A Proposal on

The Role of Wild River Algae to Improve the Livelihood of Rural and Marginalized people of Nepal

Proposal Prepared by

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Executive Summary

Energy is the basic tool for development. The correlation between energy consumption and the level of economic activity within a given society is well established, and so is the correlation between poverty and inefficient access to energy for productive purposes. Nepal is currently suffering from both electrical as well as liquid fuel shortages. These two problems feed off of each other creating a larger overall problem. Due to (load shedding/ rolling blackouts) the use of back-up generators and invertors add to increased fuel consumption and exacerbates shortages as fuel destined for transportation is now used at the household level and erodes disposable income.

The plan for farmers to switch to crops such as Jathropa and Castor Bean to supplement the national fuel supply is now being found by Jathropa Evaluation Program to be not as commercially viable as once thought, and oil yields are lower than predicted. Alternatively, Nepal possesses one of the world's largest water resources on the planet that can also be used for the growth and cultivation of algae, which can then be processed into biodiesel. Algae biodiesel production will create jobs for the more than 42-47% unemployed persons in Nepal, most of whom are impoverished and marginalized Dalit, Indigenous peoples, conflict victims and single mothers in rural areas. Producing liquid fuels from algae is a new 21st century agricultural method that combines sustainable growth, local production of energy and environmentally friendly and sustainable job creation.

The ability of algae to grow rapidly on non-agricultural land within a three week re-growth/re-harvest rates mean that farmers can harvest multiple times during the dry season, not just once every three months as with traditional crops. This also provides extra income in agricultural and marginalized communities that typically rely on crops that can be harvested once every three months.

During large scale production of algae biodiesel, a substantial amount of algae presscake residue will be left after oil extraction. This algae presscake then can be used to feed anaerobic biogas digesters in the local Village Development Commission (VDC). The combination of algae with cow dung as feedstock substantially increases methane gas output and can offset a 20-40% reduction of methane gas during the cold winter months as temperatures inside the biogas digester cool. The reported increase in methane gas out put from algae/cow dung feedstock will allow for longer cooking hours in a family household and decrease the amount of fuel wood or kerosene used in kitchens or homes during winter month's country wide.

The social and economic benefits of Energy Research Nepal's project is that it creates liquid fuel from algae and the subsequent presscake which is a waste product can then be added to biogas digesters to increase methane output and the resulting slurry from algae will contain a higher percentage of nitrogen that will substantially boost plant yield. Couple this with conservation of forest areas, skills training and education which will lead to livelihood improvement in impoverished rural areas as women and marginalized rural villagers become leaders and take leadership roles in the community.

Based on rural development models worldwide, offering a secondary source of income based on sustainable aquaculture and expanding alternative energy by producing bio-fuel with usable by-products, offers a solution to several economic and social problems. This environmental sustainability can create a new revitalized economy in rural Nepali villages.

Introduction

Nepal is currently suffering from both electrical as well as liquid fuel shortages. These two problems feed off of each other creating a larger overall problem. Due to load shedding the use of back-up generators and invertors increase fuel consumption. This adds to shortages as fuel destined for transportation is now used at the household level and erodes disposable income. Just the economic cost of "planned electrical interruptions" alone through the country's economy is costing an estimated 65 billion rupees (Rs) in lost revenue and taxes per year (Shestra, R.S., 2010).

Nepal possesses one of the world's largest water resources on the planet but most people only associate that resource with hydro-electricity. Water resources can also be used for the growth and collection of algae, which can then be processed into biodiesel, and can create jobs for the more than 42-47% unemployed persons in Nepal. (Nepal Economy 2011, CIA World Factbook)

Algae fuel is an alternative to fossil fuel and has nearly the same chemical properties as crude oil. Several corporations and government agencies worldwide are exploring ways to make algae fuel production commercially viable to replace imports and insure national energy security. (Fishman D., Majumdar M., Morello J., Pate R., Yang J., May 2010)

Algae has been researched as an alternative fuel since the early 1970's, but when crude oil prices fell to 8$ a barrel in the early 1980's research was put on hold, but the recent increase in crude oil prices and government changes in the Middle East is putting algal fuel in front as an alternative again. (Sheehan, J., T. Dunahay, J. Benemann and P. Roessler, 1998). In Nepal this local resource from rivers, streams and still water ponds can create higher income at the national level which means more social stability.

Because of high import prices of refined oil products purchased from India, and the possibility of making use of riverbeds not suitable for agriculture, along with job creation for marginalized and impoverished rural villagers, put algae bio-fuel out front as an attractive alternative fuel source. Nepal is in a prime position to take advantage of algae production and job creation potential.

