CHAPTER-I

Introduction

1.1 Background

1.1.1 Physiograpy

Located on the southern slopes of the Himalayas, Nepal lies between 26° 22' to 30° 27' N latitude and 80° 4' to 88° 12' E longitude and covers an area of 147.181 km^2, which makes up about 0.03 percent of total land surface of the Earth. The average North-South width is about 193 km and East-West length averages to 885 km making it look somewhat like rectangular in shape. The country is bordered by India in the East, West and South and China in the North. It represents three ecological zones: the Terai (plain area), the Hills and the Mountains with 23, 42, and 35 percent of the total area respectively. The elevation ranges from as low as about 60m to as high as the summit of the world at 8848 meter. The Terai belt is lowest in elevation. The country is further divided into five physiographic regions viz. the Terai with altitude up to 330m, the Siwalik in the altitudinal range between 120-2000m, the Middle Mountains with altitudinal range from 500-3000m, the High Himalayas above 4000m. Due to its topographical variation, Nepal has a wide variety of climate from tropical in the South to alpine in the North lying broadly within the subtropical climatic system. About 80% of the total precipitation falls during June to September.

1.1.2 Socio-economy

A country of cultural mosaic, Nepal is home to over a hundred of caste/ethnic groups. The country's population is exceeding 25 million. People living in rural areas account for a vast majority of 85 percent depending primarily on subsistence agriculture and natural resources. Rural sector is characterized by widespread poverty and low human development index. About 44% of the rural population lives below poverty line (WB, 2003).

1.1.3 Briefly Introducing *Jatropha* Curcas L.as a Potential crop for energy, environment and Income

"Jatropha Curcas is acclaimed as a promising bio-fuel crop ideal to convert today's unproductive lands into tomorrow's green oil fields".

Scientific Classification of *Jatropha*

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Malpighiales
Family:	Euphorbiaceae
Subfamily:	Crotonoideae
Tribe:	Jatropheae
Genus:	*Jatropha*

Fig: 1(Plant, leaf and fruit)

The Name ***Jatropha*** is derived from the Greek word **'Jatros'** means **'Doctor'** and **'trophe'** means **'Nutrition'**. *Jatropha Curcas* is a multipurpose shrub found throughout the tropics, known by 200 different names in various parts of the globe. *Jatropha* curcas, originating in Central America, is a perennial shrub. *Jatropha* cultivation has spread to Africa and Asia, specifically in tropical and sub-tropical climates. The plant is non-edible, grows in harsh climates, and produces oil-bearing seeds. Thus, recently there has been a great deal of discussion on the benefits of growing *Jatropha* to produce agro fuels. Proponents of *Jatropha* describe the plant as a vital source of energy, and largely rebuke arguments against widespread cultivation of the plant. There are many unexploited and unutilized natural resources, that holds potential for the upliftment of rural livelihood. Among them *Jatropha Curcas L.* is a most promising natural resource, with potential for reducing the problem of energy, environment and rural development. Now it is identified as a multipurpose plant resource that meets the number of objectives including rural energy (www.Jatrophaworld.org).

Jatropha plantation can be done on poor soil as it helps in reclaiming degraded land, therefore contributing in restoring the environment. As we know energy, environment and rural development are interrelated very closely to each other. Availability of natural resources and its proper utilization determines the development in certain areas. Meeting the needs through utilizing locally available natural resources leads to the sustainable development. This section of the proposal presents the importance of commercial farming of *Jatropha* Curcas L. for future fuel and rural development in Nepal, focusing in the study area. Widely distributed *Jatropha* throughout the country can meet a number of objectives including rural energy, without degrading environment, if properly harnessed. *Jatropha curcas* is an important feedstock for the production of biofuels. Its widespread use in India and Egypt is gaining popularity as a quick growing source of oil-bearing nuts that can be pressed to produce Biodiesel products. *Jatropha* has also been a crop of choice in development programs in Africa where local villages have grown *Jatropha* on small plots of land and have hand-pressed the oil for use in generators, sewing machines and small motors. Glycerin, a by product of *Jatropha* oil, can also be used to produce soap.

JATROPHA CULTIVATION

Jatropha is easy to cultivate. It can survive in degraded soils and in areas that are susceptible to long periods of drought. *Jatropha* is ideal for cultivation on marginal land, leaving prime areas available for food crops. *Jatropha* is perennial which can grow in arid conditions (even deserts), on any kind of ground, and does not require irrigation or suffer in droughts. Therefore unlike the common biofuel crops of today (corn and sugar), they are very easy to cultivate even on poor land in Africa providing great social and economic benefits for the region.

JATROPHA PLANT LIFESPAN

Jatropha takes approximately 12 to 15 months from planting to first harvest, and the plant can thrive successfully for 40 years. *Jatropha* is fast growing and it begins yielding oil in the second year and for the next forty to fifty years. Optimal yields are obtained from the sixth year, and spaced at 2 meter intervals; around 2500 plants can be cultivated per hectare (www.jatrophaworld.org).

JATROPHA OIL YIELD

Jatropha seed yields 35-40% oil.

1.1.4 *Jatropha* in context of Nepal

Nepal is known to be rich in plant bio-diversity because of her geography and climatic variations. There are over 7,000 vascular plant species found in Nepal (Anonymous, 1976). Out of these, over 700 species have been identified as medicinal plants (Ghimire, 1999), 286 species are known to be the source of oil (Singh, 1980) and out of them 92 species produce seeds with oil content exceeding 30% (Annex I). However, in some cases it has been found almost 70% e.g. Mesua ferrea. Among the seed oil bearing plants which exceeds more than 30%, *Jatropha curcas L.* is one of them and with particular references to Nepal it has remained unexplored while in other country it has been exploited significantly. No modification of engine is required to use biofuels in the ratio of 1:5 (B20) with petrodiesel. The product application extends beyond transport sector endorsing its utility in diesel generators, irrigation pump, cooking stoves, floating lamps and in generating electricity. In Nepal, though yet to take effect, decision made in January 2003 for a 10% blend of ethanol in petrol may be understood as the realization of the importance of biofuels use.

A lot of research studies have been done for different parts of *J. curcas* plant in various countries of the world. The studies have shown that it has high economic importance for its seeds because of diesel-fuel property in seed oil. Besides this it is equally important for its saponification value, good protein source, medicinal value for various treatments, as a source of good fertilizer and mollusciedes. But in Nepal a few studies have been conducted but utilization of plant has yet to be adopted. However, it is still being used traditionally by local people. The flowers and stem of *Jatropha* curcas have well-known medicinal properties, and the leaves are used for dressing wounds. The oil has been used as an organic insecticide as well as an effective treatment for snake bites and other ailments.

Seven species of *Jatropha* recorded in Nepal are identified as *Jatropha curcas L., Jatropha gossipifolia*, *Jatropha multifida, Jatropha glandalifera*, *Jatropha tanjorensis*, *Jatropha odagrica* and *Jatropha intergerrima* (Yadav, 2006). Among all species the *Jatropha curcas L.* is distributed widely in Nepal. In Nepal it is known by over 200 local names suggesting that is has wide spatial distribution throughout the country (Chhetri, M. 2006)

J. *curcas L.* is a large shrub, or a small tree, native to tropical America, but commonly found and utilized throughout most of the tropical and sub tropical region of the world. In English it is commonly known as "Physic nut" or "Purging Nut". In Sanskrit it is known as KANANANAERANDA, PARVATARANDA. It has no fixed local name in Nepal. Some of the local names are Kadam (Eastern hilly districts and Morang), Saruwa (Jhapa), Baghandi (Saptari), Bangreda (Sarlahi), Battibal (Hetauda), Nirkune (Malekhu, Dhading), Nimtel (Kavre, Sindhupalchowk), Sajiwan (Kathmandu, Nuwakot), Ratanjyoti (Dailekh, Surkhet), Inu (Kailali), Ratanjoli (Achham), Kukath (Doti).

J. curcas is found in semi-wild and cultivated conditions as well as in some places of Kathmandu Valley. The plant blossoms during April-May and produces monoecious flowers of a creamish yellow colour in loose panicle cymes. The fruit is egg-shaped with three lobes and about 2cm long. Each lobe is a compartment containing one black, white speckled seed (tricarpilary syncarpus). The immature fruits are green in colors which turn yellow during ripening stage and finally turn into black.

Jatropha plants are easy to establish, grow relatively quicker in areas of low rainfall. Propagation is easy both by seeds and cuttings (often as simply as pushing a cutting into the ground) and growth is rapid as is implied by its ability to form a thick hedge nine months after planting. Being drought tolerant, it can be used to reclaim eroded land grown as a boundary fence of live hedge in the arid and semi-arid areas. It is also called living fence because it is browsed, for its leaves and stems are not palatable to livestock. *Jatropha Curcas* grows on a wide range of climates and soils. *Jatropha* plant is established on degraded, gravelly, sandy or loamy soil with adequate nutrient content. Being a species of arid and semi-arid tropics, it survives even on areas receiving very low rainfall. *Jatropha Curcas* is highly adaptable species and its strength as a crop comes from its ability to grow on poor and dry sites.

The mature *Jatropha* trees bear male and female inflorescence, and can grow to a height of three to four meters. Each inflorescence bears up to 10 to 15 large fruits and *Jatropha* generally blooms twice a year under normal conditions. *Jatropha* is desirable as a source for biofuels given that its seeds produce up to 40% oil, and the species in general is highly resistant to drought and pests. Processed oil from crushed mature seeds can be used in existing standard diesel engines, while the residue can also be processed into biomass to power electricity plants. The seed cake, a by-product of oil production can be used as a natural organic fertilizer rich in organic matter. Research is underway to remove the toxic element prevalent in the seed cake to render it useful as an animal feed.

1.1.5 Energy Consumption Scenario in Nepal

Energy consumption per capita is used as the best indicator of development. There exist a positive correlation between the level of development and energy consumption. Higher energy consumption implies higher level of development and vice versa. Per capita energy consumption level in developed countries support the fact that energy plays important role in development. Demand for energy in countries on the path to rapid economic development like India and China is increasing with leaps and bounds. Nepal should accept its energy demand to grow considerably in the near future.

The energy consumption scenario in Nepal reflects low level of development at 1.9 % of growth rate recorded in 2006. The per capita energy consumption stands at 14.6GJ, which is among the lowest in the world.

Figure 2 Nepal's Energy Consumption by Fuel type

Source: Report by Nawa raj Dhakal, Senior Trainer (AEPC), 2008

The major sources of energy are classified as traditional, commercial and renewable sources that account for 87.67%, 11.8% and 0.53% of total energy consumption respectively. Among the traditional sources fuel wood, agriculture residue and animal dung account for 89.0, 4.34 and 6.57 % respectively. Commercial energy sources that include petroleum, coal and electricity account for 69.6, 15.0 and 15.41% respectively. Figure 1.1 above shows largest share of the pie going to the traditional sources followed by petroleum sources. The smallest share of pie belongs to the renewable sources. The share of electricity is also considerably low.

Figure 3
Energy Use on the Basis of End Use

Source:

Source:

Source: Thesis by Maya Chhetri, 2006

Energy consumption by sector demonstrates highest consumption by household sector at 90.28%, followed by transport sector with 3.78%, industrial and commercial sector consuming 3.48 and 1.45% respectively, and other sector including agriculture consuming 1.01% (economic survey). Nepal has no known deposit of fossil fuel. Except for electricity, the country depends on imports for the supply of all commercial energy products. Electricity, the sector commanding huge investment in terms of public resource allocation accounts for just over 15% of total commercial energy supply. Rural people having access to electricity stands at 5% while on the whole only about 14% of energy comes under the monetized sector.

The demand of oils as an energy source has been rapidly increasing and the mismatch between the demand and supply of oil seeds has initiated various stakeholders in the form of farmers, agro based industries, corporate sectors and, NGO's to go for large scale plantations with *Jatropha* Curcas as a commercial oil crop. The various other uses of *Jatropha* other than bio fuel source include soap production, Organic fertilizer, Medicinal Source, Pest control, etc. This makes *Jatropha* Plant a unique crop among the various bio fuel plant sources.

Why biofuels?

Sustainability in production, environmental friendly, reduction of green house gas emissions, rural development, security of supply, income generation and employment, biodegradable, non-hazardous and safer for air, water and soil.

Table: 1.1 Price of Petroleum Products from 2000 to 2008

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Petrol (Rs./liter.)	47	46	52	54	56	67	67.25	80	100
Diesel (Rs./liter.)	27.50	26.50	26.50	31	35	46	53.15	55.5	70
Kerosene (Rs. /liter.)	22	17	17	24	28	39	47.65	51	65
LPG (Rs./Cylinder)	550	550	650	700	750	900	900	1100	1200

Source: Bhattarai, K. R. (Jan, 2008); *Sajiwan bata biodiesel- Jatropha Biodiesel*

Table: 1.2 Daily Consumption of Petroleum Daily Consumption of Petroleum

S.No.	Type of Petroleum Products	Nepal (Klt)	Kathmandu Valley (Klt)	Percentage in Valley
1	Petrol	400	250	63
2	Diesel	1200	400	33
3	Kerosene	600	250	42

Source: NOC, 2007.

1.2 Statement of the Problems

Development of commercial biofuels has a great potential in Nepal. This can reduce the dependency on import of petroleum products from abroad. Even though biomass such as fuel wood, agricultural residue and animal wastes are the major contributing energy sources in Nepal, development of commercial liquid biofuels such as Biodiesel and ethanol that can replace the import of diesel and gasoline respectively are largely ignored.

Barriers

- Technology
  - Lack of Knowledge on wider use of liquid biofuels from public to policy levels.
  - Lack of knowledge of efficient technologies
  - Lack of knowledge on applications
  - Low levels of availability and promotion of biofuels compatible technology.
- Economic
  - Commercial viability unproved
  - Biodiesel production not viable without by products
  - NOC lacks finance to add blending facility
- Common Practice
  - Liquid biofuels not accepted socially as potential replacement for petroleum fuels
  - Technology associated with petroleum fuels widely available
  - Lack of public awareness on energy and economic potential of liquid biofuels
- Policy
  - No policy level priorities
  - No targeted government programs

Nepal depends heavily on traditional energy sources with its major repercussions reflected on forest depletion, health hazards, drudgery and loss of agriculture productivity. It has no known deposits of fossil fuel. Except for electricity, the country depends solely on imports for the supply of all commercial energy products spending almost one fourth of the total export earnings. The state is reportedly incurring a monthly loss of Rs. 20 million for the supply of petroleum fuel. Due to this it has to face with frequent disruption in fuel supply, in turn adversely affecting the economy as a whole. With the petroleum energy, the country is simultaneously importing pollution as well.

Nepal is known to possess a number of indigenous resources that can provide alternate energy options. Among the local resources, *Jatropha* curcas has been identified as a potential oilseed bearing plant for generating biodiesel. Biofuels are carbon neutral and therefore they are source of clean energy and are environment friendly.

For a developing country like Nepal growing energy crops like *Jatropha* entails a lot more than substituting imported fuel. It offers enormous opportunities for rural development if it is worth making investment. Making economic assessment of *Jatropha* farming is therefore a prerequisite as it provides a basis to decide the viability of exploring the potential of *Jatropha* curcas for the production of feedstock for biofuel *(Source: Nawa raj Dhakal, Senior Training Officer (AEPC); Government Policy and Programme on Biofuel in Nepal, Report, 2008).*

1.2.1 Challenges of Nepalese Energy Sector

Nepal has one of the most expensive power tariffs in the world despite having the huge free water resources, favorable terrain for its production and all kinds of human resource available in the country. This is due to no other reasons than the financial irregularities continuously present in the government and corporate systems in the country.

Table: 1.3 Petroleum Products Demand and Supply (2007)

Procucts	Year 2007			July 2008
	Demand (KL)	Supply (KL)	Sortage (%)	Sortage (%)
Petrol	132,365	101,723	23	47
Diesel	362,900	299,545	17	52
Kerosine	263,120	175,873	33	64
ATF	86,150	63,454	29	50
LPG	111,900	96,031	14	58
Total	960,035	736,626	23	54

Source: Bhattarai, K. R. (Jan, 2008); Sajiwan bata biodiesel- Jatropha Biodiesel.

Energy is the key input for technological, social and economic development of a nation. The energy supply and demand characteristics have a great role to play in order to attain sustainable development in the country. Thus, meeting Nepal's current energy demand would help foster higher economic growth. Energy demand increases not only due to the increase in population but also due to the people's access to new utilities in the market. As the rate of globalization has a quick impact in technology development, the most affected sector due to growth and globalization is the energy sector and Nepal can not be its exception. Despite endowed with huge natural resources, Nepal has not been able to tap its vast energy resources for the benefit of the country.

In Nepal, with an increase in population, agricultural and industrial activities, the demand of energy is also increasing. However, Nepal has one of the lowest percapita energy consumption rates (14.06GJ) in the world. Less than one third of population has access to electricity and in the rural areas, where most people live, access is much lower. According to recent report of the Asian Development Bank (ADB), the demand for power in Nepal has increased steadily with an annual average growth rate of 8.5 % over the past decade, and is estimated to grow at least by 7.5% annually until 2020. However, the current energy generation trend shows that meeting this anticipated energy demand is likely impossible. It is reported that approximately 10% of the total energy demand in Nepal is met at present by imported petroleum products at a cost of over 40% of Nepalese total merchandise export. Despite great potential for hydropower development, power sector development has been constrained due to lack of visionary leadership, inefficient bureaucracy, insurgency, and most profoundly the corrupt mentality of the political stakeholders (www.jatrophabiodiesel.org).

