed collection areas were identified in 3 districts namely, Gorkha, Tanahu and Chitwan on the basis of the experience gathered during seed collection. A list of 155 farmers was prepared from these three districts of Nepal on the basis of participatory rural appraisal (PRA). From Gorkha 118 households were listed, Tanahu and Chitwan had respectively 17 and 20 households in the list. A random sample of 35 households was taken which included 27 households from Gorkha, 5 from Chitwan and 3 from Tanahu.

Results and Discussion

Physic nut (*Jatropha curcas*)

Nepal Himalaya is a homeland of the "*Jatropha curcas*" plant. It is called by different names like: Kadam in the eastern hills of Nepal, Baghandi in the eastern Terai, Saruwa in the Dolakha area, Nimko Tel in the Dolalghat area of Kavre district, Baklendi in Bara, Parsa district, Bati Bal in the Makawanpur district. This plant is adapted to a wide range of climates and soils. It can grow almost on any type of soil whether gravely, sandy, or saline and thrives even on the poorest stony soils and rock crevices. Its water requirement is extremely low and withstands long periods of drought by shedding most of its leaves to reduce transpiration losses. It is a very suitable species for soil conservation areas and stabilization of shifting sand dunes. Potentiality of commercial cultivation of "*Jatropha*" lies in the uncultivated marginal land in the Terai, Inner Terai and warm climate region of up to 1100 m altitude. Although commercial cultivation has yet to be started within Nepal, it is referred from the Himanchal Pradesh of India that 2500 to 5000 plants population is planted in one ha of land, the fruiting takes place within two years of plantation. The seed yield is commercially harvested in the second year, and yield is up to one ton per ha. The yield increases significantly in the following years, and in the 6th year and onward the seed yield reaches 12 mt/ha. The maximum seed oil extraction is up to 35% by seed weight when extracted by solvent extraction (with hexane). Mechanical extraction is simpler and more appropriate for rural areas. The specific characters of *Jatropha curcas* are as follows:

1. *Jatropha curcas* is a bush that has multiple uses. When planted in gardens it protects useful plants from animals. *Jatropha* plants are used as live fence by the farmers which implies that they are on or around the cultivated land therefore, easy to obtain. Such a non-conventional use can encourage farmers to establish *Jatropha* fences resulting in better protection of cultivated crops. It does not involve serious conflict with forest species.
2. Oil expulsion technology is very simple. The seeds do not require any pre-milling preparation and pressing by rural oil press alone gives 24% oil yield. Machine pressing can yield more than 24% oil.
3. The plant can be easily propagated by cuttings and this plant thrives well on barren land where other plants cannot do well.
4. It helps control soil erosion, which helps protect the environment.
5. After the oil expulsion the cake can be used as fertilizer, which helps the farmers obtain better crop yields. It can also be fed to animals after heating for 5 minutes. The leaves can also be used as green manure during preparation of paddy bed and paddy cultivation as bio-pesticide.
6. In addition to being a diesel substitute the oil can also be used for cooking which can help save the fuel wood and kerosene.
7. The time of picking the seeds does not seriously conflict with the period of peak labour demand. Maturation of the seeds is spread over a long period allowing for part time work.
8. Planting can be encouraged on public land by communities of the poor thus helping poverty alleviation.

9. The emission after use contains less unburnt fuel than diesel hence, it is environmentally more acceptable.
10. The oil can be used in soap manufacturing and for this matter the plant is sometimes called as black soap. The oil cake can also be used for making plastic and synthetic fibre. Therefore, work on *Jatropha* can serve a base for a few other industries.
11. The traditional fishermen use the foliage extract to poison fish in rivers and ponds. However, the after effects are not adequately known. If there are no adverse after effects on the quality of water and of the fish on the consumer's health the foliage extract stands good chances of being used as insecticide on edible crops.

