UNITED NATIONS - NATIONS UNIES
ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

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A Feasibility Study on the Application of
GREEN TECHNOLOGY FOR SUSTAINABLE AGRICULTURE DEVELOPMENT:
Assessing the policy impact in selected member countries of ESCAP-APCAEM

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ACRONYMS

AAGR	Average Annual Growth Rate
ADB	Asian Development Bank
AEPC	Alternate Energy Promotion Sector
AgGDP	Agricultural Gross Domestic Product
APCAEM	United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery
APP	Agriculture Perspective Plan
ASM	Academy of Sciences Malaysia
AT	Appropriate Technology
ATA	Appropriate Technology Asia
BSP	Biogas Support Program
BSP-N	Biogas Sector Partnership Nepal
BTU	British Thermal Unit
CA	Conservation Agriculture
CAF	Chinese Academy of Forestry
CEF	Community Energy Fund
CES	Centre for Energy Studies
CF	Community Forest
CFUG	Community Forest User Group
CO2	Carbon dioxide
COPD	Chronic Obstructive Pulmonary Disease
DDC	District Development Committee
DEF	District Energy Fund
DGIS	Director General for International Cooperation of the Netherlands
DNA	Deoxyribonucleic Acid
EE	Energy Efficiency
EEI	Eco-efficiency Indicators
EMP	Eighth Malaysian Plan
ESAP	Energy Sector Assistance Program
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organisation of the United Nations
FFS	Farmer Field Schools
FUG	Forest User Group
GDP	Gross Domestic Product
GHG	Green-House Gas
GIS	Geographic Information Systems
GM	Genetically Modified
GMO	Genetically Modified Organisms
GoN	Government of Nepal
GPS	Global Positioning Systems
GT	Green Technology
GTI	Green Technology Initiative
IAP	Indoor Air Pollution
ICRISAT	International Crops Research Institute for the Semi-Arid and Tropics
ICS	Improved Cooking Stoves

ICT	Information and Communication Technology
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IFPRI	International Food and Policy Research Institute
IGNRM	Integrated Genetic and Natural Resource Management
IPM	Integrated Pest Management
ISACPA	Independent South Asia Commission on Poverty Alleviation
kFW	Kreditanstalt fuer Wiederaufbau of Germany
kWh	Kilo Watt-hour
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
MH	Micro Hydropower
MHFG	Micro Hydro Functional Group
Mtoe	Million ton of oil equivalent
MW	Mega Watt
NAP	National Agriculture Policy
NGO	Non Governmental Organisation
NMP	Ninth Malaysia Plan
OECD	Organisation for Economic Cooperation and Development
PAH	Polycyclic Aromatic Hydrocarbons
PJ	Peta Joules
PPP	Public Private Partnership
PRI	Poverty Reduction Impact
PRSP	Poverty Reduction Strategy Paper
PV	Photo Voltaic
PVC	Polyvinyl chloride
RE	Renewable Energy
REDP	Rural Energy Development Program
REF	Rural Energy Fund
REP	Renewable (Rural) Energy Policy
RET	Renewable (rural) Energy Technology
SAARC	South Asian Association for Regional Cooperation
SDG	South Asia Development Goals
SESB	Sabah Electricity Sdn. Bhd.
SHS	Solar Home Systems
SNV/N	Netherlands Development Organisation in Nepal
SOEL	Foundation of Ecology and Agriculture
SREP	Small Renewable Energy Program
STM	Sony Technology Malaysia Sdn. Bhd.
t-C	Ton of Carbon
TITAN	Trainers Association of Nepal
ToE	Ton of Oil Equivalent
TYIP	Three Year Interim Plan
UNCED	United Nations Conference on Energy and Development
UNDP	United Nations Development Programme
UNEP	United Nation's Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USCSP	United States Country Studies Program
VDC	Village Development Committee

EXECUTIVE SUMMARY

The United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery (APCAEM) aims at promoting sustainable agriculture development for the eradication of poverty by guaranteeing environmental sustainability. Such agro-based environment-friendly technology is termed as Green Technology (GT).

Literatures show GT encompasses a continuously evolving group of methods or materials, from techniques for generating energy to non-toxic cleaning products. It is that innovation which reduces waste by changing patterns of production and consumption. It is also defined as environmental healing technology, which reduces environmental damages created by the products and technologies for peoples' conveniences. Most of the businesses may not be very excited to "go green" by reducing emissions since their motto is to make money not to save the planet. The global strategy should be to help businesses do both.

The overall objective of the study was to conduct feasibility study by summarizing the overview of the status of the application of GT in selected member countries of APCAEM. The objective was also to initiate GT for bringing innovation and changes in daily life by meeting the needs of present generation without damaging or depleting biodiversity for the future generation. The present study therefore, explains link between the applied technologies and their relationships with environment-friendly agriculture; poverty reduction; rural environmental concerns; rural income and gender dimensions.

The feasibility study attempts to identify the gaps, if there are any, in the application of GT and attempts to justify their feasibility based on the results from experiments through agricultural and environmental technologies. The study identifies and assesses appropriate technologies; reviews policies; reviews impact assessment and recommends available options. Furthermore, the GT application is reviewed by further elaborating the issues on how this technology can raise farm income, conserve biodiversity, acknowledge women's participation and justify the sustainability of Mother Nature.

As reliable data on emerging technologies for sustainability assessment are still inadequate, the recommendations are largely based on qualitative methods and on an operational definition of sustainability using priority indicators. Furthermore, the review of selected regulatory measures in the chosen countries is made to find out their strength and weaknesses to facilitate GT initiative. Recommendations are made to develop favourable regulatory frameworks for the further development of GT.

The study involves consultation with relevant stakeholders to properly assess the overall value of GT application. The situation analysis of GT in general in selected member countries of the United Nations ESCAP and evaluation of the good practice model of the application of GT in selected areas in the proposed countries, namely; India, Malaysia and Nepal is expected to have produced the practical guidance for policy decisions in the subsequent phase (II) of the project with regards to the development and delivery of best practice model.

The demand for cereals in the developing countries is expected to increase by 59% in the next 25 years but the growth rate in cereal yields has declined alarmingly. The major question today is to devise the technology that will save the environment without sacrificing growth. The case for alternative agriculture technology is therefore realised to increase the yield and meet huge global demand. The advances in solar, wind, bio-energy and energy efficiency design has speeded up the development of technology-driven energy and cost efficiency mechanism to justify economic growth.

The present study shows that the adoption of GT has increased agricultural output without depleting presently available resources beyond the point of recovery. This study also found that solar photovoltaic, wind energy, biofuel, biogas, micro & small hydropower, biomass, solar thermal, improved water mill, geothermal energy, bio transgenics, organic farming, integrated pest management (IPM), agroforestry are some of the most feasible technologies in the APCAEM member countries.

There is a link between poverty reduction and growth in productivity. The productivity can be increased if local knowledge is combined with the improvement in technology to meeting particular conditions. The irrigation of deserts is proved to be economically feasible and desirable to upgrade low productivity marginal lands into higher productivity land through the improvement and development in technology. As yield increase has been an important source of growth, FAO estimates over next couple of decades, about 80 per cent of the production expansion will be linked with yield increases and about 20 per cent with agricultural land expansion. This reiterates the importance of the proposed feasibility study.

The wastewater and sewage disposal has been major threat to human health in developing Asia. The liquid waste discharged by domestic residences, commercial properties, industry or agriculture generates potential contaminants and concentrations that to some extent is minimised or recycled in the developed world. It necessitates the adoption of available and affordable technology for renewable energy including sunlight, wind, rain, and geothermal heat, which are naturally replenished. The technologies that are available are solar power, wind power, hydroelectricity/micro hydro, biomass and biofuels for transport.

Data shows agricultural land being increased by 13 per cent in the last 30 years at the expense of lowland forests and their rich biodiversity. With virtually no reserves of land with crop-production potential, Asian Development Bank's (ADB) estimate shows that land use per person will fall from 0.17 hectares in 1990 to 0.12 hectares in 2010. Furthermore, the pressure from worldwide urbanisation, manufacturing and population growth necessitates a renewed commitment to clean energy and environment solutions. The need is a balanced mix of alternative energies and the development of new technologies.

The skyrocketing costs of energy and agricultural inputs have reduced profitability, which has severely damaged the environment. This necessitates the proper assessment of the constraints and potentials of natural resources by examining policies of respective governments, and appropriateness of agro-technologies. The development of biotechnology is therefore, recommended to properly assess socioeconomic, food security and environmental impacts for helping the poor rural communities for maintaining sustainable agriculture.

Globally, including the Asian and Pacific Region, major agro-technological changes have been noticed. Such changes have been in agronomic practices; developing crop varieties with increased resistance to various diseases and pests; fertilizer-use and water conservation technology; and technologies making cultivation suitable under various agro-climatic conditions. As a reference to environment-friendly technology, organic agriculture has been considered as the fastest growing fields of the food sector. Therefore, organic agriculture has become a niche market since it forms 1%-2% of the total food market share and demonstrates a popular case for organically managed land practices.

Studies show every 1% increase in per capita agricultural output led to a 1.61% increase in the incomes of the poorest 20% of the population. On average, every 1% increase in agricultural yields reduced the number of people living on less than US$1 a day by 0.83%. Hence, development of agriculture sector, defined in terms of increased production with decreased average cost, becomes prerequisite for the overall development of an underdeveloped economy.

The revolution in Information Technology for precision farming, applied research in understanding ecological systems as production ecology and gene revolution for advancement in biotechnology have brought about major technological changes in agriculture. Although the technologies are available such as, the biotechnology, genetic engineering etc, the challenge is to determine the most suited and affordable technology by developing market mechanism for making applied technology competitive and sustainable.

In some countries government purchasing is encouraged for the products whose contents and methods of production have the smallest possible impact on the environment. In recent years, much more emphasis has been given in linking environmental factors with diversified development activities. For example, the terminologies, often used as "green building", or "high performance building", and or "sustainable building" address the impact of technology on environment. It is found that energy, water, and materials are used so efficiently while constructing the structure, it not only support the longer lifetime of the structure alone, but also the health and productivity of occupants.

The fundamental concern of any technology is its sustainability. Some popular experiments are carried out in South Asia as a simple tool for income generation. For instance, in Bangladesh, the mobile-lady offer door-to-door services in the village by taking the water testing kit for testing of water pH. They read the water pH meter measurement and explain the status of shrimp ponds for healthy harvests. They also offer additional information to the farmer and soil pH testing is one of such services provided to crop cultivators. The mobile-lady thus connects communities to the tele-centres. In the absence of mobile-lady, the farmers would either spend 2500 Taka or travel long distance to get such services.

It is sad to note that although rural women are responsible for half of the world's food production and produce between 60 and 80 per cent of the food in most of the developing countries; their contribution to global food security is not properly recognised and is overlooked in development strategies. The indigenous people especially the vulnerable women who live in a risk-averse mindset and work in under-resourced and under-privileged region of Asia need to be supported by modern technology to combat fragile ecosystems and other related externalities. This necessitates linking gender issues in policy documents to support women from poverty reduction and food security perspectives.

The world is realizing country-specific budgetary constraints and the failure of development assistance to make poor people's life better. For this obvious reason, development critiques have been asking the question "can development be exported"? Therefore, the big hope of utilizing indigenous local resources is green technologies. This alternative can be sustainable, which generates employment and increases income.

Globalisation has contributed to the decline in the demand for cereals and pulses in food basket. There is a higher demand for high-value crops such as fruits, vegetables, milk, meat, livestock products, egg, fish and other processed commodities. High transaction costs per unit of output and tough conditionality of importing countries have undermined the gains from agricultural trade in general. Poor countries have not been competitive due to the inadequacy of skill, capital, technology and required regulatory measures.

South Asia faces constraints in the governance of biotechnology. Therefore, the regulatory measures need to be strengthened for the effective management of biosafety. India initiated biotechnology as a tool for the growth of agriculture and health sectors since the Sixth Five Year (1980-1985) Plan period. Biotechnology in India has helped sustaining cotton production and also the development of virus-free potato seed, banana and micro-propagation of sugarcane through tissue culture.

In Nepal, biotechnology policy focuses on food security and poverty alleviation. As this policy largely emphasizes on the agriculture sector, the government intends to provide easy and affordable access to biotechnology products and appropriate inputs such as biofertilizers etc to the agriculturists. In principle, biotechnology should mean recombinant DNA technology and tissue culture for the development of improved products; its application is however, limited to tissue culture propagation of few economic plants such as, potato, banana, citrus and the development of animal vaccines.

Nepal is overwhelmingly an agricultural country with more than three-fourth of its people adopting agriculture as their occupation. Nepalese agriculture is heavily based on forest. Traditionally, there has been close link between agriculture, forest and livelihood of Nepalese poor. Developments in renewable energy sector of Nepal offer opportunity of cross cutting amalgamation of rural (renewable) energy sector and agriculture sectors. Examination of the possible nexus can suggest strategies for green and sustainable agriculture.

Modern biotechnology especially in agriculture has helped to do things that people could not do before. To give some examples, the technology has produced first generation of Genetically Modified (GM) crops such as herbicide-tolerant and insect-resistant crops. The examples of second-generation plants are the nutrient content like vitamin A-enriched rice and oils that have improved lipid profile. The third generation plants are being developed to provide specific health benefits. Although we find complaints about the health and environmental problems from GM crops, it has not yet been proved. Instead, the benefit of technology is much higher since it can contribute to increasing GDP, protecting biodiversity from excessive expansion of agricultural land and safeguarding human and animal health by reducing the use of agrochemicals.

To develop the regional and global competitiveness, Malaysia is commercializing the technologies through the Bio-valley Strategic Plan. As biotech thrives on innovation, the Bio-valley is a centralized development area for biotech with incentives for entrepreneurial culture, cooperative development, and collaboration between academic institutions, industry, and investors both within Malaysia and overseas. The aim of biotechnology policy is to transform and enhance the value creation of the agricultural sector and make impact on human life and economic progress. Under this policy, the scientists are actively engaged in fermentation based activities, production of valuable biologicals, plant or animal cell culture, value addition, and genetically superior planting materials.

Surveys conducted over 2,000 manufacturing companies in Malaysia reveals that several factories have already started to save energy costs. It opens up opportunities to companies that can offer energy management services for identifying ways to save energy and costs. The Academy of Sciences Malaysia (ASM) assists in upgrading the technological capabilities and competencies in the industry. A report from USAID estimates that total energy efficiency market in Malaysia will increase to US $ 557 million by 2015 from merely US $ 167 million in 1996. The fiscal incentives need to be strictly implemented to encourage renewable energy and energy efficiency technologies through investment tax allowance and import duty and sales tax exemption for the equipments used in energy conservation.

In Malaysia, the data on the quality of air and water are available on-line and on-demand basis by any individual particularly those having asthmatic and other environment-health related problems. The ICT Application in Environmental Governance in Malaysia project has proven the Best Practice in the Application of Information and Communications Technology (ICT) for Environmental Governance. It is unique in the sense that this project is considered as the only known privatised programme for monitoring the quality and air and water on-line and on continuous basis. It gives hope for replication in other member countries.

Almost 70 per cent of Indian population depends on agriculture, which is one of the energy intensive sectors. Agriculture consumes about 35 per cent of the total power generated through electrically operated pump sets. It is expected that about 30 per cent of savings is possible through appropriate technology. For example, larger valve can save fuel and power to draw water from the well. It has been shown that the farmers can save 15 litres of diesel every month by simply reducing the pipe height by 2 m. The use of good quality PVC suction pipe can save electricity up to 20 per cent.

The study identifies selected feasible technologies. **Solar photovoltaic technology** for instance, converts sunlight into electricity using semi conductor modules. Used generally for meeting lighting requirements, they can also be used for pumping water, refrigeration, communication, and charging batteries. Solar photovoltaic has application as green agricultural energy source for pumping water, street lighting in villages, lighting in rural houses and pest management.

Wind energy is in a boom cycle. Overall, wind energy contributes only 1% of global electricity generation, but some countries and regions are already producing up to 20%. Its importance is increasing in the sense that comparatively with other sources; the wind energy produces less air pollutants or greenhouse gases.

Biofuel as bio-ethanol and bio diesel have the potential to assume an important portfolio in future energy platter. Food security concerns and risks to environment and biodiversity are parameters that necessarily need to be assessed while analyzing sustainability linkage of agriculture and biofuel. Also, conversion of wasteland to farmland with some crop options can be viewed as positive impacts. This area is going to be the hot cake for future research.

In India, if all available sugarcane molasses is utilized 0.8 million kilolitres of ethanol thus produced can replace 9% of current petroleum requirements. India also estimates to have

3.1million hectares of Jatropha plantations by 2009. One hectare of plantation in average soil gives 1.6 tons of oil.

Biogas is the product of anaerobic digestion of organic matters by methanogenic bacteria. Biogas qualifies on the merits that this technology utilizes organic agricultural waste and converts it to fuel and fertilizer. Direct impacts of biogas are fuel-wood, agriculture residue, livestock manure, and kerosene savings. Increases in soil fertility and crop production have also been observed.

Hydropower plants ranging from maximum capacity of 500 kW in Nepal to 25 MW in India are conceived renewable. Generally used in rural electrification, hydropower plants can take an equally important role in facilitating irrigation and value addition at source of agricultural products.

Agriculture residues and wastes are converted to electric and thermal energy through processes like combustion, gasification, and cogeneration. **Biomass** technologies compliment mainstream crop production and reduce or completely replace consumption of traditional fuel. Experiences of some APCAEM countries portray biomass to be effective means of increasing agricultural revenue and conserving exhaustible resources.

Improved **Water Mills** (an intermediate technology based on principle of traditional water mills) in Nepal have made milling efficient (up to 3kW can be generated) and reliable, by also increasing the income of millers. In Nepal, 25,000 traditional mills are still in operation.

Geothermal technology has potential in China, Thailand, and the Philippines. A geothermal power plant not only generates electricity but also produces hot water for cold storage and crop drying.

The use of **bio transgenics** (BT) also referred to as Genetically Modified Organisms (GMO) has been growing at 45% per annum in developing countries which now account for 39% of 103 million hectares planted worldwide. Mostly in India and China, 9.2 million farmers planted BT cotton on 7.3 million hectares in 2006. Recent developments such as the modified high yield oil seeds can trigger rapid spread of transgenic crops.

Most **transgenic technologies** are under research and development phase and comprehensive results have not yet been ascertained. Among food crops few like rice, eggplant, mustard, cassava, bananas, sweet potato, lentils, and lupines have been approved for field testing in one country or the other, while some like BT Maize (mostly for feed) in the Philippines, publicly developed transgenic vegetables in China are allowed for cultivation.

Organic and biodynamic farming systems have soils of higher biological, physical, and in many cases chemical quality than that of conventional counterparts. When productivity in terms of inputs applied and outputs obtained and social costs of conventional farming are considered, organic alternative has been found to be significantly economical.

Identifying **Integrated Pest Management (IPM)** as a knowledge intensive approach dichotomous to conventional chemical intensive approach best serves the purpose of this research. IPM, especially through initiative like Farmer Field School programs where farmers are envisaged experts with their expertise emanating from routine hits and trials, interactions, and trainings have both empowered farmers and maintained agricultural and environmental balance.

Precision agriculture uses ICT to cover the three aspects of production namely for data collection of information input through options as Global Positioning System (GPS) satellite data, grid soil sampling, yield monitoring, remote sensing, etc; for data analysis or processing through Geographic Information System (GIS) and decision technologies as process models, artificial intelligence systems, and expert systems; and for application of information by farmers.

The best practice model in Nepal has been the Biogas and agro-forestry. Biogas has link with agriculture, forest, environment and overall livelihood of the people. It is capable to increase income of people, save environment and health and contributes managing time for women and children. Agro-forestry as a sustainable land-management system, increases the overall yield of the land, combines the production of crops (including tree crops) and forest plants or animals simultaneously or sequentially on the same unit of land and applies management practices that are compatible with the cultural patterns of local population.

India is second highest populated country with one of the highest growth rate in the world. This necessitates high demand for energy. India's energy demand is expected to grow at an annual rate of 4.8 per cent over the next couple of decades. Most of the energy requirements are currently satisfied by fossil fuels – coal, petroleum-based products and natural gas. Domestic production of crude oil can only fulfill 25-30 per cent of national consumption. Therefore, India is promoting jatropha. Major attraction of Jatropha lies on its growing capacity even in saline, marginal and infertile soil. Since it can grow without water, drought has no impact on it. Furthermore, it requires little maintenance that in turn reduces cost of production.

With regards to the policy in the studied countries, Nepal for instance, has neither separate nor umbrella policy for enhancing GT. Periodic plan document is the major source of policies. Currently, Nepal has concluded the Tenth Five Year Plan (2002-07) and executing the Three Year Interim Plan (TYIP) (2007/08-2009/10). In the TYIP, there are several disaggregated objectives and policies that may influence the adoption and expansion of GT.

India is one of the neediest countries for renewable energy resources. India's goal is to add 10,000 MW in the power generation capacity through sources of renewable energy. With the purpose of expanding renewable energy, India has brought several policies and programmes including "New and Renewable Energy Plan" under the proposed 11th Plan, Electricity Act, Renewable Energy Act etc. The Renewable Energy Act has been formulated to meet 20 percent of the country's total energy requirement by 2020.

Malaysia's Green Technology revolves around renewable energy. Agriculture sector is only the third large sector which contributes only 8.2 percent to the GDP. This share is heavily dominated by oil palm that is largely produced for biofuel. The country has new energy policy (5th Fuel Policy). The basic principle is to promote new sources of renewable energy to supplement to the conventional supply of energy. The fuel diversification policy which includes oil, gas, hydro and coal will be extended to include renewable energy as the fifth fuel, particularly biomass, biogas, municipal waste, solar and mini-hydro.

Malaysia's Five Fuel Diversification Policy provides the renewable energy policy guidance while the current grid-based small renewable energy programs or SREP, embodies national renewable energy strategy. The Government provides both investment incentives and tax exemption for promoting renewable energy.

There is a consensus that although there is a strong business case for "sustainability", it is one of the most difficult and complex tasks to balance between environmental and business concerns. There is a problem in balancing between the societal benefits of "green" practices and regulations with their costs.

The Inter-governmental Panel on Climate Change (IPCC) in its Fourth Assessment Report outlines human activity for creating scary effects of climate change to damage the world environment. The global temperature has risen by 1.8-4^{o}C and sea level rise of 18-59 cm is expected by the end of the century. This scenario necessitates the early success in deploying renewable carbon-free technologies by moving away from the coal and oil based economy to low carbon economy including solar, wind, nuclear, bio-fuels, hydroelectricity, batteries, hybrid cars, etc. Efforts in recent years are found in building giant space mirrors to reflect solar radiation back into space for commercializing renewable energy.

As population is expected to increase to at least 8 billion by 2020, the amount of arable land available to meet increased demand from a burgeoning population is limited. The need is to meet such demand through improved yields of commonly grown staple crops. Boosting production using fewer natural resources is possible through biotechnology. The contributions of biotechnology includes the production of "Golden Rice" which is enriched with beta carotene and iron that can help combat vitamin-deficiency, a principal cause of blindness and anemia; plants resistant to toxic metals that will increase the areas available for farming; and insect-resistant cotton that provided better yields is improving the lives of farmers in China, South Africa and elsewhere.

The development of innovative, appropriate and efficient information and communication systems is possible through the establishment of ICT infrastructure, which can prove to be nations' critical tools in the promotion of development. Among the proposed countries in the present study, Malaysia is relatively in a better financial position to use ICT technology. India has advantages to have local producer of computer hardware or software. However as the price of PC equipments is out of the range of most individuals, the service is not affordable for the majority of individuals and small businesses. The reason Nepal is way behind in terms of precision agriculture in South Asia is because the ICT content, applications, services, and management is poor.

Technologies that were reviewed for three APCAEM member countries (India, Malaysia and Nepal) were solar photovoltaic, wind energy, biofuel, biogas, micro and small hydropower, biomass, solar thermal, improved water mill, geothermal energy, bio transgenics, organic farming, integrated pest management, information and communication technology. These countries have been using all these technologies more or less to a greater extent. However Malaysia is more interested towards biofuel (oil palm production) while India is equally interested towards biofuel and other renewable sources of energy. In case of Nepal, biogas and hydroelectricity are two major areas of green technology where government policy pays special attention. But the common point of these three countries towards GT is that they have laid emphasis to energy sector technologies.

For poor people, agriculture technology including GT has little importance. The only way through which GT can support these poor people is increased wage rate in agriculture via increased productivity. But GT is not capable to compete with modern technology with inorganic manure and other chemicals. This is the possible reason for not giving priority for GT in agriculture sector in poor countries. This is also evident from the fact that in Malaysia IPM with FFS approach never got operational, in India, IPM activities are surviving through government budget. In Nepal as well, the situation of IPM is not different.

The energy service, in form of electricity from small-scale wind and solar photovoltaic, has been found indirectly encouraging farmers' incomes and savings by reducing health hazards from indoor air pollution and expenses incurring in the purchase of commercial fossil fuels; and by creating non-farm opportunities. Public investment for the promotion of these technologies is necessary. An ideal scheme would not only be socially equitable but also create structures and process flows to guarantee long-term sustainability of technologies.

The use of solar thermal, especially solar water heaters, at household level can be expected to grow with inevitable rises in energy price. However, technical assistance through public programmes will be necessary to increase application of solar dryers in agro processing. The role of agricultural cooperatives, agricultural networks and line agencies is very important towards creating markets and market links for products from clean processing.

The micro and small hydro schemes can deliver power required for agricultural growth. Irrigation canals carrying water from tailrace of power plants are also distinct possibilities. It is therefore important to consider multi-functionality of these schemes and formulate strategies accordingly.

It was observed that in the entire selected countries one or the other policy are pledges to create conductive environment for the transfer of green technology. In Nepal, the policy addresses adverse environmental impacts. However no direct linkage exist establishing green agriculture technologies as the instrument to meet this objective. Similarly, Indian policies and plans are either silent or ambiguous on greening the agriculture. Malaysian initiatives as Small Renewable Energy Programmes and Five Fuel Diversification Policy, speak inadequately on the possibilities of linkages between sustainable agriculture and energy policies. Thus to demystify the scopes of existing policies and their implications on sustainable agriculture further investigations in Phase II programme seems necessary.

Chapter One

INTRODUCTION

1.1 Background

The United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery (APCAEM) has been taking initiative to promote the agro-based environment-friendly technology termed as Green Technology (GT) to promote sustainable agriculture development for the eradication of poverty and guarantee environmental sustainability.

APCAEM is a subsidiary body/regional institution of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), which is based in Beijing, P.R. China. APCAEM is committed to contribute to the Millennium Development Goals (MDGs) through its mandated program. Out of the three cluster programmes, the current project entitled "A Feasibility Study on the Application of Green Technology for Sustainable Agriculture Development: assessing the policy impact in selected member countries of ESCAP-APCAEM" falls under Agricultural Engineering cluster. The rest two include: Food Chain Management & Agro-Enterprise Development and Trade. The proposed feasibility study on GT accommodates most of the United Nations Millennium Development Goals (MDGs), especially Goal 1 (Eradicate extreme poverty and hunger); Goal 3 (Promote gender equality and empower women); and Goal 7 (Ensure environmental sustainability). These goals are also within APCAEM's mandated functions.

The operationalisation of Clean Development Mechanism (CDM) of the Kyoto Protocol is a significant step towards promoting sustainable development in developing countries. The efforts on sustainable development have been made at the regional level as well. For example, Independent South Asian Commission on Poverty Alleviation (ISACPA) [1] has prepared South Asia Development Goals (SDG) (2007-2012) by addressing four indicators such as livelihood, health, education and environment. These indicators have twenty-two different goals under which the focused indicators of the current study like poverty, gender and environment are also included. The SDGs have been endorsed by the heads of SAARC governments during their Thirteenth Summit in New Delhi 2007. The commitment from higher political level to achieve sustainable development through environmental management is noteworthy in the sense that SAARC represents more than 50 per cent of the total APCAEM member countries (ISACPA, 2007).

The GT application is aimed at linking agriculture with the environment-friendly technology, which contributes to both poverty reduction and sustainable agriculture development. The objective of proposed study is to find out the viability of green technologies and provide a framework and direction for its development and delivery. Detailed objectives are given in section 1.2.

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[1] The SAARC leaders at their Eleventh Summit held in Kathmandu in 2002 reconstituted the Independent South Asia Commission on Poverty Alleviation (ISACPA) with Nepal as its coordinator and Bangladesh as Co-Convenor. The mandate of ISACPA as directed by SAARC governments was to undertake a comprehensive review of existing poverty alleviation policies and programmes in the region and make appropriate policy recommendations. The members of ISACPA are Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.

1.1.1 APCAEM and Green Technology Initiative

APCAEM has initiated several projects on Green Technology to enhance policy development and capacity building in selected APCAEM-member countries. The diversity of aforementioned three cluster programmes are covered by APCAEM's newly approved projects such as The "Kyoto Protocol: Potential Contribution from Agricultural Engineering"; "Agro-Biotechnology-based (Green) Enterprise Development for Sustainable Rural Livelihoods and Economic Growth (Second Phase)" and "Green Technology Policy and Application of the Eco-economy: A Case of Mushroom Cultivation Technology for Rural Enterprise Development and Income Generation". There are other equally significant projects in the pipeline (APCAEM e-Newsletter, June 2007).

The present study focuses on "green technology" application for poverty reduction, environment-friendly agriculture, rural environment, and income generation of the farmers by incorporating gender dimensions. The environmental concerns and increasing demand for green production for raising income and achieving sustainable agriculture development are one of the several reasons for rising interest in GT.