Nepalese power industry is more like a monopoly market under the control of Nepal Electricity Authority (NEA) which is responsible for generation, transmission and distribution. People are compelled to pay tariffs for one of the most unreliable supplies which are spent to pay three times salary of the majority of engineers in the name of project development! The conservative bureaucratic approach of the power development which NEA is taking is not going to help the country's economy. We have bordering countries India and China which are emerging as the world's economic superpowers. It is said that the only problem for India to maintain or increase the current economic growth is supply of sustainable energy. This offers Nepal an enormous potential for hydropower production and export to its southern neighbour. On the contrary, there was a recent agreement with India to purchase power. Nepal government's unstable policies, undue political influence on the NEA and the latter are lethargic management mechanisms have become the sole hurdles for the power development. Hence NEA's current approach and management model should be completely deconstructed and a new setup should be developed realizing the role of government's service sector, local government and private sectors. The new framework should focus on systematic development of large hydropower for export and small, medium/micro hydropower plants for local consumption to achieve the sustainable economic development.

In Nepal, over 80 % of the total energy consumption comes from traditional energy resources. Biomass being the major contributing energy sector in Nepal, more than 75 % of the energy is supplied by firewood alone followed by 9.24 % from petroleum products, 5.74% from animal waste, 3.75% from agricultural residue, 3.53% from coal, 1.47% from electricity and 0.48% by renewable resources. The sectoral energy consumption pattern shows that the residential sector energy consumption is more than 80 % while the agriculture and others are the least energy consuming sectors. According to Water and Energy Commission Secretariat report of 1995 carried out for energy end use perspective, it was reported that residential cooking alone accounts for 65%, space heating accounts for 8%, agro-processing 3%, water boiling 2%, lighting for 1% while others account for over 20% of the total energy consumption in rural household sectors. Biomass has thus been very important source of energy in the Nepalese perspective. With the recent emphasis on renewable energy, there are various opportunities for economic development using these renewable resources.

Various sectors including the government have put a strong emphasis on development of renewable energy development. However, due to disintegration of efforts made by various agencies in the development of renewable energy, a little has been achieved. For example, micro hydro sector is one of most important renewable resources, yet, the total contribution of over three decades of micro hydropower development initiatives resulted in less than 20 MW of electricity. The important benefit of the micro hydropower development is that it creates local jobs in manufacturing equipment, construction, operation and maintenance and end uses. However, existing policies on micro hydro development including subsidy grants are not creating favorable environment to the poor people and communities to support their economic activities. This subsidy policy is based on 'bigger the better' and 'more the merrier' philosophy, higher the capacity, the more the subsidy (*Source: Winrock International's Report by Jagdish Chandra Kuinkel, Sep 2008)*.

However, smaller projects usually are more expensive and generate less revenue unlike bigger projects which usually become less expensive and at the same time generate more revenue. If the government organizations such as Alternative Energy Promotion Center (AEPC) works based on the sole financial evaluation of the projects, then what is the difference between AEPC and a private company? There are numerous intangible and service aspects that need to be considered by the government sector. People of Dolpa for example that are in desperate need and micro hydro is the only alternative to support their economic activities are viewed by the same eye as that of people in Kavre where there are other options too. The subsidy is redundantly allocated where several barriers prevent from getting the real benefit for the people in remote areas. It is crystal clear that over 30% of the installed micro hydro projects are currently malfunctioning due to lack of mechanism of maintenance. Ironically, the new subsidy policy and financing mechanism largely ignores post-installation side of the projects thus making the whole micro hydro power development process truly unsustainable in the long-term.

Community based micro hydro projects envisioned by Rural Energy Development Program (REDP) of UNDP have been viewed as one of the most successful projects in terms of long-term sustainability. It has created a conducive environment for the targeted communities to empower themselves due to involvement of women, capital formation and mobilization of available resources at local levels. However, the project selection was mostly influenced by the political biasness at the district level. Since many projects were selected on the political prejudice, it failed to implement its holistic approach leaving the micro hydro projects vulnerable. Moreover, financing criteria were based on the calculation of external cost of project components that largely overlooked the local contribution generously made by the community people. Conventional financing mechanism has not been supportive to the people who are below line of poverty. Hence, the existing subsidy policy should be reviewed in order to make micro hydro projects sustainable. Micro hydro projects have little or no impact on the environment and still can be the backbone of the rural economy of Nepal provided the pro-people policies are in place.

Solar energy is another resource which has a great potential in Nepal. Nepal has over 300 sunny days in a year giving high potential of solar energy use. Generation of electricity using photovoltaic cells has become very popular in rural Nepal. The government has put heavy emphasis on subsidies for installation of solar home systems (SHSs). The problem of this system is that it is too expensive for those residing in isolated areas and even after the subsidy it is beyond the reach of low income group. Moreover, there are several issues of solar electricity through photovoltaic cells in the long-term. First, solar cells have very low efficiency resulting in extremely high cost. Second, it has several long-term environmental problems. Solar cells consist of various heavy metals including synthetic chromium, lead among others. Synthetic silicon which the solar panels are made of is not easily biodegradable. The storage batteries also consist of heavy metals such as lead and chromium and toxic acids. These metals and acids are eventually discharged at some point resulting in water, land and air pollution (*Source: Winrock International's Report by Jagdish Chandra Kuinkel, Sep 2008)*.

It was recently revealed that water has 'memory' as the humans have; it is difficult to treat water once it is contaminated. Even with the low doses of toxic chemicals in water, human health and biodiversity are threatened. The other problem is that as the solar cells are brought paying hard currencies from abroad, and the government subsidy eventually drained outside the country, hence, photovoltaic electricity is not a sustainable option. Despite such issues, solar systems are promoted pretending that it has no environmental problems. This is because our technology development are focused on short-term and based on external and physical benefits. For example, the CFCs, which were considered miracle refrigerants, were banned after over 3 decades of use. The same is anticipated for photovoltaic electricity. Even though solar energy is the most clean and largest source of energy on earth, the conversion pathways make it bad from environmental perspectives. The most recent program of Energy Sector Assistance Program (AEPC) to distribute white LED based solar tuki will have most devastating impact on human health. This light is toxic and unnatural. The spectrum of light generated by white LED is exactly opposite to the natural light and human eye needs significant adjustment to be able to view the objects and will do no good in the long-term. This programme came through the sole corporate interest and the losers eventually will be the people of remote villages in Nepal. With the same amount of investment, other energy sources such as micro hydro and wind plants could have been built wherever possible that could create economic opportunities too. This is completely absent while implementing solar tuki programme. However, the use of SHS systems can not be denied in places when any other options for energy supply are not available.

Generation of electricity by concentrating the solar rays through series of heliostats to produce superheated steam that can run steam turbine to produce electricity is another option for solar electricity generation. This can generate temperature up to 1500C. However, this technology is expensive than other renewable sources. This can produce industrial process heat comparatively cheaper than other sources. Direct application of solar energy such as water heating is one of the most efficient energy tapping system. However, conventional method is based on water heating the maximum temperature of which is limited to 1000C. If the technology is changed to oil heating instead of water, the temperature can reach over 3000C. This can be transferred to meet necessary heat requirements by means of heat exchangers. The efficiency of such systems can reach over 70% and it will have no environmental impact at al. This could be the best method to be promoted to produce the industrial process heat in Nepal. Similarly, wind energy is also considered a clean energy source. Wind energy has very good possibility in the hills of eastern and mid western districts. The government should promote this energy source by proving opportunities to private investments at the local level. National and international incentives for this green power development, tax exemption to a certain level and grid connection options should be provided to promote this source (www.svele.com).

As an example, Brazil started biofuels development after 1973's oil crisis and now bio-diesel and bio-ethanol are the major contributing energy sectors. Brazil is the world's largest producer of biofuels and is way ahead of the USA. Baggasse and molasses from sugarcane are primarily used for ethanol production and soy and palm oil are used for Biodiesel production. Fossil fuels are the alternatives for Brazil unlike other parts of the world where biofuels are alternatives.

Nepal can also learn from Brazil model to develop biofuels that can make Nepal independent from importing fossil fuels. Disruption in supply of petroleum products has not only been the problem for sustainable economic development but has also contributed to political instability. The national energy policy should focus on bio energy development for sustainable economic progress. Our policy makers should realize the fact that Nepal has high potential for development of biofuels such as biogas from waste, bio-ethanol and Biodiesel. Success of biogas projects in the country is the best example in this regard. Bio-ethanol from biogases and molasses from the sugarcane industry are the best feedstock for bio-ethanol production. Moreover, switch grass which is available in barren lands as well as waste corn stalks can be used to produce bio-ethanol. Recent developments on bio-ethanol production from lingo cellulose biomass have shown enormous potential for producing bio-ethanol from waste biomass products. Bio-ethanol can be used alone or in combination with gasoline in the current gasoline engines.

Similarly, Biodiesel can be produced from various plants and vegetable oils in Nepal. The most important source of feedstock for Biodiesel production is *Jatropha* Curcas (Sajiwan) oil in Nepal. *Jatropha* can be grown on barren lands, waste lands, and areas where other production is not possible due to dry climate. Oil from *Jatropha* oil is non-edible and can be easily converted into Biodiesel to replace the petroleum diesel. Biodiesel can also be mixed at certain concentration that significantly improves the engine performance and reduces emission. Different species of *Jatropha* found in Nepal have sufficient fatty acid content to convert them into Biodiesel. *Jatropha* is multipurpose tree which has several applications from medicine to diesel fuel. Traditionally it has been used as a natural tooth brush and paste. The oil can also be used as drying oil in industries. Once the *Jatropha* oil is converted to Biodiesel, the glycerin as its by-products can be used to make soap. *Jatropha* seeds contain over 30% oil and approximate 2.5 kg of seeds can produce a liter of Biodiesel and some amount of glycerin. Another plant species usually found in the high mountain areas called sea buckthorn also contains over 30% fatty acids in its oil which is also suitable for Biodiesel production. There are hundreds of species of plants from which the oil can be extracted to make Biodiesel fuel. This Biodiesel can be used in the conventional diesel engine without any modification. *Jatropha* oil can also be burned directly to replace kerosene lamps in rural areas. Production of Biodiesel and ethanol create over 4000 jobs per year for one TWh of energy which is highest among all energy sources and can contribute the national economy reducing the import of oil and creating local job market. India is planting *Jatropha* in millions of hectares as a national plan to replace the 30% of the transportation fleets by Biodiesel within next few years. A recent report says that *Jatropha* planted in the three countries of Guizhou Province of China totals 26,667 hectare in 2007 and the figure will exceed 266,670 hectare by 2012 that promises an increase in annual income of 62.5 to 87.5 US dollars for each working households. Hence, biofuels can significantly contribute towards the growth of national economy (www.svele.com).

1.3 Objectives of the Study

The major focus of the study is to assess the Usefulness and fruitfulness in the livelihood of rural people from Commercial farming of *Jatropha curcas* L.

The specific objectives are:

1. To provide a general introduction of *Jatropha curcas* as oilseed plant, potential for biofuel.
2. To assess the role of *Jatropha curcas* in income generation in the study area from commercial farming.
3. To explore the importance of *Jatropha curcas* in creating environmental benefits.

1.4 Significant of the Study

The significant of this study apparently lies in exploring the investment worthiness of the oilseed plant called *Jatropha curcas* for commercial farming. The study is expected to contribute in understanding investment requirement for a minimum feasible commercial farming and the benefits of *Jatropha* cultivation. The study is further expected to underscore the need to bring into use waste and degraded land through legislative and policy incentives for promoting biodiesel projects and to uplift the living condition of marginalized people.

Jatropha Potential in Nepal

- 30% of Nepal climatically favour for *Jatropha* cultivation
- There is 4.41 million hector of waste lands, if 20% of this is used with 5,000kg/ha productivity, annual production will be 4.4 million ton
- With 25% oil yield 1.1 million ton of *Jatropha* oil can be produce.

- 2.98 million ton carbon emission can be reduce

The Case against *Jatropha*

Critics of *Jatropha* have serious concerns about its environmental and social impacts. Western Australia has banned *Jatropha* due to its toxicity to humans and animals, and its ability to become a hard-to-control weed. Critics further state that claims of *Jatropha* needing no irrigation and being able to grow in poor soil conditions are misleading and false due to the unsustainably low yields. They say that *Jatropha* grown without irrigation and on poor soil only has a yield of 1.1-2.75 tons per hectare, compared to 5.25 -12.5 with irrigation. They argue that instead of marginal land being used to grow *Jatropha*, *Jatropha* will end up competing with food crops for the best lands. In a press release titled *"Fuelling Concerns,* farmers, NGOs, and people's movements from throughout India stated their opposition to large-scale *Jatropha* and agro fuel production, but defended the use of biomass produced in a local and ecological manner. They questioned the definition of "wasteland," and argued that most of these lands are "grazing lands, common pastures, degraded forests, and also lands of small and marginal communities." [6] These "wastelands" also play a critical ecological role in their current state. Critics also say that the *Jatropha* plant can be a pest bank, and increases the use of pesticides (www.fact-fuels.org).

Even the Government of India's energy adviser, Surya P. Sethi argues that concerns over food and water security are as important as those over energy security. He questions the "exaggerated claims" of available marginal lands, yield levels, costs, and the idea that bio-energy is "benign in nature." Sethi argues that even "if 60 million hectares of land are used for energy plantations like *Jatropha* Curcas and other crops, the commercial bio-energy produced would meet only 29% to 35% of the country's energy needs even 25 years from today." He adds in the same article that "only 7 to 8 million hectares of land under solar cells can give India energy independence even 25 years from today."

In fact, even if claims of *Jatropha*'s viability on marginal land holds true, there appears to be no protocols or policies set in place to prevent irrigated and arable land from being used for agro fuel production in India. A country of more than 1.1 billion people cannot afford to risk its food security in the quest for agro fuels. It is obvious that the most fertile lands that have access to irrigation will be preferred for *Jatropha* cultivation over poor quality land. Proponents of large-scale *Jatropha* cultivation fail to effectively address this major flaw. The government of India should be careful not to adopt policies which will encourage competition for land between food crops and *Jatropha*, as this would lead to unacceptable consequences, such as a further increase in malnourishment and food insecurity. If the government of India is intent on promoting *Jatropha* and other agro fuel cultivation to help meet the country's energy needs, it must first develop clear-cut policies on protecting arable land for food crops, and ensure the enforceability of these policies.

Nepal is one of the world's least developed nations, with low per capita income (GDP-per capita (PPP):$1,500(2006 est.)), and generally low socio-economic indicators. Its overall human development index value of 0.49 ranks Nepal 142nd among 173 countries worldwide. The economic situation in Nepal is not as promising as the economy still heavily dependent on agriculture sector (about 40% of GDP) but not yet diversified to solve the problem of poverty. If the agriculture sector could be more diversified by doing research works for the suitable production for the income generative agriculture production, the problem of the poverty can be reduced.

Jatropha oil is an important product from the plant for meeting the cooking and lighting needs of the rural population, boiler fuel for industrial purpose or as a viable substitute for diesel. Substitution of firewood by plant oil for household cooking in rural areas will not only alleviate the problems of deforestation but also improve the health of rural women who are subjected to the indoor smoke pollution from cooking by inefficient fuel and stoves in poorly ventilated space. *Jatropha* oil performs very satisfactorily when burnt using a conventional (paraffin) wick after some simple design changes in the physical configuration of the lamp. It is high time think for the country and utilizes fully the possibilities to reduce poverty and find the way of energy alternatives to raise the living standard of the people (www.fact-fuels.org).

1.5 Limitations of the Study

The parameters and data used in this study are derived largely from secondary sources and field observation. It does not examine the reliability and validity of secondary data. The conclusion drawn from this study may hold true to a large extent yet, some variation in cost and output should be expected for similar production elsewhere as production are dictated by location, climate, elevation, and type of soil and the level of infrastructure development. The study is further constraint by the availability of data, time and resources.

1.6 Organization of the Study

The study is organized into six chapter. The first, introductory chapter includes background of the study, problem statement, objectives, significance and limitations of the study. Here the second chapter, literature review explores about energy history, concept and history of biofuel, empirical studies on Jatropha, present status of Jatropha in Nepal and Policy and plan documents in biofuel. The third chapter covers the methodology and explains about rational for the selection of the study site, nature and sources of data, sampling procedure, research design, data collection, techniques and tools, reliability and data analysis as well. The fourth chapter is about the introduction of the study area where physical setting and demography are discussed. Fifth chapter expresses about data analysis and presentation where potential of Jatropha, status of Jatropha in Nepal, outcome of economic assessment, biodiesel and Jatropha, Income from Jatropha and environmental benefits are analyzed. Finally, the last chapter gives the conclusion and recommendations of the study.

CHAPTER-II

Literature Review

2.1 Energy History

Fire was first great energy invention of human civilization dating back to before people could read and write. Fire was found good for cooking, heating and scaring wild animals away. Biomass was chief source of fuel for a long time and it is still widely used by poor households in developing countries. As human civilization progressed, new energy sources were explored. Around 1000BC, the Chinese found coal and started using it as a fuel. It burned slower and longer than wood and gave off more heat. It served as an excellent fuel and continued to be used for centuries thereafter. When Marco Polo returned to Italy after an exploration to China in 1275, he introduced coal to the Western world. During the 19th century, the world went through a great change as the Industrial Revolution that started in England spread to the rest of Europe. North America and other parts of the world. Characterized by mass production aided by machines and the supply of much clothing, furniture and many other products, the demand for energy increased remarkably. Also, new means of transportation were developed with the application of the new technology such as the construction of the first steamboat in 1807 and the first locomotive in 1804. This situation required the invention of more effective engines and cheaper energy sources.