Income from physic nut (*Jatropha curcas*) seed and its oil

Collection and transportation of *Jatropha* seed cost about NRs. 7.00 per kg (Note: US $ 1 = NRs. 64.00). However, moisture content of the collected material was high and further drying and separation from foreign material was to be done. This reduced the weight from 1 kg to about 800 gm. About 20% weight loss occurred due to dryness and screening. Given an oil recovery percentage of 24.2%, 4.13 kg of *Jatropha* would be needed for obtaining seed collection from the farmers which would cost NRs. 39.65. In other words, a litre of Jatropha oil costs NRs. 39.65 plus pressing and distribution cost would also involve profit for distributors. However, the retail price of Kerosene is NRs. 48.00 per litre and that of diesel in NRs. 60.00 per litre at all motorable road-head points of the country. Even if the cost of *Jatropha* seed were reduced to 1/3 of its present level through competition among the farmers, cost of a litre of *Jatropha* oil would work out NRs. 13.22 per litre plus oil expulsion, transportation and distribution cost. Therefore, this would be useful to focus, at least initially, on high value uses of Jatropha oil such as medicinal use and use in the soap industry. Eventually, when the market gets established and becomes adequately competitive, using *Jatropha* oil as a substitute for diesel can become economic. However, to create a market for substituting imported fossil fuel, such works could be encouraged and promoted by the government by providing some kind of subsidy because *Jatropha* seed is being currently wasted in the country and market development for *Jatropha* is likely to help the poor in the rural areas. In addition, it helps, environmental protection and soil fertility [11].

Plant oil energy in nepal–possible alternative to fossil fuel (diesel)

Nepal has been found with vast field of fixed and essential plant oil energy both under cultivated and natural conditions. Here, only the fixed plant oil energy is dealt with for discussion [12].

Source of plant oil energy from the cultivated crop plants

Nepal produces more than 10,000 mt of edible plant oil seeds from the conventional oilseed crops. This is not enough for domestic need, and this country imports at least NRs. 1.5 billion worth edible plant oil annually from abroad for home consumption. 8% of its total industry belongs to vegetable ghee industry. However, there is enough room to improve the domestic production by using fallow cultivated agricultural land in the winter season in the Terai belt. At least, 150,000 ha of cultivated agricultural land is under fallow during the oilseed crops cultivation in the Terai region. The other possible sources of edible oil from the cultivated but non-conventional sources are rice bran, cotton seed, soybean, etc.

Source of plant oil energy from the non-cultivated crop plants

Nepal is a vast field of plant oil energy from the non-cultivated plant resources in nature that goes waste every time. This kind of plant oil energy is of two types: edible and non-edible. The edible plant oil can be used directly for the culinary purpose, and the non-edible type can be used for several purposes including for bio-diesel purpose. The main objective of this paper is to highlight the possible use of plant oil energy as bio-diesel alternative to the imported fossil fuel of diesel. Nepal has more than 500 plant species having fixed plant oil in their seeds and nuts. Moreover, most of them are abundantly available in nature. This is the very plant oil energy source this paper visualizes to utilize the fixed plant oil energy as the possible sources of bio-diesel as an alternative to fossil fuel-diesel. A list of 43 species of plants containing over 30% fatty acids in the seeds has been presented in Annex-1. Broadly, these plants can be categorized as conventional and non-conventional sources of plant oil in Nepal Himalaya [13,14].

Bio-fuel (bio-diesel) as an alternative to fossil fuel-diesel

Bio-diesel is an environmentally sound fuel source which can be used on its own or mixed with regular diesel without any mechanical change in the diesel engine systems. The mixture that is made from 85% plant oil, 15% methanol and 1% from the lye (sodium hydroxide) requires only the same basic chemical processing as soap production. This lack of requirement of expensive high technology combined with Nepal's vast untapped resource of waste plant oil energy make this country as ideal location for Bio-fuel production. Bio-diesel is a rapidly growing industry with now over 300 fuel pumps providing this fuel in Germany and with most of the western world starting up their own bio-diesel facilities. Bio-diesel is biodegradable, cost effective and locally regenerative and renewable, non-toxic, contains no sulphur, and is the least dangerous of any liquid fuel to handle. Test on European and American engines have shown a reduction of carbon monoxide and hydrocarbon emissions of 30% and 60% respectively. Smoke levels are also reduced up to 60% when 10% bio-diesel is added to regular diesel fuel. The smell of the smoke is also much more pleasant than ordinary diesel. Considering the massive change the world is experiencing in weather patterns, which is now generally accepted by the climate experts due to green house pollutants, the most important aspects of this renewable resource may be that it has a positive CO_2 balance. All of the CO_2 dispersed into the air during the combustion was first absorbed by the plants to produce the seeds rather than just neutral CO_2 balance is that plants not only convert CO_2 into seeds and above ground foliage, but also deposited the carbon into the soil through the carbon contained in roots. In the case of hemp plant, which is particularly good for oil fuel production, 30% of its carbon mass is often contained in its structure [2].