Rationale of the Study

Nepal's rural population still relies on traditional agriculture for development in the countryside which leaves few opportunities for increasing living standards. What is currently lacking is a new 21st century agricultural method that combines sustainable growth, local production of energy and environmentally friendly and sustainable job creation for the poorest and most marginalized segment of society based on a local resource widely available throughout Nepal.

The plan for farmers to switch to crops such as Jathropa and Castor Bean is now being found by Jathropa Evaluation Program to be not as commercially viable as once thought and oil yields are lower than predicted (ICJC, Jathropa Evaluation Programme, 2010). Currently numerous national energy labs and academic research institutions are actively engaged in algal research along with

over 50 private companies worldwide conducting research into algae bio-fuels. (Edwards M., Arizona State University & Centre for Management Technology (CMT) 2009),

The ability of algae to grow rapidly on non-agricultural land within a three week re-growth/re-harvest rates mean that farmers can harvest multiple times during the dry season, not just once every three months as with traditional crops. This also provides extra income in agricultural and marginalized communities that typically rely on crops that can be harvested once every three months. (Sorokin C., Krauss R.W., 1962) Since algae biodiesel is compatible with existing bus, farm tractors and diesel vehicle engines, local biodiesel produced in a Village Development Commission (VDC) can be consumed in that same VDC. (APEC Biodiesel Standards Workshop, July 2008).

The United States Department of Energy (DOE) estimates that if algae biodiesel replaced all the petroleum fuel in the United States (*20 million barrels per day)* it would require 39,000 square kilometers of grow out area which is only 0.42% of the U.S. land mass. (Sheehan, J., T. Dunahay, J. Benemann and P. Roessler, 1998) Since Nepal's energy needs are considerably less than the United States it is feasible that there is enough wild algae in the approximately 45,000 kilometers of rivers and 200,00km of streams of this country to not only replace imports from India, but to leave access bio-diesel to export into India. That is if all of Nepal's algae resources are utilized and cultivated. (*Nepal oil consumption 18,000 Barrels per day (bbl/day),* (Nepal Oil Corporation, 2009, website)

We believe through our initial academic research that with low labor costs, capital cost, and operational costs, wild harvested Himalayan River algae can be cost-competitive with conventional fuels and actually come in cheaper per barrel produced. (Campbell P.K., Beer T., Batten D., 2008, CSIRO) We also theorize from National Energy Research laboratories findings in the U.S.A, Europe and Australia that algae species in Nepali rivers also contain lipids that can be press extracted to yield biodiesel from dry algae. This in turn creates biogas digester feedstock to increase methane gas rates during winter months and save additional trees from being harvested for heating and cooking fuel. (Mann G., Schlegel M., Schumann R., Sakalauskas A., 2009) Based on rural development models worldwide, offering a secondary source of income based on sustainable aquaculture and producing bio-fuel offers a solution to several economic and social problems that can create a new revitalized economy in rural villages. (Poverty Trends in Nepal, 2003-2004).

During large scale production of algae biodiesel, a substantial amount of algae presscake residue will be left after oil extraction. This algae presscake then can be used to feed anaerobic biogas digesters in the local Village Development Commission (VDC). The combination of algae with cow dung as feedstock substantially increases methane gas output (Yan, H., 2004). This increase can offset reduced methane gas production during the cold winter months which happens as temperatures inside the biogas digester cool. (Biogas Support Programme (BSP-Nepal), 2009), (CES/IOE, 2001). The reported increase in methane gas out put will allow for longer cooking

hours in a family household and decrease the amount of fire wood used in kitchens for cooking, which in turn conserves forest areas.

Objectives

- Create environmentally friendly jobs for the poorest and most marginalized segments of society based on sustainable growth and local production of renewable energy (algae biodiesel/biogas).

- Investigate algae strains and their oil content from 25 locations across Nepal and at the same time survey rivers for density of algae in selected areas in order to study the feasibility of scaling up collection and production for algae biodiesel production. Results of the economic analyses will be used to develop a commercialization strategy to supplement the national fuel supply and analyze the number of jobs to be created throughout the country.

- Demonstrate a closed loop cycle from algae biodiesel to anaerobic biogas digester (using algae presscake) to bio slurry substantially increasing crop yields by coupling algae biodiesel production with anaerobic biogas digestion. Measurements of increased production of methane gas during cool winter months or higher altitudes by the addition of algae to cow dung as feedstock in the process will be recorded.