1.1.2 Defining the Term "Green Technology"

Technology can be termed as the application of knowledge for practical purposes. In this context, technology allows people to become more efficient or to do things that were not possible before. To benefit from technology, it needs to be successfully linked with country's overall development objectives and applied to solving socio-economic problems. The productivity increase is possible through environment-friendly and profitable technologies. Not necessary all the profitable technologies are adopted since barriers to practice new technologies and unavailability of market for environmental attributes associated with green technologies (GT) can limit their effectiveness. The adoption and diffusion of alternative practices are also influenced by the factors such as, the size of the farm, economic risk, and geographical location. This should be one of the important issues for policy consideration.

There is a link between poverty reduction and growth in productivity. Productivity can be increased if local knowledge is combined with the improvement in technology to meeting particular conditions. The irrigation of deserts is proved to be economically feasible and desirable to upgrade low productivity marginal lands into higher productivity land through the improvement and development in technology. As yield increase has been an important source of growth, FAO estimates over next couple of decades, about 80 per cent of the production expansion will be linked with yield increases and about 20 per cent with agricultural land expansion *(http://www.fao.org/Wairdocs/TAC/X5784E/x5784e08.htm).*

In recent years, efforts have been made to grow food by minimizing the use of chemical pesticides and mineral fertilizers. The benefit of green revolution is under scrutiny in terms of the experience that there has been a decline in crop yields. In Asia, rice farming system is in a state of decline necessitating the need for ecologically and socially sustainable forms of agriculture, where productivity can be increased with new technological paradigm. Therefore, since green revolution has also increased income inequality, FAO advocates Second Agricultural Paradigm[2], where the benefits of green revolution are combined with the new

2 The Second paradigm shift include: breeding of crop varieties, which is tolerant to adverse soil conditions, soil nutrient cycling, chemical and mechanical pest control etc.

generation of ideas, technologies, and institutional arrangements. The technologies should be in harmony with natural and ecological principles. The Second Paradigm shift is actually the improvement in genetic material and changes in the management to explore the possibilities for increased yields.

The "green technology" is a broad term for more environmentally friendly solutions. GT for that matter can be used as environmental healing technology that reduces environmental damages created by the products and technologies for peoples' conveniences. It is believed that GT promises to augment farm profitability while reducing environmental degradation and conserving natural resources *(http://www.ers.usda.gov/publications/aib752/aib752d.pdf).*

The risk associated with "dirty" technologies such as the petroleum products are alarmingly rising. The "clean" technologies as a result, are expected to provide lower risk alternatives. Data shows venture capitalists investing large amount of money into clean energy market and pursuing businesses facilitating renewable energy technologies that are energy efficient. One of United Nations Environmental Program's report states, in 2006, $2.9 billion was invested in clean technologies (mostly in wind, solar and other low-carbon energy technologies), which was 80% higher over 2005 (*http://www.wbcsd.org/plugins/DocSearch/details.asp?MenuId=NjA&ClickMenu=Lefenu&doOpen=1&type=DocDet&ObjectId=Mjc4NTc)*. As climate change threat has spurred green investing, UNEP coins this trend as the "world's newest gold rush".

GT covers a broad group of methods and materials for generating energy to non-toxic cleaning products. The reason this area has been significantly important is because people expect a dramatic innovation and changes in their livelihood. The development of alternative technology should attempt to benefit the planet truly protecting the environment.

Although it is difficult to precisely define the areas that are covered by green technology, it can safely be said that GT helps addressing the emerging issues of sustainability because of the advancement in science and technology. This technology should meet the needs of society in ways that can continue indefinitely into the future without damaging or depleting natural resources. In short, GT is defined as the technology that meets present needs without compromising the ability of future generations to meet their own needs.

In terms of the technology that can create products, which can be fully reclaimed or re-used, such cradle to grave cycle of manufacturing has successfully reduced waste and pollution by changing patterns of production and consumption. The innovations in technology have aroused interest in developing alternative fuels as a new means of generating energy and energy efficiency. Furthermore, GT is the application of green chemistry and green engineering, one of the most exciting fields of technology, which is supposed to transform the way that everything in the world is manufactured.

1.2 Objectives

The overall objective of the study is to conduct feasibility study by summarizing the overview of the status of the application of green technology (GT) in selected member countries of APCAEM.

The specific objectives are:

1) Identifying appropriate technology suitable for income generation through sustainable agriculture i.e., ecological agriculture, rural renewable energy, etc;
2) Examining the impact and implications of national policies for making recommendations for the extension of appropriate technology;
3) Diagnosing policy-level impact of GT on rural income generation under the sustainable agriculture development framework;
4) Reviewing the challenges and available policy options for the adoption of GT

1.3 Green Technology and Their Inter-linkages

Studies have shown that energy costs would become the second highest cost in 70% of the world's data centres by 2009 *(http://www.compelts.co.uk/index.php).* In tomorrow's world, businesses that ignore environmental impact and don't reform business processes and working practices will be less credited.

For several environmentally-sensitive projects, the environmental impact assessment have been made mandatory by the respective governments to identify, estimate, evaluate and mitigate the biophysical, social, and other relevant effects of development projects.

The wastewater and sewage disposal has been major threat to human health in developing Asia. The liquid waste discharged by domestic residences, commercial properties, industry or agriculture generates potential contaminants and concentrations that to some extent is minimised or recycled in the developed world. It necessitates the adoption of available and affordable technology for renewable energy including sunlight, wind, rain, and geothermal heat, which are naturally replenished. The technologies that are available are solar power, wind power, hydroelectricity/micro hydro, biomass and biofuels for transport. The importance for considering primary energy use (includes both renewable and non-renewable energy contained in raw fuels) is because about 13 per cent of world's primary energy comes from renewable sources, most of which comes from traditional biomass like wood-burning *(http://en.wikipedia.org/wiki/Renewable_energy)*. The understanding of these energies helps us devise policies for sustainable development, which includes environmental sustainability, economic sustainability and socio-political sustainability.

Environmental technology is the key to conservation ecology, a science of protecting biological diversity. Conservation ecology also termed as conservation biology refers to the application of science to the conservation of genes, populations, species, and ecosystems.

The laws and regulatory measures are in operation to restrict activities that causes damage to habitat or wildlife by setting aside wildlife reserves, parks and other conservation areas. In conservation, sustainable development is allowed, however, under preservation, it is completely the restriction.

1.3.1 Technology for Environment-friendly Agriculture

Widespread environmental degradation, severe poverty around the globe and the burning concerns about achieving and maintaining good quality of life were the principal factors for taking interest in intergenerational equity, in relation to access to natural resources. As most good agricultural land has already been farmed and the region have exceeded the safe limit, primarily in Asia, the natural resources availability for further farming expansion is practically exhausted. Data shows agricultural land being increased by 13 per cent in the last 30 years at the expense of lowland forests and their rich biodiversity. With virtually no reserves of land with crop-production potential, Asian Development Bank's (ADB) estimate shows that land use per person will fall from 0.17 hectares in 1990 to 0.12 hectares in 2010 *(http://www.adb.org/Documents/Conference/ Technology_Poverty_AP/adb5.pdf)*.

Furthermore, the pressure from worldwide urbanisation, manufacturing and population growth necessitates a renewed commitment to clean energy and environment solutions. The need is a balanced mix of alternative energies and the development of new technologies. The advances in solar, wind, bio-fuels and energy efficiency design has speeded up the development on technology-driven energy and cost efficiency mechanism to justify economic growth. The strength and quality of the execution of public policy determines the proper use of renewable energy by protecting environment.

There is no controversy in developing agriculture to obtain higher yield and increased income of the farmer without affecting the environment. This approach in fact, is sustainable agriculture. Sustainability has been given due consideration because in Asian countries land use has been intensified and problems such as, unplanned exploitation of the natural soil and water resources have been realised. The skyrocketing costs of energy and agricultural inputs have reduced profitability, which has severely damaged the environment. This necessitates the proper assessment of the constraints and potentials of natural resources by examining policies of respective governments, and appropriateness of agro-technologies.

The technology is a link that connects sustainability with enhanced productivity, where natural resource productivity is efficiently maintained by carefully planning the conservation and exploitation of resources such as soil, water, plants and animals. The tasks of transferring existing technology and development of cost-effective and environment-friendly biotechnology should be taken simultaneously. The development of biotechnology is recommended to properly assess socioeconomic, food security and environmental impacts for helping the poor rural communities for maintaining sustainable agriculture.

The ideal technology should be efficient, practical, cost effective and free from pollution. The sustainability factor should be looked at the ability of agricultural land to maintain acceptable levels of production over a long period of time, without degrading the environment. Some define sustainability as the maintenance of productivity under stress conditions (Gill, 1993). Agricultural sustainability in this context, should seek to maximize food production within constraints of profitability.

A UNDP and Government of China's collaborative project in arid mountains bordering the provinces of Guizhou, Sichuan and Yunnan on green technology is quite noteworthy in the sense that it helps communities and ethnic minorities in ecologically fragile and remote regions to create a new source of sustenance and to develop green energy. The production of bio-diesel by growing trees in the mountains can create a market for the oil-rich seed of the Jatropha Curcas L tree. Its widespread cultivation on barren land can lead to more fertile land and environment-friendly agriculture and ecosystem, which ultimately avoid the difficulties created by soil erosion and aridity (*http://www.undp.org.cn/modules.php*).

Box 1.1: Chinese Farm Forestry— Not Just Trees in Fields

Chinese farm forestry in Liuminying, a village south of Beijing is an interesting case for information in the context of using available resources for increasing crop yields under environment-friendly agriculture. The scientists from the Chinese Academy of Forestry (CAF) proposed the plantation of tree belts in and around the fields. The communities were provided with Paulownia and willow saplings and taught proper planting techniques. As a result, the farmers allotted more than 11 per cent of their precious land to planting trees. Later the tree covered about 17.4 per cent of the land compared to only 6.1 per cent before such initiative. It was found that even with 10 per cent less arable land, Liuminying increased its grain harvest in1993 by 38 per cent over 1990. As trees protected the crops against wind and sand storms, shed leaves to fertilize the soil and improved the micro-climate they became the most important factor for the better harvest.

Source: Zhang Dan, IDRC Reports, Vol. 23. No.1, April, 1995.

Globally, including the Asia Pacific Region, major agro-technological changes have been noticed. Such changes have been in agronomic practices; developing crop varieties with increased resistance to various diseases and pests; fertilizer-use and water conservation technology; and technologies making cultivation suitable under various agro-climatic conditions. As a reference to environment-friendly technology, organic agriculture has been considered as fastest growing fields of the food sector. Therefore, organic agriculture has become a niche market since it forms 1%-2% of the total food market share (*http://209.85.175.104/search?q=cache:IW5I3sqG3UwJ:orgprints.org/9431/01/9431_Pali_Poster.pdf+orgprints+9431&hl=ne&ct=clnk&cd=2&gl=np&client=firefox-a)* and demonstrates a popular case for organically managed land practices.

International Fund for Agricultural Development (IFAD) has conducted a study to find out the roles of organics in development programmes. It also investigates proper environment to integrate organics into future poverty reduction strategies. The organic produce has attracted the interest of farmers, governments and development agencies. IFAD study assesses organic initiatives that are diverse in terms of agro-ecological zones; product types; institutional structures; geographic areas and market orientation. Organic farming is found in harmony with the local environment using land husbandry techniques such as soil-conservation measures, crop rotation and the application of agronomic, biological and manual methods instead of synthetic inputs. Therefore, organic farming can be said as relatively a new phenomenon because the conventional farming under green revolution methods uses especially mineral fertilizers and synthetic agro-chemicals and irrigation for extracting maximum outputs. Organic agriculture is crucial for commercially oriented farmers in the context of new market opportunities in certified organic products and equally good for those poor farmers who cannot afford Green revolution approaches *(http://www.ifad.org/evaluation/public_html/eksyst/doc/thematic/organic/execsum.htm)*.

1.3.2 Agriculture Technology and Poverty Reduction

Agriculture plays a fundamental role in the economy of the least developed countries (LDCs), both in terms of size of an economic sector and element of a development strategy (Sadoulet and de Janvry 1995). It accounts for a large share of gross domestic product (GDP) (ranging from 30 to 60 percent in about two thirds of them), employs a large proportion of the labour force (from 40 percent to as much as 90 percent in most cases), represents a major source of foreign exchange (from 25 percent to as much as 95 percent in three quarters of the countries), supplies the bulk of basic food and provides subsistence and other income to more than half of the LDCs' population (FAO 2001). Since agriculture sector creates both forward and backward linkage through the income linkage, any shock in agriculture creates impact on the whole economy. Despite the importance of agriculture sector, the productivity of this sector is declining in underdeveloped countries. The per capita food production decreased by 0.8 percent in 1980's and 0.1 percent in 1990's (FAO, 2001). In the context of MDG to halve poverty by 2015, it is imperative to increase benefit from agriculture sector, as there are volumes of evidences that increased agriculture productivity is the key to reduce poverty. Continued agricultural growth is a necessity, not an option, for most developing countries, and this growth must be achieved on a sustainable basis so as not to jeopardize the underlying natural resource base or to impose costly externalities on others (Hagos, 2003). Gallup et al (1997) found that every 1% increase in per capita agricultural output led to a 1.61% increase in the incomes of the poorest 20% of the population. Thirtle et. al. (2001) concluded from a major cross- country analysis that, on average, every 1% increase in agricultural yields reduced the number of people living on less than US$1 a day by 0.83%. Hence, development of agriculture sector, defined in terms of increased production with decreased average cost, becomes prerequisite for the overall development of an underdeveloped economy.

World Bank in its World Development Report 2007 has laid emphasis to the agriculture development for poverty alleviation and has advised to put this sector in the centre of development agenda, if world wants to halve poverty by 2015. In the mean time economists have taken it as challenge to sustain and expand agriculture sector's unique poverty-reducing power. It is logical to assume that agriculture should itself be sustainable to keep and expand this power.

Sustainable agriculture integrates three main goals-environmental health, economic profitability, and social and economic equity *(http://www.sarep.ucdavis.edu/concept.htm).* Sustainability of agriculture can be maintained in various ways. The decision about which particular method or combination of methods to choose vary from country to country and region to region. Some of the common ways towards sustainable agriculture are:

a) Integrated Pest Management (IPM)
b) Rotational Grazing
c) Soil conservation
d) Water quality/wetlands
e) Cover crops
f) Crop/ landscape diversity
g) Nutrient management
h) Agro-forestry
i) Marketing

The demand for cereals in the developing country is expected to increase by 59% in next 25 years. The data shows, the growth rate in cereal yields has declined from an annual rate of 2.9% in 1967-82 to 1.8% in 1982-1994 (Janvry, Graff and et al., 2000). The need for alternative agriculture technology is thus realised to increase the yield and meet such huge demand of increasing population.

In spite of major institutional changes and dramatic achievements in food security, the developing countries in Asia still house bulk of the world's poor. The new challenge is to improve food and nutrition security at the household level, poverty reduction and sustainable agriculture. The concern is the failure of technological innovation such as Green Revolution to prevent a steady decline in the growth of yields.

It is important to understand the relationship between technological change and well being of smallholder farm households. Several literatures have shown a robust and positive effect of agricultural technology adoption on farm household well-being (*http://ideas.repec.org/p/mil/wpdepa/ 2005-14.html*). Technological change can make both the direct and indirect impact on reducing poverty. Increased production, higher gross revenues from higher volumes of sales, reduced production cost, lower yield risks, and improved natural resource management means an increased welfare to the farmers, which is the direct impact of innovation. The indirect impact is the reduced food price for net buyers, employment and wage effects in agriculture and other sectors of the economy and agriculture's contribution from foreign exchange earnings to overall economic growth.

With regards to technology, it is widely believed that alleviation of poverty depends on the sources of technology, dissemination and distribution of benefits from their adoption. This in turn, depends on the existing institutional framework, legal measures and political environment. Unless these factors are conducive and complimentary to each other, the cost of externally induced technology will be higher than the benefit from their adoption.

Mechanisation is often times treated as one of the inputs to maximize production and profit. Since mechanisation is expensive, the choice of cost-effective and suitable methods will be determined by government's overall agricultural policy. In other words, the effort should be made to create basic conditions for self-sustaining development of agricultural mechanisation. The intervention should be limited only to making adjustments to correct distortions.

Available UN publications show, new technologies when linked diligently to socio-economic and environmental issues can offer prospects for decent work and improved working conditions. As developed economies are heading aggressively for knowledge-based economy and countries in Asia still depend upon natural resources and cheap unskilled labour force, there is a threat that unless cost-effective technologies designed according to the local requirements are applied, further marginalisation in the developing world is inevitable.

The revolution in Information Technology for precision farming, applied research in understanding ecological systems as production ecology and gene revolution for advancement in biotechnology have brought about major technological changes in agriculture. However, although the technologies are available such as, the biotechnology, genetic engineering etc, the challenge is to determine the most suited and affordable technology by developing market mechanism for making applied technology competitive and sustainable (Economic and Social Commission for Western Asia, 2002).

Empirical findings have shown strong linkages between irrigation and poverty. The direct linkages operate via localised and household-level effects, whereas indirect linkages operate via aggregate or sub national and national level impacts. The benefits include: higher production; higher yields; lower risk of crop failure; and higher and year-round farm and non-farm employment. The benefits from irrigation are the opportunity for diversified cropping and switching over to high-value market-oriented production from low-value subsistence agriculture. This means an increased production can contribute to food availability and affordability to poor farmers. Since the allocation of water often times tends to be land-based, the study shows that in the short run relative benefits to the landless farmers may be poor but in both absolute and relative terms, the benefits are certain from irrigation investments. The advances in irrigation technologies, such as micro-irrigation systems, have strong anti-poverty potential (Hussain and Hanjra, 2004).

The interest for policy makers should be to assess the benefits of building institutions for the poor and their costs in failing to create assets for them. From this perspective, it is important to examine the application of technology to alleviate poverty and destitution.

In developing countries, the economic status and health is linked to the cost of food. Both the urban poor and rural poor spend about 50% of their disposable income in food (Cassman). As the developing countries are also characterised with two different scenario, the less favourable environments and high potential agro-ecosystems, the research fund in these areas should largely be directed towards diversifying and stabilizing production systems in less favourable environments where intensive cereal production is not feasible-such as, slash and burn systems in the humid tropics and subsistence cropping systems on poor soils in water-limited environments (Ibid). However, the strength of agriculture technology can be seen only when new technology makes favourable impact on economic conditions of the poor. Studies have shown a large scope for enhancing the role of agricultural technology in directly contributing to poverty alleviation. Mendola (2005) attempts to find out whether adopting a modern seed technology, for instance, causes resource-poor farmers to improve their income and decrease the propensity to fall below the poverty line? The answer is yes. The study finds a robust and positive effect of agricultural technology adoption on farm household well-being.

Global forums have unanimously agreed that technological advances have the potential to reduce poverty both in the developed and developing world. The effort needs to be made in accessing the technologies to the poor by ensuring that such innovation does not undermine the food security, health and livelihood needs of the poor. Literatures show that the rate of growth of world per capita GDP increasing by a factor of 24 with the Industrial Revolution from hardly 0.05 per cent per annum in 1000-1820 to 1.21 per cent a year from 1820 to the present (Maddison, 2001).

Some believe although technology reduces poverty, it however, is not the only contributory factor. As technology does not work in vacuum, and requires adjustments in accustomed practices, behavioural and/or organisational change is usually a *sine qua non* for realizing the full potential of new technology (Bussolo and O'Connor, 2002).

1.3.3 Green Technology and Rural Environmental Concerns

The major question today is to devise the technology that will save the environment without sacrificing growth. In the developing countries, majority live in rural areas and environmental degradation is more pervasive because of rapid deforestation, watershed degradation, loss of biological diversity, fuel wood and water shortages, water contamination, soil erosion and land degradation.

FAO considers the challenge of agriculture is to ensure people's rights to food security, at the same time the challenge also is to retain the natural resources productive for future generation. This is a difficult task because of the high rate of growth of population and declining land and water resources. This particular situation requires a shift to sustainable agriculture and rural development, which may ensure that present and future generations have equal access to the total capital of natural and human resources (*http://www.unep.org/un-env/default.asp?gegid=9*).

The financial and technological assistance to the local community has shown the task of reforestation, green farming and recycling successful in building green homeland in many countries in the world. The proper allocation of resources in development plan and annual budgets should help channelling science and technology into rural areas to support the farmers for organic farming by reducing the use of chemical pesticides and fertilizers. In Thailand, an innovative Integrated Pest Management Technique, which is conducted by mixing molasses with water and stored in open bottles to trap adult moths before they lay eggs, has dramatically eliminated the use of chemical pesticides in vegetable crops.

Degrading environment is slowing the growth in world food output. There is a less arable land available for conservation to agriculture. There is a declining trend in the productivity of agricultural inputs but the rural farmers have a compulsion to increase productivity from existing cropland. Technology, if understood as an application of knowledge for practical purposes, can be made viable to protect our planet by creating a centre of economic activity around technologies and products that benefit the environment. The need for investigating the contributions from agroecology is seriously realised in recent years. Agroecology is an approach to farming that promotes sustained yields through the use of ecologically sound farm management practices because it relies on low levels of inputs, indigenous knowledge and appropriate technologies to achieve sustainable agricultural production (Ibid).

Box 1.2: Net Income Increases by 80 Percent

Income and employment generation in the rural community has been experienced through the development of small, rural community-based, enterprises. A USAID-supported project can be taken as a success story. One small group in Lydford Moneague, a rural community in North Jamaica, pools resources and establishes the crucial linkages for community-run businesses by targeting women and disadvantaged youths to help them lead productive lives. The group brings together both the farmers and producers to produce bammies, the traditional deep-fried cassava bread through modern processing equipment. This initiative was supported through extra grants and technical assistance to improve business practices and products in rural areas. The processing equipment is believed to have increased the income by at least 80% and such income was used for the acquisition of modern farm equipment and scholarships for the poor student to go to school.

Source: Notes from USAID, Jamaica, August 30, 2007.

In Vietnam, for instance, increasing developmental activities in north have put pressures on land and water in rural agricultural areas necessitating the overuse of resources, which has contributed to environmental degradation, poor health and living conditions of farm populations. Although local communities have some knowledge about the damages, they however, lack knowledge in the environmental management in agriculture. The answer to this problem is the promotion of advanced environmental protection technologies followed by the development and execution of environmental legislation and regulations.

Provided the activities become very intense, both the traditional and modern agriculture and forestry can cause environmental degradation. The integration of agriculture and forestry with natural conditions are possible through the use of GT. Out of the 3,000 million hectares world's land surface, only 1,500 is currently used for cultivation. The reason for underutilisation is largely because of inadequate water supply, poor drainage conditions, steepness of slopes etc. This requires the need for considerable environmental protection investments and urgency of the execution of proper land management principles.

Since today's complexities in environmental deterioration is beyond science and economics alone, the remedial measures available through the existing scientific and economic instruments may be a difficult task. Empirical studies have recommended the need for the application of new innovative model to supplant the traditional decision-making methods. This new model is termed as Collaborative Environmental Planning (CEP), which is increasingly been used to solve resource issues and problems *(http://www.journaloftheoretics.com /Articles/2-1/zaki-fp.htm)*.

As environmental problem encompasses wider spectrum of socio-economic, cultural and political factors, such innovative model is recommended as a multidisciplinary approach to achieve long-term resource management and sustainability. This approach should be taken as an effort to integrate diversified disciplines and people with varying need and differences to arrive at the common solution. Such strategy may be helpful in facilitating conservation, utilisation, benefit sharing and expansion of available resources rather ceaselessly.

Americans had ranked climate change sixth out of 10 environmental concerns until 2003. It is now surprising that according to MIT Survey result of October 31, 2006 they rank climate change as the nation's most pressing environmental problems. The survey focuses on the environment, global warming and a variety of climate-change-mitigation technologies. As the climate change is ahead of ecosystems, water pollution and toxic waste in the priority list, it can be assumed that even world's top polluters acknowledge that global warming is an established problem.

The world relies on large amounts of energy. The level of dependency has increased on fossil fuels such as oil, gas and coal. The study has shown direct link between the way world produces energy and damage caused by pollution. Energy is important for sustaining the planet and therefore the task before us is to assess and utilize various sources of energy that occur naturally in the environment.

In some countries government purchasing is encouraged for the products whose contents and methods of production have the smallest possible impact on the environment (*http://www.green-technology.org/what.htm*). In recent years, much more emphasis has been given in linking environmental factors with diversified development activities. For example, the terminologies, often used as "green building", or "high performance building", and or "sustainable building" address the impact of technology on environment. It is found that energy, water, and materials are used so efficiently while constructing the structure, it not only support the longer lifetime of the structure alone, but also the health and productivity of occupants. It is believed that the impact of such structure on the local and global environment is minimal (*http://www.ncgreenbuilding.org/site/ncg//index.cfm?*).

Table 1.1: Environmental impact from intelligent products[3]

Phases	Impacts
First order effects	Increase environmental impact from an increased and more dispersed amount of ICT equipment and infrastructure. The impact will be smaller, if national and international regulation implies a reduction of the energy and resource consumption and use of hazardous chemicals during the manufacturing, the use and the disposal of the equipment.
Second order effects	Depends on the focus of environmental aspects in the development of the intelligent products and whether new and maybe more efficient products substitute less efficient products or the fleet or the stock of products among consumers increase. The focus of the optimisation is determined by governmental regulation, resource costs, customer demands etc.
Third order effects	Depends on whether the environmental knowledge base leads to competitive advantages for companies applying environmentally oriented process regulation and control, for example through governmental regulation of emissions, energy costs etc. Depends also on whether a rebound effect from the reduced energy consumption from more intelligent products induces a rebound effect, where other products are brought due to reduced energy costs.

Source: http://www.frontlinien.dk/eco/050414%20GTF%20140405%20ver4.pdf

1.3.4 Income Generation Especially to Farmers

Asia Pacific region have been experiencing massive transformation in the structure of their rural economies. For example, the benefit of such transformation in China was the success in sustaining high rate of rural transformation and speedy alleviation of rural poverty since last two decades. In East, South and South-East Asia, the first phase of transformation during early 1950s to the mid-1960s was involved in giving priority to land reform programs by developing basic physical and institutional infrastructures such as, irrigation facilities and institutional credit to the poor farmers. The green revolution was carried out during the second phase of transformation in mid-and late 60s. The third phase, during the 1980s and the 1990s was heavily involved in formulating macroeconomic reforms including structural adjustment and globalisation (Rao, 2005).

Agricultural growth supported high growth in rural non-farm sector. The technology that supported yield-increasing per hectare and labour-releasing for the employment in non-farm activities, helped increase farmers livelihood since the rise in rural demand for non-agricultural goods and timely and easy labour availability was the key factor for the

[3] The integration of electronic components into products is called Intelligent Products.

considerable growth of the rural non-farm sector. This situation contributes to the growth of rural income by raising the investible capacity of the farmer.

In the long-run growth models agriculture sector was ignored for long time by emphasizing on the industrialisation and manufacturing. The importance of examining the timing of the shift from agricultural base to industrialisation regime is currently being realised as the review shows clearly that agricultural technology has been quite successful in reducing poverty and increasing farm incomes. Self and Grabowski (2007), provide the overview of the work done by Karr and Kolavalli (1999), Mellor (2001), Thirtel (2003) and many others and justify their research hypothesis that improvements in agricultural technology are a pre-condition to, and have a significant positive impact on, long-run growth. Giovanni (2005:388) is of the view that agriculture is an industry unlike any other. He provides an empirical analysis how world agriculture has met the food needs of a six fold increase in world population over the past 200 years. It now provides food to over 6 billion people with falling real prices, and has released growing numbers of workers to the rest of the economy.

The fundamental concern of any technology is its sustainability. Some popular experiments are carried out in South Asia as a simple tool for income generation. For instance, in Bangladesh, the mobile-lady offer door-to-door services in the village by taking the water testing kit for testing of water pH. They read the water pH meter measurement and explain the status of shrimp ponds for healthy harvests. They also offer additional information to the farmer and soil pH testing is one of such services provided to crop cultivators. The mobile-lady thus connects communities to the telecentres. In the absence of mobile-lady, the farmers would either spend 2500 Taka or travel long distance to get such services (*http://www.sustainabilityfirst.org/2007/07/mobile-lady-story-of-women-empowerment.html*).

The watershed development programs have become the model of integrated genetic and natural resource management especially for dry land agriculture for raising farm income. Experiences show that such programs have improved rural livelihoods in drought-prone areas. The programme is popular since this comes as a package for rural development. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) together with other partners initiated activities with soil and water conservation and made watersheds a site for implementing integrated genetic and natural resource management (IGNRM). The introduction of improved crop varieties, construction and rehabilitation of farm ponds, introduction of innovative pest management in the watershed in Thailand, Vietnam, China and India have yielded encouraging results. ICRISAT correctly observes, while using the micro watershed as a geographical unit for soil and water conservation and management, the impact was strengthened with improved agronomical practices and diversified income generation activities. The study further shows that soil in Andhra Pradesh, Karnataka, Madhya Pradesh, and Rajasthan in India, were deficient in micronutrients such as boron and sulphur but adding these micronutrients to the soil resulted in 28 to 70 per cent increase in the yields of crops (*http://www.icrisat.org/Media/2006/media17.htm*).

1.3.5 Linking Gender Dimensions

Gender Empowerment Measure (GEM) uses variables to measure the relative empowerment of women and men in political and economic spheres of activity. Gender wise percentage share in the administrative and managerial positions and in the professional and technical positions is considered to reflect their economic participation and decision-making power.

Increasing economic dependence has restricted them to establish their own enterprises. Much of women's labour is unpaid in the APCAEM region and informal sector activities are ignored in national economic statistics. They are relatively behind men concerning training, services, equipment, and financing. This has eroded their competitiveness for generating more economic opportunities.