While coal was being used extensively by the industrial movement, some scientists were already becoming concerned about the exhaust from combustion of the fossil fuel. Some of these scientists started developing natural energy sources as an alternative to coal. The energy sources include solar, hydroelectric, wind and geothermal energy. (Chhetri, M, 2006)

Solar energy was first developed by Mouchout of France in 1860. William Adams improved the solar engine by reflecting solar radiation with several mirrors to a copper boiler elevated on a tower. Constructions of small hydro electrical power plants were also started in the 19th century. Windmills that until then were used for pumping water or grinding crops were also developed in an attempt to produced electrical power. Geothermal energy began to be used to produce electricity by the end of the century. Another big change occurred when Colonel Edwin Drake managed to drill and extract crude petroleum oil out of the ground in Titusville, Pennsylvania. It was discovered that several useful products should be produced from petroleum, including kerosene, a gas that was ideal for lighting purposes, and gasoline, a fuel that could be used for locomotive purposes. With the invention of internal combustion engines mounted on automobiles, petroleum gradually began to dominate coal in the energy industry. Nuclear energy is widely used today. Its efficiency in producing energy is very attractive but the disposal of radioactive waste that is harmful to the environment is the main concern (www.library.Thinkquest.org).

2.2 Concept and History of Biofuels

The concept dates back to 1885 when Dr. Rudolf Diesel built the first diesel engine with the full intention of running it on vegetative source. He first displayed his engine at the Paris show of 1900 and astounded everyone when he ran the patented engine on any hydrocarbon fuel available- which included gasoline and peanut oil. In 1912 he stated, "…………. *the use of vegetable oils for engine fuels may seem insignificant today. But such oils may in the course of time become as important as petroleum and the coal tar products of present time*".

Table: 2.1 Projection of potential - Biodiesel ***/various sources of biodiesel in Nepal***

SN	Source	Detail description
1	Plant oil	*Edible* Rapeseed, soybean, palm oil, corn, wheat, sunflower etc *Inedible* Jatropha, castor, linseed etc
2	Waste vegetable oil (WVO)	Since the production is very low, it may not be commercially feasible
3	Animal Fat	Fat produced from meat products but the production is also low

Source: Report by Nawa raj Dhakal, Senior Trainer (AEPC), 2008

Biofuels are renewable sources of energy derived from biological raw materials. Two sources of biofuels-ethanol and biodiesel are gaining worldwide acceptance as one of the solutions for problems of environmental degradation, energy security, import dependency, and rural employment. The UK Energy Technology Support Unit defines 'biofuels' as any solid, liquid or gaseous fuels produced from organic materials, either directly from plants or indirectly from industrial, commercial, domestic or agricultural wastes.

Ethanol, commonly termed as alcohol or ethyl alcohol is close to be perfect fuel because of low molecular weight, high oxygen content, high combustion efficiency, non-toxic and non-polluting nature. Hydrocarbon emissions from ethanol blended motor fuel are reported to be free of carcinogenic elements and that carbon-dioxide (Co2) emissions are 57% lower than of petrol (Kureel, 2007).

The renewable raw materials used for ethanol production today vary from sugar in Brazil, cereals in USA, sugar beet in Europe and molasses in India. Brazil uses 100% ethanol fuel in 20% of vehicles and 25% blend in gasoline in the rest of the vehicles. USA and Australia use 10% and EU uses 15% ethanol blended gasoline (Kureel). Brazil acquires leading position as the largest producer of ethanol almost 50% of the world's total production. Kureel (2007) claims that ethanol programme in India was taken up in the early 1940s much ahead of any other country in the world more due to rational need without commercial intent.

Biodiesel is emerging as the other significant and viable option of clean and renewable energy source. Biodiesel is reported to be carbon neutral, having almost no sulphur, no aromatics and has about 10% built-in oxygen. It is fatty acid ethyl or methyl ester. Biodiesel operates in compression ignition engines like petro-diesel. It can be stored just like the petroleum diesel fuel and hence does not require separate infrastructure (Kureel). The feedstock for biodiesel can be derived from various plant oil sources like *Jatropha*, aesandra butyracea. neem etc. Biodiesel use has been showing an increasing trend since the last one decade with countries like India, Ghana, South

Africa, Tanzania, Mali, China, USA, Indonesia, Thailand etc. putting in more thrust on biofuel sources (www.jatropha.org/de*)*.

As reported by Ewout P. Deurwaarder (2007) in his article "European Biofuel Policies", European Commission tried to stimulate biofuel use by a proposal for tax exemptions. The Biofuel Directive introduced in 2003 set a target of 2% use of biofuels in 2005 and 5.75% use by 2010 as percentage of total petrol and diesel use. There is no general support scheme for biofuels at EU level. The member states had to introduce their own policy instruments. The EU supports for biofuel is related with its agriculture policy which provides incentives to farmers producing energy crops. Since 1992, there is a set-aside policy, which requires a part of the land not to be used for food production, but it can be used for energy crops. Since 2003, farmers can also opt for direct payment for the production of energy crops. He further reports that only Germany with 3.75% and Sweden with 2.2% of biofuel use achieved the target in 2005. The average EU use of biofuels in 2005 is estimated at 1%. Most of the biofuel used in Europe is biodiesel, produced locally from rapeseed. Germany, France and Italy are the major producers of biodiesel also on a global level, Ethanol used in Spain and Sweden is produced mostly from grains as feedstock. There are also imports of ethanol from South America to Europe.

2.3 Empirical Studies on *Jatropha*

The *wikipedia*, a free encyclopedia provides accounts of *Jatropha* as a genus of approximately 175 succulents, shrubs and trees (some are deciduous like *Jatropha* curcas L.), from the family Euphorbiaceae. Plants from the genus natively occur in India, Africa, North America and the Caribbean. Originating in the Caribbean, the *Jatropha* was spread as a valuable hedge plant to Africa and Asia by Portuguese traders. The mature small trees bear male and female inflorescence and do not grow very tall.

Jatropha curcas Linn, also called physic nut, is used to produce the non-edible *Jatropha* oil, for making candles and soap, and as feedstock for the production of biodiesel. The cakes remaining after the oil is pressed, can be used as feed in digesters and gasifier to produce biogas for cooking and in engines, or the cakes can be used for fertilizing and sometimes even as animal fodder, alternatively, the entire seed (with oil) can be used in digesters to produce biogas. Large plantings and nurseries of this tree have been undertaken in India by numerous research institutions, and by women's Self Help Groups, who use a system of micro credit to ease poverty among the nation's semi-literate population of women. Extracts from this species have also been shown to have anti-tumor activity. The seeds can be used as a remedy for constipation, wounds can be dressed with the sap, and the leaves can be boiled to obtain malaria and fever remedy (www.ebay.com).

Jatropha is a kind of perennial plant with a life span of about 50 years. It may be called a small tree or large shrubs and is found in semi-wild and cultivated condition. *Jatropha* propagation may be done by vegetative cuttings or by seed. In the former case, fruiting begin in the first year itself but the age of the plant is said to come down to about 30 years. Plants raised from seedlings begin fruiting from 3rd year upto about 50 years (Singh 2002).

Hooker (1973) reported about 70 species native to American tropics. Jones and Miller (1992) also gave account of *Jatropha* distribution in the Asian and African countries as transported by Portuguese travelers where it has since become naturalized and widely utilized because of its attribute to thrive on any condition.

Studies on the potential of oil seed bearing plants in Nepal show some variation in their findings. A study by Singh (1980) reported 286 plants as oil-bearing trees in Nepal. Of these 92 species are reported to contain more than 30% of oil in the seed including *Jatropha*. GEM (1996) reports over 400 varieties of different plants genetic resources that show 12% to 77% fixed oil content in the seeds and nuts while 20 oil-seed plant species exceeding 30% oil content.

The seven species of *Jatropha* recorded in Nepal as reported by Yadav (2006) are *Jatropha* curcas L., *Jatropha* gossipifolia, *Jatropha* Glandalifera, *Jatropha* tanjorensis, *Jatropha* multifida, *Jatropha* Podagrica and *Jatropha* intergerrima. It is the *Jatropha* curcas L. that is identified as promising oilseed plant holding biodiesel potential. Distribution of *Jatropha* curcas is reported in all districts of Terai and the hill. In the mountains they are found on low-lying areas including the riverbank. Although Boswell (2003), reports that about 30% of land in Nepal is climatically favorable for *Jatropha* farming, all of it cannot be available because cropland may not be substituted for *Jatropha* farming.

Inconsistency in the findings of various studies is also found with regard to the oil-content in *Jatropha* seed. GEM claims about 50 to 55% of fixed oil in *Jatropha* seed that can be utilized as green energy. A study by Nepal (2000) observed 35.6&, 33% and 30.5% of oil in the seeds collected from three different altitude regions that include the districts of Dang at 634m, Kavre at 1100m and Morang at 72m above sea level respectively. This variation in oil-seed content according to conditions, difference in growth environment and the habitat like moisture, soil fertility and the age of the plant. Singh (2002) reports about 48-60% oil in the seed kernel or 35-45% in the seed.

2.3.1 Economic Study of *Jatropha*

The *Jatropha* project in Mail headed by Dr. Henning starting tentatively from late eighties may be presumed as the first organized system of *Jatropha* farming as energy sources and rural development. He is eminent as the father of *Jatropha* system. He worked for GTZ on Production and Use of *Jatropha* Oil as Raw Material and Renewable Energy. According to Henning, economic evaluation of the *Jatropha* activities in Tanzania based on real data show positive economic results. Similar results were demonstrated in other countries, as far as soap making was concerned. The economic use of *Jatropha* oil as fuel (direct or as biodiesel) depended very much on the level of rural labour costs, as well as on the price of diesel fuel, which is often substantially subsidized.

In his words, “economy of small scale production of *Jatropha* oil as fuel in Tanzania production and utilization of *Jatropha* oil as fuel has a positive result in the economic analysis, but only, if the raw material (*Jatropha* seeds) are not bought, but collected. If the revenues of the whole process are calculated in respect of the necessary working hours, an economic benefit is visible".

An estimate *Jatropha* cultivation by SRIPHL (2006) on hour's basis found an average time requirement of 275 hours for field maintenance per hectare and 125 hours per metric ton for seed harvest. This estimate shows an average cost for 1-hour per man work at IRs. 8 approximately under the agriculture wage rate of IRs. 64 per day. The cost per hectare of *Jatropha* feedstock production under this estimate is about IRs. 25,000 with an internal rate of return of over 50 percent (www.jatropha.org).

Saxena (2007), points out an interesting fact that there can be less productive and more productive lands in technical term, but there is no land which is waste because such land lends itself for cultivation after due treatments and *Jatropha* plantation is one of the several methods of converting waste lands for cultivation purposes. As per his estimates, more than 300 working days of employment is generated in establishing one hectare plantation of *Jatropha*. Seed collection further generates another 20-30 working days of employment per hectare every year.

According to Saxena, the involvement of traders as intermediaries between the farmers and oil-producers translate into high cost of *Jatropha*-based biodiesel at around IRs. 45 per liter. The traders buy *Jatropha* oilseed from farmers at a price of IRs. 5-6 a kg and sell to producers with an unrealistic price margin of over 100 percent at IRs. 10-12 a kg. This apart from increasing the cost of biodiesel results into substantial benefit to the traders than to the farmers.

According to Singh (2002), 1500-1700 tones of *Jatropha* oil can be had from its cultivation in 1000 hectare per year for use as biofuel. The optimum seed yield can be achieved in areas with average annual rainfall between 900-1200mm and a minimum of 250mm rainfall per year is required for the survival of the plant.

Financial analysis of *Jatropha* farming in Nepal made by Banskota and Sharma (2006) considering 25 years of plants' life span demonstrated positive net present value (NPV) and acceptable financial internal rate of return (FIRR). The analysis concluded that *Jatropha* cultivation was found financially viable even after examining the combined effects of 20% increase in cost and 20% even after examining the combined effects of 20% increase in costs about Rs. 41,000 to produce *Jatropha* seed in one hectare. The NPV for costs and benefit as provided by this estimate is Rs. 49,000 and Rs. 95,000 respectively with benefit cost ratio of 1.9 and 29% of FIRR assumed at 15% discount rate. The estimate further shows *Jatropha* seed production in one hectare can provide employment to 299 Labour Day implying 47% of cost going to farmers in the form of wage income at the rate of Rs. 85 per Labour Day.

2.3.2 Functional uses of *Jatropha*

1. **Food:** In Guinea, ashes from the roots and branches are used as cooking salt. Young leaves may be safely eaten when steamed or stewed. Cooked nuts are eaten in certain regions of Mexico. Finally, *Jatropha* leaves are used as food for the tusser silkworm as well.

2. **Fuel:** It is significant to point out that, the non-edible vegetable oil derived from seeds of *Jatropha* curcas has the requisite potential of providing a promising and commercially viable alternative to diesel oil since it has desirable physicochemical and performance characteristics comparable to diesel. Cars could be run with *Jatropha* curcas oil without requiring much change in engine design. *Jatropha* oil is an environmentally safe, cost-effective renewable source of non-conventional energy and a promising substitute for diesel, kerosene and other fuels. Physic nut oil was used in engines in Segou, Mail, during World War II. The oil burns without smoke and has been employed for street lighting near Rio de Janerio. Fruit hulls and seed shells can be used as a fuel. Dried seeds dipped into palm oil are used as torches, which will keep alight even in a strong wind.

3. **Oil:** The seeds yield up to 30-48% oil. It is used to prepare vanish after calcinations with iron oxides. Hardened physic nut oil could be a satisfactory substitute for tallow or hardened rice bran oil. In Europe

it is used in wool spinning and textile manufacture. Along with brunt plantain ashes, oil is used in making hard homemade soap.

4. **Wax:** The bark contains a wax composed of a mixture of 'melissyl alcohol' and its melissimic acid ester.

5. **Poison:** Curcas oil contains a toxin, curcasin. The albumen of the kernel is a poison, toxalbumin cursin, most abundant in the embryo. Another poison, a croton resin, occurs in the seeds and causes redness and pustular eruptions of the skin. The plant is listed as a fish poison. Aqueous extracts of J. curcas leaves were effective in controlling sclerotium spp., an Azolla fungal pathogen. The seed oil, extracts of J. curcas seeds and phorbol esters from the oil have been used to control various pests, often with successful results. In Gabon, the seeds, ground and mixed with palm oil, are used to kill rats. The oil has purgative properties, but seeds are poisonous; even the remains from pressed seeds can be fatal.

6. **Medicine:** The latex of *Jatropha* curcas contains an alkaloid known as jatrophine, which is believed to have anti-cancerous properties. It is also used as an external application for skin diseases and rheumatism and for sores on domestic livestock. In addition, the tender twigs of the plant are used for cleaning teeth, while the juice of the leaf is used as an external application for piles. The roots are reported to be used as an antidote for snakebites where seeds are used in the treatment of syphilis. Juice or latex is applied directly to wounds and cuts as a styptic and astringent to clean teeth, gums, and to treat sores on the tongue and in the mouth. It also has coagulating effects on blood plasma. A methanol extract of physic nut leaves afforded moderate protection for cultured human lymphoblastoid cells against the cytopathic effects of the human immunodeficiency virus. Preparations of the plant, including seeds, leaves and bark, fresh or as a decoction are used in traditional medicine and for veterinary purposes. A leaf infusion is used as a diuretic, for bathing, to treat coughs, and as an enema in treating convulsions and fits. Leaves are

also used to treat jaundice, fevers, rheumatic pains, guinea worm sores and poor development of the fetus in pregnant women. In Ghana the ashes from the brunt leaves are applied by rectal injection for hemorrhoids. The root bark is used to relieve the spasms of infantile tetanus and is used for sores, dysentery and jaundice. The juice of the flowers has numerous medicinal qualities.

7. **Toxicity:** The poisoning is irritant, with acute abdominal pain and nausea about ½ hour following ingestion. Diarrhea and nausea continue but are not usually serious. Depression and collapse may occur, especially in children. Two seeds are strong purgative. Four to five seed are said to have caused death, but the roasted seed is said to be nearly innocuous. Seeds contain the dangerous toxalbumin curcin, rendering them potentially fatally toxic.

8. **Insecticide/Pesticide:** The seed are considered anthelimintic in Brazil, and the leaves are used for fumigating houses against bed bugs. Also, the ether extract shows antibiotic activity against Styphylococcus aureus and Escherichia coli.

9. **Soil enrichment agent/Fertilizer:** *Jatropha* curcas oil cake is rich in nitrogen, phosphorous and potassium and can be used as organic manure. The leaves shed during the winter months form mulch around the base of the plant. The organic matter from shed leaves enhances earthworm activity in the soil around the root-zone of the plants, which improves the fertility of the soil.

10. **Raw material for dye:** The bark of *Jatropha* curcas yields a dark blue dye which is used for colouring cloth, fishing nets and lines (*Source: Bhattarai, K. R. (Jan, 2008)*; *Sajiwan bata biodiesel- Jatropha Biodiesel)*.

2.4 Present Status of *Jatropha* in Nepal

In Nepal, 286 plant species are identified as oilseed plants with 92 of them exceeding 30% oil content (Singh, 1980). *Jatropha* curcas L. is one of these oilseed plants the potentiality of which is yet be harnessed while in some other countries of Africa and Asia it is being exploited considerably.

2.4.1 Distribution and Characteristics

Jatropha curcas, a native of Caribbean Islands is also thought to have originated in either Peru of Mexico (Nepal, 2000). Distribution of *Jatropha* in Africa and Asia was likely affected by Portuguese travelers where it has since become naturalized and widely utilized. The seven species of *Jatropha* recorded in Nepal are identified as *Jatropha* curcas L., *Jatropha* gossipifolia, *Jatropha* Glandalifera, *Jatropha* tanjorensis, *Jatropha* multifida, *Jatropha* Podagrica and *Jatropha* intergerrima, Yadav (2006). It is the *Jatropha* curcas L. that is identified as promising oilseed plant holding biodiesel potential belonging to the family Euphorbiaceae (Nepal, 2000). In English *Jatropha* is commonly called as "Physic Nut". In Nepal it is known by over 200 local names suggesting that it has wide spatial distribution in the country. It is known by Kadam in the eastern hilly districts and in Morang, Saruwa in Jhapa, Baghandi in Saptari, Bangreda in Sarlahi, Battibal in Hetauda, Nirkune in Malekhu and Dhading, Nimtel in Kavre and Sindhupalchowk, Sajiwan in Kathmandu, Nuwakot and in sajiwal some western districts, Ratanjyoti in Dailekh and Surkhet, Inu in Kailali, Ratanjoli in Achham, Kukath in Doti (Nepal).