Other important advantages of this technology for this poor and fossil fuel importing country are increased self-sufficiency and a secure supply of fuel that is not reliant on roads of foreign influences. Every country would like to have its own source of fuel if only for security reasons. This might have seemed impossible for Nepal but in fact it has all the resources it needs to be energy self-sufficient.

The ability to produce the fuel where is needed without transportation is yet another advantage of Bio- fuel technology. Due to the availability of the "Sundhara Oil Expeller" made in this country, it is possible to make bio-fuel in very remote locations. The "Sundhara Oil Expeller" is designed in such a way that it can be carried by foot, it is of low cost less than US $ 1000 and can be powered by a diesel engine which can be fueled with the plant oil it produces. The converting of this oil to bio-diesel can also be accomplished in remote areas since it needs little equipments, space and technical know-how.

Bio-diesel should be able to produced in Nepal from around the same price or lower prices regular diesel, however, even if it temporarily costs more this should be offset by the fact that money spent on the fuel would go into the Nepalese economy rather than spent outside. One should understand that all that money is the leading export of most developing countries. The health system would also save money due to a decrease in respiratory illness that would surely result from a switch from the more polluting petroleum based fossil fuels.

Positive impacts of plant oils in nepal

Physic nut (Jatropha curcas) as one of the diesel tree and Castor Oil Plant (Ricinus communis) as one of the Mobil tree are abundantly found in Nepal as cost effective, locally regenerating and fossil fuel substituting plant oil energy is environmentally friendly enough not only from the carbon monoxide and visible smoke point of view, but also from the further plantation point of view due to economic harvest of such oil- bearing seeds and nuts by the resource poor farmers and the poorest of the poor at the farm and village levels creating employment and income generation. Such fixed plant oil from the seeds and nuts of natural plant resources of non-timber forest products will be able to solve the country's problems of multidimensional nature as follows:

1. Employment and income generating aspects will be automatically created at the farm and village levels to alleviate poverty at the grassroots level.

2. Deforestation will be minimized due to development of cost effective and locally regenerative alternative energy of plant oil at the farm and village levels substitute fuel wood. On the other hand, plantation of such oil-bearing trees and plants by rural people themselves will improve the forestation. As a result, environment will be improved.
3. Depletion of soil fertility due to burning of agricultural residues and animal wastes such as cow dung of manuring nature, as a source of fuel wood will be recovered when the plant oil energy will be developed at the farm and village levels.
4. National security on diesel energy will appear when bio-diesel will be developed from the plant oil energy development. It is not very far from reality that it only needs the moral support from the government as it is supporting for diesel import from outside.
5. Edible plant oil can be regained if the government will provide the moral support for massive commercial production of oilseed crops and processing of seeds and nuts of edible plant oil-bearing nature like butter oil seeds (Butter tree seeds, Prinsepia seeds, etc.)

Field survey

Every household derived more than 50% income from agriculture. Average land holding per household is 15.88 ropani (0.9 ha). *Jatropha* is planted as live fence by 97% of the respondents and the 155 sampled farmers together have an estimated number of 587 thousands plants. None of the farmers having *Jatropha* collected seed until last year for lack of both day-to-day household use as well as market. They do not know where to sell and no buyer approaches them. However, 25% know that *Jatropha* oil is used for lighting, 20% as a raw material for soap manufacturing and 5% medicinal use. The remaining 50% do not know about its use. 91% respondents reported that *Jatropha* seed collection has conflict with normal farm activities particularly harvesting of paddy and planting of winter crops where as 9% did not see any conflict. This may be due to climate differences in different places. If *Jatropha* activities go ahead 83% farmers feel that will bring changes in farming systems. About 91% said that they would grow *Jatropha* if market were available. All the respondents use firewood for cooking purposes and kerosene for lighting.

Laboratory findings

Jatropha seed collection was taken to Development Consultancy Services (DCS) in Butwal and pressed by FAKT machine manufactured in Germany. The oil recovery percent was found to be 24.2%. Samples of *Jatropha* seed and oil cake were sent to Government of Nepal, Food Research Laboratory, Babar Mahal in Kathmandu for chemical analysis. The seed was reported to contain 49.7% fat and the oilcake was reported to contain 10.7% fat both on weight basis. Oilcake was also analyzed for assessing major plant food nutrient. It was found to contain 4.3% nitrogen, 0.42% phosphorous and 0.53% potassium.