It is sad to note that although rural women are responsible for half of the world's food production and produce between 60 and 80 per cent of the food in most of the developing countries; their contribution to global food security is not properly recognised and is overlooked in development strategies (*http://www.fao.org/GENDER/en/agri-e.htm*). The indigenous people especially the vulnerable women who live in a risk-averse mindset and work in under-resourced and under-privileged region of Asia need to be supported by modern technology to combat fragile ecosystems and other related externalities.

The fact that women in sub-Saharan Africa cultivate almost 120 different plants in the spaces alongside men's cash crops reveals that they have fairly good knowledge about the value and use of genetic resources for agriculture. The secondary crop production such as legumes and vegetables, which have essential nutrients, has rescued the poor farmers during the lean seasons when harvest fails. Women in Asia and Africa carry major responsibility for food security, but little attention has been given to find out the impact of agriculture policy on the livelihood of women.

In most of the conflict-prone areas of the world, livelihood assets of the rural people are destroyed and social capital and natural resources have been undermined, creating problems in social support networks. Rural-to-urban migration and increasing numbers of remittance workers have increased the numbers of female-headed households by necessitating women to assume important role in agriculture. About one-third of all rural households in sub-Saharan Africa are headed by women. FAO observes, this feminisation of agriculture has placed a substantial burden on women's capacity to produce, provide, and prepare food (Ibid). Linking gender issues in policy documents to support rural women is crucial from poverty reduction and food security perspectives.

Women's engagement in diverse farm and non-farm activities such as cultivating cereal crops, secondary crops, animal husbandry, forest, post-harvest technology, etc are noteworthy. There is inadequate policy support to improve the efficiency of women's involvement in such diversified areas. A pilot Time Use Survey, which was conducted by the Central Statistical Organisation in India, indicates that 51% of the work of women that should qualify for inclusion in GDP is not recognised as such and it remains unpaid (*http://southasia.oneworld.net/article/view/117846/1/*).

Women contribute to family income through both unremunerated home labour and production for income. Low remuneration paid to women keeps their households' incomes in the poverty zone. Women in developing countries do not own land; have limited access to capital and modern technologies. They are overworked and underpaid. The priority is to guaranty complete legal equality for women in all spheres by removing discriminatory legislation and by enacting workable legislation that gives them equal rights of ownership in house, land and others.

In the context of biodiversity conservation, it is normally believed that not much thought has been given to understand and acknowledge local knowledge systems and grassroots innovations. The women have made innovative contribution to cope with the stress in conserving biodiversity and sustainably managing natural resources. The effort should be made to develop approaches to document women's knowledge and innovations with regards to conservation and management of bio-diverse resources. The approaches that address gendered issues and policies for biodiversity management can be replicated by adding value in the existing knowledge.

The quality information technology with the help of geographical information systems can be developed through mapping the local and gendered dimension of agriculture to precisely understand the site-specific information to develop appropriate technology. For instance, such detail information may be helpful to figure out the kind of responsibility to be given to men and women and provide technical assistance accordingly. In some areas, rice becomes women's crop and in other areas it is men's crop. Since women in developing countries carry children on their back, long stem rice is more appropriate for women where it is a women's crop. Similarly, where it a men's crop, short stem rice with higher yield should be the men's job (*http://www.geocities.com/margaret_grieco/femalefa/genagri.html*).

In countries where food security is largely considered women's responsibility, agricultural development becomes a complex social issue. Therefore, a proper understanding of gender dimensions with regards to the need for involving women as a leader and professional in the transfer of new technologies and practices should be recognized. Women's role ranges from managers to landless labourers in South Asia. They play a pivotal role from planting to harvesting and post-harvest operations. In India and Nepal a huge diversity of the agro-ecological system exists. Gender planning should therefore, be supported by gender/sex segregated data as an effort to create gender-sensitive agricultural data base to be integrated into the planning process.

1.4 Methodology

The study is based on both the primary and secondary sources of information. Data collected through field visit and information generated from focus group discussions on green technology is primary source of information. The literature reviewed and stated in the text of the report is the basis for secondary source.

The feasibility study attempts to identify the gaps, if there are any, in the application of Green Technology and attempts to justify their feasibility based on the results from experiments through agricultural and environmental technologies. To do this, following activities are carried out;

As reliable data on emerging technologies for sustainability assessment are still inadequate, the recommendations are largely based on qualitative methods and on an operational definition of sustainability using priority indicators.

The review of selected regulatory measures in the chosen countries is made to find out their strength and weaknesses to facilitate GT initiative and recommendations are made to develop favourable regulatory frameworks for the further development of GT.

1.4.1 Selection of Technology

In general, the seven criteria have been proposed to judge the appropriateness of technology by Robert C. Wicklein in his paper entitled, "Design Criteria for Sustainable Development in Appropriate Technology: Technology as if People Matter" (*http://www.iteaconnect.org/ Conference /PATT/PATT14/Wicklein.pdf)*. The issues have been analysed in the present study by linking the strength or weaknesses of the stated technological applications to find out if they help in meeting the stated objectives. In other words, the current study attempts to use most of these criteria while assessing the technology for sustainable development.

a) **System Independence**: It is the ability of the technological device to stand alone for doing the required job. Whether the technology will require relatively more capital or labour will be analysed to check system independence of the technology. Since all three country covered in the study are developing country with high population pressure and unemployment, labour intensive technology will be system independence on the ground of cost. It is also kept in mind that required input for the technology is available or not.

b) **Image of Modernity**: People should perceive themselves as modern by adopting the technology. The message is people's realisation that technological device can elevate the user's social status as well as need a basic human need. Image of modernity requires that the social status of people who adopt it either increases or remains unchanged. Although social status is contextual and is quite difficult to measure, it is common in all three countries that people who are member of social organisations have high social status. It has also been found that the people who are engaged in formal organisation are more likely to adopt new technology. A study carried out by Yokoyama and Ali (2006)[4] found that Malaysian rice farmers who are members of formal organisation produce more rice. Similarly, Adhikari (2006) found that farmers with membership in social organisation have more probability to adopt new technology. Similar evidences are available for India as well. Hence to check image of modernity, effort is made to analyze whether there is any probability that people with membership in formal organisation refuse to adopt the technology.

c) **Individual Technology vs. Collective Technology**: It is the criteria to look into the societal/cultural standards in which the technology operates. In other words, it is the careful assessment of the technology that is based on group approach and becomes more system dependent. A society geared towards individual or single family unit will need more system independent technology. Collective technologies are more easily adopted as collective action reduces transaction cost. The success story of community forest in Nepal is an evidence to prove that collective technology relatively becomes more successful. Similar situation has been experienced in Malaysia and India.

d) **Cost of Technology**: Affordability of the technology is an important indicator for their wider use since cost is the major factor in encouraging or discouraging the application of appropriate technology in developing economies. Although the level of cost is high or low is a relative concept, in all three countries labour is relatively cheaper than capital, and therefore, labour-intensive technologies are less costly.

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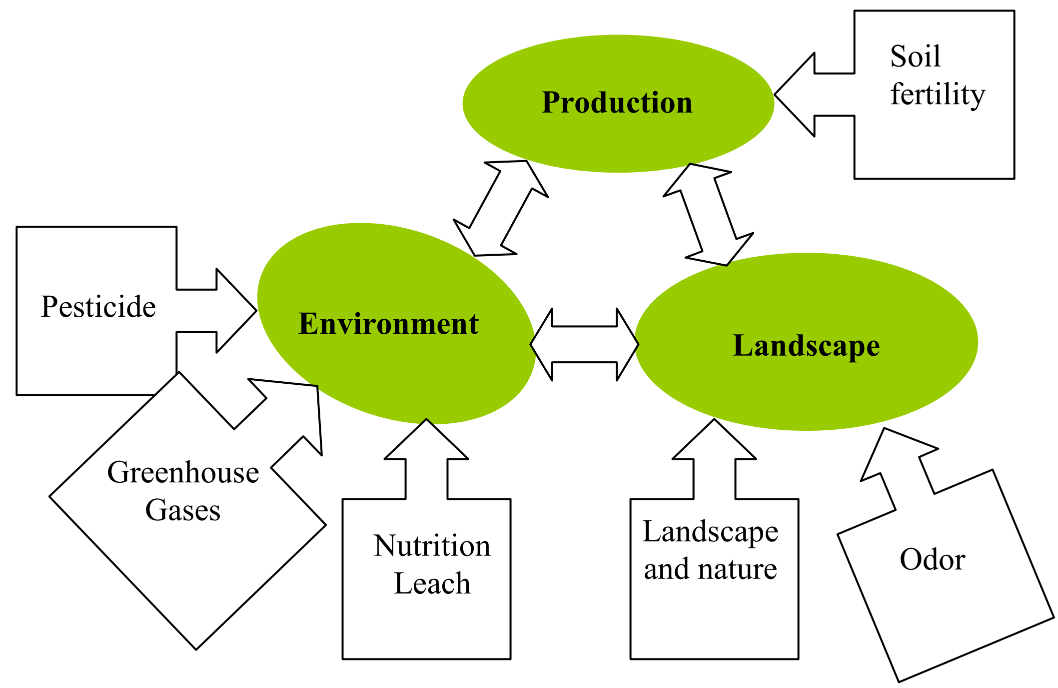
4 Yokoyama, Shigeki and Abu Kasim Ali.(2006).Social Capital and Farmer Welfare in Malaysia. Poster paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

e) **Risk Factor**: It is an important factor to find out how smoothly technology works in the local production system and the supportive system that explains to what degree is the technology *system dependent or system independent*. This indicates the need for understanding two types of risk- both the internal and external risk. Although analysis of risk is necessary before applying new technology, it is almost impossible to remove all risks. In this analysis risk is considered on the basis of change in income level of people. If there is possibility of decreasing the income level of people then that technology will be more risky.

f) **Evolutionary Capacity of Technology**: If the chosen device is static it will relatively reflect the short-lived solutions to a much larger problem. The technology, which supports the continuation of development by enhancing capability to expand, can be expected to compete at the regional, national and international level.

g) **Single-Purpose and Multi-Purpose Technology:** In contrast to single purpose technology, multipurpose technologies are the ones that furnish a variety of applications (e.g. a tiller that can be used for tilling the land, powering water pump, and drying rice).

According to Borch et.al. (2004) "The future environmentally friendly farming technologies are assessed and chosen in accordance with their contribution on three areas, where operating economical plans, green accounts and nature plans are treated equally." Components of Green Technology can be explained as shown in figure1.



Production, Environment, Landscape and Nature Values – Constitute A Unity When Green Technologies Are Selected For Future Agricultural Systems

Figure 1.1: Three bottom lines

Source: Adopted and modified from Borch et.al. (2004)

Thus any green technology is evaluated on the basis of its contribution on three bottom-line areas- environment, production and landscape and nature values. Furthermore, selected technology is identified for its contribution to the factors discussed in section 1.2.

1.4.2 Situation Analysis

The situation analyses of selected technologies in selected countries are made to find out how they are working, what are the costs and benefits and how the system can be sustained. In our analysis following factors are considered;

a) **Current Performance:** Performance of the technology is explained on the basis of their success and failure stories. The current performance has also been assessed on the basis of percentage share of population adopting particular technology.

b) **Policy:** Current government policy towards such technology has been identified. The review of selected regulatory measures in the chosen countries is made to find out their strengths and weaknesses to facilitate GT initiative and recommendations are made to develop favourable regulatory frameworks for the further development of GT.

c) **Cost-Benefit:** Cost-Benefit analysis of the technology has been carried out. A detailed cost-benefit analysis with valuation in quantitative technique is not possible due to time constraint. So components of costs and benefits along with risk factors and externalities have been identified.

d) **Performance Indicator:** The performance and sustainability of the technology has been reviewed. Therefore, the operational, technical, economical and environmental aspects of the selected technology have been considered.

1.4.3 Expected Output

The study involves consultation with stakeholders, community, users, and others to properly assess the overall value of the application of GT. The extension of environmentally-sustainable conservation agriculture through awareness creation in agronomic, economic and environmental benefits is achieved through interaction amongst agricultural experts, administrators/policy makers and farmers. The situation analysis of GT in general in the APCAEM region and evaluation of the good practice model of the application of GT in selected areas in the proposed countries, namely; India, Malaysia and Nepal is expected to have produced the practical guidance for policy decisions in the subsequent phase (II) of the project with regards to the development and delivery of best practice model.

Chapter Two

STATUS OF GT IN APCAEM MEMBER-COUNTRIES (NEPAL, INDIA AND MALAYSIA)

One of the goals of green initiative is conserving energy. Energy-efficient technology is not only environment-friendly; it is also job creator. As soon as the demand for green IT is increased, it becomes a potential source of numerous, high-paying jobs. In some of the countries the local government have been initiating "Green Vision" to power nearly the entire city with renewable and efficient energy technologies. In California, the government has already mandated that all of its public utilities must generate 20 per cent of their power from renewable sources by 2010 (*http://www.govtech.com/gt/268814*). The California Public Utilities Commission intends to raise that threshold up to 33 per cent by 2020.

The world is realizing country-specific budgetary constraints and the failure of development assistance to make poor people's life better. For this obvious reason, development critiques have been asking the question "can development be exported"? Therefore, the big hope of utilizing indigenous local resources is green technologies. This alternative can be sustainable, generates employment and increases income. The example of potential wealth and the future of GT in the existing resources of developing countries can be illustrated as below from recent IDRC report.

"Among animal products, we find meat of course, but also leathers and hides, gelatin and steroids. The realm of minerals produces oil and industrial materials, but also precious and semi-precious stones, fertilizers, and clays. The plant kingdom offers the greatest and most varied range of possibilities: medicinal or aromatic herbs, plants and yield dyes or steroids-quite apart from those that are staples of human sustenance" *((http://archive.idrc.ca/books/ reports / v231/overview.html)*.

Globalization has contributed to the decline in the demand for cereals and pulses in food basket. There is a higher demand for high-value crops such as fruits, vegetables, milk, meat, livestock products, egg, fish and other processed commodities. High transaction costs per unit of output and tough conditionality of importing countries have undermined the gains from agricultural trade. The selected countries in the study lack both the required regulatory measures and adequate technology.

Absence of appropriate technology has limited the scope for getting benefit from productive resources such as land and water, and financial services. The technology is needed for increasing productivity and raising farmer's income. It is difficult for the smallholders with less than two hectares of land to sustain their livelihoods by growing staple food grains. The answer is the diversification into other high value crops and energy crops, or medicinal herbs and aromatic plants, which are less environmentally invasive. Given the technological support, smallholders with high labour-to-land ratio may be in advantageous position in high-value agriculture, which usually requires more labour.

First, only agricultural growth has not guaranteed the eradication of poverty and creating additional employment opportunities for generating rural income. Secondly, producing food in sufficient quantity may not open up global market unless the competitiveness of agriculture is increased by developing value-added foods based on higher quality standards and improved processing techniques.

It is noteworthy that transformation of the structure of output has been accompanied by the decline in the share of employment in agriculture in APCAEM region. The process of transformation of the structure of production across sectors through commercialization and diversification has helped countries to move gradually from subsistence food-crop production to a diversified market-oriented production system.

But the misuse of modern farming inputs has created serious environmental degradation particularly soil degradation and deforestation in the green revolution areas. The challenge is to blend modern science and technology with traditional knowledge base. As an example, affordable eco-friendly technologies for sustaining growth can be possible through the technology in converting urban waste into wealth.

An increase in production is possible through technologies that are profitable and environmentally benign. The challenge is therefore to achieve agricultural growth through the green technology along a sustainable path. This reality has speeded up the innovation and diffusion of environmentally-sustainable conservation agriculture (CA). The genetic modification of micro-organisms through the biotechnology can make agriculture competitive.

Green biotechnology is biotechnology applied to agricultural processes. The example is an organism designed to grow under specific environmental conditions or in the presence (or absence) of certain agricultural chemicals. It also tends to produce more environmentally friendly solutions than traditional industrial agriculture. An example of this would include a plant engineered to express a pesticide, thereby eliminating the need for external application of pesticides.

South Asia faces constraints in the governance of biotechnology. Therefore, the regulatory measures need to be strengthened for the effective management of bio-safety. India initiated biotechnology as a tool for the growth of agriculture and health sectors since the Sixth Five Year (1080-85) Plan period.

Biotechnological intervention in India has contributed to sustain cotton production. The development of virus-free potato seed, banana and micro-propagation of sugarcane through tissue culture has become possible through biotechnology.

In Nepal, biotechnology policy focuses on food security and poverty alleviation. As this policy largely emphasizes on the agriculture sector, the government intends to provide easy and affordable access to biotechnology products and appropriate inputs such as biofertilizers etc to the agriculturists. In principle, biotechnology should mean recombinant DNA technology and tissue culture for the development of improved products; its application is however, limited to tissue culture propagation of few economic plants such as, potato, banana, citrus and the development of animal vaccines.

Nepal is the signatory of the United Nations Framework Convention on Climate Change (UNFCCC). Although Nepal is one of the lowest contributors in South Asia of greenhouse gas emissions, the need is to reduce increasing local pollutants and improve energy performance. Nepal can learn low-cost green technology through capacity-building programs with assistance from related UN agencies. Although very recent glacial lake out-brust such as Chho-Rolpa in Nepal is believed as the result of global climate change, inadequate studies on the vulnerability assessment for climate change has left room for guess work.

Dhakal (*http://www.iges.or.jp/en/ue/pdf/dhakal/dhakal_NEA1.pdf*) has made the estimation of greenhouse emissions from the fuel combustion in Nepal. The United States Country Studies Programme (USCSP) also states that GHG inventory was constructed, the mitigation options of GHG emissions in energy sector was identified and vulnerability assessment for water resources and agriculture were carried out. The result shows that GHG emissions and per capita GHG emissions for Nepal is relatively very small in the region and within APCAEM member countries. One of the reasons for low GHG emissions is negligible percentage share of thermal (diesel and coal) power generation, the major contributor of GHG emissions, in Nepal.

Table 2.1: Structure of energy consumption, Nepal

Thousand tonne of oil equivalent

Energy Sources	**2003/04**	**2004/05**	**2005/06**	**2006/07∗**
Traditional	7,397	7,558	7,278	4,852
Fuel wood	6,591	6,733	6,454	4,303
Ag. Waste	319	328	471	314
Animal Dung	487	497	353	235
Commercial	1,059	1,014	1,149	766
Coal	171	152	672	448
Petroleum	747	705	261	174
Electricity	141	157	216	144
Others	45	45	52	35
Total	**8,501**	**8,617**	**8,479**	**5,653**

∗ Estimate of first eight months
Source: Economic Survey, 2006/07

Also in case of CO_2 emissions, Dhakal has conducted some studies in Kathmandu Valley. The result shows, although the volume of CO_2 emissions from passenger transportation is relatively small in the valley compared to other developed regions of the world, it has increased in 2004 by 5.2 times since 1989 and is estimated to double by 2025 from 537 thousand tons in 2004 (*IGES, 2007*).

Nepal is overwhelmingly an agricultural country with more than three-fourth of its people adopting agriculture as their occupation. Nepalese agriculture is heavily based on forest. Traditionally, there has been close link between agriculture, forest and livelihood of Nepalese poor. Developments in renewable energy sector of Nepal offer opportunity of cross cutting amalgamation of rural (renewable) energy sector and agriculture sectors. Examination of the possible nexus can suggest strategies for green and sustainable agriculture.

Inter-linkages between renewable energy and agriculture in Nepal can trigger increase in agricultural productivity; reduce consumption of depletable natural resources and imported fossil fuel, increase value of rural production and increase in rural agro-business activities.

Table 2.2: Status of alternative energy and biogas (in Numbers)

Activities	Progress in FY 2004/05	Progress in the first 8 months of FY 2005/06
Distribution of solar dryer and cooker	294	78
Establishment of Biogas plant	17,478	23,330
Maintenance of old plants	26,040	13,620
Establishment of cottage solar system	11,928	14,611
Establishment of improved water mill	779	678
Production of micro hydropower	717	1,199

Source: Economic Survey, FY 2005/06, Kathmandu.

To develop the regional and global competitiveness, Malaysia is commercializing the technologies through the Bio-valley Strategic Plan. As biotech thrives on innovation, the Bio-valley is a centralised development area for biotech with incentives for entrepreneurial culture, cooperative development, and collaboration between academic institutions, industry, and investors both within Malaysia and overseas *(http://www.nbbnet.gov.my/plan.htm).* The aim of biotechnology policy is to transform and enhance the value creation of the agricultural sector and make impact on human life and economic progress. Under this policy the scientists are actively engaged in fermentation based activities, production of valuable biologicals, plant or animal cell culture, value addition, and genetically superior planting materials *(http://www.dbtindia.nic.in).*

The comparative status of major energy and economic indicators in Asia and world is given in Table 2.3.

Against the view that natural gas prices are linked with crude oil prices, the Asian Energy Outlook 2020 assumes that they would not rise as fast as crude oil prices because of the supply capacity supported by new projects and more flexible price determination methods. The report also documents historical trend that coal prices do not have a strong correlation with crude oil prices.

World primary energy consumption increased by 1.7 per cent during 1980-2000. It is now expected to increase at an average annual rate of 2.1 per cent (13.6 billion oil-equivalent tons) over the forecast period i.e., 2000-2020. This increase is 15 fold from the 9.1 billion tons in 2000.

Coal, oil and natural gas are supposed to contribute about 90 per cent of the increase in primary energy consumption indicating the major role in energy sources. Consumption of natural gas will increase at the average annual rate of 2.6 per cent, the highest among the fossil fuels.

Table 2.3: Major energy and economic indicators

	Asia			World		
			AGGR (%)			AGGR (%)[1]
	2000	2020	2000-2020	2000	2020	2000-2020
GDP (billion s of US dollars at 1995 value)	9,361	17,805	3.3	34,251	58,570	2.7
GDP (developing Asia*)	3,673	10,432	5.4			
Population (millions)	2,423	4,570	3.2	9,057	13,593	2.1
Primary energy consumption (millions of tons of oil equivalent; Mtoe)						
Coal (Mtoe)	1,049	1,811	2.8	2,325	3,489	2.0
	(43%)	(40%)		(26%)	(26%)	
Oil (Mtoe)	938	1,720	3.1	3,494	5,072	1.9
	(39%)	(38%)		(39%)	(37%)	
Natural gas (Mtoe)	237	598	4.7	2,107	3,490	2.6
	(10%)	(13%)		(23%)	(26%)	
Final energy consumption (Mtoe)	1,511	2,826	3.2	6,103	8,900	1.9
Transportation sector (Mtoe)	346	786	4.2	1,781	2,730	2.2
	(23%)	(28%)		(29%)	(31%)	
Power sector (Mtoe)	276	619	4.1	1,088	1,935	2.9
	(18%)	(22%)		(18%)	(22%)	
CO_2 emissions (millions of tons of carbon-equivalent; Mt-C)	1,975	3,627	3.1	6,507	9,852	2.1
GDP per capita of population (US dollars at 1995 value/person)	2,818	4,348	2.2	5,544	7,596	1.6
Primary Energy consumption per capita of population (toe/person)	0.73	1.12	2.1	1.47	1.76	0.9
Primary Energy consumption per unit of GDP**	259	257	-0.04	264	232	-0.65
CO_2 emissions per unit of GDP***	211	204	-0.18	190	168	-0.61
CO_2 emissions per unit of primary energy consumption ****	0.815	0.794	-0.13	0.718	0.725	0.04
Automobile ownership volume (millions of vehicles)	140	336	4.5	757	1,222	2.4
Automobile ownership volume per thousand of population (vehicles per thousand of population)	42	82	3.4	123	159	1.3

[1] *Average Annual Growth Rate (AGGR) (%)*

**Asia excluding Japan*

** toe/millions of US dollar at 1995 value*

**** t-C/millions of US dollar at 1995 value*

***** t-C/toe in parentheses percentage shares of totals*

Source: RIS, 2005

The world oil consumption will also increase at the rate of 1.9 per cent. Because of the expansion of economic activities, the Asian countries will have to depend heavily on the

Middle East for the supply of oil. As Asia has ample supply capacity for natural gas and coal, the region requires utilizing coal and nuclear power alongside natural gas to guarantee the stability of oil supply.

An overview of the status of world primary energy consumption can provide us some insights about trend and direction of energy consumption for making appropriate recommendations to maintaining global consumption standards and formulating country and or region-specific regulatory measures (Table 2.4).

Table 2.4: World primary energy consumption (by Region) (Unit: Mtoe)

	Actual		Forecast		AAGR (%)			
	1990	2000	2010	2020	2000/ 1990	2010/ 2000	2020/ 2010	2020/ 2000
North America	2,137	2,555	2,863	3,196	1.8	1.1	1.1	1.1
	(27.4)	(28.2)	(25.9)	(23.5)				
Central and South America	382	526	710	980	3.2	3.0	3.3	3.2
	(4.9)	(5.8)	(6.4)	(7.2)				
OECD Europe	1,624	1,764	1,953	2,116	0.8	1.0	0.8	0.9
	(20.8)	(19.5)	(17.7)	(15.6)				
Non-OECD Europe	1,468	1,001	1,197	1,385	-3.8	1.8	1.5	1.6
	(18.8)	(11.1)	(10.8)	(10.2)				
Africa	201	259	336	455	2.5	2.7	3.1	2.9
	(2.6)	(2.9)	(3.0)	(3.4)				
Middle East	224	385	492	703	5.6	2.5	3.6	3.0
	(2.9)	(4.3)	(4.5)	(5.2)				
Asia	60	2,423	3,335	4,570	3.9	3.2	3.2	3.2
	(21.2)	(26.8)	(30.2)					
China	673	932	1,406	2,063	3.3	4.2	3.9	4.1
	(8.6)	(10.3)	(12.7)	(15.2)				
Japan	439	525	543	561	1.8	0.3	0.3	0.3
	(5.6)	(5.8)	(4.9)	(4.1)				
India	187	322	452	684	5.6	3.4	4.2	3.8
	(2.4)	(3.6)	(4.1)	(5.0)				
Other Asian countries	361	644	934	1,263	6.0	3.8	3.1	3.4
	(4.6)	(7.1)	(8.4)	(9.3)				
Oceania	102	129	149	166	2.4	1.4	1.1	1.3
	(1.3)	(1.4)	(1.3)	(1.2)				
Other regions	14	15	18	22	0.9	1.7	1.9	1.8
	(0.2)	(0.2)	(0.2)	(0.2)				
OECD country total	4,517	5,317	5,981	6,633	1.6	1.2	1.0	1.1

	Actual		Forecast		AAGR (%)			
	1990	**2000**	**2010**	**2020**	**2000/ 1990**	**2010/ 2000**	**2020/ 2010**	**2020/ 2000**
	(57.8)	(58.7)	(54.1)	(48.8)				
Non-OECD country total	3,293	3,740	5,073	6,961	1.3	3.1	3.2	3.2
	(42.2)	(41.3)	(45.9)	(51.2)				
World total	**7,811**	**9,057**	**11,053**	**13,593**	**1.5**	**2.0**	**2.1**	**2.1**
	(100.0)	**(100.0)**	**(100.0)**	**(100.0)**				

Note: Figures in parentheses indicate percentage shares of totals.
Based on data from "Energy Balance of OECD countries" and "Energy Balances of Non-OECD Countries, "IEA; forecast figures prepared by the IEEJ.
Source: (RIS, 2005)

The increasing demand in energy, clean water, improved health and good standard of living can be addressed through environmentally preferable processes that offer cleaner, renewable and more efficient products and services creating zero waste. At the initiation of ESCAP there is increasing interest in Asia and the Pacific region to apply green growth approach. The environmental suitability of economic growth for the improved well-being of all is the major aim and therefore ESCAP has been focusing on the capacity building measures and tools for the application of green technology. To facilitate such green growth in the region, the capacity building activities have been worked out under the Strategic Framework Programme for the biennium 2008-2009. ESCAP has emphasised following five major areas:

a) Promotion of green taxation and budget reform
b) Development of sustainable infrastructure
c) Promotion of sustainable consumption, including demand side management
d) "Greening" of the market and promotion of green business
e) Development of Eco-efficiency Indicators (EEI)

Series of activities carried out by APCAEM on green agriculture technology is therefore, directed towards achieving aforementioned priority areas.

The use of alternative technologies will not only reduce the dependency on imported oil, but also create employment opportunities. The review shows that some technologies are in the stage of capability demonstration- others are in use, and could be readily adopted on a large scale. Besides the growing potential of solar-thermal electricity generators, feasibility studies are underway to look into the possibility of space-based solar power. The bottom-line of the competitiveness among nations is the level of present energy consumption and their future estimates. To compare Asia with global energy consumption level, see the following table:

Table 2.5: Primary energy consumption in Asia (by Region) (Unit: Mtoe)

	Actual		Forecast		Average Annual Growth Rate (%)			
	1990	**2000**	**2010**	**2020**	**2000/ 1990**	**2010/ 2000**	**2020/ 2010**	**2020/ 2000**
China	673	932	1,406	2,063	3.3	4.2	3.9	4.1
	(40.5)	(38.5)	(42.2)	(45.1)				
Japan	439	525	543	561	1.8	0.3	0.3	0.3
	(26.4)	(21.7)	(16.3)	(12.3)				
South Korea	93	191	262	303	7.5	3.2	1.5	2.3
	(5.6)	(7.9)	(7.9)	(6.6)				
India	187	322	452	684	5.6	3.4	4.2	3.8
	(11.3)	(13.3)	(13.6)	(15.0)				
Indonesia	52	98	144	209	6.5	3.9	3.8	3.9
	(3.1)	(4.1)	(4.3)	(4.6)				
Taiwan	48	83	110	132	5.6	2.9	1.9	2.4
	(2.9)	(3.4)	(3.3)	(2.9)				
Singapore	13	25	36	48	6.3	4.0	2.9	3.4
	(0.8)	(1.0)	(1.1)	(1.1)				
Malaysia	20	47	74	110	8.7	4.6	4.0	4.3
	(1.2)	(1.9)	(2.2)	(2.4)				
Philippines	18	33	57	96	5.9	5.6	5.5	5.5
	(1.1)	(1.4)	(1.7)	(2.1)				
Thailand	29	58	89	145	7.3	4.4	5.0	4.7
	(1.7)	(2.4)	(2.7)	(3.2)				
Vietnam	5.8	14	33	54	9.5	8.7	5.2	6.9
	(0.3)	(0.6)	(1.0)	(1.2)				
Hong Kong	11	15	18	20	3.8	1.7	1.1	1.4
	(0.6)	(0.6)	(1.0)	(1.2)				
Other Asian Countries	71	80	111	144	1.2	3.4	2.6	3.0
	(4.3)	(3.3)	(3.3)	(3.2)				
Asian total	**60**	**2,423**	**3,335**	**4,570**	**3.9**	**3.2**	**3.2**	**3.2**
	(100.0)	**(100.0)**	**(100.0)**	**(100.0)**				
Developing Asia	**21**	**18**	**2,792**	**4,010**	**4.5**	**3.9**	**3.7**	**3.8**
	(73.6)	**(78.3)**	**(83.7)**	**(87.7)**				

Note: Figures in parentheses indicate percentage shares of totals. Based on data from "Energy Balance of OECD countries" and "Energy Balances of Non-OECD Countries, " IEA; forecast figures prepared by the IEEJ.