The spatial distribution of *Jatropha* curcas is recorded in the terai and inner terai throughout Nepal upto 1400 meter altitude. District wise, *Jatropha* is distributed in all districts of the terai and hill while in mountain districts they are found on low-lying areas including the riverbanks (Singh, 2000). They are also found abundantly in the districts of Gorkha, Lamjung, Kaski, Tanahun, Kavre and Sankhuwasabha.

Seeds from Dang, Morang and Kavre demonstrating different topography and altitudinal variation showed oil content of 35.6%, 30.5% and 33% respectively. It was also found that oil percentage increased corresponding to increase in seed maturity (Nepal). Traditional expeller used by local people in eastern Nepal reported extraction of oil between 20-25%. Oil content varies depending on plant quality. It was observed that the protein value of sampled seeds was 23.52% in oil cakes and 15.19% in seeds of *Jatropha* showing good source of protein. Similarly, the nitrogen and phosphorous value in oil cakes suggests it can be a potential source of bio-fertilizer. The oil characteristics ranked in the range of cooking oil, while saponification value equal to that of palm oil which is used as raw material in soap making (Nepal) (Chhetri, M, 2006).

2.4.2 Application and Plantation

Potential of *Jatropha* seed as biofuel source has been identified some few years back and is being exploited to some extent in some countries of Africa and Asia. In Nepal, farmers are not familiar with the economic value of *Jatropha*; it is basically used as fences around their cropland to prevent cattle browsing. The plant is not palatable by animals. However, *Jatropha* is being replaced by other plants for fencing these days. Traditionally, rural people used the twig of the plant as natural toothbrush. In some remote villages *Jatropha* seeds are used for illumination. The seed cover is removed manually and are woven into a string to use as candlelight. Extraction of oil from *Jatropha* seeds was popular in eastern hilly districts of Bhojpur and Sankhuwasabha. The collected fruit-seeds were sun dried for 2/3 days and seed cover (bark) removed by stroking with long sticks. Traditional oil expeller called KOL did extraction of sun dried seeds. Oil extraction by this method was observed in the range between 20-25% of seed weight. The oil was used for illumination and other medicinal purposes. Shed leaves of *Jatropha* are composed for making green manure and used in crop farming. The sap is popular with children who use it to blow as bubbles (Boswell, M. J, 2003).

Extraction of oil from *Jatropha* seeds was undertaken at RECAST using Sandhara Oil Expeller manufactured by D.C.S. Butwal. The oil was used for generating electricity. It has also tested *Jatropha* oil on diesel engine for 800 hours and reported to have worked well. Extraction by this unit may leave certain amount of oil with the oil cake but such processes are farmer friendly and can be established and used at local level. Plantation of *Jatropha* is undertaken by some organizations and individuals. But commercial farming in large scale has yet to start. An experimental plantation of *Jatropha* was initiated by RECAST in collaboration with the UK-Oil Seed Project in 1999 in an area of 15 hectares in Khairenitar of Tanahun districts and in 5 hectare area in Musetunda of Kaski Districts in 2003. Nepal Salt Trading Limited has planted *Jatropha* for experimentation in 0.5 hectare in Biratnagar. Agro-forestry Promotion centre is doing plantation in Jhapa, and Gopal Charity Trust (SCT) in Lahan. GCT distributes seedlings produced in its nursery to local farmers. Similarly, Gupta Nursery in Butwal of Rupandehi district also raises nursery for the distribution of seedlings to local farmers with buy back guarantee. The distributed seedlings are raised from hybrid seeds. Gupta nursery is a case of profit-oriented undertaking while GCT is carrying out as an experimental project.

2.4.3 Deduction

India is sixth in the world in energy demand accounting for 3.5% of world to commercial energy from hydrocarbons at all. India's import of crude oil is expected to go up from 85 million t to 147 million t by 2007. Hydrocarbons, in India predominantly diesel (ca. 80 *%,* in Germany >40%) are responsible for most of the transportation fuel in India; the transport sector is the most problematic as no realistic alternatives have been found so far. Overall transport crude oil demand was >50 Mio T in 2001.

In India, a larger share than in other countries is needed for transport purposes, in particular for diesel. Consumption is expected to rise at an annual 5.6% rate and by *65%* until 21) 11. Domestic supply can presently satisfy 22% of demand and dependence on crude oil imports (>18 billion $/a) is increasing. There is a growing demand gap between production and consumption. At the same time, per capita consumption with 480 kg oil equivalent and 260 Mio people below the poverty line (>20% worlds poor) is quite low. Indian petrol reserves arc expected to last for another 20 years plus. Rising and volatile prices and respective foreign exchange costs are one of the main risk factors of the Indian economic and social development prospects.

In Europe and the US blends between 5 and 20% of bio-diesel are used as well without engine modification, in the US so far a total of 400.000 m3/a. In France 135 *(5%* bio-diesel blend) is mandatory. Sometimes a low percentage additive for lubrication and sulfur removal from diesel fuel is used as well In Europe bio-diesel is mainly made from rapeseed, sunflower, in the US from soybean and in Malaysia increasingly palm oil is being utilized. Nicaragua is cited as an example where *Jatropha* oil is used for bio-diesel to replace petro-diesel.

From a total of RS 1500 Corers total Government contribution (300 Mio S/Euro) the major share (RS 1200 Corers) is earmarked to be spent for nurseries and plantations. Legislation is to secure that use of B5 (5% blend) and successively B20 (20% blend) become mandatory all over India (www.greenfuel.com).

Bio-energy, as a replacement for transport fuel can be alcohol, bio-oil or bio-diesel. Bio fuels are to reduce negative environmental effects through lower emissions and climatic impacts. Local production of bio energy is projected to have a broad range of positive economic, social and environmental implications. Upgrading eroded and deforested land, creation of employment and income is part of the argument. The national program wants to stop soil and forest degradation and its environmental implications, generate employment for the poor, in particular for women, reduce climatic change and improve energy security.

Alcohol, mainly in form of ethanol is planned in India in be made from sugar cane directly or from molasses and to replace *5%* of motor spirit for spark ignition engines. The alcohol program has started already. Bio-oil, without further processing, is only suitable for sturdy compression ignition engines (diesel), or asks for considerable motor modifications and maintenance. Therefore, the Indian Government focuses the processing to bio-diesel from plant oils. However, a direct use in rural engines, water pumps, tractors and generator sets to produce electricity are additional options to provide rural energy and energy security to the rural population.

Bio-diesel, considered an equal replacement of petro-diesel (with 5% less efficiency), can be made after trans-esterification from virgin or used vegetable oils (both edible and non-edible). It is meant to be produced in India mainly from *Jatropha* curcas and, to a lower extent, from other non-edible virgin oils (in particular Pongomia pinnate, called honge or pinnata, as well as Neeni, Mahua). It requires little or no engine modification up to 20% blend and minor modification at higher percentage blends. The use of bio-diesel results in substantial reduction of un-burnt hydrocarbons, carbon monoxide and particulate matters. It is considered to have ahnost no sulphur, no aromatics and has about 10% built in oxygen, which helps to bum it fully. Its higher cetane number improves the combustion quality. Almost all present emissions standards are expected to be reached with bio-diesel.

While the country is short of petroleum reserve, it has large Arabic land as well as good climatic conditions, potential to produce biomass to be processed into bio-fuels. Demand of edible oil is higher than production, so edible oils, as mainly used in Europe and the US for transport oil, are considered not eligible. As well, edible oils are much more expensive, sometimes by a factor 3-5, in India.

Instrument to promote non-edible oils is hoped to be buy-back arrangements with oil companies to be put in place and mandatory use of bio-diesel blends. The *Jatropha* program is to be combined with other programs of the Ministry of Rural Development to attract growers, entrepreneurs and financial institutions so that a "self sustaining programme of expansion takes off? on its own, with the Government playing mainly the role of a facilitator. Hence, for the expansion phase, the Government will need "to give only marginal financial support". The rural community will have the first right of access to the oil for its own use. Responsibility for availability of sufficient processing units will be with the Ministry of Petroleum. Studies have revealed that "direct and indirect impact of bio-diesel e.g. employment generation, balance of trade, emission benefits etc. are substantial and need to be accounted for" while considering the duty structure on bio-diesel and HSD (www.ebay.com).

However, a clear comparison between the yields and economics of different edible and non-edible oils, and why production of non-edible oils for farmers is expected to be more viable than of edible oils, has not been found inside the program argument. Duty structure is meant to be designed in a way that the price of bio-diesel will be slightly lower than that of imported petro-diesel fuel.

Jatropha curcas is considered most suitable since it uses lands, which are largely unproductive for the time being and are located in poverty-stricken and watershed areas and degraded forests. *Jatropha* is planned as well to be planted under the poverty alleviation programme that deal with land improvements.

For the planned 13 Mio ha *Jatropha*, 3 Mio ha are to be identified in 38 Mio ha under stocked forest, 3 Mio ha hedge equivalent from 140 Mio ha of agricultural land and 2 Mio ha for absentee landlords since, *Jatropha* does not require looking after and gives a net income of Rs 15000/ha". In addition, land comes from 2.4 Mio ha out of 24 Mb. ha of fallow lands; two Mio ha from integrated watershed development programme; one Mio ha from stretches of public land along railway, roads/ canals and 4 Mio ha from "other waste lands".

As a by-product the oil cake and glycerol are to be sold to reduce the cost of processing Biodiesel to par with the oil price. The sales cost of bio-diesel is expected to be very close to the cost of oil obtained for production, since the cost of trans-esterification is meant to be recoverable to a great extent from the income of oil cake (3-5 Rupees/kg) and glycerol (50 Rupees/kg). The cost of bio-diesel is expected to reach between 15 and 16.3 Rupees at an assumed price of RS 5 per kg of seed and at 3.2 kg of seed for I liter of oil. "Thus the plantation, oil extraction and production of bio-diesel are economically feasible". Overall oil bio-diesel recovery is expected to be 91% at an oil portion of 35%. There is a plant density of 2500 trees per ha assumed, in mixed forestry areas 2500 trees each are considered one ha. An average seed yield of 1.5kg/tree and 3.75 tiha are expected corresponding to 1.2 t of oil /ha and 2.5 t of fertilizer. Bio-diesel is expected to be available on the market from 2005/2006 onwards. Work created of 300 "man" days /ha would allow 550.000 people to escape poverty in the first part of the program. A transesterification plant is meant to cost Rs75 Corers (5/Euro 12.5 Mio; I crore is equivalent to Rs 10 Mio.), and procurement and expeller centre Rs 80 lakh (S/Euro 160.000; one lakh is equivalent to Rs 100.000),) NEEDS AND RESPONSIBILITIES (www.ebay.com).

1. **<u>Production of *Jatropha curcas*</u>**

Table: 2.2 Production of *Jatropha*

Time of cultivation	Estimated weight of fruit (in case of no irrigation) kilogram	Estimated weight of fruit (in case of irrigation) kilogram
1 year	-	250
2 year	250	1000
3 year	1000	2500
4 year	2000	5000
5 year	3000	8000
Above 6 year	4000	12000

Source: Bhattarai, K. R. (Jan, 2008); *Sajiwan bata biodiesel- Jatropha Biodiesel)*

Considerable plantation of *Jatropha* had been undertaken in Zimbabwe by a number of active organizations involved in its promotion including the Agricultural Research Trust (ART), the Biomass Users Network (BUN), the Forestry Commission (FC) and the Plant Oil Producers Association (POPA). An estimated four million *Jatropha* plants have been planted in Zimbabwe by the end of 1997 amounting to nearly 2,000 hectares of plantations.

Although it is known that *Jatropha* can be established from seed, seedlings and vegetatively from cuttings, very little written information is available in Africa about the silviculture and management of *Jatropha*. Plants from seeds develop a typical taproot and four lateral roots, and cuttings do not develop a taproot (Heller J. 1996). *Jatropha* is a fast growing plant and can achieve a height of three meters within three years under a variety of growing conditions. Seed production from plants propagated from seeds can be expected within 3-4 years. Use of branch cutting for propagation is easy and results in rapid growth; the bush can be expected to start bearing fruit within one year of planting. (Jones & Miller, 1992, p. 8)

Whilst *Jatropha* grows well in low rainfall conditions (requiring only about 200 mm of rain to survive) it can also respond to higher rainfall (up to 1200 mm) particularly in hot climatic conditions. In Nicaragua for example, *Jatropha* grows very well in the country's hot climate with rainfall of 1 000mm or more. Experience in Zimbabwe has shown that high rainfall in the relatively cooler parts of the country does not encourage the same vigorous growth. However, in the low-veld areas, such as in the mid-Save region, *Jatropha* grows well, although comparative yields have not been established. *Jatropha* does not thrive in wetland conditions. The plant is undemanding in soil type and does not require tillage. In southern Africa, the best time for planting is in the warm season to avoid the cold season since the plants are sensitive to ground frost that may occur in the cold season. (BUN newsletter 1996).

The recommended spacing for hedgerows or soil conservation is 15cm - 25cm x 15cm-25cm in one or two rows respectively and 2m x 1.5m to 3m x 3mm for plantations (Jones N, Miller J.H. 1992, p.7). Thus there will be between 4,000 to 6,700 plants per km. for a single hedgerow and double that when two rows are planted. The number of trees per hectare at planting will range from 1,600 to 2,200. Wider spacing is reported to give larger yields of fruit, 794 kg/ha and 318 g/shrub (Heller J. 1996).

In equatorial regions where moisture is not a limiting factor (i.e. continuously wet tropics or under irrigation), *Jatropha* can bloom and produce fruit all year. A drier climate has been found to improve the oil yields of the seeds, though to withstand times of extreme drought, *Jatropha* plant will shed leaves in an attempt to conserve moisture which results in somewhat decreased growth (Jones and Miller, 1992, p.7).

Seed production ranges from about 0.4 tons per hectare per year to over 12 t. /ha. /a., after five years of growth (Jones N, Miller J.H. 1992). Although not clearly specified, this range in production may be attributable to low and high rainfall areas. In Mali, where *Jatropha* is planted in hedges, the reported productivity is from 0.8 kg. – 1.0 kg. of seed per meter of live fence (Henning R. 1996). This is equivalent to between 2.5 t. /ha. /a. and 3.5 t. /ha. /a.. The practices being undertaken by the *Jatropha* growers currently need to be scientifically documented along with growth and production figures. The growth and yield of wood may be in proportion to nut yield and could be improved through effective management practices.

Woody biomass growth, unlike seed production, is not recorded in any articles to hand. Although it needs to be tested, it is possible that nearly one-third of net primary production (NPP) in *Jatropha curcas* may be in the form of woody biomass. However, it needs to be tested if there is tradeoff between growing *Jatropha* plants for optimizing woody biomass vs. seed production for oil. Reportedly, *Jatropha* trees/bushes live up to 50 years or more. Like all perennial plants, *Jatropha* displays vigorous growth in youth that tails off gradually towards maturity.

Existing literature indicates that the Agricultural Research Trust of Zimbabwe (ART) has laid down trials of different provenance of *Jatropha curcas*. Such research work is vital in determining the most appropriate provenance and optimum management systems and must be pursued. The current status of this work may give an important insight into the management and yield of *Jatropha* in Zimbabwe. Although non-toxic varieties of *Jatropha curcas* were sent to Zimbabwe for planting, (Gubitz G. M. et al eds. 1997, page 203), their current locations are unclear. It is however possible that ART included these varieties in their provenance trials. Success of such varieties would make the seed cake following oil extraction suitable as animal feed without a need for its detoxification.

Although *Jatropha* is adapted to low fertility sites and alkaline soils, better yields are obtained on poor quality soils if fertilizers containing small amounts of calcium, magnesium, and sulfur are used. Mycorrhizal associations have been observed with *Jatropha* and are known to aid the plant’s growth under conditions where phosphate is limiting. (Jones & Miller, 1992, p.7)

A perceived advantage of *Jatropha* is its capability to grow on marginal land and its ability to reclaim problematic lands and restore eroded areas. As it is not a forage crop, it plays an important role in keeping out the cattle and protects other valuable food crops or cash crops. *Jatropha* products from the fruit - the flesh, seed coat and seed cake - are rich in nitrogen, phosphorous and potassium (NPK) and are fertilizers that improve soil. *Jatropha* hedges and shelterbelts by improving the microclimate and providing humus and fertilizers to the soil can further enhance the productivity of other agricultural crops.

However, the above uses can be constrained by the prevalence of pests and diseases that attack *Jatropha*. Existing literature indicates that contrary to popular belief that toxicity and insecticidal properties of J. curcas are a sufficient deterrent for insects that cause economic damage in plantations, several groups of insects have overcome this barrier. Particularly noteworthy is the insect order of Heteroptera that has at least 15 species in Nicaragua that can extract nutrients from physic nut. The stem borer from the coleopterous family of Cerambycidae that is known as a minor pest in cassava can kill mature physic nut trees. The relatively few leaf-eating insects present are not capable of doing much damage once the trees have passed the seedling stage. Biological control can make use of beneficial arthropods – polyphagous predators and specialized parasitoids – either by conservation or augmentative releases; the first alternative being the more cost efficient (Grimm & Maes, 1997). In some areas of Zimbabwe the golden flea beetle (Podagrica spp.) can cause harm – eat young leaves and shoots, particularly on young plants. *Jatropha* is also host to the fungus "frogeye" (Cercospera spp.) common in tobacco. The workshop will examine the issue of pests and diseases that afflict *Jatropha* in further detail to ensure that it is safe to be used as a live fence and/or boundary plantation for various agricultural and cash crops.