Demonstration sites

Field visits in Central and Western Nepal showed that Dumre Bazar of Tanahu and Arya Bhanjyang of Palpa district have considerable number of *Jatropha* from where collection of enough seeds can be easily done. These sites are also using a large number of diesel engines for running rice mills and oil expellers. It is to be noted that the villagers are not collecting large amounts of *Jatropha* seeds and in coming years the collection of *Jatropha* seeds is likely to be far less than availability.

DCS Sundhara oil expeller (SOE) in Nepal [9]

Background

Development Consultancy Services (DCS) is a joint venture of the United Mission to Nepal and Government of Nepal whose mission is to serve the people of Nepal by developing and promoting technology, which is appropriate in Nepal. In line with the mission, DCS conducts research and development of appropriate technology products promotes and transfers them to Nepali ownership.

Small oil mills are important features of the economy of Nepal. At present more than 1000 units of such oil mills are running in Nepal. Most of them are imported from India. They are heavy in weight (about 1000 kg), which makes difficult to transport to the installation sites. Moreover, their energy consumption is high (8 kW) which cause high operational cost. Other outstanding problem of it is quality spare parts.

Keeping these facts on consideration, DCS with technical assistance of FAKT (a German consulting firm) and Tinytech Ltd./Rajkot, India, have modified the heavy weight expeller to energy efficient and lightweight oil expeller named SUNDHARA, meaning Golden Stream. The recent version of the Sundhara Oil Expeller is 3.4.

Salient feature of sundhara oil expeller

a. Specially designed for mid and high hills.
b. All steel parts.
c. Little noise.
d. Minimal wear and tear.
e. Ease in operation and maintenance.
f. Can expel range of oilseeds.
g. Requires small areas to install.
h. Thin oilcake is obtained.
i. Body made of sheet metal.
j. Chain drive instead of heavy gears with perfect protection from dirt and dust.
k. Very low weight compared to locally available expellers.

Technical specification of SOE

Overall weight	: 265 kg
Chamber size	: L = 416 mm and φ = 100 mm
Cage bar size	: 19 X 6 X 200 mm
Screw/worms	: Special design of 40, 30 and 20 mm pitches
Average throughput	: 30 kg rapeseed per hour
Average power requirement	: 3 kW
Screw RPM	: 36
Residual oil	: 8-11%
Passed required	: 2-3
Overall dimension	: 80 X 110 X 120 cm^3

Economic calculation

On the following conditions,

Per day working hours	: 8
Per month working days	: 24
Throughput, kg/hour	: 30
Manpower requirement	: 1

Operated by electric motor

Existing rate

Current expelling charge for seed, NRs./kg : 1.6

Results and Discussion

Calculated cost for use: NRs./hour	: 33.93
Calculated expelling cost, NRs./kg	: 0.94

Profit with the existing conditions

Profit, NRs./Kg	: 0.66

The calculation is for a mill, which operates on custom milling. It shows that a miller can earn an income of NRs. Four thousand five hundred and forty five plus salary of the man every month if he runs one SOE operating for customers only. If the SOE is run by a water turbine, the profit will be increased by 25 percent.

Deliverable

The availability of the technology is one of the important aspects for overall development of the country. Oilseed production data of the country shows that the requirement of the country is expeller having a capacity of 30 kg of oilseed per hour, which can be run economically in our rural areas throughout year. DCS has started production of SOE on order basis. DCS has already installed 4 SOE's in Nepal and One in Bhutan and in near future, 6 additional mills are installing in Nepal and exporting 4 to Mali, Africa, and one to the Philippines. DCS not only provides the machines, but provides technology for expelling different oilseeds as well. It gives operational, repair and maintenance training to the entrepreneurs. It helps the entrepreneur to promote their business showing economic importance of other oilseed rather than rape/mustard seed. DCS is committed for after sale service. It gives guarantee for the machines and also reaches to the entrepreneur's home whenever requested besides their regular spare parts of the Sundhara Oil Expeller.