Source: (RIS, 2005)

Malaysia represents a vibrant economy with growing industrial sector and strong natural resource portfolio. Mining, energy (commercial) and agriculture (palm oil, sugar, rice, and rubber wood) are competitive products of natural resource economy. Malaysia initially relied overwhelmingly only on tin and rubber. It is a broad-based and diversified economy now, which is world's 19^{th} largest trading nation. The government plans to revitalize agriculture sector as the third pillar of economic growth. It is a leading palm oil producer and exporter where Biofuel Bill has been passed in 2007 to promote bio-diesel industry.

By 2020 Malaysia intends to assume full industrial development. It has been achieving a sustained growth of 9 per cent per annum. As the demand for energy is increasing rapidly largely because of the industrialisation and commercialisation, the challenge is to sustain efficient supply of energy at economically acceptable cost. Accordingly concerns on energy and environment entities are expected to increase in domestic policy and politics. Also important is the analysis of the impact that biofuel production can have on Malaysian agricultural sector. Agro-business has been facilitated as an alternative activity. Higher value added of the agriculture sector was estimated to expand by 3.1% in 2007 (MOF, 2007).

Table 2.6: Primary commercial energy supply in Malaysia (Percent)

Source	**1995**	**2000**	**2005**
Crude Oil & Petroleum Products	54.3	53.1	50.8
Natural Gas	35.5	37.1	39.9
Hydro	5.0	4.4	3.4
Coal & Coke	5.2	5.4	5.9
Total (PJ)	**1294.0**	**1674.0**	**2375.0**

Source: http://www.cogen3.net/presentations/asean/malaysia_energy_situation.pdf

Selected statistical information is given below to show the level of technology indicators for the year 2002:

Table 2.7: Agricultural sciences and technology indicators-snapshot data, Malaysia (Year 2002)

Agricultural workforce		**Agencies**
Total agricultural R&D researchers (in full time equivalents)		
Public	1,117.6	20
Private	91.5	16
Public researchers by degree level (shares)		**20**
PhD	31.4%	
MSc	40.9%	
BSc	27.7%	
Public female research staff (shares)		**18**
PhD	22.4%	
MSc	32.7%	

Agricultural workforce		Agencies
BSc	48.0%	
Total	*33.9%*	
Support-staff-per-scientist ratios		**18**
Technical	1.8	
Administrative	1.1	
Other	1.7	
Total	*4.6*	
Total agricultural R&D expenditures in million 2000 local currencies (Ringgit)		
Public	633.4	20
Private	33.5	16
In million 2000 PPP dollars		
Public	385.4	20
Private	20.4	16
Sources of financing, government agencies (shares) government	**56.2%**	**11**
IRPA	9.3%	
Cess	27.2%	
Other	7.3%	
Research focus of public and private research staff (shares)		**35**
Crops	55.6%	
Forestry	14.3%	
Livestock	10.7%	
Fisheries	6.7%	
Post harvest	6.5%	
Other	6.2%	
Main crops: oil palm (39.8 %), fruits (17.2 %), rice (9.5 %), rubber (9.2 %), vegetables (8.4%), and ornamentals (5.6 %)		
Main livestock items: beef (23.5 %), dairy (23.5 %), poultry (19.0 %), and sheep and goats (16.4 %)		

Source: IFPRI Website

It is true that technology has dramatically influenced a broader gamut of human life. Because of its advantages of becoming more precise, predictable and efficient, modern biotechnology especially in agriculture has helped to do things that people could not do before. To give some examples, the technology has produced first generation of Genetically Modified (GM) crops such as herbicide-tolerant and insect-resistant crops. The examples of second-generation plants are the nutrient content like vitamin A-enriched rice and oils that have improved lipid profile. The third generation plants are being developed to provide specific health benefits *(http://findarticles.com/p/articles/mi_qn6207/is_/ai_n24373048).* Although we find complaints about the health and environmental problems from GM crops, it has not yet been proved. Instead, the benefit of technology is much higher since it can contribute to increasing GDP, protecting biodiversity from excessive expansion of agricultural land and safeguarding human and animal health by reducing the use of agrochemicals. The Malaysian government has given priority to agricultural technology especially on the economic benefit from GM crops to reduce food import bill. The technology has already shown the improvements in promoting cocoa and pepper, tropical fruits, flowers and forest trees in terms of yield, disease resistance, shelf-life, colour and quality.

With its gas reserves estimated to last for 33 years and oil reserves available until next 19 years, the need for strengthening renewable energy has been given due consideration *(http://www.innovasjonnorge.no).* Furthermore, as part of 2020 vision Malaysia has vowed to increase share of sustainable energy with target of 20% needs being met by renewable energy. Malaysia's commercial demand for energy created largely by industrialisation is projected to continue its upward trend, from 1,244 Petajoule (PJ) in 2000 to an estimated 2,218 PJ in 2010. At present, the energy supply mix in the country is made up of gas (70%), coal (22%), oil (2%) and hydropower (6%).

Although petroleum products are the main source of energy consumption, its share in total energy consumption is declining and the consumption of natural gas is in increasing trend largely because of the Fuel Diversification Policy. See table below:

Table 2.8: Final commercial energy demand[1] by source (2000-2010)

Source	**Petajoules[2]**			**% of Total**			**Average Annual Growth Rate**	
	2000	**2005**	**2010**	**2000**	**2005**	**2010**	**EMP**	**NMP**
Petroleum Products	820.0	1,023.1	1372.9	65.9	62.7	61.9	4.4	6.1
Natural Gas[3]	161.8	246.6	350.0	13.0	15.1	15.8	8.8	7.3
Electricity	220.4	310.0	420.0	17.7	19.0	18.9	7.1	6.3
Coal and Coke	41.5	52.0	75.0	3.4	3.2	3.4	4.6	7.6
Total	**1,243.7**	**1,631.7**	**2,217.9**	**100.0**	**100.0**	**100.0**	**5.6**	**6.3**
Per Capita Consumption (giga-joules)	**52.9**	**62.2**	**76.5**				**3.3**	**4.2**

Notes: 1 Refers to the quality of commercial energy delivered to final consumers but excludes gas, coal, and fuel oil used in electricity generation

[2] Joule is the unit of energy to establish the equivalent physical heat content of each energy form. One megajoule= 10^6 joules and one petajoule (PJ) = 10^5 joules. One PJ = 0.0239 million tones of oil equivalent (mtoe). One toe = 7.6 barrels.

[3] Includes natural gas used as fuel and feedstock consumed by the non-electricity sector.

Source: Ministry of Energy, Water, and Communications and Economic Planning Unit, NMP

The Ninth Malaysia Plan (NMP), 2006-2010, builds on the commitments of The Eighth Malaysia Plan (EMP), 2001-2005, which manifested Renewable Energy as the new or "fifth" fuel, in promoting sustainable energy production and consumption. The Ninth Plan emphasizes energy efficiency both on production and utilisation by duly meeting environmental objectives. Prioritised renewable resources of the Eighth Plan were biomass, biogas, municipal waste, solar, and mini-hydro. Biomass, (oil palm, wood residue, rice husk, etc) was especially the focal point of financial incentives. The government provided tax allowances, import duty exemption, and sales tax exemptions.

Energy-related several organisations and mechanisms were created. Renewable energy initiatives for the period 2005 -2010 are parcelled in line with the thrust of the National Mission *to improve the standard and sustainability of quality of life* under the objective of *improving sufficiency and sustainability of energy supply.* Strategies of the energy sector that are congruent with renewable energy growth and promotion are:

a) Ensuring sufficiency, security, reliability, quality, and cost-effectiveness of energy supply.
b) Reducing high dependence on petroleum product by increasing the use of alternative fuels.
c) Promoting greater use of renewable energy for power generation and by industries.
d) Intensifying energy efficient initiative in the industrial, transport, and commercial sector as well as in government buildings
e) Expanding rural electrification coverage, particularly in Sabah and Sarawak.

In addition to customary renewable energies, NMP anticipates to develop palm oil based biofuel, cost effective wind, solar, hydrogen, and fuel cells technologies. Research and Development, capacity building, and knowledge sharing are also integrated in NMP.

The average daily solar insulation in Malaysia is 5.5kWh/m^2, which is equivalent to 15MJ/m^2. It indicates that the climatic conditions in Malaysia in terms of solar power are favourable for the development of solar energy due to abundant sunshine (Ibid). The solar energy is being used to generate electricity and heat. In the electricity generation sector, solar energy is converted to electricity and used in those niche areas that have not been connected to the national grid. Water heaters that use solar energy are widely used in the urban area. Clean energy technology intervention in Malaysia can result in increased agriculture revenue especially as agricultural waste would be feed for biomass energy. Energy supply diversification and reduction in emission are other probable outcomes. However, drive to increase biofuel production can risk biodiversity and food security concerns.

Energy efficiency strategy in Malaysia is noteworthy, which is provisioned under the Malaysian Energy Efficiency Improvement Project. Energy audits to identify potential energy savings in eleven energy-intensive industries such as cement; ceramics; food; glass; iron and still; pulp and paper; rubber and wood; oleo-chemical; plastic and textile are undertaken.

Surveys conducted over 2,000 manufacturing companies in Malaysia reveals that several factories have already started to save energy costs. It opens up opportunities to companies that can offer energy management services for identifying ways to save energy and costs. The Academy of Sciences Malaysia (ASM) assists in upgrading the technological capabilities and competencies in the industry. A report from USAID estimates that total energy efficiency market in Malaysia will increase to US $ 557 million by 2015 from merely US $ 167 million in 1996.

The fiscal incentives need to be strictly implemented to encourage renewable energy and energy efficiency technologies through investment tax allowance and import duty and sales tax exemption for the equipments used in energy conservation. Under the renewable energy incentives the companies intending to generate energy using biomass (palm oil waste, rice mill waste, sugar cane mill waste, timber or sawmill waste, paper recycling mill waste, municipal waste and biogas) were eligible to apply for Pioneer Status for 5 years or Investment Tax Allowance of 60% on qualifying capital expenditure incurred within a period of 5 years to be utilised against 70% of the statutory income for each year assessment.

Based on United Nations Conference on Environment and Development's (UNCED) principle of public access to environmental information, in Malaysia, the data on the quality of air and water are available on-line and on-demand basis by any individual particularly those having asthmatic and other environment-health related problems. The ICT Application in Environmental Governance in Malaysia project has proven the Best Practice in the Application of Information and Communication (ICT) for Environmental Governance. It is unique in the sense that this project is considered as the only known privatised programme for monitoring the quality and air and water on-line and on continuous basis. There are 50 Continuous Air Quality Monitoring Stations and 10 Continuous Water Quality Monitoring Stations through out Malaysia *(http://www.stockholmchallenge.se/data/ict_appl_in _environmental).* The project has accomplished following three important criteria:

a) creating greater credibility, and thus, the trust between the Government, the Industry, and the Public, on the true state of the environment;
b) providing greater transparency and accountability, and thus, instilling faith in every one concerned on the environment; and
c) raising greater awareness among all concerned of environmental issues in Malaysia and the region (Ibid).

The same source says the collection of data and dissemination has improved from about 33 per cent to over 92.5 per cent; and the unit cost has reduced from RM40 per sample to less than RM6 per sample, 85 per cent improvement in productivity, thus saving in public expenditure.

Sony Technology Malaysia Sdn Bhd (STM) is a multinational electronic company, which employs a workforce of approximately 5000 and manufactures televisions, digital versatile decoders (DVDs), and electronic components. The STM has established Green Partner Environmental Quality Approval Programme to educate the suppliers about the need for eliminating hazardous substances such as cadmium, lead and mercury from their products. This is important to meet the SS00259 technical standard for qualifying as green partner.

Energy efficiency initiatives are designed towards the reduction of the dependency on petroleum products by increasing the use of alternative fuels. Such initiatives have particularly addressed conundrums in the industrial, transport and commercial sectors as well as government buildings.

The five year Malaysian Building Integrated Photovoltaic Technology Application Project was initiated in 2005 to facilitate broad-based utilisation of photovoltaic technology in the buildings. It is believed that this will eventually create a sustainable market and possibly grid-connected photovoltaic systems.

In India, the total government funding for agricultural research and education rose to Rs. 25 billion in 2000, which was ten-fold increase over the past four-decades period. India's expenditure as percentage of agricultural gross domestic product (AgGDP) has increased during 1960s and 1980s but remained around only 0.4 per cent during 1990s. The average research intensity for all developing countries remains at 0.6 per cent, which is 1 per cent globally (ICAR, 2007). Increased need for research agenda and declining public funds has necessitated the development of alternative technology to increasing productivity and efficiency in research allocation.

Indian Council for Agricultural Research has been playing significant role in India to increasing the productivity and profitability of agriculture through its Agricultural Engineering and Technology Division. This division has five broader areas such as:

a) Farm Mechanisation,
b) Post harvest conservation and value addition,
c) Irrigation and drainage engineering,
d) Energy management, and
e) Information Technology.

The mission from such arrangement is to facilitate timely and efficient agricultural operations through the development of precision mechanisation systems. This initiative also intends to develop mechanisation systems for dry land agriculture, hill agriculture, horticulture, livestock and fisheries. The development of implements and machines suited to women farm workers has been very effective. Other thrust areas include; energy management, processing of biofuels and utilisation of non-conventional energy sources in agricultural production and processing activities and also the reduction of post harvest losses, value addition to agricultural produce and utilisation of agricultural residues and processing byproducts *(http://www.icar.org.in/agengg.htm).*

The achievements are many including the development of renewable energy technologies of solar refrigerator; low cost solar cookers and water heaters; high efficiency cook stoves; pyrolysed briquette fuel; gasifiers; liquid fuels from crop residues; biphasic digestion of agro residues; animal-operated agro-processing units; bullock- operated generator for utilisation of agricultural residues and other renewable energy sources.

The recent agricultural research acknowledges the fact that technologies have contributed to the production and promotion of people’s access to basic facilities. The technology is believed to address the principle of social inclusion while reducing poverty and hunger. Followings are the major achievements from agricultural technology:

- Food grain production increased from about 45 million tonnes in 1951–52 to over 200 million tonnes at the beginning of this century,
- Productivity of major cereals increased from 700 kg per hectare in 1961–62 to over 1700 kg per hectare by 2001–02,
- Science and technology coupled with social engineering have helped to promote conservation, restoration and commercial forestry and the regeneration of coastal mangrove wetlands,
- Rural drinking water supply has been made nearly universal through the design of simple water pumps and the application of remote sensing and hard rock drilling techniques, and

- Rural energy systems have gained enormously from scientific work related to the harnessing of biogas, biomass, solar and wind and other forms of renewable energy (*http://farastaff.blogspot.com/2008/01/measures-of-impact-of-science-and.html*).

This indicates the prospect for strengthening pro-poor environment friendly agriculture through available and cost-effective agricultural technology. In this context "Vision 2025" of the National Centre for Agricultural Economics and Policy Research is noteworthy.

Box 2.1. System of Rice Intensification: A New Approach

Paddy is a highly water intensive crop. Increasing scarcity of water even in irrigated areas has led a question-mark on continued sustainability of paddy/wheat and paddy-paddy cultivation cycle practiced in the north-west and other irrigated parts of India. Intensive water use has led to water logging, land degradation, loss of soil nutrients in large parts of the country. The yield of paddy has also stagnated over the years and currently hovers around 2.2 tonnes per hectare as the vigour of Green Revolution varieties has dissipated. Very few new paddy varieties have been brought out in recent years. The System of Rice Intensification (SRI) provides a new approach to rice cultivation which is less water intensive, saves a paddy seeds and requires lower application of chemicals and fertilizers. The SRI approach contrasts sharply with the cultivation practices propagated by Agricultural Research Systems across the world.

The Tamil Nadu Department of Agriculture is promoting SRI under "Integrated Cereal Development Program-Rice" and had targeted to cover 9000 acres under SRI in 2004-05. Acharya N.G. Ranga Agricultural University, Hyderabad has also taken up propagation if SRI on a large scale in all districts of Andhra Pradesh. In Karnataka SRI practices have been taken up by many NGOs as a part of Tank Rehabilitation Projects. Community Based Tank Management Project Consultancy Services, a Centre at the Agricultural University at Bangalore funded by World Bank have taken up SRI as a part of their Water Management component. Similar effort is currently being made in Pondichery also. PRADAN, a NGO working for the welfare of poor in largely tribal parts of the country has taken up extension of SRI in Jharkhand, West Bengal and Orissa.

The evaluation carried out by PRADAN of SRI system shows that results have been very encouraging. In 2005, it reported an average paddy production of7.7 tonnes per hectares which was 2 ½ times the district average. Of the total 163 families who took up SRI cultivation over 60 per cent reported yields in the range of 5-9 tonnes per hectare. Average straw output was also higher. The SRI has major advantages over the conventional paddy cultivation. It requires only half the water per hectare compared to conventional farming practices. This is extremely important in view of the water crises facing the country. Increased productivity leads to increase in farmers' income. As a majority of paddy cultivators are small and marginal farmers, it not only improves their income but also leads to food security and poverty reduction. As the SRI consumes less fertilizers and pesticides, it is also environment friendly.

Source: A Compendium of Best Practices towards Attainment of the SAARC Development Goals, ISACPA, SAARC, 2007.

At present, on the average, Indian population consumes 25 million BTUs (expressed in millions of BTUs per year) of energy per year and consumes about 500 cubic meters of water. The average energy consumption in the European Union is over 150 million BTUs per citizen per year, and over 500 cubic meters of water *(http://www.ecoworld.com/home/articles2.cfm?tid=416).* From the same source, Ed Ring observes, "….assume that India's per capita energy production will need to get to at least 50% of that currently enjoyed by Europeans. Taking into account projected population increases, this means India's total national energy production per year will need to quadruple from 25 quadrillion BTUs per year to 100 quadrillion BTUs per year." The technology should be the answer to avoid such eventuality.

There is a need to aggressively facilitate the use of affordable eco-friendly technologies to sustain growth. Science and technology can be harnessed to convert urban waste into wealth. Advocating the application of green technologies in five key areas of growth, Indian Prime minister Man Mohan Singh has said the labour-intensive farm sector needed new technologies to raise yields; and, at the same time, prevent degradation of scarce land and water resources. As part of the national water mission, Indian government has been promoting water-saving technologies.

In India, the demand for private transportation is alarmingly increasing because of the inadequacy of public transportation system. The development of eco-friendly and affordable public transportation solution is not therefore, a question of choice, but the need of hour.

There is a huge construction work going on in India. The concept of environment-friendly or green building needs to be adopted by developing locally relevant all-weather building technologies and construction methodologies to reduce increasing dependency on air-conditioning.

Almost 70 per cent of Indian population depends on agriculture, which is one of the energy intensive sectors. Agriculture consumes about 35 per cent of the total power generated through electrically operated pump sets. It is expected that about 30 per cent of savings is possible through appropriate technology. For example, larger valve can save fuel and power to draw water from the well. It has been shown that the farmers can save 15 liters of diesel every month by simply reducing the pipe height by 2 m. The use of good quality PVC suction pipe can save electricity up to 20 per cent *(http://www.nedcap.org/index_files/Page2210.htm).*

The agriculture sector produces foodstuff and non-food vegetable products such as tobacco, jute, and hemp that have economic value. In these processes, agriculture is linked to fertilizer production, post-harvest processing and transporting of foodstuff even before the core production processes of foodstuff. The concern in India is to reduce energy consumption while delivering the food service.

Higher energy consumption for irrigation crops can be significantly reduced through the use of more efficient pump sets (easily available technical measures to improve the efficiency of irrigation pump sets can be applied) and water-frugal farming methods.

The use of energy in pumping ground water and using farm machinery can be reduced through the application of renewable energy such as wind-driven pumps, solar drying etc.

Table 2.9: India: Projections of future energy supply potential from 'Carbon-Free' sources

Energy Source	Energy Generation Potential by 2030	Assumptions
Wind	100 Billion kwh	45,000 MW Capacity operating at 20% load factor
Biofuel	575 billion kwh	30 million hectares of land planted. Oil yield of 1.5 tons per hectares. Ethanol production of 10 billion liters from cellulose feed stocks
Hydro	400 billion kwh	84,000 MW operating at 55% load factor
Coal (with carbon capture)	Depends on how soon India develops carbon capture and sequestration technologies and identifies site for long-term sequestration.	
Nuclear	260 billion kwh	35,000 MW of nuclear power, 24,000 MW from light water reactors. Large-scale breeder and thorium reactors start after 2030 and hence share of nuclear could grow significantly after 2030
Solar	Depends on how soon India develops utility scale solar PV and thermal technologies.	

Source: Bharadwaj, 2007

The coal fired power plants, petrochemical, automobile, pulp and paper, and textiles industries have made our life comfortable but one should not ignore the detrimental effects of these industries to the environment.

Most ignored aspects for checking up environmental damages is the legislation and the growth of regulating institutions. Inadequate financial resources have limited the use of green technologies and hence the possibility of initiating environment-friendly alternative resources.

Indian Institute of Technologies and others have offered following categories of cleaner and green technologies:

- Agricultural related practices and food processing
- Recycling of waste water and production of potable water
- Renewable energy resources
- Biodegradable materials
- Industrial biotechnology
- Pollution free engineering processes

While advocating the use of affordable eco-friendly technologies for sustaining growth, the Indian Prime Minister Man Mohan Singh has emphasised the development and use of technology that converts waste into wealth.

2.1 Selected Areas and Technologies

2.1.1 Criteria for Selection

The Green Technology is the knowledge for conserving natural environment and resources and reducing human involvement. GT can operate in diversified areas such as bio-fuel, eco-forestry, renewable energy, and solid waste management. However, it is neither viable nor required to adopt all the available technologies at one time without considering country-specific strengths and weaknesses. Hence in the context of present study technologies are examined with respect to environment-friendly agriculture; poverty; rural environment; income generation; gender and other related indicators. Technologies have largely been selected on the basis of their (i) link with the people's livelihood; (ii) potentiality and (iii) existing performance in the national economy.

In chapter II the overview of the green technologies adopted in diversified sectors in the proposed APCAEM countries are briefly elaborated. The appraisal of the applied technology would provide us the prospects of their feasibility.

The feasibility of selected technologies has been recommended after extensive appraisal of the applied technologies by linking them with economics, environment and manufacturing concerns, and market for end products.

The appropriate technology (AT) is considered to be suitable in developing countries, where high technology can not be operated and maintained. As it is largely labour-intensive, it is advocated in comparison to capital-intensive technology, especially where they involve high capital or maintenance cost.

Appropriate technology requires investigating about technological change. The selection of tools and techniques as an appropriate technology is an important element in helping communities to decide what their future should be like. The choice of tools also assists in understanding the fact that technologies can embody cultural biases including political and distributional effects, which go far beyond a strictly economic evaluation *(http://www.villageearth.org/pages/Appropriate_Technology/index.php)*. In other words, appropriate technologies search for those technologies that have beneficial effects on income distribution, human development, environmental quality, and the distribution of political power (Ibid).

As local farmers, villagers and other communities understand their needs much better than outside experts, it is found that these communities invent, create, and contribute to the technological process to meet their needs. Based on the experience, local people can also prioritize solutions to safeguard labour and capital, as grassroots activity is crucial in developing the appropriate technology. The inclusion of these communities in the early phase of project vision is therefore extremely important. Appropriate technology can not be justified in establishing a wind generator in a place with little or no wind and installing solar modules in a place with little sun *(http://www.gdrc.org/techtran/appro-tech.html)*. Farmer's choice of technologies (Green Technology) supported by research for making farming practices sustainable is being very popular as they increase farm profitability while reducing environmental degradation and conserving rural resources.

By developing and adapting indigenous practices and technologies, there is a possibility to find low cost solutions to local problems without resorting to expensive and often inappropriate imported technologies (*http://www.atasia.org.uk/web/default.aspx*). The Appropriate Technology Asia (ATA), a British non-governmental organisation is running programs in India (sustainable energy, sanitation, education and construction programs), China (community based, cross-sectoral programs in some of the highest and most remote areas) and Nepal (community-based agricultural, health and community development programs in central and northern belt).

ATA intends to develop capacity of local community by promoting low cost and environmentally low impact technologies including: appropriate building methods such as rammed earth construction; passive solar architecture such as solar heated buildings; promotion of UNICEF approved pour flush toilets; development of improved irrigation, inter-cropping and permaculture systems; introduction of fuel efficient household cooking and heating techniques (Ibid).

The realisation of appropriate technology in developing world, especially in the context of sustainable and environment-friendly development is because such technology requires fewer resources, is easier to maintain, has a lower overall cost and less of an impact on the environment *(http://en.wikipedia.org/wiki/Appropriate_technology).*

2.1.2 Feasible Green Technologies

Following are the selected renewable energy technologies;

A. Solar Photovoltaic

Solar photovoltaic technology converts sunlight into electricity using semi conductor modules. Used generally for meeting lighting requirements, they can also be used for pumping water, refrigeration, communication, and charging batteries. Solar photovoltaic has application as green agricultural energy source for pumping water street lighting in villages, lighting in rural houses and pest management (BCSE, 2004).

Since the technology efficiently produces low-cost, high-power photovoltaic cells, this new generation of solar energy can be one of the most affordable and efficient energy sources in the future. Professor W.S. Sampath from Materials Engineering Laboratory at the Colorado State observes, "Without moving parts or external fuel, photovoltaic devices directly convert absorbed sunlight into electrical current". The high –powered devices produce no waste or pollution.

In India daily solar incidence varies from 4-7 kWh per square meter depending on the location and averages to 5.5kWh. There are about 300 clear sunny days in most part of the country (MNRE, 2008). The solar radiation in Malaysia is high by world standards. For example, even in Kualalumpur, a PV system receives 30% more energy than an equivalent system in Germany. In Malaysia monthly average solar radiation is 4000 to 5000 Whr/m^2 and solar energy received in a year is 16 times the annual Malaysian conventional energy requirement (EcoSecurities, 2003). In the late 1990s the Ministry of Rural Development has undertaken the provision of photovoltaic systems for rural electrification.

Solar map developed by Centre for Energy Studies (CES, 2005) shows 4.7kWh/sq.m/day average annual Global Horizontal Solar Irradiance in Nepal.

B. Wind Energy

Wind energy is in a boom cycle. Overall, wind energy contributes only 1% of global electricity generation, but some countries and regions are already producing up to 20% (http://eib.ptm.org.my). Its importance is increasing in the sense that comparatively with other sources; the wind energy produces less air pollutants or greenhouse gases.

Wind turbine for electricity or mechanical power generation is a proven technology. Available in 75% of the world, wind turbines of sizes ranging from 900 W to 50 kW can be applied off-grid for pumping and treating drinking water, irrigation, telecommunications, homes, schools, clinics and for supplementing larger power stations (BCSE, 2004). Wind turbines used in pumping water for irrigation can increase agricultural growth without carbon emission.

In Asia wind energy growth is on the rise. India and China have been performing well in installing this facility. China till 2004 had installed 150,000 small wind turbines (ibid). China has now moved from tenth position to number eight with 1,260 MW. India estimates total wind generation capacity of 45,000 MW (MNRE, 2008).[5] In Nepal river corridors have been observed to have high wind potential (CES, 2005). As in other countries, in Malaysia the availability of wind resource varies with location. University Kebangsaan Malaysia study conducted in 2005 reported that the use of a 150 kW wind turbine in the Terumbu Layang had some success (*http://eib.ptm.org.my/index.php?page=article&item=100,136,144*).

The research scholars in British Columbia observe that recently devised Davis Hydro Turbine works like an underwater windmill that could meet up to 40 per cent of the world's electrical needs while not harming environment or depending on solar cycles (*http://india_resource. tripod.com/ alternateenergy.html*).

C. Biofuel

Biofuel as bio-ethanol and bio diesel have the potential to assume an important portfolio in future energy platter. Caution is mandatory in evaluating biofuel as green agricultural technology. Food security concerns and risks to environment and biodiversity are parameters that necessarily need to be accessed while analyzing sustainability linkage of agriculture and biofuel. Also, conversion of wasteland to farmland with some crop options can be viewed as positive impacts.