In summary, the workshop will examine issues relating to silvicultural production systems and nutrient requirements of *Jatropha curcas* can be summarized as below:

- What are the best management techniques (planting practices, spacing, etc.) to promote the optimum growth of *Jatropha* to optimize for instance nut production?
- What types of edaphic factors, climatic conditions provide best for *Jatropha curcas*, both from the perspective of fruit and biomass? What is the ideal rotation age for nuts and the plant? What varieties, including non-toxic varieties perform better in southern Africa?
- How can *Jatropha curcas* plantations by themselves or in agro-forestry combinations (climatic conditions and management practices) alleviate problems of devegetation and soil erosion and improve the environment.
- Available biological control/IPM techniques to control of pests and diseases of *Jatropha*.

2. *Jatropha curcas* as an Energy Source

Table: 2.3 Oil from *Jatropha curcas in different country*

S. No.	Country	Production in Metric Ton
1	France	3,28,000
2	Germany	2,46,000
3	Italy	78,000
4	Austria	27,000
5	Belgium	20,000
	Total	7,00,600

Source: Bhattarai, K. R. (Jan, 2008); *Sajiwan bata biodiesel- Jatropha Biodiesel)*

Jatropha oil is an important product from the plant for meeting the cooking and lighting needs of the rural population, boiler fuel for industrial purposes or as a viable substitute for diesel. Substitution of firewood by plant oil for household cooking in rural areas will not only alleviate the problems of deforestation but also improve the health of rural women who are subjected to the indoor smoke pollution from cooking by inefficient fuel and stoves in poorly ventilated space. *Jatropha* oil performs very satisfactorily when burnt using a conventional (paraffin) wick after some simple design changes in the physical configuration of the lamp.

About one-third of the energy in the fruit of *Jatropha* can be extracted as oil that has a similar energy value to diesel fuel. *Jatropha* oil can be used directly in diesel engines added to diesel fuel as an extender or trans-esterised to a bio-diesel fuel. In theory, a diesel substitute can be produced from locally grown *Jatropha* plants, thus providing these areas with the possibility of becoming self sufficient in fuel for motive power. There are technical problems to using straight *Jatropha* oil in diesel engines that have yet to be completely overcome. Moreover, the cost of producing *Jatropha* oil as a diesel substitute is currently higher than the cost of diesel itself that is either subsidized or not priced at "full cost" because of misconceived and distorted national energy policies. Nevertheless the environmental benefits of substituting plant oils for diesel provides for make highly desirable goals.

In 1995, the Rockefeller Foundation (RF) and the German Government's Technical Assistance Programme (GTZ) joined together to evaluate the use of plant oil as a renewable fuel source for rural development in three of the countries -- Brazil, Nepal and Zimbabwe. Since species whose cultivation would not displace other agricultural crops nor compete for land with greater opportunity for other applications were being considered, *Jatropha curcas* emerged as a prime plant for investigation. This workshop builds on the earlier work of this initiative and examines rural development and generation of employment in southern Africa to determine the issues, need and prospects for further research and development. The workshop will therefore discuss various issues including:

- Status of ongoing and potential research focusing on the applicability of *Jatropha* oil to meet the cooking and lighting needs of rural households and its competitiveness in substituting diesel in various stationary and mobile applications
- Economic feasibility of *Jatropha* oil in meeting the energy services needs;

- Available technology and products to meet the above mentioned needs and status of technological research;
- Role of the private sector and government policies in commercialization of *Jatropha curcas* products.

3. Other products of *Jatropha curcas*

Although ability to control land degradation and oil production are most important environmental uses of *Jatropha*, its products provide numerous other benefits that would additionally improve the living conditions of the rural people and offer greater income opportunities through enhanced rural employment. For instance, the *Jatropha* oil can be used for soap production and cosmetics production in rural areas and all parts of the plant have traditional medicinal uses (both human and veterinary purposes) that are being scientifically investigated.

The oil is a strong purgative, widely used as an antiseptic for cough, skin diseases, and as a pain reliever from rheumatism. *Jatropha* latex can heal wounds and also has anti-microbial properties. *Jatropha* oil has been used commercially as a raw material for soap manufacture for decades, both by large and small industrial producers. Soap from *Jatropha* oil is being made by small informal industries in rural areas in both Zimbabwe and Mali. A large manufacturer is interested in using *Jatropha* oil to substitute tallow in commercial soap making. The monthly requirement of this industry alone is 2,000 liters of oil. To supply this demand would require between 18,000-22,000 ha of *Jatropha* plantation or 30,000-40,000 km. of *Jatropha* hedges or a combination of the two. Currently tallow fetches higher price than diesel in Zimbabwe. What are the possibilities of using commercial interest as above to create a capacity for *Jatropha* oil to address issues of rural energy equity and employment generation?

The oil cake cannot be directly used as animal feed because of its toxicity, but it is valuable as a fertilizer having nitrogen content comparable to chicken manure and castorbean seed cake. The toxicity of the seeds is because of curcin (a toxic protein) and diterpene esters. Apparently seeds of Mexican origin have less toxic content and with proper processing they can be eaten. Although there are laboratory studies indicating detoxification, its feasibility and profitability on a large scale is yet to be investigated (www.Reinhard.Henning.com).

The workshop will therefore:

- Examining the potential market for various *Jatropha* products;
- Assessing the value of these products to the rural population;
- Determining the optimum combination for their use; and
- Proposing a strategy to maximize rural development, energy equity and employment.

Plant oils extracted from a diversity of non-edible seeds and nuts are a valuable energy resource which could be utilized for energy supply requiring only modifications to existing technology. These oils are capable of fuelling Diesel engines, cooking and lighting appliances and may be processed into other products such as soap, molluscicides and bio-pesticides or used as feedstock for small-scale industrial processes. As well as providing a clean, renewable substitute for imported fossil fuels, conserving the dwindling forest resources and other biomass, the residue which remains after the seeds have been crushed is potentially a nutritious animal fodder and can replace chemical fertilizers and so help to preserve the role of organic fertilizers in traditional farming systems.

Sajiwan (*Jatropha curcas L.*) is one such oil-bearing perennial that can attain the dimensions of a small tree or large shrub and is distinguished by an ability to propagate vigorously from either seed or cutting, be resistant to drought and be tolerant of poor soil quality. Sajiwan (translated as 'long life') can live up to 50 years and has many names and traditional uses throughout the country. It may be most familiar as a living fence around agricultural land or as a natural toothbrush or as a popular entertainment for children who delight in blowing bubbles from the sap. Climatic conditions are favorable for the cultivation of Sajiwan in about 30% of the country so there is immense opportunity to encourage its cultivation.

Utilisation of these oil-bearing plants for energy supply has attracted considerable attention recently. Much of this interest, unsurprisingly in the wake of rising oil prices and choking urban air pollution, has focussed on the novelty of an operating Diesel engine that has been undergoing endurance testing to 1000 hours in the oil expeller and engine testing facility at The Research Centre for Applied Science and Technology (RECAST) under Tribhuvan University. Some 250 trouble-free hours have now been achieved with natural Sajiwan oil; a clean and renewable diesel substitute.

This is undoubtedly a first and a significant achievement but more than this it reinforces a vision in the management of oil-bearing resources in which complementary social, economic and environmental initiatives can be driven by the production of clean renewable fuel oil. Some years ago this vision inspired the modification of engine testing facilities at Oxford Brookes University and a programme to investigate the performance of a range of plant oils. These, the first tests ever conducted with indigenous oils revealed in particular the potential of natural Sajiwan oil as an engine fuel and formed the scientific basis for the current endurance testing programme at RECAST. The Green Energy Mission and Development and Consulting Services, Butwal (manufacturers of the Sundhara Oil Expeller) were instrumental in supplying oils for these early tests.

In this vision the promotion of end uses for the oil, such as fueling Diesel engines, is crucial because they will stimulate a demand for resources and so promote economic enterprise in rural areas in cultivation, seed collection and processing as well as those activities associated with end use and in the production of related technology. The use of Sajiwan oil in a 30% mixture with kerosene to fuel cooking stoves and as a pure, clean-burning, fuel in certain types of wick lighting as well as in the manufacture of soap has proved to be successful too. End uses, for example, associated with oil seed processing by-products are of equal importance in this vision. The use of oil cake as a fertilizer in rice cultivation has been very encouraging in this respect returning equal productivity to imported chemical alternatives.

Resource enhancement is central to the vision. Clearly resources will need to meet demand but equally we should look to the generations of farmers who have realized benefits to crop production by cultivating living fences around their lands to pre-empt browsing livestock. Resource enhancement has other important attributes too: root systems enhance soil stability during heavy rain or dry and windy conditions and since leaves are shed each year there will be improvements in local soil quality. This vision advocates cultivation alongside trails, roadsides and river margins as well as in National Park Buffer Zones and in marginal lands so food production is not compromised. In the first oil seed energy plantation in the country some 40, 000 Sajiwan plants have now been established on marginal lands at Khairenitar in Tanahun District in co-operation with the Women's Development Section of the Ministry of Local Development and the Institute of Forestry and a further 40,000 plants are to be introduced this year. In this initiative oriented specifically to the welfare of women it is expected that after 5 years the oil yield from these plants will rise to meet the annual diesel requirements of 15 agro-processing mills and may be several times higher (*Source: "Kathmandu Post" April 1st 2001 by Dr Mick Boswell in the heading, In a Nut Shell: Wealth, Health, Energy and Environment)*.

Improvements in air quality are crucial in this vision. Indoor air quality is a serious concern for much of a population engaged in subsistence agriculture, especially women, while local air quality has become a serious concern with industrial growth and global air quality is threatening the fabric of life itself. Plant oils are clean burning and have much to offer on all these scales. When used as a substitute for fuel wood, agricultural residues or kerosene in cooking and illumination there is potential to improve respiratory and eye health and reduce the drudgery of solid fuel collection and utensil cleaning in the rural household. As a diesel substitute, exhaust smoke levels are lower and because there is little, if any, sulphur in plant oils, emissions of sulphur oxides and hence acid deposition are markedly reduced.

Climate change is a most serious threat facing the global community and whilst this threat has arisen from industrial activities elsewhere, the effects will be experienced, and may already be manifest, here. All living plants sequester carbon dioxide from the atmosphere during photosynthesis and all hydrocarbon fuels, including plant oils, release carbon dioxide on combustion. The carbon dioxide released by plant oils during combustion, however, is a part of the carbon sequestered by the living plant from the atmosphere during growth, the remaining carbon being stored in the woody stems and root system, consequently, atmospheric carbon dioxide levels are actually reduced by storage in the plant for its lifetime (a 'carbon sink'). As a diesel substitute further reductions are realized by offsetting the carbon dioxide released from petroleum products.

There are concerns regarding the economic viability of plant oil as a fuel. Seed collection is a very significant cost in the production of plant oil but this has halved in a single year as cultivation is becoming more organised and for this reason will continue to fall. On the other hand the cost of petroleum products continues to rise in the international market with devastating effect on poor countries lacking their own resources. Prices will continue to rise, not only because resources are finite and consumption is increasing but also because of international concern as the evidence continues to suggest that recent catastrophic global weather patterns are attributable to climate change and that worse is to come.

Rather than focussing on the economic viability of plant oil as a fuel, however, this vision recognises that it is the overall system of fuel production on which economic viability is accurately evaluated. By-products such as oil cake have an additional commercial value as fertiliser as do increased crop yields arising from the cultivation of living fences to pre-empt browsing livestock. In the longer term it should be possible to market a nutritious animal fodder from oil cakes in which case fuel oil would be a lesser value by-product from oil cake production (*Source: "Kathmandu Post" April 1st 2001 by Dr Mick Boswell in the heading, In a Nut Shell: Wealth, Health, Energy and Environment).*

Energy analysts refer to 'social costs' when evaluating the real costs of energy production; these being real costs to a society that arise from energy supply over and above the market price for the energy. Social costs are not insignificant. Loss of economic activity from fuel shortages during the trade and transit impasse with India in 1988 is a social cost as is health care arising from illness due to the urban air quality in Kathmandu. The Intergovernmental Panel on Climate Change are warning that 'Many parts of the world have recently suffered major heat-waves, floods, droughts and extreme weather events leading to significant loss of life and economic costs. While individual extreme weather events cannot be directly linked to human-induced climate change, the frequency and magnitude of these types of events are expected to increase in a warmer world'.

This vision acknowledges, conversely, a 'social value' as being a real economic benefit to a society arising from the production of energy. Rural enterprise based on oil seed resources would promote social stability and cohesion in a nation ill at ease with the fruits of 'development' with opportunities for entrepreneurs, manufacturers and employment. At the same time this would relieve the pressure in the cities from urban drift and stimulate rural-to-urban linkages for wealth generation in both the rural and urban context. Indigenous fuel and fertilizers would help to reduce imports and so conserve foreign currency reserves as well as promoting a national self-reliance.

Environmental protection has a social value. Utilization of plant oils for rural energy would both conserve and enhance natural forest resources as well as reducing the consumption of agricultural residues for fuel. Agricultural residues and oil cake would then be available to boost crop yields and at the same time reduce the consumption of costly and imported chemical alternatives. Cultivation of plants around field boundaries boosts crop yields by pre-empting browsing livestock; root systems and leaf-shed improve soil stability and quality. Clean, available fuel impacts positively on health and on drudgery and ultimately economic productivity (*Source:*

"Kathmandu Post" April 1st 2001 by Dr Mick Boswell in the heading, In a Nut Shell: Wealth, Health, Energy and Environment).

Mitigation of carbon dioxide emissions has a social value on local, national and global scales. It is a tragedy that the impacts of climate change are an imposition from elsewhere on a country lacking resources and so least able to deal with its consequences. As well as taxation of the carbon produced from the combustion of petroleum products, the large-scale cultivation of forests dedicated solely to carbon storage is high on the international agenda. It is very likely that international support will be forthcoming for sustainable energy systems in 'developing countries' and many would argue that the industrialized countries have an obligation in the circumstances. Cultivation of a crop that not only stores atmospheric carbon but also yields a high-grade carbon dioxide neutral fuel may prove to be attractive to the international community and at the same time facilitate a sustainable national programme of expansion in the longer term perhaps initially by providing a subsidy on plant oil to reflect social value and to stimulate both end use and resource enhancement.

There are multi-disciplinary technical refinements that are yet required in cultivation, agriculture and in the technology of seed processing and end use etc. which require financial investment before wider dissemination can be contemplated. There is a strong commitment to continue fulfilling this vision, to continue working with the wider community with the multi-disciplinary expertise of the universities at hand and unique oil expelling and engine testing facilities in Nepal and Britain.

The oil plant *Jatropha curcas* (L) (*Jatropha*) or physic nut is a multipurpose and drought resistant large shrub or small tree. Although a native of tropical America, it now thrives throughout Africa and Asia. It grows in a number of climatic zones in tropical and sub-tropical regions of the world and can be grown in areas of low rainfall and problematical sites. *Jatropha* is easy to establish, grows relatively quickly and is hardy. Being drought tolerant, it can be used to reclaim eroded areas, be grown as a boundary fence or live hedge in the arid/semi-arid areas.

The wood and fruit of *Jatropha* can be used for numerous purposes including fuel. The seeds of *Jatropha* contains (. 50% by weight) viscous oil, which can be used for manufacture of candles and soap, in the cosmetics industry, for cooking and lighting by itself or as a diesel/paraffin substitute or extender. This latter use has important implications for meeting the demand for rural energy services and also exploring practical substitutes for fossil fuels to counter greenhouse gas accumulation in the atmosphere.

These characteristics along with its versatility make it of vital importance to developing countries subjected to decreasing tree cover and soil fertility because of increasing population and development pressures. Nearly half the world's poorest people live on marginal lands with the number expected to increase from 500 million to 800 million by 2020. These areas are by definition isolated and fragile, with soils susceptible to erosion and subjected to environmental stresses of deforestation, prolonged droughts, and decreasing soil and ground water. Although southern Africa is rich in biodiversity and production potential, large areas are under semiarid and arid conditions with a moderate-to-high risk of drought. Plants species like *Jatropha* that can grow on lands not usually attractive for agriculture and supply raw material for industry, fuels for basic energy services and improve environment are therefore an obvious choice that needs to be assessed carefully and comprehensively.

Jatropha is not browsed, for its leaves and stems are toxic to animals, but after treatment, the seeds or seed cake could be used as an animal feed. Being rich in nitrogen, the seed cake is an excellent source of plant nutrients. Various parts of the plant are of medicinal value, its bark contains tannin, the flowers attract bees and thus the plant has honey production potential. Like all trees, *Jatropha* removes carbon from the atmosphere, stores it in the woody tissues and assists in the build up of soil carbon.

Despite these characteristics, the full potential of *Jatropha* is far from being realized. There are several reasons – technical, economic, cultural and institutional -- that need further discussion and examination. The growing and management of *Jatropha*, either on private public or community lands is poorly documented and there is little field experience that is being shared, especially in southern Africa. Currently, growers are unable to achieve the optimum economic benefits from the plant, especially for all its various uses. The markets for the different products have not been properly explored or quantified, nor have the costs or returns (both tangible and intangible) to supply raw materials or products to these markets. Consequently, the actual or potential growers including those in the subsistence sector do not have an adequate information base about the potential and economics of this plant to make decisions relating to their livelihood, not to mention its commercial exploitation.