Expected Output

Within 12 months of the project's initiation, a detailed report is to be submitted in both English and Nepali including an open-forum workshop to report on the project's initial findings and encourage the contribution of additional expert information. The report shall include both quantitative and qualitative data analysis. Figures, charts and bar diagrams will also be used for analysis and interpreting the gathered information from our standardized template for algae data collection.

The project will develop expertise in this particular area of study, encourage collaboration and networking between Nepali and International NGO's in bio-fuels processing, integrated agricultural markets and related job creation for marginalized and impoverished rural residents.

This will involve overlays of information on river drainage basins, the portion of this land area that is poorly suited to agriculture, and the portion of land with access to small streams that can be utilized for algae cultivation.

The project aims not only to summarize available data but also to identify gaps in the data. These data gaps also represent an opportunity to find out what additional work needs to be done to obtain a comprehensive picture of algae bio-fuel potential from cultivation and collection of wild and cultivated river algae.

An economic model encompassing a "Nothing Wasted, Everything Used" philosophy for the program will be developed from the beginning of the project, and a preliminary economic assessment will be undertaken. Results of the economic analyses will be used to develop a suggested commercialization strategy. The life-cycle from (algae collection / algae processing / bio-gas digester usage / biodiesel sales / forest protection) will be undertaken to determine how best to proceed and include the greatest economic benefit for the largest amount of impoverished rural residents involved at the Village Development Commission (VDC) level. This commercialization strategy will be the basis for ERN's Phase 2 scaled-up production project.

Justification of the Study

In Nepal there are a total of 317 algal taxa (Cyanophyceae 16.08%, Bacillariophyceae 26.81%, and Chlorophyceae 57.09%) belonging to 100 genera that have been recorded in Eastern Nepal's still water habitats and slow flowing rivers. Additionally 14 genera are being described for the first time from this country which leaves reason to believe others will be found in the future. (Rai S.K., 2006), (Rai S.K., Rai R.K. and Jha S., 2010), (Rai S.K., Subba B.R., Limbu K.P., 2008).

Algal biomass offers the possibility of a sustainable feedstock that is widely available throughout Nepal. River algae grows rapidly, yields more bio-fuel per hectare than oil plants, contains no sulfur or other toxic substances, is highly biodegradable, and does not compete with food production on agricultural land. (Algal Biomass Organization (ABO), 2010 Finance Summit) Algae could thus contribute significantly to the overall resource potential of bio-fuels to displace petroleum and be used as an innovative livelihood solution to critical social and economic problems plaguing Nepal.

Energy Research Nepal's Phase 1 study will show the possibilities of collecting wild Himalayan river algae on a scale large enough to produce algae biodiesel to supplement the national fuel delivery chain. Nepal contains abundant river systems throughout every corner of the country, meaning that the possibility of positive economic impact to every segment of society in rural locations is achievable. After initial extraction of oil from algae for biodiesel, the remaining presscake residue can undergo anaerobic digestion by being added to biogas digesters for increased methane gas output when mixed with cow dung. We plan to demonstrate a closed loop cycle of usage from algae biodiesel to anaerobic biogas digester to bio slurry for an increase in crop yields. (CMS, 1996, Biogas Technology), (Demont, D.,A. Sckeyde, and D A. Ulrich, 1990)

ERN's goal is to start a project that generates money from itself and becomes self sustaining. By providing skills training for local residents in renewable energy, profits can then be used for community based natural resource management, poverty reduction, water resource management and livelihood improvement in impoverished rural areas. Marginalized, indigenous low caste women and men are the beneficiaries becoming leaders and taking leadership roles of renewable energy programs and management in local VDC's.

Limitations of the study

Due to the time constraints and limited resources this study will be conducted in only 25 districts across Nepal. This will affect the amount of algae samples that can be collected in rivers or still water areas visited and surveyed. Findings cannot be generalized across the entire country and every species cannot be catalogued and processed into biodiesel as we will not be able to cover every square meter of river and waterways in Nepal. Load shedding is also an issue for timely recording of results which can delay data entry for 24-36 hours. Algae density is at its minimum level during the monsoon high water flow and at its densest during the dry season minimal flow, meaning that water levels in the river effect algae growth. The relationship of algae density will directly affect the amount of algae biodiesel and presscake produced.