In India if all available sugarcane molasses is utilised 0.8 million kiloliters of ethanol thus produced can replace 9% of current petroleum requirements. India also estimates to have 3.1million hectares of Jatropha plantations by 2009. One hectare of plantation in average soil gives 1.6 tons of oil. Prospect of Jatropha is especially lucrative as it can be grown on wasteland and thus can immensely supplement farmers' income. Thailand aims to consume 1.6 million TOE of biofuel by 2010. China proposes to meet 15% of its transportation needs through use of biofuel by 2020. Cassava recognised as biofuel crop in China can be grown in 2.471 million acres of barren land (Chaturvedi, 2007). Similarly, Malaysia committed to

5 Estimated 45,000 MW takes sites with wind density greater than 250W/sq.m at 50 m hub height with 3% land availability in potential areas for setting up wind farms at 12 hectare/MW.

production of bio-diesel from palm oil. To cut diesel subsidy bill, the government in Malaysia intends to make a palm oil-based fuel a mandatory additive at petrol pumps by 2008 *(http://www.planetark.com/dailynewsstory.cfm/newsid/32867/story.htm).* With crude oil prices expected to remain high, Malaysia sought to encourage national use of a biofuel that is made from 95 per cent diesel and 5 per cent processed palm oil. Malaysia is undertaking research in this particular area and a number of companies have ventured into this business.

In Nepal, Jatropha, a non-edible oilseed bearing shrubs is estimated to be climatically favourable in 30 per cent of Nepal's land. Ethanol can be prepared from molasses, which comes as a byproduct in sugar factories. However, Nepal Standard demands that for anhydrous to be eligible as a substitute fuel it should be 99.5 per cent pure *(http://www.kantipuronline.com/kolnews.php)*.

D. Biogas

Biogas is the product of anaerobic digestion of organic matters by methanogenic bacteria. Biogas qualifies on the merits that this technology utilizes organic agricultural waste and converts it to fuel and fertilizer. Direct impacts of biogas are fuel-wood, agriculture residue, livestock manure, and kerosene savings. Increases in soil fertility and crop production have also been observed. Biogas also solves the problem of indoor air pollution and improves household or communal sanitation.

India's biogas potential is estimated to be 12 million biogas plants (MNRE, 2008). Nepal carries the potential of 1.9 million biogas plants. In Malaysia Palm Oil Mill Effluent (POME) can generate 177 MW (EcoSecurities, 2003) and China can generate 4 billion cubic meters of biogas (Chen, 2002).

E. Micro & Small Hydropower

National convention of renewable hydropower varies across nations. Hydropower plants ranging from maximum capacity of 500 kW in Nepal to 25 MW in India are conceived renewable. Generally used in rural electrification, hydropower plants can take an equally important role in facilitating irrigation and value addition at source of agricultural products.

Table 2.10: Labor involved in Sisne Hydropower Project

District	Category	Unskilled	Semi-Skilled	Skilled	Total
Palpa	-	197	4	2	203
Pyuthan	A	82	6	2	90
Rolpa	A	61	7	2	70
Dailekh	C	11	3	1	15
Dang	B	30	6	1	37
Kapilbastu	C	47	2	1	50
Arghakhanchi	-	34	1	0	35
Total		**462**	**29**	**9**	**500**

Source:www.http://www.usaid.gov/our_work/economic_growth_and_trade/energy/publications/newsletters/2006-4_eu_jul-aug.pdf

Energy Update, Issue 4, July/August 2006, USAID refers an interesting example from Winrock International's study. The government of Nepal has designated 33 of the 75 development districts of Nepal as "severely affected" by conflict. Similarly, 6 are in category A as most severe, 9 in category B, and the rest 18 in category C. These are the populations who are separated from traditional social support networks. About 500-1000 people are normally needed per site in labour-intensive infrastructure project such as hydropower plant construction. The information from Winrock's study in 0.75 MW Sisne Khola project in Palpa reveals that out of 300 workers from outside Palpa, 265 were from "severely affected" districts. Fifty-three per cent alone were from category A districts. The nature of IDPs was as such that they moved in families and often multiple members of their family got employment and opportunities for skill enhancement. As a result, the former unskilled workers from these groups were found working as semiskilled or skilled workers.

A large reserve of untapped small hydropower potential approximating 15,000 MW[6] exists in India. Economically feasible hydropower potential of Nepal is believed to be 42000 MW. In Malaysia potential of 25000 MW was identified till the end of 2001 (EcoSecurities, 2003).

The integration of off-grid mini and micro hydropower with agriculture, especially in scattered communities, is crucial. Observations have been that energy tariff of hydropower schemes decline with increment in load factor of the power plant. In such relation, agricultural power inputs will assume the dual role of sustaining revenue of power structures and increasing productivity of agriculture. Recognizing this linkage Rural Energy Development Programme (REDP) in Nepal has made provision for soft loan to entrepreneurs interested in setting up micro-hydropower electricity based-micro enterprises.

F. Biomass

Agriculture residues and wastes are converted to electric and thermal energy through processes like combustion, gasification, and cogeneration. Biomass technologies compliment mainstream crop production and reduce or completely replace consumption of traditional fuel. Experiences of some APCAEM countries portray biomass to be effective means of increasing agricultural revenue and conserving exhaustible resources.

India estimates biomass availability of 600 million tons from agriculture and forest residue corresponding to 16,000 MW and 5000 MW from sugarcane bagasse (MNRE, 2008). Malaysia's biomass capacity was reported 488 MW in 2000 (EcoSecurities, 2003). A nearly completed biomass project in Malaysia intends to use rice husk as the main source of fuel. It will have a 10 MW capacity and produce sufficient energy for 30,000 households. There are 28 approved biomass projects that involve the installation of 194 MW of grid-connected capacity. Improved Cooking Stoves (ICS) that increase efficiency of household cooking and reduces in-door pollution is one of the success stories of Nepali renewable energy sector.

G. Solar Thermal, Improved Water Mill, Geothermal Energy

These clean technologies are found to contribute in adding value to agriculture products.

Food processing, animal husbandry, dairy, and aquaculture are identified sectors for application of solar water heating and researches on solar drying of agro products including

6 Extracted from database of 4096 hydropower sites of aggregate 10, 071 MW and of up to 25 MW capacities.

paddy, coffee beans, tobacco, groundnuts, banana, bamboo, rubber, etc have been carried out in Malaysia (EcoSecurities, 2003). European Union committed to contribute EUR 150,000 to promote solar thermal for supply of process heat along with hot water supply for health posts and tourism industry, solar cookers for clinics, schools and tourism industry. Agro processing activities as milk chilling, tea withering and drying, drying of handmade paper, and drying of crops and spices are expected beneficiaries (EUD, 2007). Malaysia estimated annual value of solar thermal potential to be RM 3,023 millions (MEWC, 2007). The solar thermal market has however, been slow to take off for commercial and industrial uses largely because of the low electricity prices in Malaysia compared with other countries.

The Tenth Plan in India pledged to install 1005000 sq. m solar water heating systems and 162000 solar cookers of which 995000 sq. m and 70978 were installed respectively.

Improved Water Mills (an intermediate technology based on principle of traditional water mills) in Nepal have made milling efficient (up to 3kW can be generated) and reliable, diversified agro milling and increased income of millers. 25,000 traditional mills are still in operation in Nepal.

Seventy-nine geothermal manifestation areas have been identified in Malaysia (NRE, 2007). Similarly, geothermal manifestations in Nepal occur in 28 localities (Ranjit, 2000). Geothermal technology has potential in China, Thailand, and the Philippines. A 300 kW geothermal power plant not only generates electricity but also used hot water for cold storage and crop drying (BCSE, 2004).

H. Bio Transgenics

The use of bio transgenics (BT) also referred to as Genetically Modified Organisms (GMO) has been growing at 45% per annum in developing countries which now account for 39% of 103 million hectares planted worldwide. Mostly in India and China, 9.2 million farmers planted Bacillus thuringiensis (Bt) cotton on 7.3 million hectares in 2006. (Pehu, et al, 2007) Recent developments like modified high yield oil seeds verities can trigger rapid spread of transgenic crops.

Risks as lateral transfer of genes and pollution of natural gene pool, dominance of multinational companies through Intellectual Property Rights clauses, reduction in arable land, production decline, and loss of bio diversity are associated with bio transgenics. (Sahai, 2005) The costs of monitoring and regulatory mechanisms are yet other hurdles for transferring benefits to smallholder farmers. However increased and consistent yield, reduced pesticide costs, (Pehu, 2007) and reduced post harvest loss along with opportunities like drought resistant crops and nutritional quality enhanced crops (Pental, 2005) open avenues for efficient and sustainable agriculture.

Most transgenic technologies are in research and development and comprehensive results have not been ascertained. Among food crops few like rice, eggplant, mustard, cassava, bananas, sweet potato, lentils, and lupines have been approved for field testing in one country or the other, while some like Bt Maize (mostly for feed) in Philippines, publicly developed transgenic vegetables in China are allowed cultivation. (Pehu, 2007) India has been conservative in permitting transgenic food cultivation (Pental, 2005). However, Cotton transgenic, Bt Cotton has received clearance in both India and China. Malaysia has empanelled biotechnology as one of the drivers of new agriculture in the Tenth Malaysian Plan. (NMP, 2006)

I. Organic Farming

Organic and biodynamic farming systems have soils of higher biological, physical, and in many cases chemical quality than that of conventional counterparts. When productivity in terms of inputs applied and outputs obtained and social costs of conventional farming are accounted organic alternative has also been found to be economically competitive (Reganold, 2000). Bhattacharyya, et al (2005) estimated size of global organic market to be U.S. $ 26 billion.

The Foundation of Ecology and Agriculture (SOEL) in 2004 reported global organic area to be 24 million hectare. Of each nation's total agricultural land 0.03% in India, 0.06% in China, 0.65% in Sri Lanka and 0.08% in Pakistan was under organic management. In 2005 SOEL reported 10% increase in area under organic farming.

National Planning Commission of India in 2000 recognised organic farming as a thrust area. National Programme for Organic Production was launched subsequently with National Steering Committee's approval on national standards, accreditation criteria for accrediting inspection and certification agencies, accreditation procedures, and inspection and certification procedures (Bhattacharyya, 2005). In Nepal preliminary drafts of organic certification policies and procedures have been developed and organic market has prospered especially through private sector. Consolidating organic standards, certification/ regulatory mechanisms, technology packages, and market network can support organic farming and therefore sustainable agriculture.

J. Integrated Pest Management (IPM)

Identifying IPM as a knowledge intensive approach dichotomous to conventional chemical intensive approach (Bartlett, 2002) best serves the purpose of this research.
IPM, especially through initiative like Farmer Field School programs, where farmers are envisaged experts with their expertise emanating from routine hits and trials, interactions, and trainings, have both empowered farmers and maintained agricultural and environmental balance (Dilts, 2001).

Bartlett (2005) reports Food and Agriculture Organisation led Inter Country Programs (IPC) for IPM Farmer Field Schools (FFS) in Asia, national IPM programme in Indonesia (1989-2000), and national projects of smaller scales in Bangladesh, Cambodia, China, and Nepal. Additionally, IPC also launched regional spin-off programs focusing on IPM for cotton and vegetables. Between 1989 and 2004, approximately U.S.$ 100 million in grants were allocated for IPM with FFS approach. Since inception around 2 million farmers in Asia have participated.

Among the selected countries in Malaysia IPM with FFS approach never got operational. In India most of IPM activities are funded from the government budget. This along with reasons like extant extension systems and federal decision-making structure barricaded successful implementation of IPM with FFS approach. Contrastingly, in Nepal despite initial incertitude between 1997 and 2001 some 8,600 farmers participated in IPM through FFS. In 2003 The IPM Trainers Association of Nepal (TITAN) with government officials, NGO staffs, and farmers as members was launched (ibid). The region is rich in farming traditions and biological resources. In India alone, several bio-pesticides (*Trichoderma viridi*, *Bacillus thurengiensis* BT, NPV, GV, etc), botanical pesticides (neem), bio-control agents (*Trichogramma, Cryptolaemus, Chrysoperla*, etc) are available (Bhattacharyya, 2005) to supplement IPM.

K. The use of Information and Communication Technology (ICT) for Facilitating Green Technology

While information and communication technologies could add little direct value to agricultural yield, possibilities also are that they can be the centre of paradigm shifts.

Since GT has emerged as a strong force to regulate climate change and build globally based, environmentally sustainable solutions, organisations are using ICT to reduce carbon emissions and develop and support business models with a green focus. This relationship is considered while ICT is recommended to serve as a green technology.

It is believed that the use of ICT improves energy efficiency in the economy, starting with buildings, lighting and the power grid. ICT enables economy a green behaviour. For example, the most advanced computer servers consume the same amount of energy as a standard light bulb; if widely used they could offer potential energy savings up to 70%. The European Commission presumes that real gains from green ICT will come from developing energy efficient ICT solutions that impact the other 98% of global emissions *(http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/733).* The intention of elaborating ICT in the present Green Technology is with this intention.

Precision agriculture uses information and communication technologies (ICT) to cover the three aspects of production namely for data collection of information input through options as Global Positioning System (GPS) satellite data, grid soil sampling, yield monitoring, remote sensing, etc; for data analysis or processing through Geographic Information System (GIS) and decision technologies as process models, artificial intelligence systems, and expert systems; and for application of information by farmers. Adjustments in volume and timing of fertilizer and pesticide inputs and limited input leakage to environment are expected in precision agriculture (Hrubovcak, 1999). ICT can also be useful in knowledge intensive farm management as IPM. Global Plant and Pest Information Services of FAO at *http://www.ecoport.org*, United States' Department of Agriculture's National IPM Network at *http://www.ipmcenters.org/index.cfm*, North American Plant Protection Organisation's Phytosanitary Alert System at *http://www.pestalert.org/index.cfm? NAPPOLanguage Pref='English'* are some information portals for IPM. Opportunities to link niche products and producers to markets can also give impetus to low input indigenous agricultural production.

The Government of Nepal's Information and Technology Act 2004 supports ICT intervention for agricultural development and environmental management (ITP, 2004). Ninth Malaysian Plan commits to use of ICT for providing access to market and trading information. Supply and Demand Virtual Information (SDVI) system, e-trade, and Agribazaar portals, Medan InfoDesa facilities are expected to support agro marketing. (NMP, 2006).

2.2 Good Practice Model

There is a surge of innovation among large firms based around environmental technologies, which are largely directed towards greener production. World watch in the 'State of the World 2008' estimates US $100 billion being spent during 2007 in those industries and technologies which tackled climate change by creating new opportunities for businesses *(http://news.bbc.co.uk/1/hi/business/7179047.stm).* The same report states renewable energy, which saw $52 billion of investment, in 2006, up by 33 per cent; and carbon trading, which reached at $30 billion in 2006, was triple that of the previous year. It indicates that environmental technology has become the hottest area for venture capital. Many are still unaware, and many undermine the impact of green technology. It is heartening to note that Carbon Trust in its survey of business leaders found that only 1% of all UK firms knew an account of how much carbon dioxide they produce.

The innovation, adoption and dissemination of best practice model should be considered under global priority area. Efforts are made through various initiatives to implement sustainable development policies and practices. Such practices include, the promotion of green building know-how and technologies for the construction of zero net energy buildings which can reduce demand by design and be highly efficient and generate at least as much energy as they consume *(http://www.wbcsd.org/templates/TemplateWBCSD5/layout.asp).*

Imparting knowledge about the judicious use of scarcer fresh water is important. Although access to fresh water is a local issue, however, if water is saved in one part of the world, it will be difficult to make it available elsewhere. Similarly, if it is consumed, it may be unavailable for others. From policy perspective, it is necessary to find out if water is distributed fairly or unfairly and who should decide at what level?

Since sustainable practice increases competitiveness, it requires significant change in the operation behaviour of enterprises. Bringing about change is possible through education and training at the corporate level for assisting the employees and managers in achieving professional goals. Capacity building programme can therefore, be taken as an instrument for the application of best practices.

The objective of this section is to establish link between the applied technologies and their relationships with environment-friendly agriculture; poverty reduction; rural environmental concerns; rural income and gender dimensions. To focus on these inter-linkages cases of selected countries have been presented.

2.3 Case Studies

2.3.1 NEPAL: Biogas

In the simplest of words biogas, a combustible gaseous mixture primarily of methane and carbon dioxide, is a product of anaerobic digestion of organic matter by methanogenic bacteria. When produced under controlled conditions inside a biogas plant, it can serve to meet energy requirements for cooking, lighting, refrigeration, electricity generation, and internal combustion engines. Slurry or digested effluent from biogas plant has high fertilizer value. Both energy and agriculture products of biogas technology and its minimal adverse environmental implications make it an appropriate green agricultural technology. Revived biogas sector of Nepal is the result of a consolidated effort of public and private stakeholders; and donor agencies. Establishment and institutionalisation of the elements of biogas industry in Nepal further suggests an appropriate and inclusive scheme for renewable energy promotion to all strata of the society. Biogas Support Programme (Phase I-IV) has been instrumental in promotion of biogas in Nepal.

Any generic biogas plant is also known as bio-digester, bioreactor or anaerobic reactor. Under favourable circumstances a kg of cow dung can generate 0.023 to 0.04 m^3 of biogas while pig dung, chicken dung, and human excreta can yield 0.04 - 0.059 m^3, 0.065 - 0.116 m^3, and 0.020 - 0.028 m^3 respectively (Werner, et al 1989). The cubic meter requirement for cooking per person is approximated to be 0.2 to 0.3 m^3. At the user's end (Smith, et al) reckon biogas stoves to have minimal greenhouse gas contribution. They reveal biogas stoves to be 1.07 times more efficient than a Liquefied Petroleum Gas (LPG) stove, 1.22 times more efficient than kerosene stove, 3.15 times more efficient than traditional fuel wood stove, and 4.63 times more efficient than traditional agriculture residue stove.

Biogas and sustainability

Biogas has links with agriculture, forest, environment and overall livelihood of the people. These links can be shown with the aid of following figure 2.1. Biogas can be deployed to increase incomes and save the environment and has great impact on the health and time saving for women and children.

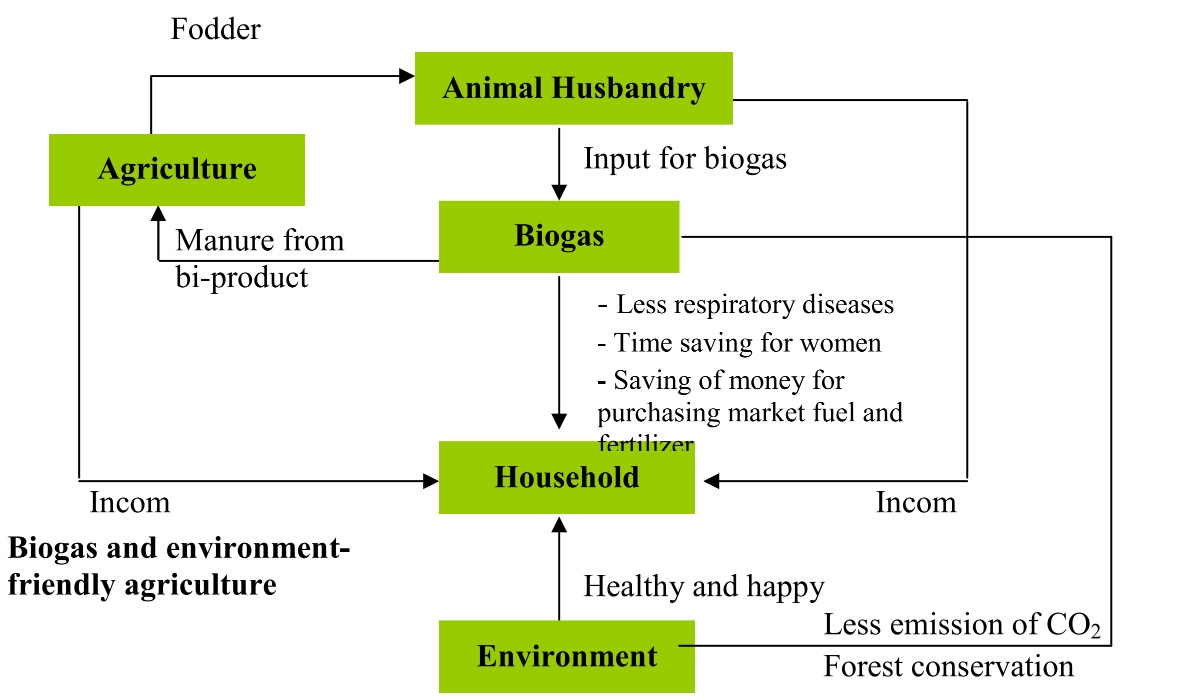


Figure 2.1: Sustainability and biogas

Advantage of biogas technology is effluent or slurry, a byproduct of anaerobic digestion. Alexander's (1967) reports on nitrogen associated superiority of bio-slurry over Farm Yard Manure (FYM) and compost, Shen (1985) reports on pesticide value of bio-slurry, Lakshmanan (1993) reports on positive action of bio-slurry on seedling metabolism, etc.

Empirical study in India shows 4 to 40 % increase on the yield of 12 cereals and vegetable crops (Tripathi, 1993). In China 6 year application of bio-slurry was reported to double the grain yield, elevate organic content of soil by 1.4%, reduce amount of chemical fertilizer by 86%, and quadruple net income per hectare (Keyun et al, 1990). Similarly, in Phillippines effluent application gave higher yield than use of chemical fertilizer (Maramba, 1978) and in Thailand a study concluded that slurry could be as effective as chemical fertilizer (Tentscher, 1986). Bio-slurry can provide 10 to 15 % of the total feed requirement in cattle and swine and 50% for ducks (Alviar, et. al., 1980). In China faster growth and better food conversion were observed in pigs during an experiment (Tong, 1995) and net profit from use of digested slurry as compared to chicken manure as fish feed was 3.5 times greater (Jiayu, et. al., 1989). Incremental yield over control in Nepal were found to range from 10 to 30% (CMS, 1996). A survey of 510 biogas users observed 75.3% using different forms of bio-slurry (compost, dry or untreated). 39% of participants acknowledging increased agro-production in khet, 42% in bari, and 52% in garden kitchen (CMS, 2007)[7]. Hence use of biogas reduces use of fertilizer, pesticides, and insecticides. Similarly it reduces emission of green house gasses and maintains soil quality.

Biogas and poverty reduction

Biogas creates impact on poverty through reduced health and sanitation problem, time saving and increase in income level. The adoption of biogas has positive implications on rural health and sanitation condition. Centre for Integrated Development, India envisions linking biogas and sanitation and improving sanitation for 90,000 beneficiaries (DM, 2007). Similarly biogas and communal sanitation have been bundled in achieving sustainable Decentralised Wastewater Treatment (APCAEM, 2007). BSP in Nepal envisions improving rural sanitation by connecting 93,150 toilets in 69% of the plants to be installed till June 2009. Survey of altogether 1,200 respondents showed that 90% Nepali household with biogas plant had proper toilets as compared to 60% of non-biogas household. Biogas companies induced the stronger concerns for health and sanitation in 27% of investigated biogas households. Also, 60% of biogas households attached toilets with biogas digester. Livestock sheds also saw improvements after installation of biogas with more users maintaining provisions for urine collection pit (CMS, 2007). Equally significant is contribution of biogas in reducing smoke borne diseases especially to women. Pokhrel, et al., (2005) acknowledge a strong association between incidence of cataract and use of solid fuel (fuel-wood, agriculture residue, cow dung) burning stove. Similarly, Zhang et al., relate incidence of acute respiratory infection, chronic obstructive pulmonary disease (COPD) and lung cancer with solid fuel usages. Biogas in Nepal has been replacing traditional fuel-wood stoves, straw stoves, and dung burning stoves. Table 10 shows the impact of biogas on various smoke borne diseases in the surveyed 100 Nepali households.

As the table reveals, biogas installations improved problems related to eye and respiratory syndromes. Additionally, households were observed to practice cleaner sanitation reducing indoor air and solid waste pollution. Cases of burning were also reduced (SNV/BSP, 2000).

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7 Khet: large farm; bari: small farm

Table 2.11: Impact of biogas on various smoke-borne diseases

Disease/ Problem	Problems in the Past (HH) in %		Condition at Present (HH) in %	
	Yes	No	Improved	Same
Eye Illness	61	39	60	1
Eye Burn	39	61	38	1
Tuberculosis and lung problem	6	94	6	0
Problem in Respiration	50	50	49	1
Asthma	8	92	7	1
Dizziness/headache	34	66	17	17
Intestinal	50	50	20	30

Source: SNV / BSP, 2000

APCAEM countries spend 0.4% in Pakistan to 4% in Mongolia of their GDP as public expenditure on health. Population using improved sanitation ranges from 83% in Iran to 11% in Nepal. Among the select countries (India, Malaysia, and Nepal) in India only 14% use sanitation and average public expenditure in health is 1.53% of GDP (HDR 2007). Beside direct impacts as employment creation, income generation, and savings of energy expenditure, biogas can indirectly contribute to poverty reduction by improving health and female literacy. In Nepal, on average a person from poorest quintile spends NRs. 124 in government and NRs. 198 in private institution per medical consultation. This segment of population has mean per capita income of NRs. 5,140 and per capita consumption of NRs. 4,913. On the other hand fuel wood expenditure is in the range of 10-15% of total expenditure (ibid). Biogas reduces these expenditures in user households. Amatya et. al. (2006) indicates poverty reduction implications of biogas in the following table.

Table 2.12: Poverty Reduction Impact (PRI) of Biogas Energy

Poverty Reduction Indicator (PRI)	PRI in Household Sector	PRI in Industrial Sector	PRI in Commercial Sector	PRI in Social Sector
Security (Income, Employment, Credit)	√	√	√	√
Knowledge and Information			√	√
Health	√			
Drudgery Reduction	√			
Empowerment/Inclusion				
Gender Equity	√			
Environmental Sustainability				√

Source: Amatya, et. al., 2006

Biogas and rural environment

From the environmental standpoint biogas contributes in conservation of forest resources, reduces indoor pollution, decreases greenhouse gas emission, and helps in cutting down the use of chemical fertilizers. Aksu Sanjiang Breeding Company in China anticipated 55,000 tCO_2e Carbon Emission Reduction by capturing methane from open lagoons and additional 2,500 to 4,000 tCO_2e by displacing grid electricity in a pig farm biogas generation project (WB, 2007). On average a Nepali biogas plant installed with Biogas Support Program's technical standards saves 2 tons of fuel-wood, 25 liters of kerosene, and 0.35 tons of agricultural residues. Supplemented by 0.6 tons of organic manure, BSP biogas plant also reduces use of chemical fertilizers. As methane combustion is smokeless and non-toxic, biogas as cooking fuel significantly improves household environment. The following table shows net greenhouse gas saving implications of Nepali biogas plants.

Table 2.13 Net greenhouse gas saving per digester in Nepal (tCO_2/biogas plant/year)

Size of plant	Terai	Mid-hills	Average (Terai and Hills)
4 m^3	3.17	5.75	4.46
6 m^3	7.27	8.00	7.63
8 m^3	9.33	9.94	9.63
10 m^3	7.44	7.87	7.65
Average of all sizes			**7.35**

Source: (Pandey 2005)

An average BSP standard biogas plant saves 7.35 ton Carbon equivalent. Optimal emission saving were observed in 8 m^3 plants. BSP estimates the annual carbon revenue of US $ 607,000 from two projects registered with the World Bank (BSP 2007). Decrease in land and forest degradation from uncontrolled grazing is another benefit of biogas. 80.65% of the users of BSP supported biogas were found have shifted to stall feeding practices. Among them majority of the households (67.5% in hill and 69.7% in Terai) adopted fodder cultivation after installation of biogas (CMS 2007).

Karki et. al., 2005, give accounts of three scenarios where in i.) 86,000 BSP biogas plants are installed ii.) 100,000 BSP biogas plants are installed iii.) 1.3 million BSP biogas plants are installed and observe the amount of fuel-wood and kerosene saved.

Table 2.14: Daily fuel-wood and kerosene savings from biogas in Nepal

Scenarios	Amount fuel-wood replaced (tones per day)	Amount of kerosene replaced (liters per day)
86,000	490	29,240
100,000	570	34,000
1.3 million	7410	442,000

Source: Karki, et.al, 2005

At 2002 prices, the projected fuel wood savings and kerosene saving of Scenario 3 translate into savings of NRs. 11.93 million/day and NRs. 8.28 million /day, respectively.

Biogas and income generation to farmers

Biogas has income generating potential through

a) **Increased agriculture productivity:** Besides increasing agriculture output, as biogas requires to keeping animal husbandry, it also diversifies income sources of the farmers.

b) **As a substitute for fuel wood and commercial fuel:** Biogas saves the time for collecting fuel wood. The time saved can be used in income generating activities. Similarly people will not have to spend money for purchasing commercial fuel such as kerosene. This will save expenditures.

c) **Reduced health cost:** Use of biogas reduces indoor air pollution which results in reduced health cost and increased working days. This will have impact on income generation of the farmers.

Biogas and gender issue

Biogas is a source of energy that is mainly used for lighting and cooking purposes. If energy is used for household purpose then it must have impact on women as "women are most affected by energy crises" (Batliwala and Reddy, 1996). In one study carried out by Mahat (2002) in Kavre district of Nepal found that it takes minimum two hours for women to collect fuel wood from their own field. It takes up to eight hours if they don't have trees on their own land. Biogas saves this time of women which they can use in other activities such as education, income generation etc.