It is therefore timely to examine the potential role that *Jatropha* can play in meeting some of the needs for energy services for rural communities and also creating avenues for greater employment. It is important that the discussion on the exploration of potential of *Jatropha* should include the multiple stakeholders involved in research, utilization and exploration of this oil plant including government officials, NGOs, private sector, etc. Most importantly representatives of local communities must be included to examine any existing or latent demand for the plant to determine the framework for any future initiative based on the outcome of the discussions on the potential of *Jatropha curcas* hence this workshop (*Source: "Kathmandu Post" April 1st 2001 by Dr Mick Boswell in the heading, In a Nut Shell: Wealth, Health, Energy and Environment).*

2.5 Biofuel in Policy & Plan Documents

- Rural Energy Policy, 2006
- Three Years' Interim Plan, 2007/08-2009/10

Rural Energy Policy, 2006

Overall Goal and Objectives

- To contribute to rural poverty reduction and environmental conservation by ensuring access to clean, reliable and appropriate energy in the rural areas (Clause 2)

Objectives

- To reduce dependency on traditional energy and conserve environment by increasing access to clean and cost effective energy in the rural areas (Clause 2.1)
- To increase employment and productivity through the development of rural energy resources (Clause 2.1)
- To increase the living standards of the rural population by integrating rural energy with social and economic activities (Clause 2.1)

Rural Energy Policy, 2006

Major Policies… Emphasis on-

- Development of the environmental friendly, suitable and affordable RE technologies (Clause 3.1 & 3.5)
- Decentralization (institutional setup from central to local level) and Capacity development of local bodies (Clause 3.2 & 9);
- Rural Energy Fund at central & local level (Clause 3.3)
- Community management through social mobilisation (Clause 3.10)
- Private sector participation (Clause 3.11)
- Credit mobilization from financial institutions (Clause 3.12)

Source: Nawa raj Dhakal, Senior Training Officer (AEPC); Government Policy and Programme on Biofuel in Nepal, Report, 2008.

Rural Energy Policy, 2006

Working Strategies…

- Activities related to awareness creation for the use of bio-fuel, ... will be conducted by encouraging the use of local skill and resource (Clause 4.3.4)
- Technology for bio-fuel, ... will be developed and disseminated by identifying suitable location (Clause 4.3.2)
- Development and promotion of bio-fuel, ... will be encouraged (Clause 5.8)
- Research and development and dissemination will be emphasized on non-edible vegetable oils that can be used as energy (Clause 10.5)

Three Years' Interim Plan, 2007/08-2009/10

Policy & Working policies (Ch. 35; Environmental Management- Clause 7)

- Carbon trade will be promoted to achieve benefit from CDM under the Kyoto Protocol
- Necessary mechanism will be developed and implemented under the principles of "Polluters Pay" & "Pollution Prevention Pays"

Programmes

(Ch. 35; Science & Technology- Clause 8)

- Necessary study and research will be carried out to use bio-ethanol as fuel

Three Years' Interim Plan, 2007/08-2009/10

Long Term Vision (Ch. 35; Science & Technology- Clause 4)

- RE promotion contributing to rural development, enhancing rural economy and quality of life, increasing the employment opportunities and environmental sustainability
- Reducing the dependence on the external sources of energy
- Reducing the dependence on the conventional energy sources
- Generating financial resources through carbon trading
- Contributing to the broader national goal of achieving social inclusion and gender mainstreaming

Three Years' Interim Plan, 2007/08-2009/10

Quantitative Targets (Ch. 35; Science & Technology- Clause 6)

- Development of 300,000 units of improved cooking stove and installation of other bio-energy technologies

Source: Nawa raj Dhakal, Senior Training Officer (AEPC); Government Policy and Programme on Biofuel in Nepal, Report, 2008.

Strategies (Ch. 35; Science & Technology- Clause 7)

- Priority to development & promotion of bio-energy, … … considering the needs & resources available in rural areas
- RE promotion through decentralization (DDC: DEEU/S)

- R & D, technology transfer; programs on cost reduction and capacity enhancement

Three Years' Interim Plan, 2007/08-2009/10

Policy and Working Policies (Ch. 35; Science & Technology- Clause 8)

- Capacity development for utilization of available bio-energy resources in the rural areas
- Reduced dependence on imported energy sources with the development of alternative energy sources
- Promotion of bio-energy technologies and awareness building for the utilization of these technologies
- Public and private sector participation
- Financial supports: subsidy and credit

Three Years' Interim Plan, 2007/08-2009/10

Programs (Ch. 35; Science & Technology- Clause 9)

- **Bio-energy Program**
    - Total of 300,000 improved cooking stove and other bio-energy systems are proposed to be developed
    - Research and studies on bio-fuel
    - Feasibility study and promotional activities on such energy technologies as gasifier, briquettes and bio-fuel

Major Govt. Interventions so far

- RECAST has conducted test on diesel engine with unesterified plant oil
    - 800 hrs test completed with positive results
    - Proposed for field test
- Plantation of *Jatropha* in western Nepal
    - Land provided by Institute of Forestry, Pokhara
    - Cultivated by women groups
    - Equal sharing of profit between 2 parties
- Sundhara Oil Expeller designed by Development and Consultancy Services can by bought in market

Major Govt. Interventions so far

- AEPC organized was in Nov 2007 to bring forward different interventions and interest to a forum
    - As a result, various organizations started intervention
    - Non-edible plant oil for running electric generator in Okhaldhunga and irrigation pump in Siraha
    - SNV and WWF organized a study on assessing the potential of biofuel in Nepal
- AE Task Force of GoN recommended utilization of biofuel in Nepal
- AEPC study in 2007 on the economic, technical and environmental aspects of using E10 and E20
- Positive findings and recommendations
- GoN in November 2008 has again decided to blend 10% ethanol in petrol
    - MoCS floated a tender to purchase anhydrous ethanol to blend in petrol to produce E10

GON's Biofuel Programme

- One of the special programmes for building New Nepal in the current FY 2008/2009
- Major activities:
    - Awareness raising, production and dissemination of information materials on biofuel
    - Formulation of biofuel promotion strategy
    - Establishment of *Jatropha* Nurseries in different regions
    - Capacity building for *Jatropha* plantation
    - Installation of biodiesel processing centers and biodiesel filling stations in five regions of Nepal
    - Conduction of pilot projects on biofuel

Source: Nawa raj Dhakal, Senior Training Officer (AEPC); Government Policy and Programme on Biofuel in Nepal, Report, 2008.

Services from *Jatropha* curcas

Nitrogen fixing: Soil improver: Press cake cannot be used in animal feed because of its toxic properties, but it is valuable as organic manure due to nitrogen content similar to that of seed cake from castor bean and chicken manure. The nitrogen content ranges from 3.2 to 3.8%, depending on the source. Tender branches and leaves are used as a green manure for coconut trees. All plant parts can be used as a green manure. Boundary or barrier or support: Widely cultivated in the tropics as a living fence in fields and settlements. J. curcas is not browsed by cattle; it can grow without protection and can be used as a hedge to protect fields. Intercropping: In Madagascar, the plant is used as a support for vanilla.

Erosion control: *Jatropha* curcas has been used for soil conversation. In Cape

Verde, *Jatropha* curcas was recently planted in arid areas for soil-erosion control. *(Source:* Bhattarai, K. R. (Jan, 2008); *Sajiwan bata biodiesel-Jatropha Biodiesel)*

Biodiesel Processing

Biodiesel is produced from straight vegetable oil of *Jatropha* by converting the triglycerides into methyl esters with a process known as transesterification. The *Jatropha* oil is blended with alcohol and catalyst mixture, which is kept at reaction temperature for specific duration under agitation and sent to the settling tank. The ester is collected and washed to get pure biodiesel.

The bio-diesel plant consists of reaction vessel with heating and agitating device, catalyst mixing vessel, settling tanks and washing tank. The Capacity of pilot biodiesel plant is 250-300 liters/day.

Steps involved during process of biodiesel production

a. Mixing of alcohol and catalyst
b. Transesterification and separation
c. Biodiesel washing

d. Alcohol removal
e. Glycerin neutralization
f. Product quality standardization

The benefits from Biodiesel are:

1. Biodiesel is produced from renewable sources
2. Biodiesel is similar in properties to diesel fuel
3. Biodiesel is Eco-friendly oxygenated fuel
4. Biodiesel contains less sulphur
5. Biodiesel can be used in diesel engine without major engine modifications
6. Biodiesel prolongs the life of engines
7. Biodiesel reduces exhaust gas emissions as compared to diesel fuel.

Source: Bhattarai, K. R. (Jan, 2008); *Sajiwan bata biodiesel- Jatropha Biodiesel*

Storage of Biodiesel and its effect

The biodiesel industry is still young and relatively small, so as it grows to a larger scale and when an infrastructure is developed, the cost of producing and marketing biodiesel may decline. New cost-saving technologies will likely be developed to help producers use energy more efficiently, increase conversion yields and convert cheaper feedstock into high-quality biodiesel. However, in the longer term, the biggest challenge may be the ability of the feedstock supply to keep up with growing demand. The supply of soybeans, rapeseeds and other feedstock available for biodiesel production will be limited by competition from other uses and land constraints.

As such the key to the future of Biodiesel is finding inexpensive feedstock that can be grown by farmers on marginal agricultural land, and *Jatropha* is one of many plants that hold a great deal of promise. *Jatropha* proves to be a promising biodiesel plantation and could emerge as a major alternative to Diesel thus reducing our dependence on Oil imports and saving the precious Foreign Exchange besides providing the much needed Energy Security. *Jatropha* oil displacing conventional fossil fuel makes the project fully eligible as a CDM project, i.e. recipient of Co2 credits.

Some Institutions, Forum, Company, Nurseries working for Biodiesel in Nepal

1. National Agricultural and Environmental Forum (Narayan path 7, siddharthanagar Bhairahawa)
2. Center for Integrated Research and community Development, CIRCOD (Lahan-Siraha)
3. Bhairab Darshan Sajiwan Urja Prawardan,(Palpa-Nepal)
4. Manigram Jadibuti Tatha Phalphul Nursery (Butwal-Nepal)
5. EMI Urja Bikas Company
6. Green Energy Mission Nepal (Chabel-Kathmandu)

EUROPEAN POLICY ON BIOFUELS:

During the 1990's the European Union tried to stimulate biofuels by a proposals for tax exemptions for biofuels, but failed to get these approved by the Member States. Later, in 2003, the Biofuels Directive was introduced. It sets a target of 2% of biofuels in 2005 and 5.75% in 2010, as percentage of total petrol and diesel use. The Member States may deviate from these targets, but their reasons to do so should be motivated. The Directive was evaluated in 2006 and mandatory targets were considered. There is no general support scheme for biofuels on the EU level; the Member States had to introduce their own policy instruments. Only at the agricultural level, there is EU support for farmers producing energy crops. Since1992 there is a set-aside policy, which requires a part of the land not to be used for food production, but it can be used for energy crops (*Source: Bhattarai, K. R. (Jan, 2008*); *Sajiwan bata biodiesel- Jatropha Biodiesel).*

Air NZ Conducts Test Flight with *Jatropha* Biodiesel

The world's first commercial aviation test flight powered by the sustainable second-generation biofuel *Jatropha* has been successfully completed in Auckland. More than a dozen key performance tests were undertaken in the two hour test flight which took-off from Auckland International Airport. A biofuel blend of 50:50 *Jatropha* Biodiesel and Jet A1 fuel was used to power one of the Air New Zealand Boeing 747-400's Rolls-Royce RB211 engines. The test flight was a joint initiative between Air New Zealand, Boeing, Rolls-Royce and Honeywell's UOP, with support from Terasol Energy.

Air New Zealand Chief Executive Officer Rob Fyfe says the completion of the flight is a significant milestone and something every New Zealander should be proud of *(Source: Bhattarai, K. R. (Jan, 2008); Sajiwan bata biodiesel-Jatropha Biodiesel)*.

Works done in INDIA for the production of *Jatropha*

The former President of India, Dr. Abdul Kalam, is a strong advocate of *Jatropha* biodiesel. He recognized plant *Jatropha* as one of the most potential oil crop for the tropical and sub=tropical regions. In his speech in 2006, he said that out of the 60 million hector of wasteland available in India, over 30 million hector are suitable for *Jatropha* cultivation. Recently, the State Bank of India provided a further boost to the cultivation of *Jatropha* by signing a Memorandum of Understanding with D1 Mohan to give loans totaling 1.3 billion rupees to local farmers in India, to be paid back with the money that D1 Mohan pays for the harvested *Jatropha* oil blended with diesel to power its diesel engines with great success. Many Indian states have already jumped onto the *Jatropha* train, including Andhra Pradesh, Chhattishgarh, Karnataka, Tamil Nadu, Rajasthan, Maharasthra, and Ahemdnagar. *Jatropha* has been held up as a reliable source of income for India's poor rural farmers, providing energy self-sufficiency, while reducing fossil fuel consumption and greenhouse gas emissions. Several states have distributed plants free of charge to small farmers, encouraging private investment in *Jatropha* plantations and setting up biodiesel processing plants. The ministry of Rural Development, which is to coordinate the national mission on biofuels.

The state of Chhattishgarh has the most well-developed *Jatropha* biodiesel programme in the country. It has given away 380 million *Jatropha* seedlings to farmers, enough to cover 150000 hector, and also provided 80oil presses to various village governing bodies with guarantees to buy back *Jatropha* seeds at 6.5 rupees a kilogram.

Pushpito Ghosh has been working on the plant for a decade and now directs the Central Salt and Marine Chemicals Research Institute (CSMCRI) in Bhavnagar. CSMCRI's mandate was to make the transesterification process affordable for use in village; it estimated that nearly 80000 villages are currently without access to fuel or electricity. Daimler Chrysler, on the other hand, announced it was to take two of its Mercedes C-Class cars on a 6000 kilometer road-test across India using Ghosh's biodiesel *(Source: Bhattarai, K. R. (Jan, 2008); Sajiwan bata biodiesel- Jatropha Biodiesel).*

Key Factors which influence the yield and oil percentage of *Jatropha* Curcas L.

1. Bioclimatic
2. Quality of Soil
3. Irrigation
4. Weeding
5. Fertilizer
6. Spacing
7. Genotype
8. Disease and Pest Control
9. Pruning
10. Harvesting Method
11. Storage

Advantage of Jatropha Curcas

- Can be grown in areas of low rainfall (200mm/year)
- *Jatropha* is easy to establish, grows relatively quickly and is hardy
- Can be cultivated on west land, low fertility marginal and others lands such as along the canals, roads and on borders of farmers' fields as a boundary fence or live hedge in the arid/semi-arid areas and even on alkaline soils.
- *Jatropha* seeds are easy to collect as the plants are not very tall
- *Jatropha* is not browsed by animal

- Various parts of the plants are of medicinal value, the bark contains tannin, the flowers attract bees and thus the plant has honey production potential
- Seed production ranges from about 0.4 tons per ha per year to over 12t/ha
- *Jatropha* products from the fruits seed coat and seed cake are rich in N, P, and K and improve soil
- The plant start giving seed in a maximum of two years after planting
- Raising plants in nurseries, planting and maintaining them and collection of seed provide rural employment.
- *Jatropha* remove carbon from the atmosphere stores it in the woody tissues and assists in the builds up of soil carbon. It is thus environment friendly.
- *Jatropha* can enhance the productivity or other agricultural crops by improving the microclimate and providing humus and fertilizers to the soil.

(Source: Bhattarai, K. R. (Jan, 2008); *Sajiwan bata biodiesel- Jatropha Biodiesel).*

Steps Ahead

- Liquid biofuels, natural alternate fuel for agriculture subsistent Nepal
- Better management and efficient use of agro based (*Jatropha* oil) fuels is necessary
- High local value addition, easily adaptable technology; stimulate local economy
- Strong government commitment required
- Mass sensitization on production and applications
- Highlight role of liquid biofuels in lessening economic and environment losses to the country
- Address energy security problems

Source: Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

Fossil Fuels: Unsustainable Option

- Annually, about 40% of Nepal's export earning is spent on importing fossil fuels (MoF, 2007)
- Has huge effect on Nepalese economy
- Used in productive sectors
- None of it is produced in Nepal
- Supply is irregular
- Price is fluctuating and basically high

Sustainable Solutions

- Hydropower: longer gestation and huge investment
- Wind: Insufficient data, not very potent
- Solar: Very expensive, mostly imported equipments
- Biogas: Successful at small scale/ household level
- Biofuel: Very promising and the BEST solution

Why Biofuel?

- Biofuel is long term sustainable solution for this world
- Locally produced and decentralized
- Immediate partial replacement of fossil fuels possible
- Biodiesel –diesel and Bioethanol-petrol blending
- Small scale to large scale
- Rural Areas – Cooking, Lighting, Agro processing, Electricity generation
- Urban Areas – Transportation +
- Employment generation- New income source to the farmers, employment opportunities along the value chain

Appropriate biofuel resources

- Good prospect for producing **ethanol from molasses** that is abundantly available as a byproduct of sugar mills
- **Biodiesel from *Jatropha*** and other inedible plant seeds that are available and can be cultivated in Nepal

Source: Report by Nawa Raj Dhakal, Senior Trainer (AEPC), 2008

Availability

- 1 MT sugarcane produces 220 liter rectified spirit
- The sugar mills can produce 7,624 Klt. rectified spirit (95% purity)
- This would be enough for Kathmandu Valley which requires 9125 Klt. ethanol annually if E10 is used
- GoN announcement: E10 Blending in 2002
- Still 1 mill has 30 Klt./ day capacity (10950 Klt./ year) while other 3 are ready for investing
- Hence if govt. implements ethanol use, sugar industries can grow their capacities

Appropriate source of Biodiesel

- *Jatropha* Curcas L
- Can be grown even in low yielding areas
- Needs least effort and care
- It is common for fencing purpose in various regions of Nepal starting from the southern plains to lower parts of Mahabharata hill range.

Potential projection- Biodiesel from Jatropha

- Nepal has 12% (1,764,285 ha) estimated wastelands suitable for *Jatropha* plantation
- 1,000 liter/ha/year avg yield = ca 1,764 million liters
- Present annual requirement is 438 million liters even if for 100% diesel substitution
- Could start with 2% blend or B2 or also with filtered plant oil
- Many unrecorded *Jatropha* plantations
- Private sector have also shown interest in biofuel and feedstock plantation

Way Ahead

- Fixation of price and mechanism for ethanol
- Utilization of available resource
- Action research on biodiesel (pilot projects)
- Encourage plantation of biofuel feedstock

- Capacity building of stakeholders
- Establish biofuel processing industries
- Provide market to product
- PPP approach
- GoN yet needs to create mechanisms that can allow the production and use of biofuel in Nepal
- Regulatory mechanism should be formed for
    - Quality control (seeds, technology, processing procedures, product, blending)
    - Scale of production
    - Allocation of areas for production
    - Standard farming practices/procedures

Source: Nawa raj Dhakal, Senior Training Officer (AEPC); Government Policy and Programme on Biofuel in Nepal, Report, 2008.