Methodology in Brief
Data Collection Techniques

Primary Data Collection

No.	Description
1	***River Basin Survey*** A.) GIS software survey for river mapping to determine possible harvest yields and optimum habitats for algae. Large sites identified throughout this survey should be harvested and cultivated first. As we learn more about the how and where algae grows naturally in the Himalayan drainage basins and watersheds, upgrades in harvesting techniques and prime locations will upgraded during our research. B.) We must visit rivers of varying sizes, altitudes and terrain talking an initial survey of the amount of wild algae present. Additionally, algae strains must be collected and catalogued from each type of river system/habitat. C.) Algae samples at various locations will be collected and preserved in a 4% formaldehyde solution in a 400ml collection bottle. Temperature of water as well as pH value will be recorded. Light/radiation intensities and close proximity vegetation will also be noted during sample collection.
2	***Lab Testing Algae for Lipid Content*** *A.)* Yet unknown is the exact (oil/lipid) content of cold water Himalayan algae species. Typically cold water algae strains contain a higher concentration of lipids. We need identification of strains by a University Biology or Botany Department. Once lipid content is determined by Gas Mass Spectrometer (Gas Mass) testing a more exact cost work up can be given. (*Sheehan, J., T. Dunahay, J. Benemann and P. Roessler,1998). See*

	Secondary Data Collection B.) This information will allow us to begin a database cataloguing species by lipid content. The frequently observed genera in most of the localities were Oscillatoria and Anabaena of Cyanophyceae; Navicula, Pinnularia, Synedra, and Gomphonema of Bacillariophy ceae; and Spirogyra, Cosmarium, and Closterium of Chlorophyceae. *(Rai S.K., 2006), (Rai S.K., Rai R.K. and Jha S., 2010), (Rai S.K., Subba B.R., Limbu K.P., 2008).*
3	***Algae Processing*** A.) Wet collection of algae from the river. B.) Algae is then dried in sunlight to 10% moisture content. C.) Oil Extraction, the dried specimen is taken to a local pressing mill, where the oil must be separated from the algae biomass. The simplest method is mechanical crushing. When algae is dried it retains its oil content, which then can be "pressed" out with an oil press. Many commercial manufacturers of vegetable oil use mechanical pressing to extract oil. Optimal oil extraction techniques will be strongly dependent on using a “Nine Bolt Spailor Oil Press”. D.) Pressing mill creates algae press cake after extracting oil. Resulting oil and green cake (residue) are separated.
4	***Biogas from Algae Presscake Residue*** A.) Algae biomass/presscake residue is then added to anaerobic digestion bio-gas plants. Subsequent monitoring with the kind help of (BSP Nepal) of the plants with pressure testing equipment will verify precise additional methane gas yields from cow dung/algae presscake mixed feedstock. B.) Rates of replaced wood usage and number of forest hectares saved by increased output of methane gas in bio-gas digesters due to addition of algae presscake residue will be studied and recorded.
5	***Processed Algae Biodiesel Sales Avenues*** A.) Setting up a supply chain to a final buyer for crude bio-diesel. That will be National Oil Corporation (NOC) or fuel processors involved in the Transesterification of Jathropa or Castor Bean Seed Oil operating in Nepal. B.) Set up a supply chain to vendors to sell un-processed crude oil bio-diesel to farmers for use in tractors which can burn un-modified 100% bio-diesel.

6	***Economic Modeling*** A.) An economic model encompassing a "Nothing Wasted, Everything Used" philosophy for the program will be developed from the beginning of the project, and a preliminary economic assessment will be undertaken. B.) The life-cycle from (algae collection / algae processing / bio-gas digester usage / biodiesel sales / forest protection) will be undertaken to determine how best to proceed and include the greatest economic benefit for the largest amount of impoverished rural residents involved at the Village Development Commission (VDC) level.
7	***Final Decision on Commercialization*** Results of the economic analyses will be used to develop a suggested commercialization strategy.
8	***Job Creation*** River system survey results will give prime locations for scale-up and related job creation through collection of algae in local VDC's after initial small scale harvesting trials.

Secondary Data Analysis

Tribhuvan University Biochemistry Laboratory in Kirtipur will oversee and conduct testing of collected algae samples. The testing will consist of three parts: **Biochemistry**, **Bond Structure/ Molecule and Physical Test**.
❖ **Biochemistry Test** will consist of testing for Carbohydrate, Lipid/Oil/Fat, and Protein content percentages.
❖ **Bond Structure and Molecule Test** will consist of a Spectroscopy test. Mixture of solution for lipid extraction and comparison. Glycerin will also be extracted.
❖ **Physical Test** will consist of Clarity, Density/Specific Gravity, Viscosity, Volatility/ Heat Combustion.

Duration of study

The duration of the study is for 12 months. Proposed time frame for different stages of research is as follows:

S.N.	Description	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2012	Feb	Mar
1.	GIS river mapping and Survey												
2.	Field data/sample collection												
3.	Data compilation & analysis												
4.	Production of Algae Biodiesel												
5.	Monitoring of biogas plants												
6.	Report Submission and Presentation												

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