Installation of biogas benefits women by improving their health, reducing drudgery, employing them, and uplifting their status in household and society. Dasgupta et. al, (2006) report of adverse effects of Indoor Air Pollution (IAP) in traditional fuel using Bangladeshi households, especially to household members who are exposed to IAP for longer periods of the day. They observe prime-age men have half the exposure of women and elderly men are significantly lower exposure than elderly women. Similarly Balakrishnan et. al, (2004) state women in their traditional capacity as cook are subjected to much greater daily exposure. CMS, 2007 survey found a drastic reduction in eye infection and headache (>40%), reduction in cough (34%), and respiratory diseases (23%) in subjects previously having such problems. Rural women are found to spend significant portion of their time in collecting fuel-wood or dung cakes, raring livestock, cooking, and cleaning utensils. Opportunity cost of fuel-wood collection, a daily 5- 10 kms walk in Tanzania or over 3 hours a day in rural India, often results in young girls being kept out of school (HDR 2007). Biogas as readily available and efficient fuel helps in reducing time spent on these drudgeries. Study by Devpart (1998) estimate saving of 2.38-hours/day/ family.

The table above shows time saved as positive and time spent as negative time. Dependency and unsustainable consumption is likely to make fuel-wood collection a more drawn out activity. CMS, 2007 reports that a household saves 220 minutes (3.4 hrs) daily. 28.6% of BSP users' households were also found to deploy the saved time in income generating activities. It also reveals that during construction of biogas plant 55.3% of unskilled labour are women and 66.1% of women received more cooperation and cohesion from family members after biogas installation.

Table 2.15: Average time allocated to different biogas related activities before and after installation of biogas plant

Activity	Saving in Time (Hour/Day)
Cattle Care	(-) 0.01
Collection of Water	(-) 0.35
Collection of dung	(-) 0.07
Mixing of water and dung	(-) 0.15
Cooking	(+) 1.11
Cleaning cooking utensils	(+) 0.39
Lighting fuel collection	(+) 0.09
Collection of firewood	(+) 1.38
Total saving of time	**2.38 hours/day/family**

Source: Devpart, 1998

Table 2.16: Phase wise progress of biogas

Program	Biogas plants installed	Focal Agency for Implementation	Financial Assistance
BSP Phase I ('92 to '94)	6,824	SNV/N[8]	DGIS [9]
BSP Phase II ('94 to Feb '97)	13, 375	SNV/N	DGIS
BSP Phase III (March '97 to June '03)	91, 196	SNV/N	DGIS, KfW[10], GoN[11]
BSP Phase IV (July '03 to July 16, '07)	61,110	BSP-Nepal[12]	DGIS, KfW, GoN

Source: G. Nepal., 2007

Pandey (2005) states that market based scaling up were first effectively demonstrated by BSP in 1992. BSP promoted a technology that had been distributed by a single government supported company for 10 years and reintroduced it creating competition among private construction companies while maintained strict quality control norms. Subsidies for users were provided through those companies that abided by quality standards. At present, BSP-N monitors quality standards, disseminates subsidies, and ensures proper after sales services. BSP project cycle for household biogas plant construction and after sales services includes active roles of private companies, micro-finance institutions, development and commercial banks, regulating units as quality control unit and monitoring units, and MIS. Following the success of biogas other Renewable Energy Programs in Nepal replicated BSP's promotion strategy. Subsidies have been serving as incentives both for users and biogas companies. While users are entitled to subsidy amount and get access to low cost energy option, biogas companies get a larger profit margin. A study by Nepal (2007) indicates that a net profit of

8 Netherlands Development Organisation in Nepal
9 Director General for International Cooperation of the Netherlands
10 Kreditanstalt fuer Wiederaufbau of Germany
11 Government of Nepal
12 Nepal: Biogas Sector Partnership Nepal

NRs. 2000 to 2500 per plant is available for biogas companies. Following table shows the trend of subsidy in biogas along with sources of financing.

Table 2.17: Year wise subsidy rate by sources of financing[13]

Year	Subsidy Rate (NRP)					Subsidy for poor (NRP)			Donor		
	Terai	Hill	Remote Hill	4 & 6m^3	LPD	Terai	Hill	Remote Hill	Govt. Nepal	KFW	SNV
1994/95	7,000	10,000									
1995/96	7,000	10,000									
1996/97	7,000	10,000	12,000						10%	79%	11%
1997/98	7,000	10,000	12,000						12%	77%	11%
1998/99	7,000	10,000	12,000						14%	78%	8%
1999/00	6,000	9,000	11,000		1,000				16%	76%	8%
2000/01	6,000	9,000	11,000		1,000				18%	74%	8%
2001/02	5,500	8,500	10,500		1,000				20%	72%	8%
2002/03	5,500	8,500	10,500		1,000				20%	72%	8%
2003/04	5,000	8,000	11,000	500	500				21%	71%	8%
2004/05	5,000	8,000	11,000	500	500				22%	70%	8%
2005/06	5,000	8,000	11,000	500	500				23%	69%	8%
2006/07	5,000	8,000	11,000	500	500	1,500	2,500	3,500	24%	68%	8%
	6,000	9,000	12,000	500	500						
2007/08	6,000	9,000	12,000	500	500	1,500	2,500	3,500	25%	67%	8%

Source: G. Nepal, 2007

In December 2006, 65 biogas companies, 16 biogas appliances manufacturing companies, 130 Micro Finance Institutions and 2 commercial banks collaborated with BSP in directly benefiting 1, 099,413 persons. Additionally 11,000 persons were employed through BSP initiatives. BSP- Nepal indicated with 98% of 152, 945 plants in operating status, the total equivalent power output in MW per year is 422. (BSP 2007)

Table 2.18: Summary of cost and benefit of biogas

Cost	Benefit
Installation cost	Time saving for women
Maintenance cost	Reduced expenditure for kerosene and other fuel
Transaction cost for searching	Conserved forest
	Manure for farming
	Less use of fertilizer
	Reduced respiratory dieses
	Income from CO_2 fund

13 **1.** It was started with two subsidy rates during BSP I and II phase. From 01 March 1997 (i.e. 2053/54) onwards a third rate of NRP 12,000 was given for remote hill districts. **2.** Additional subsidy for small size (4 & 6 m3) plants started from 2057/58 onwards with NRP 1,000. **3.** Additional subsidy and LPD subsidy rates reduced to NRP 500 each from 2060/61 **4.** There are two type of subsidy rate for the fiscal year 2063/64as NRP 1,500 for Terai NRP 2,500 for Hill and NRP3,500 for R. H. The remaining 285 plants from the fiscal year 2062/63 are paid as per the same subsidy rate of 2062/63.

Table 2.19: Evaluation of technology for adoption

Characteristics	Impression	Reason
System Independence	Yes	Less capital is required, available through subsidy
Image of Modernity	Yes	People feel proud after installing it
Individual vs Collective	Collective	Individual during installation, collective for maintenance and operation
Cost of Technology	Low	Relatively less than other source of energy
Risk Factor	Very low	After sales service is readily available
Evolutionary Capacity	Very high	Increased restriction of using forest product and scarcity and expensive hydroelectricity
Single and Multi Purpose	Multipurpose	Cooking, lighting, manure and even to run small rice mill.

2.3.2 NEPAL: Agro forestry

King and Chandler (1978) observe agro-forestry as sustainable land-management system, which increases the overall yield of the land, combines the production of crops (including tree crops) and forest plants or animals simultaneously or sequentially on the same unit of land and applies management practices that are compatible with the cultural patterns of local population. Agro forestry is differentiated with other forms of land use through two major characteristics (Rai and Handa, NA);

a) The deliberate growth of woody perennials on the same unit of land along with agricultural crops and animals either in some form of spatial mixture and in some temporal sequence; and
b) There must be significant interaction: ecological and other components of the practice.

In the Nepalese context, agro-forestry could be the major technology to be adopted. This is because in one hand agro-forestry system is deep rooted in Nepalese culture since Vedic era. This will make adoption easy for Nepalese farmers. On the other hand agro-forestry has capacity to play a major role in the United Nations' efforts to meet its Millennium Development Goals, which include eradicating poverty and hunger, promoting gender equality and ensuring environmental sustainability *(http://www.undp.org.np/publication/html/mdg2005/mdg2005.php).*

Growing trees on farm is common practice in Nepal. According to Agriculture Census 2001/2002 (CBS, 2004) out of 3,364,139 holdings of land 1,357,843 holdings have at least two trees (permanent crop). The total area of compact plantation becomes 33,237.6 hectare and number of trees are 11,169,587. Similarly, out of 3364139 holdings fodder tree has been planted in 585,447 holdings followed by bamboo in 353,197 and thatch in 266,305 holdings. This shows agro forestry as an integral part of Nepalese farming system.

Agro forestry practices can be described in two broad categories: farm -based and forest-based (Regmi, 2003). In farm-based practices forest comes to farm i.e. it includes home garden, planting trees in the farmland etc. In the forest based practices agriculture move to forest i.e. people collect food, fruit etc in the forest. Farm based agro forestry is adopted in individual basis. Forest based agro forestry, in these days, is being carried out through community forest.

There are several species of tree that are grown in and around the farmland. But there is no compact list of such trees. Agriculture census 2001/2002 has listed some fruits but not other trees. All other trees except fruits have been counted under fodder, thatch and bamboo heading. The fruits and other permanent crops that are listed are orange, junar, lemon, lime, sweet orange, other citrus, mango, banana, guava, jack fruit, pineapple, lychee, apple, pear, plum, papaya, pomegranate, other fruit, tea. The website run by Nepalese foresters *(http://www.forestrynepal.org*) has listed following major agro forestry species in Nepal.

As a threat, although CFUGs have been successful in terms of their institutional capacity to organize people for forest management, the livelihoods of the local forest-dependent communities, particularly the poor and disadvantaged, have not improved as expected. Similarly, as overall monitoring is still poor, it has been experienced that in many occasions, policy decisions are less consultative and interactive, leading to poor outcomes. These issues need to be addressed from equity perspectives.

Box 2.2: Community Forestry in Nepal

Nepal's community forestry (CF) was initiated in the late 70s with an establishment of Community Forest User Groups (CFUGs), as autonomous institutions under the Forest Act 1993, Forest Regulations 1995 and Operational Guidelines 1995. CFUG is a self-governing, independent legal entity registered at the District Forest Office (DFO), which operates within defined forest boundary with the legitimate members of the users group.

The system is based on the management and utilisation of the available forest resources by the local community/user groups to earn their livelihood. The experience shows conservation and management by the community has contributed to the growth of forest cover and increased yields for commercial use. The additional advantage of CF programme includes the restoration of degraded forest land, resumption of greenery, an increment of bio-diversity, empowering women, poor and the disadvantaged groups and increase in income.

Implementation Modalities

The preparation of operational forest working plan by the community, needs to be approved by the general assembly of CFGU to hand them over the forest.

The capacity is built by collaborating with relevant stakeholders such as the user group federation, NGOs, civil society organisations and local governments. This helps the community to developing the rules and executing plan.

Outcome and Impact

By 2005, about 1.45 million households in the country, which means 35 per cent of the population is involved in community forestry management program. Altogether 14,337 Community Forestry User Groups (CFUGs) have been formed of which the women community members are comprised of 778. A total of 1,219,111 hectares of National forest have been handed over as community forests and 1,647,444 households have benefited (http://www.umb.no/statisk/ior/discpaper/Aryal.pdf).

CF has been contributing towards improving forest condition and people's livelihoods through a) capital formation in rural communities; b) policy and governance reform of various organisations and agencies; and c) enhancing the process of community empowerment and social change. It has contributed to increasing natural, social, human, financial, and also the physical capital. The community forest is in itself a natural capital.

The forest conditions have been relatively better after handing over to the management to the users' group and availability of forest products has also been possible through the reduced opportunity costs especially for rural women for the collection of forest products. Afforestration, protection of denuded hills, the silvicultural operation, and access to market have been the major advantages from environment-friendly sustainable agro-forestry practices to increase income and support better livelihoods. CF has been the major instrument for addressing the critical issues on inclusive development. This has increased social cohesion by enhancing social capital of those, who were excluded from mainstream development.

The visits from domestic and international visitors, trainings and demonstration of the schemes of management have increased the capacity of stakeholders and users' group. This in fact has developed human capital. There has been significant development in the creation of physical capital such as village trails, bridges, community building etc. The financial capital on the other hand, has been generated through the sale of the forest products and also through levies and outside grants (Ibid). The Ministry of Forest and Soil Conservation reports, the generated amount is almost equal to government's allocated annual forestry development budget to all the 75 development districts of Nepal. The savings is thus used to provide grants and access to credit to poorest households within the users' group at low interest rate. Benefits of the community forestry have gone to the poor, to alleviate poverty.

Community forestry is the only national programme in the country that has been successful in creating of thousands of local institutions at community level (i.e. FUGs) engaged continuously in building their capacity as viable local institutions. Not only this participatory bottom-up planning process have also begun to institutionalize the process of preparing annual and periodic plans.

As strength, the Nepalese experiences have shown that the CF Development Programme has various advantages including the development of successful participatory culture; legalisation and consensus-based decision-making power of the FUGs; and the success in the sustainable forest management and biodiversity conservation.

Source: Ministry of Forests and Soil Conservation, Government of Nepal

Table 2.20: Major agroforestry species for Nepal

For Terai/Siwalik		For Middle Mountain		For High Mountain	
Botanical Name	**Nepali**	**Botanical Name**	**Nepali**	**Botanical Name**	**Nepali**
Albizzia sps.	Siris	*Ficus semecordata*	Khanyu	*Juglans regia*	Okhar
Artocarpus lakoocha	Badhar	*Litsea monopetala*	Kutmero	*Populus* sps	
Dalbergia sissoo	Sisau	*Bassia butyracea*	Chiuri	*Salix* spps	Bains
Eucalyptus camaldulensis	Masala	*Ficus infectoria*	Kabro	*Sauraria nepalensis*	
Ficus semecordata	Khanyu	*Erythrna arborescenes*	Phaledo		
Leucaena leucocephala	Ipilipil	*Morus alba*	Kimbu		
Populus spp.		*Prunus cerasoides*	Painyu		
Sesbania grandifolia	Dhaincha	*Albizzia* spp.	Siris		
		Alnus nepalensis	Utis		
		Bauhinia spp			

Source: Adapted from http://www.forestrynepal.org

Table 2.21: Common fuel wood species for agroforestry

For Terai		For Mid Hills		For High Mountain	
Botanical Name	**Nepali**	**Botanical Name**	**Nepali**	**Botanical Name**	**Nepali**
Acacia nilotica	Babool	*Albizzia lebbeck*	Kalo siris	*Betula alnoides*	-
Acacia auricoloformis		*Alnus nepalensis*	Utis	*Juniperus* spp.	-
Anogeissus latifolia	Banjhi	*Betula alnoides*	Bhojpatra	*Quercus lanata*	Thulo banjh
Terminali tomentosa	Asna	*Eurya acuminata*	Jhingane		
Eucalyptus camaldulensis	Masala	*Bauhinia variegata*	Koiralo		
Gmelina arborea	Gamari	*Castanopsis indica*	Katus		
Largerstroemia parviflora	Bot dhangero	*Quercus lanata*	Thulo banjh		
Azadiracta indica	Neem				
Dalbergia sissoo	Sisau				
Bauhinia variegata	Koiralo				

For Terai		For Mid Hills		For High Mountain	
Botanical Name	**Nepali**	**Botanical Name**	**Nepali**	**Botanical Name**	**Nepali**
Albizzia lebbeck	Kalo siris				
Adina cordifolia	Haldu				
Bombax ceiba	Simal				

Source: Adapted from http://www.forestrynepal.org

Table 2.22: Common fodder species for agroforestry

For Terai		For Mid Hills		For High Mountain	
Botanical Name	**Nepali**	**Botanical Name**	**Nepali**	**Botanical Name**	**Nepali**
Albizzia procera	Seto siris	*Brassiopsis hainla*	Chuletro	*Celtis australis*	Khari
Dalbergia sissoo	Sisau	*Castanopsis tribuloides*	Musure katus	*Quercus lamellosa*	Thulo phalant
Ficus semicordata	Khanyu	*morus alba*	Kimbu	*Q. leucotricphora*	Sano banjh
Gmelina arborea	Gamari	*Saurauria nepalensis*	Gogan\ Tingur	*Q. semecarpofolia*	Khasru
Grevia optiva	Bhimal	*Albizzia odratissima*	-	*Taxsus baccata*	Lauth salla
Acacia nilotica	Babul	*Erythrina arborescens*	Phaledo	*Populus ciliata*	Banghe kath
Leuceana leucocephala	Ipilipil	*Ficus roxburghii*	Nimaro	*Brassiopsis glomerulata*	Kalo chuletro
Litsea monopetala	Kutmero	*Ficus nimarolis*	Dudhilo	*Quercus lanata*	Thulo banjh
Michelia champaca	Champ	*Artocarpus lakoocha*	Badhar	*Salix babylonica*	
Sesbania grandiflra	Dhaincha	*Bauhinia purpurea*	Tanki		
Terminali alata	Asna	*Bauhinia variegata*	Koiralo		
Zizyphus jujuba	Bayer				
Ficus nimarolis	Dudhilo				
Azadirahta indica	Neem				

Source: Adapted from http://www.forestrynepal.org

Agrosilvoanimal (Farm forestry and Slope agriculture land technology) and Agrosilviculture (shifting cultivation and Taungya) are the best-practiced systems of agro forestry in Nepal (Sharma, 2007). The major objectives of farm forestry include providing basic needs of fodder, fuel wood, small timber, fruits; water erosion control and waste land utilisation. Slope Agriculture Land Technology is for controlling erosion while Taungya is to supply fuel wood, poles, small timber for local consumption, to reduce fire hazards and to transfer of weeding costs to the agricultural sector. Although shifting cultivation is taken as one of the major cause of deforestation, people are practicing it because they don't have alternatives for survival. However, shifting cultivation is being discouraged in Nepal.

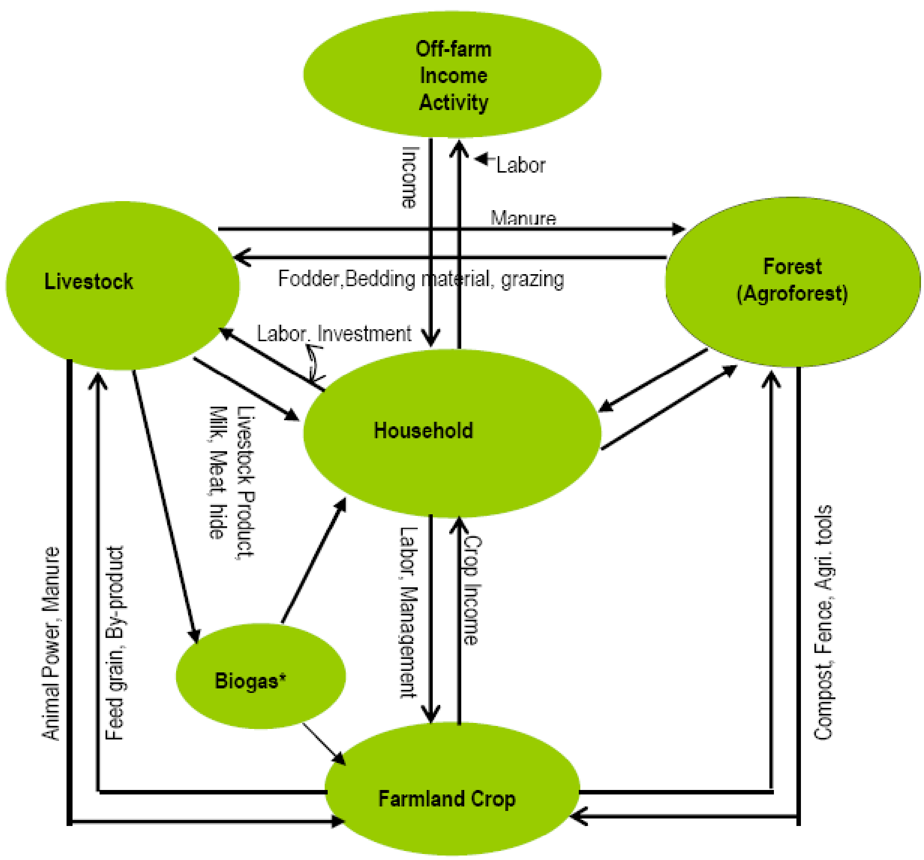
Agro forestry and Sustainable Agriculture

There are several advantages of agro forestry towards sustainable agriculture such as;

a) Trees bring resources, groundwater and nutrients etc for annual plant.
b) Trees can resist drought.
c) Trees provide fodder to the animal, reduce pest problem and provide various product for subsistence and sale, such as firewood, biofuel, timber, food, building material, material for tools, fibre, medicine etc.
d) Tree can provide other environmental benefit such as soil improvement, erosion control, ground water management etc. *(http://www.ecocomposite.org/agriculture/agroforestry.htm).*

Following diagram shows the benefit of agro forestry and link with sustainability.

Fig 2.2: Inter-linkages of Agro forest, Agriculture, Household, and Livestock



* link of Biogas has been explained in the section of Biogas

Source: Adopted and modified from ecoagriculturepartners.org/documents/meetings/Nairobi04/posters/Ghimire_abstract.pdf

Agro-forestry and environment-friendly agriculture

Adoption of agro-forestry technology improves the various environmental components of agriculture. Some of them are resource conservation, carbon sequestration, biodiversity conservation, improvement in soil fertility and structure etc. Agro-forestry helps to improve the soil fertility through (Rai and Handa, NA):

a) More efficient nutrient cycling within the system and consequently more efficient utilisation of nutrient that are either inherently present in the soil or externally applied;
b) Biological nitrogen fixation and solubilisation of relatively unavailable nutrients;
c) Increase in the plant-cycling fraction of nutrients, with their resultant reduction beyond the nutrient-absorbing zone of the soil;
d) Complementary interaction between the component species of the system, resulting in a more efficient sharing of nutrient resources among the components;
e) Enhanced nutrient economy, because of different nutrient-absorbing zones of the root system of the component species;
f) Moderating effect of additional soil-organic matter on extreme soil reactions and consequently improved patterns of nutrient- release ability.

There is indirect benefit of agro-forestry for environment friendly agriculture through the route of agro-forestry ➔ livestock ➔ biogas ➔ environment friendly agriculture.

Agro forestry, Income generation to farmers and poverty reduction

Many people in Nepal and other underdeveloped countries are poor and reside in the rural area. These people are engaged in subsistence types of agriculture. Livelihood of these people can be improved through adoption of agro-forestry. Agro-forestry can increase their income and reduce poverty through

a) Increased food production through improved soil quality;
b) Selling tree by-product such as fruits, wood and other forest product extracted from agro-forest;
c) Selling livestock product such as milk, meat etc.

Agro-forestry is more profitable than forestry or agriculture alone, and may have a number of social and organisational advantages (Amatya and Newmann, 1993).

Table 2.23: Net benefit from agroforest, agriculture and forest

Net benefits ('00000 NRs/ha)

Year	Forestry alone	Agriculture alone	Agroforestry
1	-0.37	0.1	-0.25
5	0.02	0.095	0.09
10	0.02	0.095	0.12
20	5	0.085	7.085

Source: Adopted from Sharma, 2007

Table clearly shows that in the first year both forest and agro forest give negative net benefit. But as soon as fifth year is reached, agro forest starts to be more beneficial than forest or agriculture.

Agro forestry and Rural Environment

Environmental impact of agro-forestry has already been discussed in section (a). Agro-foestry has very high potential of carbon sequestration. A study on the North China Plain revealed that agro-forestry has ability to sequester carbon from the atmosphere at a yearly rate of about 1.23×10^6 tons of carbon, which is very high in comparison to mono-cropping (Wang and Feng 1994). Agro forest can control the erosion problem. Indonesian researcher in West Java found low level of erosion in land with agroforest than cultivated land (Kusumandari and Mitchell 1997). Similarly agroforestry increases biodiversity that may be useful, beside other benefit, to reduce pest attack in the crops (Noble, 1997). Tall trees may act as wind blocks to shelter harvestable crops, reduce wind erosion and delay the attack of desertifying sands (Gwyther,2004).

Agro forestry and Gender Issue

Nepalese rural woman have very high workloads due to responsibility in both farm and household. In agriculture, women share the responsibility of planting, transplanting, weeding, harvesting, carrying grains to the mill for grinding, including collecting wood, water and fodder. Similarly, in the household, women's task includes collecting fuel wood, which is major source of energy for cooking, cooking food, tending livestock, collecting fodder etc. A buffalo requires about two heads of fodder which is collected by women (Bhatta et.al.,1994). More than three-fourths of household time spent collecting forest products are done by women (Kumar and Hotchkiss, 1988). Adoption of agrofoestry will reduce time required for all these activities and increase welfare of women.

Table 2.24: Summary of cost and benefit of agroforestry

Cost	Benefit
Initial investment	Income of farmer
Opportunity cost of land	Improved social wellbeing
Marketing cost for forest product	Improved environmental quality
	Reduced threat from pest, insect and animal on other crop
	Women empowerment

2.3.3 INDIA: Biofuel- Jatropha

Petroleum products are no longer well-suited source of energy due to their non-renewable characteristics and their role in accelerating global warming. Continuous rise in oil price adds further to the problem especially for the people of underdeveloped countries. Biofuel could be the possible solution for this problem. Many countries have already practiced production and use the biofuel. Indonesia and Malaysia are growing palm oil while Brazil heavily grows sugarcane for producing this renewable source of energy. There can be long list of benefits of biofuel. For example;

a) Using biofuel reduces the problem of global warming.

b) Provides new market for farmers. If farmers of under developed countries start to produce feedstock for biofuel then there income will change considerably.
c) Due to renewable nature; there will be no fear of energy crisis in the world.
d) Since farmers of both developed and underdeveloped countries will produce it; there will be no monopoly market for fuel in the world, etc.

However, there is risk associated with the production of biofuel. Due to high price of biofuel in comparison to staple foods, farmers of underdeveloped country may divert resources such as arable land and water towards production of feedstock. This may result in high and unstable price of food grain, scarcity of staple foods followed by hunger and poverty. To overcome from the problem of trade off between biofuel and food grain, IFPRI (2006) has recommended producing feedstock for biofuel in marginal land.

India is second highest populated country with one of the highest growth rate in the world. This necessitates high demand of energy. India's energy demand is expected to grow at an annual rate of 4.8 per cent over the next couple of decades (Gonsalves, 2006). Most of the energy requirements are currently satisfied by fossil fuels – coal, petroleum-based products and natural gas. Domestic production of crude oil can only fulfill 25-30 per cent of national consumption (ibid). In this situation India is also promoting biofuel. Since January 2003, a minimum 5% ethanol blend in petrol has been mandatory in India in nine states and four Union territories. By 2005, the ethanol content should reach 10% (Brook and Bhagat, 2004). One of the major sources of biofuel in India is sugar cane. However, Indian farmers have already been experiencing lowered price of sugar cane due to over production (ibid). Another feedstock on which India is relying on is Jatropha. There are several projects and programs that are being run to produce *Jatropha* as feedstock for bio-diesel in India.

Jatropha is the short name of *Jatropha curcas* which is also known as Physic nut. Major attraction of Jatropha lies on its growing capacity even in saline, marginal and infertile soil. Since it can grow without water, drought has no impact on it. Furthermore, it requires little maintenance that in turn reduces cost of production. It grows 1.5-3.0 m high, and is capable of stabilizing sand dunes, acting as a windbreak and combating desertification (ibid). Jatropha's productivity is also high. The yield per hectare is 0.5 to 12 tons depending on soil quality and rainfall (Makkar and Becker, 1999 *cited in* Brook and Bhagat, 2004). Jatropha can give 0.75 to 2 tons of bio-diesel per hectare from fifth year onward of its plantation (Fiodl and Eder, 1997 *cited in* Brook and Bhagat,2004). Jatropha can be useful for other crops as well because it has capacity to repel other animals and insects. Jatropha has its importance not only for producing bio-diesel but also for producing variety others products as every parts of this plant can be used in production of one item or the other. Explaining its importance Brook and Bhagat (2004) write "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. The plant lives, producing seeds, for over 50 years, dark blue dye and wax can be produced from the bark, the stem can be used as a poor quality wood, and the roots help in making yellow dye. The flowers of Jatropha curcas and the Jatropha stem have well-known medicinal properties, and the leaves can be used for dressing wounds."

Jatropha and Sustainable Agriculture

Gonsalves (2006) has listed several benefits such as, reduced emission of harmful pollutants, reduction in green house gas emission, increased employment, energy security, improved social well being etc. Referring to inter-linkages of green technology with sustainability discussed in section 1.2, Jatropha as appropriate technology is evaluated in the following analysis.

Jatropha and environment-friendly agriculture

Jatropha production has very high potential to ensure environment-friendly agriculture. Some of the elements of exhibiting this attribute are:

- Less use of fertilizer and pesticide
- Reduce emission of green house gasses
- Maintains the soil fertility
- Pleasant landscape through intensive farming
- Reduce soil erosion

Since Jatropha can grow in saline, marginal and less fertile land, this does not require the use of fertilizer. Similarly its characteristics of repelling animals and insects, this useful plant not only denies insecticides and pesticides but also helps to reduce the use of these harmful elements in the agriculture of its periphery. Jatropha can directly contribute to reduction of GHG emission. In comparison to petroleum diesel, bio-diesel reduces emission of particulate matter by 40-65%, unburned hydrocarbons by 68%, carbon monoxide by 44-50%, sulphates by 100%, polycyclic aromatic hydrocarbons (PAHs) by 80%, and the carcinogenic nitrated PAHs by 90% on an average (Brook and Bhagat, 2004). Finally, since Jatropha can be grown in marginal and less fertile land, it will reduce desertification and embellish the landscape.