CHAPTER-III

Methodology

This section of the thesis reveals the study area, modes of research, tools and techniques of the data collection, its processing modalities and analyzing techniques.

3.1 Rational for the selection of the study site:

The rationale of this study area apparently lies in exploring the investment worthiness of the oilseed plant called *jatropha curcas* for commercial farming. The study is expected to contribute in understanding investment requirement for a minimum feasible commercial farming and the benefits of *jatropha* cultivation. The study is further expected to underscore the need to bring into use waste and degraded land through legislative and policy incentives for promoting biodiesel projects and to uplift the living condition of marginalized people.

3.1.1 General Introduction of "Siyaram Nursery":

Siyaram Nursery lies in Dumraha VDC of Sunsari district, the eastern part of Nepal. The Nursery occurs in 1hacter land where 2500 seeds of Jatropha are cultivated for commercial purpose. It was started in 2062. Siyaram Nursery is playing vital role as seedling suppliers. Siyaram Nursery has also provided employment for many needy people and helped for income generation. Siyaram Nursery is successfully running and had elaborated two more branches in Siraha and Saptari.

3.2 Nature and Sources of data

The study is based largely on both secondary as well as primary data. Primary information was obtained to assess the farming status from the project site at Dumraha VDC in Sunsari District and from the one day seminar in Butwal and three days training in Khumaltar, Lalitpur conducted by AEPC (Alternative Energy Promotion Center). Whereas, secondary source materials were drawn from printed literatures, websites, journals, proceedings, books and reports prepared by the concerned authorities.

1. Primary Data: The primary data needed for the study will be collected by using interviews, attending seminars and field observation.

***2. Secondary Data*:** The secondary data needed for the study will be collected from books, internet, journals, newspaper article, dissertations and reports.

3.3 Sampling Procedure

The respondents for the study have been selected by convenience sampling. The people engaged in the *Jatropha* farming are limited and the way they are farming is also very few in the study areas. Since the study population is limited and very few, convenience sampling has been performed to select the sample respondents.

3.4 Research Design

The research is explorative in nature as it intends to investigate the parameter and factor variables used in cultivation and assess their cost and returns. The research has been conducted by using case study research design. The research assesses the previous status of *Jatropha* use in the study areas and the way it is being used at present. It also assesses the *Jatropha* use for different aspect of peoples' life as energy, income and for clean environment.

3.5 Data collection, Techniques and Tools

The tools used to obtain information for this study were formal and informal interview with key informants and literature survey. A checklist and field observation was operationalized for collecting primary information.

The primary data have been collected by using the following techniques and tools.

Table: 3.1 Tools and Techniques

S.N.	Techniques	Tools
1.	Interview	Checklist/interview guide
2.	Observation	Checklist
3.	Seminar	Checklist

a. **Interview:** The people in the study areas were interviewed by using interview guide containing questions including past farming of Jatropha, farming culture, cost benefit, land preparation, selection of seed, economic benefit of Jatropha over other crop plants, potential for bio diesel and other usefulness.

b. **Observation:** the study areas and farming sites, farming pattern, involvement of family members were observed using checklist.

c. **Seminar:** all the jatropha experts were invited for the first national seminar in Jatropha held in Butwal by AEPC, where each and everyone shared their experience about Jatropha cultivation.

3.6 Reliability

The reliability of the study has been measured by using alternative form method. The same question had been in two different forms to acquire the same data.

3.7 Data analysis

After finishing interview schedule from field observation collection of data had been preceded. Various computer programmes had been taken and simple statistical tools like; table, graphs has been used for data analysis. In this stage, descriptive methods were used for qualitative data. The data has been presented on the tables and graphs/figures according to the study. And also photographs have been presented wherever they are useful.

CHAPTER-IV

Introduction of Study Area

This chapter deals with general information of the study area, location, climate, demographic characteristics of the study area and socio-economic characteristics of the population composition, age, sex, educational status, marital status, economy and general status of the user group in the study area.

4.1 Physical Setting

The present study site "Siyaram Nursery" is situated in Dumraha VDC, one out of the Forty nine of the Sunsari District of Koshi Zone in terai of Eastern Development region. The district is situated between $26^0$23' North to $26^0$55' North Latitude and $87^0$5' east to $87^0$16' east Longitude. The altitude of the district ranges from 152meters to 914meters above the sea level. *Sunsari* district is bordered by *Morang* district in the east, *Saptari* and *Udayapur* in the west, *Dhankutta* in the North and *Bihar (India)* in the south. The district covers total area of 1257sq.km. The total household number is 2909 where lies the population of 15662, out of which 7802 is male and 7860 are female.

4.2 Demography

Dumraha VDC is characterized by plural caste/ethnic groups. There are forty one ethnic and caste groups inhabiting in the VDC. Tharu is the dominant population group in the VDC whereas; Halidhor is the least dominant one.

Table: 4.1 Distribution of Population in Dumraha VDC on the basis of Caste and Ethnic groups

Tharu -5102	Musahar-1321	Dhanuk-1289	Jhagar-1147	Chettri-1000
Brahmin(Hill)-774	Koiri-769	Muslim-591	Teli-414	Bhujel-314
Sarki-296	Yadav-281	Baniya-234	Sunuwar-190	Mallah-177
Chamar/Harijan-153	Kalwar-153	Newar-138	Unidentified Caste-136	Haluwai-128
Brahman (Terai)-120	Hajam/Thakur -115	Rai-113	Kami-83	Damai-79
Badi-68	Magar-67	Sanyasi-67	Kahtwe-65	Kayasta-50
Badhea-47	Barae-39	Kumal-27	Unidentified dalit-19	Tamang-18
Limbu-18	Chepang (Praja)-17	Danuwar-14	Nuniya-12	Halidhor-5
Others-12	Total-15662			

(*Source: Village Profile, 2001.)*

CHAPTER-V

Data Analysis and Presentation

This chapter presents summary of the analysis.

5.1 Potential of Jatropha

- Jatropha also known as *Kadamb* in the East and *Sajiwan* in the West in local languages is widely accepted as a highly potential oilseed plant. Its advantages consist of manifold attributes. It holds potential for addressing energy, environment and unemployment problems.
- Jatropha seeds provide feedstock for biodiesel production for use in transportation. Its oil can replace diesel used in generator, agro-processing, irrigation pump, etc. The oil can also be used as raw material in soap, paint and varnish industries. The by-products like oil-cake can be used as biofertilizer, as livestock feeds, feedstock for biogas production; its bark can provide raw materials for dying, shed leaves promotes soil fertility by using them as decomposed manure, *jatropha* plantation helps in carbon sequestration, restore water table etc.
- As a localized and decentralized system of feedstock production, Jatropha farming holds great potential for generating income and employment at the local level thereby contribute to poverty reduction.
- A proven mix of 20% of biodiesel with petro-diesel as additive fuel can be used without requiring modification of the conventional engine.
- It is less demanding in terms of soil. The plant can grow in marginal and poor soil.
- The ideal condition to secure economic yield is reported in well-drained soil within the range of 1200m above sea level with the annual mean rainfall between 800-1200mm and mean annual temperature above 20^{o}c.
- It has a short gestation period ranging from 1-3 years when plants start bearing fruit seeds.
- Oil content in the plant has been found in the range between 25-35 percent of the weight of the seed.

5.2 Status of *jatropha* in Nepal

- Jatropha species indigenous to Nepal are recorded within the altitude of 1400m above sea level. Their distribution is found in all districts of the terai and hills and in low-lying areas of the mountains.
- The practice of planting *jatropha* for fencing or as hedgerows to protect crops from cattle browsing is disappearing as it is being replaced by other plants.
- The economic and environmental potential of jatropha is yet to be recognized by the locals and by the state.
- In some villages, jatropha seeds are crushed to extract oil using traditional method. The oil is used for illumination.
- Over 30% of oil content has been found in the seeds collected from the districts of Dang, Kavre and Morang locating in different altitude.
- The experimental project of *jatropha* initiated by RECAST in collaboration with the Nepal/UK Oilseed Project in Khairenitar of Duleigauda VDC of Tanahun district demonstrated extremely low survival rate and very negligible seed yield was recorded after sixth year of plantation.

5.3 Outcome of economic assessment

- The initial investment for feedstock production from jatropha farming at an inflated cost of inputs is approximately Rs. 74,000 per hectare with 50% replantation in the second year, though it is likely to vary depending on the socio-economic and ecological condition of the area where plantation is undertaken.
- At the given investment cost, returns are positive with the benefit cost rate of 1.25 higher than unity, internal rate of return of 20% greater than the cut off rate or the discount rate assumed at 15% and the pay back years within reasonable period of 10.8 years.
- Optimum returns can be expected if labour is available for Rs. 100 per day, seed yield is 2kg or more plant and the selling price of seed is Rs. 15 per kg. At this rate BCR is 4.1, IRR is 64% and the pay back year is less than 4 years. This suggests that huge net profit can be expected from the fourth year on.

- Optimum returns from feedstock production can provide good opportunity for investment in biodiesel generation as well and bring down its cost.
- More than 70% of cost consists of components that go to the farmers as income in the form of wages and supply price of inputs.
- Additional financial benefit can be had from carbon trade if *jatropha* seed is used for biodiesel production.

Potential projection- Biodiesel from Jatropha

- Nepal has 12% (1,764,285 ha) estimated wastelands suitable for Jatropha plantation
- 1,000 liter/ha/year avg yield = ca 1,764 million liters
- Present annual requirement is 438 million liters even if for 100% diesel substitution
- Could start with 2% blend or B2 or also with filtered plant oil
- Many unrecorded Jatropha plantations
- Private sector have also shown interest in biofuel and feedstock plantation

Table: 5.1 Economics of Biodiesel made from Jatropha Curcas

SN	Items	Amount (Rs)
1.	100 kg seed @ Rs 10/kg	1000.00
2.	Oil extraction/others charge @ Rs 2/kg	200.00
3.	Transesterification cost @ 10/kg oil	300.00
	Total	1500.00
	Sale	
1.	70 kg of oil cake @ 5	350.00
2.	Glycerol 3 kg @ 35	105.00
	Total	455.00
	Net expenditure (27 Lit. oil)	1045.00
	Cost of Biodiesel / Lit.	38.70

Source: Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

5.4 Biodiesel and Jatropha

In the wake of growing energy crisis, bioenergy is gaining acceptance as a reliable energy option in the world over. In fact, Rudolph Diesel had envisioned the use of biofuels when he invented the diesel, engine. He had himself used peanut oil to run the engine. In 1912 he stated, "….. the use of vegetable oils for engine fuels may seem insignificant today. But such oils may in the course of time become as important as petroleum and the coal tar products of present time" (www.Jatrophaworld.org). This is what the global energy trend is revealing today. Chief factors motivating promotion of bioenergy are ensuring security, tackling green house gas emission and creating rural economic opportunities.

Today, 21 countries are producing biodiesel. Brazil, USA and Europe are leading producers and consumers of biofuels. Brazil may be recognized as the world leader in promoting liquid biofuel since the last 25 years. She alone produces 50% of world's liquid biofuel (Shrestha et. El 2006) used largely in the transport sector.

Liquid biofuel such as biodiesel can be produced from a number of edible and non-edible oilseed plants. Soyabean, nuts, palm, linseed, rapeseeds, etc. are some of the edible oilseed plants that may be used for producing biodiesel. Similarly, non-edible plants like neem, *Jatropha* curcas, karanji, pongamia, wild apricot etc. are identified as oil-bearing trees; most promising of these is *Jatropha* curcas that could be preferred over edible plants.

The biofuel yield of various crops has been measured, and is usually given in barrels of oil per square mile per year. Corn is a common biofuel crop in the USA, but it yields less than 200 barrels (per square mile per year). Rice for example yields almost 1000 barrels, however it is an essential worldwide food crop as are most of the other potential biofuel crops. It is simply not viable to use good quality arable farmland for growing biofuels, biofuel crops need to be grown on marginal land if we are to benefit from them. This is where *Jatropha* scores highly. Not only does it have a great yield of well over 2,000 barrels of oil per square mile per year, it also increases the fertility of the land on which it is grown so that it can potentially be used for food crops in subsequent years.

Its widespread use in India is gaining popularity as a quick growing source of oil-bearing nuts that can be pressed to produce Biodiesel products. *Jatropha* has also been a crop of choice in development programs in almost every country where local villages have grown *Jatropha* on small plots of land and have hand-pressed the oil for use in generators, sewing machines and small motors. Glycerin, a by product of *Jatropha* oil, can also be used to produce soap. As the *Jatropha*, through which bio diesel will be produced and can bring a new revolution in oil and petroleum refineries. In India, petroleum sectors like BPCL, IOCL, and HPCL joined their hands so as to bring *Jatropha* cultivation Biodiesel in markets which tend to reduce the future shortage of oil consumption.

In India, there is growing pressure from corporations and pro—agro fuel groups for the government to adopt a policy on developing *Jatropha*, one which would include direct subsidies for the industry. Those pushing for large-scale *Jatropha* cultivation concede that *Jatropha* alone cannot meet all of India's energy requirements, but state that it is part of the solution in meeting growing energy demand and curbing climate change. *Jatropha* advocates in India claim that the country has between 50-130 million hectares of 'wastelands' that can be used to grow the plant. They argue that India is in a good position to develop a *Jatropha* based agro fuel industry because of its ability to use wasteland instead of using arable land. They claim that one of the main arguments critics of biofuels often make, the food vs. fuel argument, does not apply to *Jatropha*, because it does not compete with food crops for arable land. Proponents of the *Jatropha* plant as an agro fuels source argue that it allows farmers to grow their own diesel and decentralize the energy economy, to the economic benefit of farmers. One *Jatropha* plant will give an average of one liter of Biodiesel per year for 40 years.

5.5 Income from Jatropha

Plantation of *Jatropha* can be an integrated approach to create income and supply energy for rural development. It can be used for manufacture of candles and soap, in the cosmetic industries, for cooking and lighting. It can help to reduce the poverty and generate opportunity for the rural people and utilization of unproductive land. Bio-diesel is produced from the seed of *Jatropha* and can be mixed with kerosene and diesel to produce bio-fuels. It also will save Nepal's billions rupees annually in the fuel import bill.

a. Cost and benefit

Table: 5.2 Estimated Cost and Income Details for 1hactor

Year	Production/plant(kg)		Production/hector (Kg)	Production cost (Rs.12/Kg)	Cost	Income
	Unirrigated land	Irrigated Land				
1st						-31,500
2nd					3,000	-3000
3rd	2	3	5,000-7,500	60,000-90,000	12,000	48,000-78,000
4th	2.5	3.5	6,250-8,750	75,000-1,05,000	12,000	63,000-93,000
5th	3	3.5	7,500-8,750	90,000-1,05,000	15,000	75,000-90,000
6th	3.5	4	8,750-10,000	1,05,000-1,20,000	15,000	90,000-1,05,000
7th	3.5	4	8,750-10,000	1,05,000-1,20,000	15,000	90,000-1,05,000

Source: Poudel, P (2008). *Nepal ma biodiesel Ko Kheti,* Sha, T.N. Poudel K.P. Publication, Kathmandu,

<u>Costs and Returns</u>

<u>Costs</u>

An estimate of costs and returns from cultivation of *Jatropha* plantations/hedgerows' scenarios is crucial to analyzing its role in rural development. Costs, as well as returns are involved at different stages of the growing and harvesting of *Jatropha curcas* and the manufacture/use of different plant products and include both tangible and intangible components of each. For instance an estimate of the following cost heads would be required for any economic analysis:

1. Cultivation of *Jatropha*

a. Planting costs; c. Tending costs,

b. Establishment costs; d. Other costs (specify).

2. Wood

a. Pruning; f. Pole production;

b. Thinning; g. Other products specify;

c. Felling; h. Storage costs of products;

d. Firewood production; i. Transport costs;

e. Charcoal production; j. Other costs specify.

3. Fruit

a. Collection; e. Charcoal production from shells;

b. Removal of flesh; f. Storage of products, (oil, cake, shells, flesh, etc.);

c. Removal of shell; g. Transport costs;

d. Extraction of oil, (state method); h. Other costs (specify).

4. Capital & Labor costs

a. Buildings

b. Machinery and equipment

c. Labor as per respective activity

Returns

Similarly several types of returns from the growing and use of the products from *Jatropha curcas* need to be carefully estimated. The obvious returns pertain to sale or market prices of the different products. These returns should be recorded and then compared to the cost of the growing plus management of the plants and the manufacture of the products to arrive at profitability of various products.

Some of the costs and returns have been indicated in the literature while others may have to be extrapolated from estimates for similar crops. A discussion document that provides a perspective on various economic costs and benefits is being prepared and will be ready prior to the meeting. The discussion in the afternoon of the last day will focus mainly on the socio-economic analysis gleaned from the workshop and the paper to generate insights for future investigation and research and development.

EXPECTED OUTPUT

The expected output will be

- A good understanding of the role of *Jatropha curcas* in rural development;
- Based on that understanding a broad commitment from the national participants to pursue *Jatropha* curcas for rural development; and
- A strategy for field implementation.

It is hoped that the deliberations will pave the way for a Plan of Action to galvanize the planting and use of *Jatropha curcas* by rural communities to improve their well being and livelihood in association with the private sector and assisted by appropriate government policies.

b. Seed selling

Table: 5.3 In case of cultivation in land we can get following pattern of production:

Year	Kg per tree
1st year	3 kg/tree
2nd year	6kg/tree
3rd year	9kg/tree
4th year	10-12kg/tree
5th year	10-15kg/tree

Source: Bhattarai, K. R. (Jan, 2008); *Sajiwan bata biodiesel- Jatropha Biodiesel*

c. **Nursery**

Table: 5.4 Financial Investment for *Jatropha*'s farming in Rs.