Recommendations For Sustainable Green Energy Development In Nepal

Recommendation for Further Work on *Jatropha curcas* in Nepal

1. To begin the work on *Jatropha*, collection of the seeds has to be done during the months of October-November when the fruits mature. Delay in seed collection would result in a delay by a year in demonstration.
2. Data on the share of income of the farmers from various sources in such a way that allows assessing the contribution of *Jatropha* is to be collected before or right after beginning the project.
3. Base line data on the source and extent of fuel wood use, fertilizer use and in-situ use of leaves as green manure would be helpful in the future evaluation of the project.
4. Data on the share of labour days use, at present, in different farm activities would be helpful to assess the impact of *Jatropha* oil project on employment.
5. Available quantity of seed of other promising oil plants in different locations can help in future.
6. Sundhara Oil Expeller is suitable for the country like Nepal.
7. Commercial production of the seeds and nuts is possible.
8. Reliable processing tool is available within the country.
9. Light and efficient diesel engine can be imported easily.

Recommendations for further work on plant oil energy development in Nepal

Pilot project on demonstration of commercial production of plant oil energy

The Government should help financially the active NGOs and financial institutions working in the field of alternative energy developments at the farm and village levels in demonstrating a pilot project on commercial production of plant oil energy which will be commercially and economically viable, and which will be substitute/alternative to the firewood, agricultural residues and animal wastes of manuring nature and imported underground fossil fuel like petrol, diesel, and kerosene oil.

Government subsidy program on commercial production of plant oil energy

Private companies and individual entrepreneurs willing to promote commercially plant oil energy in the country should be encouraged through government subsidy in different components of commercial production of plant oil energy like commercial cultivation of plant oil energy yielding trees and plants, manufacture of "SUNDHARA OIL EXPELLER" at commercial scale purchase of this expeller and related aspects.

Awareness creating programme on plant oil energy development

The Government should help the related organizations, NGOs, and communication mass medias in creating program on plant oil energy development as cost effective, locally regenerative, environmentally friendly and sustainable alternate energy substitute/ supplement to firewood, agricultural residues and animal wastes of manuring nature and imported fossil fuel. Tele serial film production on plan t oil energy development in the country and its show through television network, and other communication media should be developed with the help of the government.

Strengthening further research on plant oil energy development in Nepal

The Government and international NGOs should encourage local NGOs, private organizations and individuals to conduct further effective research on plant oil energy development and its use in Nepal.

Promotion of agro forestry for sustainable green energy development in Nepal

Agro forestry is a sustainable management system for land that increases total production combines agricultural crops, tree crops and forest plants and/or animals simultaneously or sequentially, applies management practices that are compatible with the cultural patterns of the local population. It is estimated that 10,000 square kilometre of area in Dolpa and Mustang Districts were devoid of sufficient vegetation indicating the "Desertification" process which is now extending in other areas (NPC, 1982). Such a process of desertification will eventually lead this Himalayan country to unexpected Himalayan desert-a new negative phenomenon created by human activities. The most important way to improve the degraded situation of energy supply and deforestation in rural areas of Nepal Himalaya is by developing agro forestry systems and technologies on the farmlands of individual farm households, especially in the mid and high hill farming systems with "green energy" plants of Nepal Himalaya. In the Terai region, development of agricultural residues of non-farming nature would be useful. Agro forestry provides not only sources of timber, fuel wood and fodder but also important sources of non-timber forest products (NTFPs) for employment and income generation to alleviate poverty, promote biodiversity conservation and sustainable green energy development through least intervention in the natural reserve of forest, and environmental improvement in Nepal [15].

Conclusion

Collection and transportation of plant oil including *Jatropha* as a substitute for diesel can become economic. However, to create a market for substituting imported fossil fuel, such works could be encouraged and promoted by the government by providing some kind of subsidy because *Jatropha* seed is being currently wasted in the country and market development for *Jatropha* is likely to help the poor in the rural areas. In addition, it helps environmental protection and soil fertility.

One of the future fields for research and development in plant oil energy production and utilization is processing of the crude plant oil in different forms. Nepal needs to introduce this technology and abroad for refining plant oil in different forms. The author is not familiar with the existing plant oil refinery systems in the country. However, the author is very interested to help this Himalayan region in developing a cost effective, locally renewable, environmentally friendly and sustainable alternative plant oil energy as an alternative to fossil fuel, firewood, agricultural residues and animal wastes of manuring nature which is the major cause of deforestation and low agricultural productivity in Nepal and other similar developing countries. Plant oil energy will be the Future Aboveground Petrol Mining to substitute the fossil fuel to maintain and continue today's total transportation system in the world in a very sustainable way even after 2050 s. Let us build this world with the Green Energy with the theme-Safe and Sustainable Energy for the 21st Century".

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