Jatropha and poverty reduction

According to 1996 agriculture statistics of India, out of 142.81 millions hectares of net sown area, only 55.05 millions hectares area is irrigated *(http://agricoop.nic.in/statistics /land1.htm)*. Similarly about 19 millions hectares area is barren and uncultivable land while about 13 million hectares area is cultivable wasteland (ibid). It indicates high potentiality of land availability for Jatropha production. If 13 million hectare area of wasteland is used for Jatropha production and one man is employed per hectare then 13 million new jobs will be created. If poor and marginal people own such land then the income form the sale of Jatropha will have additional impact on poverty. It is estimated that biofuel sectors requires approximately fifty percent less investment than petroleum sector to create one additional employment (Uppal,2004). It was expected during first phase of National Bio-diesel Mission that plantation of Jatropha in 400 thousand hectare area would create 3680 person year employment (Gonjalves, 2006). Hence Jatropha will have direct impact in reducing poverty without disturbing the current production pattern of food grain. Jatropha production will increase the supply of energy in India. Use of biofuel in Indian rural area will improve social status of the poor.

Jatropha and Rural Environment

Since Jatropha production doesn't require pesticide, insecticide, fertilizer and irrigation, its production will not have adverse impact on soil, water and air. Like other agriculture activity, Jatropha production is not dependent on agriculture; it will have no negative impact on forest and biodiversity. Rather its production will improve the soil quality of saline and wasteland and stop desertification.

Jatropha and Income Generation to Farmers

Main use of Jatropha is for its oil obtained from its seed. A farmer can produce Jatropha seed to 3.25 ton/hectare/year; current market price of which is about INR 5000 per ton (Gonjalves, 2006). This gives only INR 18750/hectare/year. This amount is far less than the amount from sugar cane. But the income is more due to two reasons. First, production cost is almost negligible for Jatropha. Second, this plant is grown to that area where opportunity cost of land is almost zero. Beside the seed, other parts of Jatropha can also be used which also furnishes income. If we internalize the externality such as less insects in crops, stable price of food grain etc. of Jatropha then resulting income will be far high than other crop.

Jatropha and Gender Issue

Women carry out most of the farm work in India. But Jatropha production does not require labour-intensive maintenance and care; it can save time of woman members of the farm household.

Government's Policy on Jatropha

Former President of India Dr. A.P.J. Abdul Kalam said, "India needs to grow Jatropha to tackle dry land and generate bio-diesel." (cited in Brook and Bhagat, 2004). This indicates the India's commitment to Jatropha. India has announced National Bio-diesel Mission. The mission is to meet 20 percent of countries diesel requirement through bio-diesel by 2011-2012. Government has decided to use Jatropha seed as the feedstock for biodiesel (Gonjalves, 2006). The project will be implemented in two phases (ibid). In phase I, government will establish Jatropha nurseries, cultivate 400,000 hectares with Jatropha, establish seed collection and Jatropha oil extraction centres, and the installation of a 80,000 Mt/year transesterification to produce bio-diesel from Jatropha oil. Phase II will consist of a self sustaining expansion of the programme leading to the production of bio-diesel to meet 20 per cent of the country’s diesel requirements by 2011-12.

Problem with Jatropha Production in India

Following are the problems revealed by farmers regarding Jatropha cultivation (Dhanda, 2004 *cited in* Gonjalves, 2006)

1. Lack of confidence in farmers due to the delay in notifying, publicizing and explaining the government bio-diesel policy
2. No minimum support price
3. In the absence of long-term purchase contracts, there are no buy-back arrangements or purchase centres for Jatropha plantations
4. Lack of availability certified seeds of higher yield containing higher oil content
5. No announcement of incentives/subsidy and other benefits proposed to be provided to farmers
6. Non-availability of cultures of Jatropha

Table 2.25: Summary of cost and benefit of jatropha

Cost	Benefit
Direct production cost	Income of farmer
Opportunity cost of land	Improved social well being
Reduced income of petro-product seller	Improved environmental quality
	Reduced threat from pest, insect and animal on other crop
	Reduced risk from oil price and import shocks

Table 2.26: Evaluation of technology for adoption

Characteristics	Impression	Reason
System Independence	Yes	Less capital is required
Image of Modernity	Yes	Relatively new concept so people will not hesitate to adopt in the ground of social prestige
Individual Vs Collective	Collective	For economies of scale people will have to grow collectively
Cost of Technology	Very low	Only labour is the significant input
Risk Factor	Very low	Little will be at stake as it is grown in marginal land
Evolutionary capacity	Very high	Fuel shortage in India will expand the Jatropha production
Single vs Multi Purpose	Multipurpose	There are many use of Jatropha. Jatropha is not only a cash crop but also technology to save environment and fill the gap of energy supply

2.3.4 MALAYSIA : Biomas

Biomas is available on a renewable basis through forest and mill residues, wood wastes, agricultural crops and wastes and animal wastes etc. Because of the high sunlight intensity and high rainfall, production of biomass is possible throughout the year. Major contributor of biomass is palm oil industry, mainly lingo-cellulosics *(http://phoenix1.iserver.net/pdf/16.Prof.Hassan.pdf)*.

Special incentives are essential to minimize environmental pollution since it causes indiscriminate dumping. Burning of biomass produces emission of smoke and toxic chemicals, which also necessitates operational legislation. The uncertainties regarding economic feasibility, uninterrupted supply, quality etc should be carefully assessed to use biomass as sustainable alternative energy source, which is considered to be environmentally sustainable.

The major concern in Malaysia is to reduce overdependence on depletable sources of energy. As Malaysia's National Energy Policy (1979) has three objectives such as diversifying supply sources, promoting efficient utilisation of energy and ensuring the regulation for environmental protection, the government formulated National Depletion Policy (1980) and Four-Fuel Diversification Policy (1981) to meet these objectives.

Wood residues, palm oil waste and agricultural waste are being converted into usable forms of energy for heat generation. Increased utilisation of such renewable energy including biomass and municipal waste has worked as a means of pollution control *(http://unpan1.un.org/ intradoc/groups/public/documents/APCITY/UNPAN003226.pdf).*

Table 2.27: Potential power generation from oil palm residues at palm oil mills in Malaysia (Year 2000)

Type of Industry	**Production ('000 Tonne)**	**Residue**	**Residue Product Ratio (%)**	**Residue Generated ('000 Tonne)**	**Potential Energy PJ**	**Potential Electricity Generated (MW)**
Oil Palm	59800	EFB at 65% MC	21.14	12641	57	521
		Fiber	12.72	7607	108	1032
		Shell	5.67	3390	55	545
	Total Solid			16670	220	2098
	POME (3.5 m^3 per ton of CPO/65% of FFB)			38870		320

Source: Malaysian Oil Palm Statistics 2002, 22nd Edition, MPOB

Chapter Three

IMPACT OF GREEN TECHNOLOGY

3.1 On Promoting Green Practices

There is an international call for all types and sizes of enterprises- government, non-government to not-for-profits to promote sustainable and environmentally responsible business practices. These enterprises can collectively jump on the "green" bandwagon. The message for increasing market opportunities for their products can be disseminated through environmental-awareness initiatives. The advantage of reducing the impact of climate change through the reduction of carbon footprint can be explained by creating awareness about new technologies. The awareness is helpful in understanding market trends, environmental threats and opportunities.

Recently, a new Green Technology Initiative (GTI) has been launched in London to help IT stakeholders to limit environmental impact of their IT infrastructure. In other words, it means limiting the carbon emissions associated with IT equipment. Reducing the carbon footprint is in line with British Governments' target of a 20% reduction in greenhouse gas emissions by 2020 (*http://www.greentechnologyinitiative.org/*). There is an overwhelming interest in making the system greener but majority lack information on how to do it?

A new opinion poll by Zogby/TechNet shows 77% U.S. voters believe America has not done enough to facilitate green practices *(http://www.prnewswire.com/cgi-bin/stories.pl?ACCT=104&STORY=/www/story/01-18-2007/0004508297&EDATE=)*. They must do more to promote and implement sound energy strategy i.e., the green technologies. As increased consumption of oil and coal has been a matter of serious concern, the development of Green Tech Policy Agenda through public-private partnership for achieving energy security, environmental protection and competitiveness is important. It is now believed that the damages from global warming are almost certain. Nobel laureate Al Gore observes, "the degree of certainty, which was already very high, is now as close to certain as scientists are ever willing to say something certain" *(http://www.macworld.co.uk/news /index.cfm?newsid=17120)*.

China has been aggressively involved in the development of environmentally friendly farming practices such as growing organic produce and helping raise food safety standards. The Agriculture Ministry states, in last three years, cultivable land using harm free organic methods have grown fourfold accounting for one-fifth of China's agriculture *(http://news.indiainfo.com/2007/06/18/china.html)*. A safe, fine quality and nutritious food produced and processed by specific model under the principle of sustainable development, which is known as "green food" was first proposed in 1989 in China and the development and management of green food was formally initiated in 1990 (Lijuan, 2003). The sustainable green agriculture has been showing satisfactory results from several perspectives- economic benefits, social efficiency and eco-environmental effectiveness.

3.2 On Sustainable Agriculture, Rural Income and Poverty Reduction

Non-sustainable land-use practices and highly erosive monsoon rains are the contributing factors for low agricultural productivity and hence high incidence and severity of poverty in many parts of Asia. The discussion on sustainable agriculture becomes incomplete if we do not consider environmental degradation in the context of development. Sustainability should also be resource-saving, not one-sided resource usages. Rapid growth of urbanisation and increasing demand has made the poor a victim of natural resource degradation largely in the form of shortage of fuel, fodder, and drinking water. In India in particular and in Nepal in general, there is inadequate investments in irrigation, rural electrification, on the public distribution system and in creating assets for the poor for alleviating poverty.

It is true; agriculture technology offers opportunities for raising food grain production in land scarce countries, the information that many Asian countries lack to properly address the potential adverse effect or favourable impact of these technologies on the poor. Some empirical studies are available that show a robust and positive effect of agricultural technology adoption on farm households' wellbeing suggesting that there is a large scope for enhancing the role of agricultural technology in "directly" contributing to poverty alleviation (Mendola, 2003).

When commodity prices collapsed in 1985, the implementation of Malaysia's National Agriculture Policy, 1884 slowed down by switching over to manufacturing and high-tech sector. It is common practice everywhere as the economy progresses. Malaysia also got lessons from South East Asian currency crisis, when they had enough manufactured products but did not have the buyers. In the absence of buyers of manufactured products, it is naturally difficult to pay for food imports. Therefore, as the third largest component of the GDP, agriculture is still a vibrant sector and its sustainable growth is government's priority. This sector has shown extraordinary resilience, especially in cushioning the impact of the Asian Financial Crisis of 1997.

Last sixty years development history in India shows agriculture playing as a backbone for increasing the overall growth rate per capita income. However, the yield rates for most of the agricultural products are lower except in sugarcane; tea, coffee and jute. In case of wheat, average yields in the Netherlands and Ireland are more than three times India's yield rates and in all other major crops, India's productivity is lower than world averages *(http://www.thomex.com/article/resources_details.aspx?ID=R_2007060414180&catid=C_20070807182510).* When crops suffer because of the bad weather and price rises, the economy suffers. This situation makes adverse effect on Nepalese economy because of the excessive imports of essential goods including food grain. Therefore, since agriculture is one of the effective pillars to reduce poverty, increase farm income and confront widening rural-urban income disparities, the impact of climate change on agriculture needs to be given due consideration by facilitating green technology.

3.3 On Contributing to Income Generation through Ecological Agriculture and Rural Renewable Energy

Since energy improves productivity in major sectors of the economy that contributes to GDP, it can create employment and increase income. With backward agriculture and high poverty levels, the policy for making choices of the appropriate alternative energy technology is very important. The per capita energy consumption in developing countries stands at 400 units as against a minimum of 8000 units in developed countries *(www.yesweb.org/2006/Publications_Papers%20_august%203_2006/Call%20for%20papers/sriram%20raju_paper.doc).* The possibility of improving per capita energy consumption levels is through renewable energy technologies. The shift from fossil-fuel economy to a renewable energy based economy has made it possible to reduce carbon dioxide emissions. The study shows, the contribution of carbon dioxide emissions from the use of renewable energy is the least as compared with those from other fuels, and is of the order of 0.001% per kWh, as against 1.2% per kWh for coal and 0.6% per kWh for oil (Balakrishnan, 1999).

Box 3.1: Ecological Agriculture

There are organisations that involve community residents to help them improve food quality and increase the production of natural and healthy food by sustaining the environment through ecological farming. The success story can be found in Auroville, a place which is located on the Southeast Coast of India in Tamil Nadu, 100 miles south of Madras and just north of the city of Pondicherry. Auroville has 80 different settlements spread out over 2,600 acres within a 20 square-mile circle. Auroville has 1000 people from 30 different countries. In the vicinity area, there are a dozen Tamil villages with a total population of 25,000 (http://www.miraura.org/aa/av/av-phys.html).

The history of farming in Auroville begins in 1969, when farmers, foresters and garden growers took to working with ecologically friendly means and tools, to cure nature. In ecological agriculture, it is important to understand the relationship between traditional farming and modern agriculture by using eco-friendly technologies namely windmills, solar energy, drip irrigation, micro sprinklers and methane gas collectors. There are several other activities, which can be considered in ecological agriculture. These may include: seed banks, introduction of vegetables and fruits from other tropical countries and food processing.

Although inadequate funds in the developing economies, after the removal of subsidies in irrigation, fertilizers and power, the farmers face risk of crop failures, eco-friendly practices have created employment opportunities enhancing farmers' skills. Auroville works in 35 local villages, directly benefiting 2,000 people and indirectly 30,000+through its team of 20 development workers. There is a collective endeavor and cooperative spirit, where residents work and in return receive their meals through the production of food and reforestation (http://www.auroville.org/environment/agri_history.htm). The mission is to promote environmental awareness, health awareness and community hygiene. Small grants are provided for the community service initiatives on a cost-sharing basis with village groups.

The experience of Auroville farms is worth noting. For distribution and marketing, of the produce, which are qualified organic, are sold through the Foodlink centres of Auroville Farm Group. Rice and vegetables are offered for the meal in the communal solar kitchen and for distribution among schools. To encourage the sustainable eco-friendly agriculture, the management for the common storage and creation of marketing development outlets can save the loss of significant part of surplus harvests.

Source: http://www.auroville.org/environment/agri_history.htm

Renewable energy technology has been the best substitute for improving the quality of life of rural households in terms of cooking and lighting, producing bio-fertilizers, and food production activities. In many developing countries renewable energy has helped Small and Medium Enterprises to process high value cash crops. The consideration of ecological agriculture is also one of the important strategies developed recently, which integrates agricultural production techniques in line with rural economic environment. Special care is given to the conservation, utilisation and efficient use of available resources.

The study led by Graham Brookes of PGE Economics Limited of Dorchester, UK shows biotech crops, planted using conservation tillage practices have helped retain carbon in the soil since it is herbicide -tolerant. Similarly, insect-resistant crops can dramatically reduce the need for spraying and also significantly reducing farm fuel use. The result shows by 2005, during 10th year of use (1996-2005) on 87 million hectares by 8.5 million farmers, 9 billion kilograms of carbon dioxide emissions were reduced, which was equivalent to removing nearly 4 million family cars from the road for an entire year. The Brookes estimate further reveals biotech crops contributing $5 billion in net farm-level economic benefit to farmers in Argentina. In 2005, the farmers in the developing world received 55 per cent of the additional net farm income generated by biotech crops globally (http://www.pgeconomics.co.uk).

The message is shift from the traditional environmental policy towards ecological modernisation through green technology makes incredible impact on rural income.

3.4 Enhancing Policy Development and Capacity Building in the Application of Green Technology

Ineffective policy on human resource development for capacity building affects development. The successful application of appropriate technology depends on the schemes for imparting knowledge, skills and understanding, and bringing about the changes in the attitude for desired change. Technology adoption requires capacity building on institutional strengthening. This may require new organisational structures. The institutions needed especially for sustainable agriculture include; agricultural education and training institutions as well as extension services, think tanks, community organisations and NGOs. Therefore capacity building programme for the promotion of agriculture technology will be recommended for managing natural resources for sustainable development. This has happened where HRD has been linked with national development plans since capacity building as said before would mean awareness-rising, education and training, attitude change, confidence building and participation in decision-making.

Studies have been conducted by the Goteborg Universlty to find out ways of combining structural-institutional models of environmental capacity-building and social constructivist discourse analysis into a more satisfactorily and fully covering theory of environmental policy change.

3.5 National Policies for GT: Impact, Implication and Challenges

In the literature of technology adoption, four paradigms are frequently cited to explain determinants of technology adoption and its adoption process. The first paradigm is due to Rogers (1962) known as "the innovation-diffusion-adoption model". According to this model, adoption is a mental process through which an individual passes from hearing about an innovation to its adoption that follows awareness, interest, evaluation, trial, and adoption stages. This paradigm emphasizes the role of information, risk factors and the social position of the decision makers in the community (Upadhyay, Young et al. 2003).

The second model is due to Aikens et al. (1975) known as economic constraint model. According to this model lack of resource endowment is the major constraint for potential adopter. Lack of access to capital and inadequate farm size significantly obstruct adoption decisions. Although this model is accepted by various scholars (e.g. Hooks, Napier et al.), its superiority has been challenged by Nowak (1987).

The income paradigm assumes households to be profit maximizer. According to this paradigm farmers adopt those technologies that increase their net return. Since it assumes the profit maximisation behaviour, this theory is very much near to the neoclassical theory of economics. The strength of this approach lies in understanding the role played by one of the major factors that motivate or inhibit innovation: change in income (Upadhyay, Young et al. 2003). However this approach is unable to identify the heterogeneity among farmers'(Nowak 1987) and can not explain why certain profitable technologies are not adopted (Neill and Lee 2001).

The utility paradigm takes households as utility maximiser. They make their adoption decision based on utility maximisation instead of income maximisation. In utility paradigm, a household responds to many factors, including income, but also including non-income factors such as environmental quality, social benefit and /or altruism (Upadhyay, Young et al. 2003). It can be said that that utility paradigm has synthesised all the three models explained above.(Feder and Umali 1993)

In conclusion, borrowing from Feder and Umali (1993), it can be said that the current theoretical and empirical literature recognizes that adoption behavior, is complex and often requires a blend of the income, utility, economic constraint and diffusion paradigms. Thus, researchers often include economic variables and social-cultural variables, as well as information variables, in their studies (Nowak 1987) to explain technology adoption behaviour. Hence adoption and expansion of GT is influenced by not only by direct policy for GT but also by other policies such as credit policy, education policy, women empowerment policy etc. In this chapter government policy and its impact and challenges towards promotion and expansion of GT has been summarised for Nepal, India and Malaysia. A detailed analysis is left for phase II program.

3.5.1 Nepal

In Nepal there is neither separate nor umbrella policy for enhancing GT. Periodic plan document is the major source of policies in Nepal. Currently Nepal has concluded Tenth Five Year plan and has implemented Three Year Interim Plan (TYIP). In TYIP there are several disaggregated objectives and policies that may influence the adoption and expansion of GT.

There is single objective for agriculture that may promote GT. The objective is to conserve, promote and utilize agricultural biodiversities through the development and dissemination of environment friendly technologies. The policy for agriculture sector towards promotion of GT is to provide special concessions and facilities to poor farmers living below the poverty line for the use of practices such as improved farm yard manure, compost manure, *giti* manure and urine management. However the impact of this policy may be outweighed by the policy that ensures financial concessions and technical services for activities such as using fertilizer and pesticides. Agriculture sector policy is mainly guided by Agriculture Perspective Plan (APP) and National Agriculture Policy-2005 (NAP-2005). NAP-2005 in its section B, article 31 have mentioned about promoting organic farming.

NAP-2005 speaks about natural resources and environment conservation in its section C. However this section does not clearly mention about GT. According to policy, government will make arrangement for minimizing negative impact of chemical fertilizer and pesticides, production and use of organic manure will be promoted, biodiversity and In Situ conservation will be promoted, and agroforestry will be developed. However NAP-2005 is silent about strategies for implementing these policies. So it is difficult to access its impact on poverty, sustainable agriculture and adoption and expansion of GT.

Rural Energy Policy 2006 (REP-2006) is another major policy towards promoting GT. REP-2006 has covered almost all energy related GT such as small and micro-hydro project, biogas, biofuel and biomass gasification, solar energy, wind energy, improved cook stove, rural electrification, etc. Although there is not single to show the causality between energy consumption and growth and possible feedback effect for Nepal, capacity of all these energy sources for reducing poverty and sustainable development are theoretically proved (For example see Biswas et.al. 2001). Major problem with the policies in underdeveloped countries are weaknesses in implementation. However the beauty of REP-2006 is that it lays emphasis on public-private-partnership. The policy focus is on integration of local government, donor agencies, national government and private sector. Subsidy and credit is provided for adopting renewable energy sources (see biogas for Nepal in previous chapter). The national plan has put alternative energy in top priority. TYIP has identified four major programme viz. wind energy program, bioenergy program, solar energy program, small and Micro-hydropower programme to promote renewable energy in Nepal. Beside that, policy has opened the door for possible production of bio-fuel through oil seed.

Government of Nepal has brought Subsidy Policy for Renewable (Rural) Energy,2006 with the objective to enhance renewable energy in the rural area where most of the poor people live. Energy subsidy policy also aims to attract private sector and new donors for the provision of renewable energy in the Nepalese rural area. The policy is to provide subsidy for Micro Hydro Power, Solar Energy (Solar home system, Solar dryer, Solar water pump, Solar cooker), Improved Water Mill, Biogas, Wind energy, Improved cook stove and subsidy for R&D of other renewable energy sources. Subsidies vary from types of renewable energy to location of using it. For example subsidy for Biogas is NPR 6000 for low land districts while it is NPR 15000 for mountain district.

Although the policy looks sound, dissemination rate is a bit slow. This may be due to “poor are too poor to adopt”. The subsidy provided for adoption of these technologies is only a fraction of the total expenditure. Furthermore, as stated in TYIP, difficult geographical structure of the country, lack of skilled manpower, lack of awareness are also some other causes of slow rate of adoption.

At national level, Renewable Energy or Alternate Energy programs were incorporated as Priority 1 programs through The Tenth Plan, also known as Poverty Reduction Strategy Paper (PRSP). In short, PRSP envisioned renewable or alternate energy programs as one of the instruments for poverty alleviation. Expectations were that the programs would raise purchasing power of the local people (as local technologies would be developed), increase consumption of alternate energy, and reduce dependency on imported energy (as cost of installation would lower through proper utilisation of local resources and means). It was envisioned that Renewable (Rural) Energy Technology (RET) programs on the long run would accelerate economic development, improve livelihood of rural people, increase employment opportunities, and maintain environmental sustainability. Amidst such developments, renewable energy sector has burgeoned with efforts of both government and non-government stakeholders. Traditionally key players in the off-grid and Renewable (rural) Energy Programs (REP) have been Ministry of Science and Technology through Alternate Energy Promotion Centre (AEPC) at implementation level and National Planning Commission at planning level. This ensemble of public stakeholders was devised when Energy Sector Assistance Programme (ESAP) with funding primarily from Danish and Norwegian governments intervened in 1998. Later, Rural Energy Development Programme (REDP) of United Nation's Development Programme (UNDP) and the World Bank further consolidated ESAP. Renewable Energy Policy was first introduced in 2000 and later revised in 2006.

ESAP was designed to be a 15-20 year program, which was commenced in Nov 1998. Budget for EASP Phase I (1999-2004) was DKKK 120 million and for ESAP Phase II (2007-2012) it remained at DKKK 346.6 million. For both the programs, AEPC has been the public implementing agency. Excluding institutional support to AEPC, the major programme components of ESAP I have been technical support for Micro Hydro (MH) development, solar energy promotion, improved cooking stoves (ICS) promotion, and investment support and other activities. The latter converged on installing a mechanism to disburse subsidies for promotion of solar energy component and MH component. ESAP I operated adhering principles of Public Private Partnership (PPP) whereby implementation was assigned to companies qualified under criteria set by AEPC. AEPC assumed regulation and coordination responsibilities. Subsidies were used as incentives to incite private companies and NGOs to promote programme components in case of Solar Home Systems (SHS) and MH. ESAP I was quantitatively successful and deserves due credit as unlike most other development initiatives, it did not falter even in peak of Maoist Insurgency. ESAP II is continuation of ESAP I. Programs as Institutional Strengthening of Rural Energy Sector, Biomass Energy Component, Mini Grid Support Program, Solar Support Program, and Financial Assistance Component correspond to similar programs of ESAP I. Subsidy channel, Interim Rural Energy Fund of ESAP I, accordingly has been transferred to Rural Energy Fund (REF) for ESAP II. However, some major changes in subsidy delivery mechanism, particularly in Micro/Mini [14] Hydro component, distinguish programme approach of ESAP II. Biogas Support Programme (BSP) has been another major programme with major success in biogas sector. BSP works with mechanism similar to ESAP program, distinguished only by commercial and development banks as financial intermediaries.

14 Hydropower plants with capacity of under 500kW are eligible for subsidy.

Box 3.2: Challenges and Opportunities for Alternative Energy in Nepal

Challenges

The challenges facing the alternative energy sector include: i) the grants available from the donor agencies covering only a fraction of the cost of installation of alternative energy technologies and lack of arrangements for easily accessible credit for majority of population, ii) developing the possibilities for the connection of small and micro-hydropower plants to the national grid in future in case of expansion of the national grids, iii) increased utilisation of micro hydropower for productive uses besides its use in meeting the household consumption, and iv) integration of alternative energy in the development plan of local institutions and capacity building of local institutions to undertake selection, promotion, coordination and monitoring and evaluation of alternative energy promotion programs.

Opportunities

- Government of Nepal and donor countries have considered alternative energy as priority sector for development and promotion
- Alternative energy has implicit potential to contribute in strengthening rural economy through promotion of trade and industry and employment promotion at local level.
- Alternative energy can be promoted to help low income, marginal and disadvantaged and contribute to rehabilitation of the households displaced by conflict by providing them electricity and cooking fuel.
- Alternative energy is environment friendly energy source and the possibilities of reducing green house gas emission levels with the promotion of alternative energy, and the savings in the carbon emission levels; thereof has created possibilities of carbon trading in the global market.
- Increasing private sector participation in the alternative energy promotion and the increasing competition in the service provision has helped enhancing the accessibility of technology to the consumers, reducing the cost, improving the quality of technology and accelerating the services.

Source: Adopted from Three Year Interim Plan, National Planning Commission, Nepal

Another implementation model that has prevailed in RET sector, especially Micro Hydro, is that of Rural Energy Development Programme (REDP). Funded by UNDP and World Bank, REDP too formulates subsidised Micro Hydro projects but is different from ESAP programme in its dependency with local governments and eventually National Planning Commission. In REDP projects, local bodies, as District Development Committee (DDC) and Village Development Committee (VDC) are required to support MH programs by equity investment and by endorsing projects in mainstream development programs. Subsidies are disbursed by AEPC through District Energy Fund (DEF). DEF in turn supports Community Energy Fund (CEF) which is agglomerated financial pool with investment from DDC, VDC, DEF, and community assembled Micro Hydro Function Group (MHFG). Though suppliers/installers in REDP programs are AEPC qualified companies, MHFG acts as core decision-making body at implementation level. The ideological difference between REDP and ESAP programs is the implementation strategy. While ESAP programs seem inclined to encourage private sector intervention, with subsidies as incentives, REDP programs are more

dependent on local and regional institutions and use subsidies to reduce financial burden on them.
RET programs as aforementioned were streamlined into national development planning in PRSP or The Tenth Plan (2002-2007). Preceding PRSP, the 7th Plan indicated roles of decentralised Hydropower in developing and expanding agriculture and cottage and small industries. The 8th Plan (1993-1997) and The 9th Plan (1998-2002) brought attention to poverty alleviation and rural development by accelerating employment generating economic growth, human resource development and population reduction. In broad economic philosophy, both the 8th and 9th plan stated government's commitment to liberalize the economy and pursue free-market oriented policies. While The 8th Plan allocated 5.1% of total energy investment in renewable energy, The 9th Plan installed AEPC as pivot organisation for renewable energy. Rural Energy Development Fund and intentions to assist agriculture, cottage and small industries, irrigation, and water supply by RET programs were delineated in The 9th Plan. Devolution of public sector expenditure and resource mobilisation authority to self-governing local bodies and policies to maximize participation of local NGOs have also been of significance in development of renewable energy policies. In general, one or the other major RET programs through RET policies have been in agreement with mandates and strategies of Government of Nepal.

The government has made the provision of subsidised loan without any collateral to rural poor and woman through more than 112 micro finance institutions. This has positively contributed to the socio-economic condition of the rural poor and women with an access to biogas as cooking fuel.

3.5.2 India

Currently two third of total energy production in India is from thermal power followed by one fourth from hydroelectricity and only about eight percent from Renewable Energy Sources that include SHP, BG, U&I and wind energy. Current reserve-to-production ratio for coal, oil and natural gas are 235, 23 and 35 years respectively (Ghosh, NA). This makes India, with population that is one sixth of the world population, one of the neediest countries for renewable energy. India's goal is to add 10,000 MW in the power generation capacity through sources of renewable energy. With the purpose of expanding renewable energy India has brought several policies and programs including "New and Renewable Energy Plan" under the proposed 11th plan, Electricity Act, Renewable Energy Act etc.

Renewable Energy Act has been formulated to meet 20 percent of countries total requirement of energy from this sector by 2020. The major provisions in the act are (ibid)

- Solar water heating to be made mandatory throughout the urban areas of the country by 2012, in a phased manner.
- A time-bound programme of demonstration of solar rooftop lighting systems in 10,000 government buildings by 2010, also incorporating building integrated photovoltaic.
- Conversion of fossil fuel based industrial heating to solar thermal heating using new solar concentrator technology or its hybrids.
- India has at present about 30,000 MW captive generating units (industrial units), of which about 18,000 MW are diesel based. The draft law proposes time-bound conversion of these captive units to
  - Biofuel based generation. This will save large amounts of diesel.
  - Provision for small biomass based energy systems for rural areas.