Topics	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
Land preparation	5000	-	-	-	-
Cost of plant	12,500	-	-	-	-
Fertilizer	4,000	2,000	2,000	2,000	-
Labour Charge (planting)	3,000	-	-	-	-
Cutting, Pruning	3,000	1,000	-	-	-
Other Expenses	4,000	-	-	-	-
Collection, Drying	-	-	10,000	10,000	15,000
Total	31,500	3,000	12,000	12,000	15,000

Source: Bhattarai, K. R. (Jan, 2008); *Sajiwan bata biodiesel- Jatropha Biodiesel*

5.6 Environmental Benefits

The most important part of biofuels is that they do not produce greenhouse gases to contribute global warming. If the biofuels conversion process does not involve contamination of synthetic chemicals, the CO2 and other gases produced from biofuels are acceptable to plants. Emission of greenhouse gas particularly CO2 is of great concern today. Even though CO2 is considered as one of the major greenhouse gases, production of natural CO2 is essential for maintaining life on earth. Note that all, CO2 are not same and plants apparently do not accept all types of CO2 for photosynthesis. There is a clear difference between the contaminated CO2 from industrial process and clean CO2 produced from renewable biofuels such as from wood burning and human respiration. As various toxic chemicals and catalysts are used during fossil fuel refining, the danger of generating CO2 with higher isotopes cannot be ignored. Hence, it is clear that CO2 itself is not a culprit for global warming but the industrial CO2 which is contaminated with catalysts and chemicals, likely becomes heavier with higher isotopes and as a consequence plants cannot accept this CO2. As the plants have lives as humans have, they always discriminate lighter CO2 against heavier portion of CO2 from the atmosphere. While taking into account the impact of CO2 for global warming, we must distinguish between natural and industrial CO2 based on the source from which it is emitted and a pathway of the fuel that emits CO2 following from source to the combustion. Thus, development of biofuels in Nepal not only helps achieve sustainable economic growth but also helps save the environment. There should be policy shift to consider biofuels as mainstream energy sources and petroleum fuels as alternatives.

"*Jatropha* has also been proven to have strong anti-erosion qualities which make it ideally suited for use in Haiti. A recent study on watershed preservation commissioned by USAID this year reinforced this fact, adding that it was more effective than the tree-planning efforts that have been used to help reforest Haiti. It grows 5 to 10 feet high, and is capable of stabilizing sand dunes, acting as a windbreak and combating desertification." [3]

In *Hope in Jatropha* , the authors claim that "what makes *Jatropha* especially attractive to India is that it is drought-resistant and can grow in saline, marginal and even otherwise infertile soil, requiring little water and maintenance. It is hearty and easy to propagate — a cutting taken from a plant and simply pushed into the ground will take root. The plant lives, producing seeds, for over 50 years." [4]

a. Fencing (protection from cattle, reduced landslide, control grazing): In addition, the authors of *Hope in Jatropha* further claim that "*Jatropha* naturally repels both animals and insects —it can be planted along the circumference of farms to protect other crops.

b.Fertilizer (by product oilcake being used as compost fertilizer): *Jatropha* seedcakes, produced as a by-product of pressing the oil, make an excellent organic fertilizer or protein-rich livestock feed, and another by-product is glycerin.

c. Carbon dioxide emission: *Jatropha* absorbs large amounts of carbon dioxide from the atmosphere and therefore earns carbon credits.

CHAPTER-VI

Conclusion and Recommendation

6.1 Conclusion

Based on the findings of the study it may be concluded that the manifold advantages of jatropha plantation is appealing enough for encouraging investment. The turnover from the cultivation of jatropha for producing feedstock for biodiesel shows it is commercially viable and thus can attract private investment as well. Over and above the financial return, growing jatropha tree holds immense opportunity for addressing rural unemployment and to pull people out of poverty. As the plant can also thrive on marginal land, it provides opportunity for making productive use of waste and idle land thereby ensuring access of landless and marginalized people to the use of natural resources. The localized and decentralized system of feedstock production promise wide distribution of benefits of jatropha cultivation across the country in the potential ecological zones.

Nepal depends solely on imported petroleum fuel. Growing Jatropha feedstock for biodiesel production holds great implications not only for our energy sector but also for the economy as a whole. Reduced dependency on imported fuel simultaneously means saving foreign exchange, overcoming loses, creating opportunities for employment and rural development and last but not the least reducing carbon emission. Against this backdrop, embarking on biofuel sooner than later the country will benefit significantly.

6.2 Recommendation

Based on the findings of the study, investment in Jatropha farming is strongly recommended.

6.2.1 Potentialities

1. Jatropha seed-oil can be used in transport as diesel substitutes, for making soap, use as fuel for cooking, for operating diesel generator,

generating electricity, etc. It is thus a source of clean and improved energy.

2. Nepal stands to benefit greatly from jatropha cultivation as feedstock for biodiesel production. The use of biodiesel will reduce the use of imported fossil fuels which will simultaneously save foreign exchange, reduce losses incurred by the state on petroleum fuel.
3. As biodiesel is carbon neutral, Nepal will contribute to reduce in green house gas emission.
4. In a developing country like Nepal, faced with mass rural unemployment, Jatropha farming holds great potential for generating employment and income opportunities at the local level.
5. Landless and marginalized people can be made potential beneficiaries of employment opportunities.
6. Oil extracted from Jatropha can be used in soap production. This can help in developing local enterprises for income generation.
7. Oil cake generated as by-product of oilseed has the properties to substitute chemical fertilizer or can be used as animal feeds.
8. As Jatropha farming can be done on any soil condition, it helps in reclaiming degraded and waste land, thereby contributing in restoring the environment.
9. Investment in Jatropha farming is reasonably yielding even at escalated cost and lower return.
10. It is an investment opportunity with great possibility for optimum return.
11. There is also an opportunity for financial gain from carbon trade under the clean development mechanism (CDM) of the Kyoto protocol.

6.2.2 Promotional measures

1. Experimental cultivation using various production technologies before going into commercial farming is suggested so as to have a choice from best plantation potions with maximum yield.
2. Productivity enhancement is the only way to maximize output and return.

3. Subsidy and soft loan is likely to encourage investment in Jatropha farming even from local community.
4. Formulation of biofuel friendly policy is strongly recommended to encourage investment in the production of feedstock for biodiesel.
5. The need of institutional mechanism for the development of biofuel is widely felt in the country.
6. There is a great scope for research in Jatropha to make it as a viable energy option.
7. An investigation to find out the causes of crop failure in Khairenitar-based Jatropha plantation initiated as an experimental project by RECAST and Nepal/UK Oilseed Project is strongly recommended.

References

Aryal, M (2008). *Sajiwan ko tel le gadi chalyo*, Kantipur Daily, Kantipur Publication, Kathmandu.

Aryal, M. (2008). *Tel Nikalne Sajiwan Khetima Aakarshan Badhdo*, Kantipur Daily, 3 August, Kantipur, Publication Kathmandu.

Bagani, Reinhard K. Henning, *Jatropha* curcas L. in Africa. *Assessment of the impact of the dissemination of "The Jatropha System" on the ecology of the rural area and the social and economic situation of the rural population (targeted group) in selected countries in Africa.*

Banskota, K. Sharma, B. (2006); *The Economics of Biofuels*: Opportunities and Challenges, Report on National Seminar on the Prospect of Liquid Bio-fuels Nepal, 29 May 2006, Kathmandu Nepal. Center for Energy Studies, Institute of Engineering, Tribhuvan University, Kathmandu, Nepal.

Bhattarai, K. R. (Jan, 2008); *Sajiwan bata biodiesel- Jatropha Biodiesel,* Makalu Publication, Kathmandu, Nepal, Page 148.

Boswell, M.J. (2003): *Plants oils: Wealth, Health, Energy and Environment*, Proceedings of International Conference on Renewable Energy Technology for Rural Development (RETRUD-03) 12-14 October2003, Kathmandu, Center for Energy Studies, Institute of Engineering, Tribhuvan University, Kathmandu, Nepal.

Chhetri, M. (2006), *Economics of Jatropha Oilseeds Plants Indigenous to Nepal*, Master Thesis; Submitted to Central Department of Rural Development, TU.

Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

Jones, N. and Miller, J.H. (1992): *Jatropha Curcas: A Multipurpose Tree Species for Problematic site.* The World Bank, Asia Technical Department, Agriculture Division.

Nawa raj Dhakal, Senior Training Officer (AEPC); *Government Policy and Programme on Biofuel in Nepal, Report,2008.*

Nepal, K.M. (2000). *Characteristics and Potential of seeds Obtained from Jatropha species indigenous to Nepal,* M, Sc. Thesis; Submitted to Central Department of Botany, TU.

Poudel, P (2008). *Nepal ma biodiesel Ko Kheti,* Sha, T.N. Poudel K.P. Publication, Kathmandu,

Saxena, A.P. (2007), *Jatropha as Feedstock for Biofuel: Policy and Development Issues,* in Proceedings of 4th International Conference on Biofuels, 1st February 2007, New Delhi: warlock international India.

Shrestha Acharaya, A. (2002): *Energy Economics in Nepal (Issues and Options),* Udaya Books Pvt. Ltd., Kathmandu, Nepal.

Shrestha, G.L., R.B. Bhandari and B.Shrestha (1995). Oil Seed Plant of Nepal: A Brief Introduction. Green Energy Mission/Nepal.

Shrestha, J.N., Ale, B.B., Pradhan, S. (2006): *Application of Liquid Bio-fuel in World Scenario,* Report on National Seminar on the Prospect of Liquid Bio-fuels in Nepal, 29 May 2006, Kathmandu Nepal, Center for Energy Studies, Institute of Engineering, Tribhuvan University, Kathmandu, Nepal.

Shrestha, R.K. (2007), *Role of Energy in Rural Poverty Alleviation*, Nepalese Journal of Development and Rural Studies, Central Department of Rural Development, TU.

Singh, N. (1980). *A study on vegetable oil, oil seeds –bearing Plants in Nepal*. Research center for Applied Science and Technology (RECAST), TU, Nepal.

Singh, R.B. (2002): *Non-Conventional Economic Plant-Jatropha curcas Linn,* published by JUSAN, Kathmandu, Nepal.

THT, (2005): *India to use bio-fuel*, The Himalayan Times, 28th August.

Tiwari, M. (2006): *Bio-fuels can lessen Nepal's Oil Woes*, The Kathmandu Post, 6th march 2006, Kathmandu, Nepal.

Uppal, J (2006*): Bio-fuels- Opportunities and Challenges*, In Proceedings of 3rd International Conference on Bio-fuels held from January 18-19th 2006, New Delhi: Winrock International India.

Yadav, T.N. (2006): *The Plantation of Jatropha Bio-diesel Plant,* paper presented in an interaction programme on bio-diesel, Lahan, Nepal 2006.

http://www.*Jatropha*.org/de

http://www.*Jatropha*.org.nz

http://www.*Jatropha*world.org,

http://www.*Jatropha*biodiesel.org,

http://www.svlele.com

http://www.greenfuel.co.uk

http://www.ebay.com

http://www.biodieseltoday.com

http://www.look.com

http://www.smartveg.com

http://www.Reinhard.Henning.com

http://www.fact-fuels.org.

Annex - A

Questionnaire

1. General information -

    - Name of respondent
    - Age
    - Religion
    - Education
    - Occupation
    - Sex
    - Marital status

2. Socio economic information of the respondent

Serial no.	Land type	Area in bigha	Cultivation ownership			Remark
			Self	Rented out	Rented in	
Total						

3. What is the major source of your earning?

    - Jatropha farming
    - Service
    - Agriculture
    - Business

4. How to select the appropriate seeds?

5. Land selection process?

6. Way of plantation?

7. What is the view towards Jatropha farming? Does that support your livelihood?

    - Positive / yes
    - Negative / no

8. For which purpose you use Jatropha?

Household purpose	Medicinal purpose	Selling purpose

9. How much Jatropha seeds do you sell per year? What is the price for per Kg?

10. Which time is most favorable for Jatropha farming?

Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec

11. What is the role of Jatropha farming in your livelihood?

12. Can Jatropha farming become a permanent source of income for you?

- Yes
- No

13. Do you process the seeds for oil after collection or not?

14. Are there any kinds of outside support for Jatropha Nurseries or not? If yes, what kind of help?

Financial	Technical	Others

15. What should be done for the improvement of the marketing?

16. Do you think Jatropha farming can play vital role in income generation?

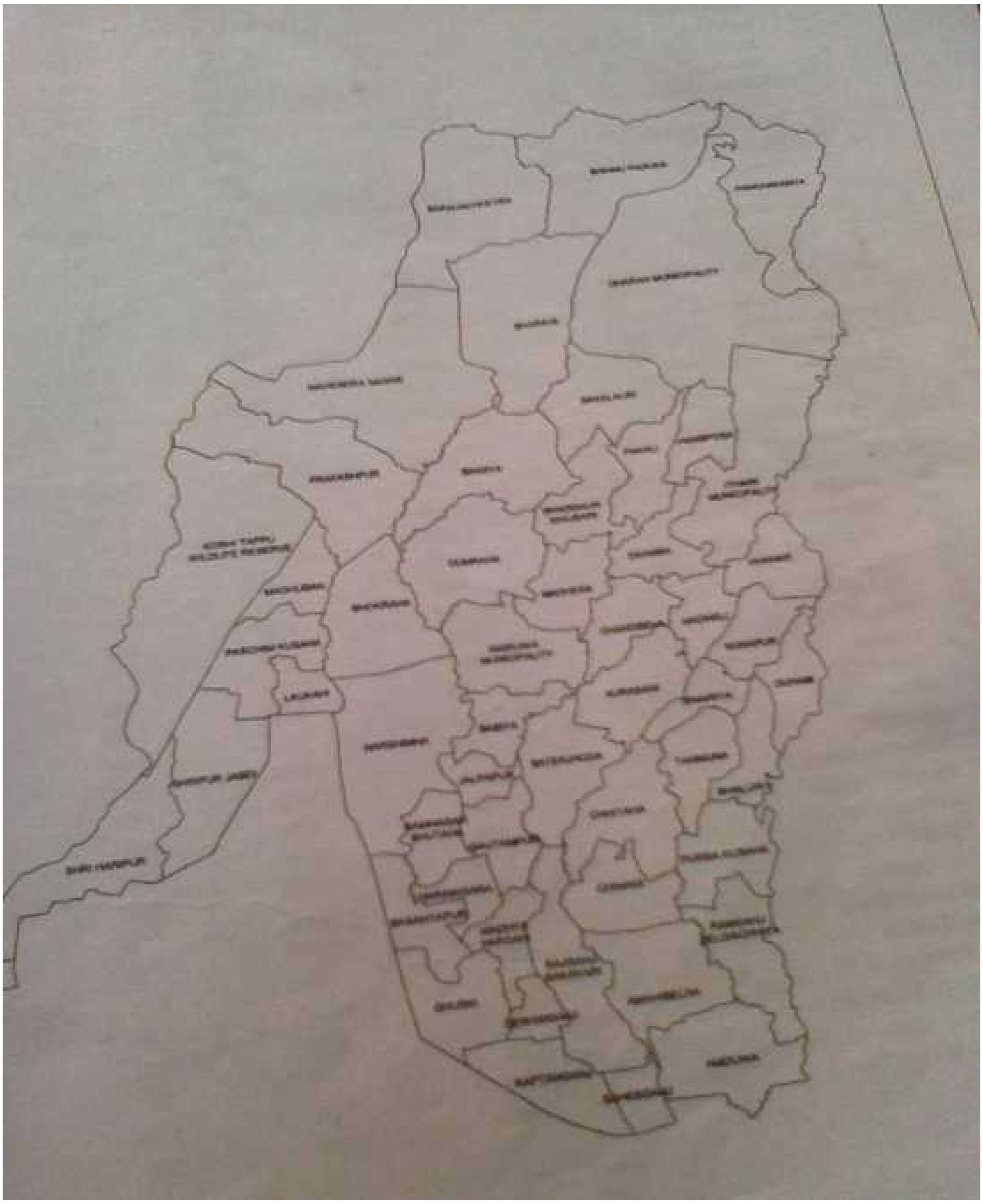
17. How can Jatropha farming play vital role in environmental benefits?

18. Do you think Jatropha farming play vital role for local development?

Annex – B

Photographs

Photo-1- Map of Sunsari district



Source: Population of Nepal

Village Development Committee/Municipa lities Population Census 2001

Photo-2- Cycle from Jatropha Plant to Biodiesel use in Vehicle

1. Jatropha Plant

2. Jatropha Seed

4. Biodiesel used in Vehicles

3. Oil extracted from the seed

Photo-3 -Workers in Jatropha Farm

*Source: Field work, 2008 (*Nursery of Jatropha, Lahan)

Photo-4- 6months old Jatropha Plant

Source: Field work, 2008; Siyaram Nursery, Sunsari

Photo-5- Three stages of fruit in one plant

Source: Fieldwork

Photo-6- Well developed jatropha

Source: Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

Photo-7- Plucking the mature Jatropha seeds

Source: Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

Photo-8 -Two years old Jatropha plant

Source: Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

Photo-9 -Way of Jatropha Plantation

Source: Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

Photo-10- Jatropha used for Fencing

Source: Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

Photo-11-Jatropha Farm of India

Source: Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

Photo-12-Petroleum Products Sortage in Kathmandu

Source: Jagdish Chandra Kuinkel, Winrock International; report on Opportunity of liquid biofuels (jatropha) in Nepal, Sep 2008.

Photo-13-Petroleum Products Sortage in Kathmandu

Source: Nawa raj Dhakal, Senior Training Officer (AEPC); Government Policy and Programme on Biofuel in Nepal, Report, 2008.