- Indigenous development of small wind power systems up to 25 kW (and hybrids) for stand-alone applications.
- Widespread application of co-generation concepts (heat and power) for lighting, heating and cooling.

The act has also made provisions for accelerating biofuel development and transportation energy to displace fossil fuel. The backward and forward linkage of biofuel production on employment and income generation has already been explained in the report.

The act aims to achieve all the growth and development in renewable energy through market-based policies and instruments. However, the country like India where there is rampant market imperfection, it is dubious to achieve the goal through market mechanism.

3.5.3 Malaysia

Malaysia's Green Technology revolves around renewable energy. Agriculture sector is only third large sector to contribute. Agriculture sector contributes only 8.2 percent to the GDP. This share is heavily dominated by oil palm that is largely produced for biofuel. In the Ninth Plan Malaysian government expects to increase oil palm by 5.5 percent with the expansion in planted area. Government aims to expand oil palm industry during the Ninth Plan period. But there is controversial arguments regarding benefit of oil palm. There is no doubt that expansion of oil palm production will increase the use of biofuel and income of farmer. But it may create the problem of food shortage, as there will be less arable land for producing staple food item.
In the energy sector, Government of Malaysia aims to reduce the dependency on petroleum product through use of alternative source of energy. For this government has planned for greater use of renewable energy for power generation. During the Ninth Plan period renewable energy will be mainly produced from oil palm, municipal waste, solar power and wind power. Rural electricity programme through solar hybrid and micro-hydro will also be implemented during the Ninth Plan period.

Malaysia has the new energy policy (5th Fuel Policy). The basic principle is to supplement the conventional supply of energy; new sources of renewable energy will also be encouraged. The fuel diversification policy which includes oil, gas, hydro and coal will be extended to include renewable energy as the fifth fuel, particularly biomass, biogas, municipal waste, solar and mini-hydro. For electricity generation, largely biomass resources such as oil palm and wood waste as well as rice husks will be widely used. Palm diesel and hydrogen fuel are other potential sources of energy.

Malaysia's *Five Fuel Diversification Policy* provides the renewable energy policy guidance while the current grid-based *small renewable energy programmes or SREP*, embodies national renewable energy strategy. Government provides both investment incentives and tax exemption for promoting renewable energy. Similarly appropriate grant and subsidies are also provided for renewable energy.

The Ninth Malaysian Plan (2006-10) focuses on the promotion of technology- and innovation-driven strategies. The share of manufacturing to GDP is projected to increase from 30.8 per cent for the Eighth Plan to 31.8 per cent in the Ninth Plan. The Plan intends to intensify the development of the resource-based industries. It is expected that petrochemicals, pulp and paper, rubber, wood and palm oil products as well as food industries will significantly contribute to add value in the manufacturing products by promoting inter-industry and inter-sectoral linkages.

The Plan also guarantees customised fiscal and non-fiscal incentives to enhance R&D, special skills development as well as global partnerships. From green technology and environmental management perspective the development and utilisation of renewable energy (RE) is proposed to further intensify. To support this initiative the Plan proposes to support the implementation of Small Renewable Energy Programme (SREP) and the utilisation of Clean Development Mechanism (CDM). The government proposes to utilize municipal waste under RE projects. By 2010 about 300 MW is expected to be generated and connected to the TNB Grid in Peninsular Malaysia and 50 MW to the Sabah Electricity Sdn. Bhd. (SESB) Grid in Sabah *(www.ptm.org.my/division/download/Chapter19_Energy4.pdf)*. During the Plan period stand-alone systems of solar hybrid with biomass based co-generation is planned under the RE projects. Malaysia expects to become a world leader and hub for palm oil. Through the formulation of relevant regulations for blending of petroleum diesel and palm biofuel, the government further plans to promote the development of biofuel using palm oil as renewable source of energy.

The success can be measured on the basis of implementation of energy efficiency (EE) programs that focuses on energy saving features in the industrial and commercial sectors. In this perspective, EE programs such as efficient lighting and air conditioning systems are crucial. In the industrial sector, the improvements in plant, equipment and processes are essential. This should follow the development of local expertise in the manufacture of EE equipment and machineries as new sources of growth.

Malaysia is one of the well-known ASEAN countries that uses and promotes renewable energy. However the success has been minimal. The main reason of little success may be higher installation and per unit cost of electricity generated from renewable sources. In comparison to conventional electricity that cost 4-6 cent/kWh, electricity from solar thermal power costs 20-25 cents/kWh followed by biomass (7-15 cents/kWh), geothermal (7-10 cents/kWh), small hydroelectricity (5-10 cents/kWh) (Hansen, 1998).

Chapter Four

CHALLENGES AND ALTERNATIVES

4.1 Challenges and Alternatives

The detailed explanation of feasible technologies has already been given in chapter two. An overview of the challenges and relevant options are briefly elaborated in this chapter.

There is a consensus that although there is a strong business case for "sustainability", it is one of the most difficult and complex tasks to balance environmental and business concerns. In other words, there is a problem in balancing between the societal benefits of "green" practices and regulations with their costs. This situation is elaborated by Professor Jim Sweeny by saying "….in at least two crucial areas — energy management and materials management — a gap remains between societal benefits and private business benefits".

Storms, floods, droughts and wildfires are the results of climate change. We know the earth's average temperature has risen by 0.7 degree Celsius since pre-industrial times *(http://www.eugenestandard.org/mdb/publi/15_factsheetcasestudies%20final2.pdf).* As CO_2 emissions are the major factor for causing climate change, the major task is to adopt energy demand reduction measures and significant growth in renewable energy for reducing CO_2 emissions.

The use of technologies at the status quo level will create health hazards to the people and life that surrounds the planet. The Inter-governmental Panel on Climate Change (IPCC) in its Fourth Assessment Report outlines human activity for creating scary effects of climate change to damage the world environment. The report states a rise in global temperature by 1.8-4^{o}C and sea level rise of 18-59 cm by the end of the century. This scenario necessitates the early success in deploying renewable carbon-free technologies by moving away from the coal and oil based economy to solar, wind, nuclear, bio-fuels, hydroelectricity, batteries, hybrid cars, etc. Efforts in recent years are found in building giant space mirrors to reflect solar radiation back into space for commercializing renewable energy (Bhardwaj, 2007).

As the adverse impact from climate change in ecosystem, agriculture, fresh water and human health is going to be the major threat, APCAEM countries need to immediately prepare themselves for need-specific alternative technologies. It is advisable to seeking technical and financial support from relevant UN agencies in capacity building programs for the mitigation of unforeseen eventualities.

Although rich countries can relatively take more benefits from renewable sources to meet their energy demands, it seems extremely difficult to derive adequate electricity or liquid fuels to sustain the current high per capita rates of consumption from renewable sources. This suggests the fact that sustainable future may be possible only when we get success in significantly reducing current material "living standards" and in gross economic activity. The limitations of conventional energy sources are as such that resources for power generation i.e., coal, gas, etc. are limited.

Solar photovoltaic (PV) technology facilitates in converting the solar energy in electrical energy and is being used for applications such as lighting, water pumping, communication systems, remote area villages electrification, telecom applications, traffic signaling and railway signalling systems. This system has proved to be effective in rural electrification projects around the world. The fundamental problem of PV is the inadequate information on the potential and limitations of its application. Therefore, unless the potential contribution of PV to rural development and poverty alleviation is not properly examined, it will be difficult for the developing countries to make financial as well as political commitment.

Wind pumps and generators can be used in remote areas. Currently, wind turbo-generators on wind farms have been providing electricity in the cities. The data shows United States and Denmark have produced most of the world's wind-generated electricity. Wind generators don't produce greenhouse gas emissions but they cause vibrations, noise and visual pollution. Similarly wind-generated electricity does not cause air pollution, it does cost more to produce than electricity generated from coal *(http://www.sustainableenergy.qld.edu.au/fact/factsheet_6.html).*

Since 2005 the prices of essential commodities have risen by an average of 75 per cent. Poor people are struggling hard to afford a simple life-sustaining diet because the price of rice, wheat, maize and feedstock has gone up between 30 and 50 per cent just in 2008 *(http://onlinejournal.com/artman/publish/article_3059.shtml)*. As more and more agricultural land is being turned over to the production of crops used to manufacture biofuels, there is an increasing global food crisis. The bottom-line is renewable and environmentally-friendly energy resources are necessary for petroleum replacement. However, this should not be at the cost of world's poor suffering from a scarcity of affordable staples.

Hydropower projects are a cheap renewable energy source. It has the potential to be internationally competitive across a wide range of new energy sources. However, literatures show land acquisition problems associated with hydropower plant. The reservoir schemes require large extents of lands to be acquired resulting in displacement of families. For the poor countries it is a costly affair because much of the untapped hydro potential especially in the Himalayas demand development of infrastructure such as road, long transmission lines etc. before the construction of the plant. Often times there are delays in environment and forest clearances. Financing hydropower projects also necessitates the management of various types of risks such as foreign exchange risks in borrowing from foreign lender. Weak legislation in the recipient countries has created repatriation risk. Despite the fact that hydro is the answer for complementing to sustainable development, there is a country risk such as the country's creditworthiness, the possibility of confiscation under unstable and changed political system especially in poor countries.

It is widely acknowledged that biomass energy is the only energy source that is completely CO2 neutral- meaning that it does not increase the carbon dioxide in the atmosphere. The constraints associated with biomass fuels are largely technical i.e., the availability of land and not competing with food, and price. As main constrain to biomass fuels is the price, energy price agenda needs to be revised to encourage the implementation of Climate Change Convention under the current prices of oil. Study reveals that enhanced plant biomass accumulation in response to elevated atmospheric CO2 concentration could dampen the future rate of increase in CO2 levels and associated climate warming *(http://www.nature.com/nature/journal/v440/n7086/abs/nature04486.html).* Therefore, the cost of cleaning the atmosphere is going to be a lot more expensive than helping biomass fuels come into the market.

Currently geothermal energy accounts for roughly 0.25% of the annual world energy consumption. It is justified that exploitation of geothermal resources is generally far less a cause of pollution than fossil fuel combustion. However, the possible adverse environmental effects are identified as scenery spoliation, drying out of hot springs, soil erosion, noise pollution, and chemical pollution of the atmosphere and of surface and groundwater. Some measures have been implemented to reduce the adverse environmental effects from geothermal energy utilisation. These measures include directional drilling and injection of spent geothermal fluid *(http://sp.lyellcollection.org/cgi/content/abstract/236/1/297).*

As population is expected to increase to at least 8 billion by 2020, the amount of arable land available to meet increased demand from a burgeoning population is limited. The need is to meet such demand through improved yields of commonly grown staple crops. Boosting production using fewer natural resources is possible through biotechnology. The contributions of biotechnology includes the production of "Golden Rice" which is enriched with beta carotene and iron that can help combat vitamin-deficiency, a principle cause of blindness and anemia; plants resistant to toxic metals that will increase the areas available for farming; and insect-resistant cotton that provides better yields and is improving the lives of farmers in China, South Africa and elsewhere.

Indiscriminate use of chemicals such as pesticides has led to widespread resistance to pests, soil and water pollution, affected soil fertility, and resulted in higher pesticide residue levels in foods. It is believed that integrated pest management and integrated nutrient management practices can help alleviate such problem. However, the constraint is the illiteracy of the farmers and knowledge-intensive nature of such practices *(http://www .thehindubusinessline.com).*

Organic farming avoids the use of pesticides, herbicides, synthetic fertilizers and genetically modified organisms; therefore it is less damaging to the environment. The big question is the sustainability of organic farming. There are environmental costs of transporting organic inputs to the farm. Therefore, to be sustainable, animal manures, composts, and other soil enhancers need to be produced in the farm itself.

The development of innovative, appropriate and efficient information and communication systems is possible through the establishment of ICT infrastructure, which can prove to be nations' critical tools in the promotion of development. Among the proposed countries in the present study, Malaysia is relatively in a better financial position to use ICT technology. India has advantages to have local producer of computer hardware or software. However as the price of PC equipments is out of the range of most individuals the service is not affordable for the majority of individuals and small businesses. The reason Nepal is way behind in terms of precision agriculture in South Asia is because the ICT content, applications, services, and management is poor. In terms of the development of Green Technology, there is a need to reinforce agricultural policy directions and continuing reforms in agricultural policy and research organisations.

Available records show, unless the environment is protected, the mission of achieving high and sustainable levels of growth and employment is not possible. There is a global consensus in accepting climate change as a villain to development. China and India are charged as world's leading emitters of greenhouse gases, these countries together with other emitters should design green technologies such as clean-burning coal, to combat the worst effects of climate change. Since it is the most cost-effective technology, clean coal processes can be designed to capture and store carbon dioxide that would be released by coal as it is burned.

Environmentally responsible and economically rewarding use of complex technologies demands knowledge and foresight. The technologies should satisfactorily facilitate the growth of green businesses. The environment should be created to inform potential rewards, challenges, and consequences of green technologies so that the concerned stakeholders can make informed decisions in adopting new technologies to green their businesses *(http://www.greentechforum.net/about/).*

Chapter Five

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The review shows when used correctly agro-environment-friendly technology has promoted sustainable agriculture growth and reduced widening rural-urban income disparities. The application of green technology is the answer for sustainable development but poor countries have not been able to use applicable technology largely because of their inability to afford to the available alternatives. Efforts are needed to align economic development policies with the goal of increasing the realization of human capabilities. GT in the reviewed countries has mostly minimized environmental hazards and made farmers more productive through enhanced efficiency. The lesson that has been drawn from this study is since distributive structure and property system especially in India and Nepal is not very satisfactory, care should be given to access land and credit; the access in health, the access in clean water and education; and above all the access in employment.

In assessing the applied technologies, it was realized that sustainable agriculture as defined and elaborated by FAO was resource conserving; environmentally non-degrading; technically appropriate; and economically and socially acceptable. However, as it is generally agreed in case we fail to precisely define the scope of work, the term “sustainability” becomes both ambitious and ambiguous.

The greater is the chance of the failure of macroeconomic policies; the worse is the case in income inequality. If the policies on food security and income generation fail to address poverty and malnutrition, the objective of elevating economic status of majority of the poor at the individual and household level through the application of green technology remains incomplete. The major concern of the United Nations through the use of agricultural technology is therefore, to guarantee the distribution of the benefits of increased agricultural productivity rather equitably.

Information technologies and their inter-linkages with agri-food sector are vital to understand the strength of pro-poor and environment-friendly agricultural technology. An open debate needs to be organized and facilitated at regular intervals on the need for investment in the technology, reason for their acceptance, strength and weaknesses for the adoption, and investigating the reason for their rejection.

In terms of the use of electronic equipment, the weak regulatory measures (regulation, directives, and standards) especially on the purchase, operation and disposal, has attracted interest on the global political agenda about the environmental impact of the electronics industry. Although the adoption of technology and regulatory compliance is on the average painful in the developing world, there are many valuable business benefits to be gained by opting for "greener" power. Examples from selected countries have revealed clearly that GT reduces operational cost.

Electronic communication networks as a powerful information infrastructure connects enterprises and knowledge bases. As the new information system has been developed as a parallel traditional physical world, the development of its infrastructure to connect indigenous practices into the modern system should be given top priority.

Under the Corporate Social Responsibility, the businesses of large corporations who have ignored environmental impact have been rated less attractive to environmentally savvy investors and consumers. The technology has helped receiving more from a firm's asset. For example, storage consolidation and virtualization have dramatically increased asset utilization and reduce costs. In short, the adoption of new technologies has helped improve overall business processes and working practices (*http://compelts.co.uk/index.php*).

The present study shows adoption of Green Technologies have increased agricultural output without depleting presently available resources beyond the point of recovery. Though selection of technology is by default condition dependent one or the other renewable energy technology and green agriculture strategy can in all circumstances be pragmatic. Inter-linkages of technologies with society should be deliberated in advance to access their roles in achieving the expected outcomes. The review on alternates shows an assessment should not occur in isolation. Instead, implications on income and opportunity creation; output, input, and ecological balance, gender equity, etc. should be considered with due attention. Green technologies assure potency for sustainable agricultural growth but significant effort will be required to substitute conventional practices.

Several studies have shown food production among small landholders is positively correlated to the increased use of industrial inputs and marketing opportunities for food crops. This demands a favorable macro environment that allows farmers to enhance the use of inputs. A concerted effort is therefore, needed to create environment that helps farmers connect safely with market, making them able to avoid externality.

5.2 Recommendations

5.2.1 On Reviewed Technologies

1. Technologies that were reviewed for three APCAEM member countries (India, Malaysia and Nepal) were solar photovoltaic, wind energy, biofuel, biogas, micro and small hydropower, biomass, solar thermal, improved water mill, geothermal energy, bio transgenics, organic farming, integrated pest management, information and communication technology. The use of these technologies is in the limited scale. Although "energy poverty" is one dimension of poverty that is necessary to alleviate human poverty, and other forms of poverty (income or capability poverty), only this form of poverty is not important as most of the poor people in this region reside in rural areas with agriculture as the major occupation. In this context, the simultaneous improvement in agriculture productivity, employment creation, and promotion of alternative renewable energy is the only answer.

2. Agriculture depends on energy services for efficient access to resources, increased labour and capital productivity, and value addition. Efforts to develop indigenous energy sources are important to enhance the culture of practicing eco-friendly energy resources. There is a need to design effective communication packages to create awareness.

3. It is important to note that among the decentralized electricity systems, small-scale wind and solar photovoltaic systems are intermittent and weather dependent sources. Taking into account the cost factor, such solutions are not the most economical solution to the agricultural households. However, even at household level wind or solar powered pumps can mitigate natural shocks and risks to small landholders. At community level, application of wind and photovoltaic systems is possible through technical assistance and concessional credit access to use the technology especially for storage facilities like granary, cold storages, etc.

4. The energy source in the form of electricity from small-scale wind and solar photovoltaic has been found contributing to farmers' incomes and savings. This technology reduces health hazards from indoor air pollution and expenses incurred in the purchase of commercial fossil fuels. It creates non-farm opportunities. Therefore, from long-term growth perspective, an enhanced public investment policy for the development of these technologies is recommended.

5. Agriculture and energy sector is being linked with biofuel. Malaysia, India and even Nepal are now interested towards fuel producing crops. India has laid emphasis on *Jatropha Curcas* while oil palm is major agriculture crop in Malaysia. One of the major problems with energy crop is that it may take land from food crop production. This will increase scarcity of food crop and price of staple food. Through regular assessment of these technologies, the government should offer opportunities to the people to balance between the benefit and cost of food crop versus fuel crop.

6. The use of solar thermal, especially solar water heaters, at the household level can be expected to dramatically grow in future because of the continued rise in energy price. However, technical assistance through public programmes will be necessary to increase the application of solar dryers in agro processing. The role of agricultural cooperatives, agricultural networks and line agencies is very important towards creating markets and market links for products from clean processing. As in the case of communal biogas, wind, and photovoltaic technologies, the support through soft loans is recommended to incite farming communities to adopt improved water mills. Also, micro enterprises based on IWM should be promoted to reap all possible benefits.

7. The micro and small hydro schemes can deliver power required for agricultural growth. Equally, the development of irrigation canals carrying water from tailrace of power plants should be considered. It is therefore important to carefully assess the possibility of multi-functionality of these schemes.

8. Opportunities in genetic biotechnology may far exceed the limitations and prerequisites of technologies transferred during the South Asian Green Revolution but the risks emanating from inefficiencies and capital inadequacy to farmers can also be more severe. Devising adept mechanism therefore will pose colossal challenge to all involved stakeholders. Technology appraisal through scientific experiments and field transfer through capacity enhancement of farmers should be of equal importance. Programmes as IPM schools of East Asian countries can be emulated with modifications to attain accelerated results and comprehensive assessment method should be deployed to precisely quantify the performance of diffused technology.

9. Food security and safety are quite different issues and demand discriminate consideration. Food safety involves attributes and quality of food depends on biological, physical, and chemical conditions. Food safety can be confirmed scientifically and assessed objectively. Perhaps the mightiest thrust to organic agriculture will come from aware consumers demanding safe food. Traceability systems, which convey food safety information to consumers and trade partners, will distinguish organic products in the food market. In this regard, public institutions can play an important role in standardizing organic agriculture sector by developing guidelines and imposing regulatory and monitoring measures.

10. Integrated Pest Management (IPM) has graduated from technical mix of various components to farmer led programme. Farmer Field Schools (FFS) have been the driving force of several successful IPM programmes. Experiences have demonstrated that FFS offers trainers and farmers the platform to debate observations strengthening indigenous investigations and discovery based learning. Removal of subsidies on pesticides, decoupling staple food production from pesticides, strong coordination between national and international agencies and diversion of funds formerly spent on chemical use to human resource development are recommendations for any government committed to IPM.

11. Information and communications technology (ICT) is not an end but is a means to achieve the goal of poverty alleviation through sustainable agriculture. Many APCAEM member countries have been developing ICT with sound policy environment. However, as the end users of this technology should be poor farmers, they are the one who lack these accesses. In this context, the Governments should initiate such programmes which may take ICT to poor people.

12. Finally, there are policies for green technology in each country. But these policies face implementation problem. In some cases, there are conflicting rules. This necessitates close scrutiny of the existing policies and a commitment to harmonize contradictory policies.

5.2.2 On Phase II Programme

1. The present study is only a first step to understand the need, opportunities and strengths of GT on reducing poverty through sustainable agriculture. The reviews show the immediate need for undertaking Phase II programme in APCAEM member countries by establishing institutions, generating resources, and developing technologies for green practices on the basis of the gaps and alternatives exhibited in the study.

5.2.3 On Policy Adoption

1. It was observed that in the selected member countries included in this study, one or the other policy are in operation to create conductive environment for the transfer of green technology. Therefore, the development and execution of the implementing rules for each of the existing acts needs to be considered.

2. In Nepal, the current Three Year Interim Plan (TYIP), Renewable (Rural) Energy Policy, 2006 and National Agriculture Policy, 2005 advocate mitigation of adverse

environmental impacts. The mandatory provisions of integrating green agriculture technologies into the poverty reduction strategy paper is therefore, recommended.

3. In India, policies should be revisited to avoid ambiguity about the application of technology by explicitly elaborating green practices into New and Renewable Energy Plan, Electricity Act, Renewable Energy Act, etc.

4. Malaysian initiatives as Small Renewable Energy Programmes and Five Fuel Diversification Policy speak inadequately on the possibilities of linkages between sustainable agriculture and energy policies. To avoid this confusion, the scopes of existing policies and their implications on sustainable agriculture needs to be further investigated.

5. Other areas of investigations in the region should include but not be limited to the following issues:
   - Prepare a baseline data on the application of green technology in APCAEM member countries,
   - Investigate the emerging issues in the application and policies of renewable energy technology in APCAEM- member countries,
   - Assess the impact of input subsidies on sustainable agriculture in selected countries,
   - Review the benefit and cost of Biofuels as an alternative green agriculture technology,
   - Assess organic farming guidelines and markets in selected countries,
   - Analyze the potential of IT industry in reducing greenhouse gas emissions and environmental degradation,
   - Identify the modality, resource need and impact of investment in human resource development for sustainable agriculture.

5.2.4 On the Causal Effect of Green Technology on Poverty

1. Green technologies will be most beneficial if they are portrayed as opportunities to secure livelihoods. As these alternates permeate several cross cutting issues, strategies for their dissemination should encircle broader livelihood concern.

2. In the context of APCAEM members, where majority are developing countries, poverty alleviation can be intrinsically linked with green technology because it has strong and positive correlationship with environment. However, generalizing this linkage may not be the most practical approach as poverty problems and green technology options vary from country to country. The task therefore, should be to focus on tackling specific problems without neglecting broader issues.

3. Further studies are needed that contain numerous entities relating causal effect of green technology on poverty. This can contribute to realizing the indices to access the impacts of green technology adoption.

5.2.5 On the future development of green technology in Asia and the Pacific

1. In the context of climate change and sustainability, the notion of "carbon footprint" has been dominating global executive agenda in recent years and will be so in future. The miracle brought about by the advancement in technology is also suffering from various types of its negative impact on environment; rising energy consumption and resulting carbon emissions by the industries and rising middle class; and uses of hazardous substances in the manufacturing process.

2. The ADB's publication states technology reduces poverty since it transforms stagnant economies into dynamic ones in two ways: a) technological progress can generate a steady rise in output per person, hence in real incomes and b) these rising incomes can stimulate higher educational attainment, which generally leads to smaller families and higher living standards, while furthering technological and economic advancement (*http://www.adb.org/Media/Articles/2002/475_Technology_Poverty*). Many initiatives have been launched in the Asian and Pacific region on the economy of ecology. The task is to find out correctly on how it is being perceived by end-user organizations, what the incentives for investment are and what are the likely threats and constraints. The information thus derived should help formulate Phase II programme in near future.

3. During the course of this feasibility study, it was observed that one or more renewable energy technologies and environment friendly agricultural techniques are feasible in any of the selected countries. Large agrarian economies can readily adopt biomass and biofuel to meet energy requirements. Though, caution in technology selection and investment in research and development are imperative. Biogas can simultaneously meet household and communal energy needs of farming establishments. Public investment to incite adoption by delivering incentives to users and disincentives to non-users will be an important factor in growth and consumption of these alternates.

4. Resources replenishing naturally as hydropower, solar, and wind technologies are equally lucrative opportunities. The extension and continued research in green technology is therefore necessary to improve efficiency of energy services and also contribute to increase rural income, employment, and empowerment opportunities as stated in aforementioned sections.

5. Agricultural inputs like biotechnology and integrated pest management can go hand in hand as resources of one can be exploited by the other. Though unfailing caution is recommended in diffusion of biotechnology until experiments clear all prevailing speculations, its use in future crop production is clear possibility. Public systems should be encouraged to invest in research in this area. Success of IPM Farmer First School method can be emulated in encouraging efficient adoption of biotechnologies.

6. Finally, ICT is most likely to assume a binding role linking green technologies, farmers, markets, programmes and governments in achieving sustainable agriculture. Involvement of both public and private sector in ICT is recommended to increase its reach. Further, ICT can offer APCAEM member countries a unique opportunity to cooperate at different levels.

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Annex A

INDICATIVE DEVELOPMENT, RESOURCES, AND ENERGY RELATED INFORMATION

Indicators	India	Malaysia	Nepal	World
HDI				
Human Development Index Value-2005	0.619	0.811	0.534	0.743
Life expectancy at Birth Years	63.7	73.7	62.6	68.1
GDP per capita (PPP US$)-2005	3452	10882	1550	9543
Education Index	0.620	0.839	0.518	0.750
GDP per capita (PPP US$) rank minus HDI rank	-11	-6	8	0.761
HDI Trends				
1975	0.419	0.619	0.301	
1980	0.450	0.662	0.338	
1985	0.487	0.696	0.380	
1990	0.521	0.725	0.427	
1995	0.551	0.763	0.469	
2000	0.578	0.790	0.502	
2005	0.619	0.811	0.534	
Human and poverty Index (HPI-1)				
Rank	62	16	84	
Value	31.3	8.3	38.1	
Probability at birth of not surviving to age 40 (% of cohort) 2000-05	16.8	4.4	17.4	
Adult illiteracy rate (% aged 15 and older 1995-2005	39.0	11.3	51.4	
Population not using an improved water sources (%) 2004	14	1	10	
Population below income poverty line (%)				
$1 a day 1990-2005	34.3	<2	24.1	
$2 a day 1990-2005	80.4	9.3	68.5	
National Poverty line 1990-2004	28.6	15.5	30.9	
HPI-1 minus income poverty rank	-13	9	11	
Demographic trends				
Total population (Millions)				
1975	613.8	12.3	13.5	4076.11
2005	1134.4	25.7	27.1	6514.81
2015	1302.5	30.0	32.8	7295.11
Annual population growth rate				

Indicators	India	Malaysia	Nepal	World
1975-2005	2.0	2.5	2.3	1.6
2005-2015	1.4	1.6	1.9	1.1
Water sanitation and nutritional Status				
MDG Population using improved sanitation (%)				
1990	14	..	11	49
2004	33	94	35	59
MDG Population using improved Water sources (%)				
1990	70	100	70	78
2004	86	100	90	83
MDG Population under nourished (% of total population)				
1990	25	…	20	20
2004	20	4	17	17
Economic Performance				
GDP				
US$ billions 2005	805.7	130.3	7.4	
PPP US$ billions 2005	3779.0	275.8	42.1	
GDP per capita Annual growth rate				
1975-2005	3.4	3.9	2.0	
1990-2005	4.2	3.3	2.0	
Average annual change in consumer price Index (%)				
1990-2005	7.2	2.9	6.8	
2004-05	4.2	3.0	6.8	
Inequality in Income or expenditure inequality measure				
Richest 10% to poorest 10%	8.6	22.1	15.8	
Richest 20% to poorest 20%	5.6	12.4	9.1	
Gini Index	36.8	49.2	47.2	
Structure of Trade				
Imports of goods and services (% of GDP)				
1990	9	72	21	19
2005	24	100	33	26
Exports of goods and services (% of GDP)				
1990	7	75	11	19
2005	21	123	16	26

Indicators	**India**	**Malaysia**	**Nepal**	**World**
Terms of Trade (2000=100) 2004-05	76	99	..	
Energy and the environment				
Electricity consumption per capita				
(Kilowatt-hours)	618	3196	86	2701
(%change) 1990-2004	77.6	129.6	104.8	..
Electrification rate (%) 2000-05	56	98	33	76
Population without electricity (millions)	487.2	0.6	18.1	1577.0
Forest area				
% of total land area % 2005	22.8	63.6	25.4	30.3
Total forest area (thousand sq.km) 2005	677.0	208.9	36.4	39520.3
Total change (thousand sq.km) 1990-2005	37.6	-14.9	-11.8	-1252.7
Average annual Change (%) 1990-2005	0.4	-0.4	-1.6	-0.2
Carbon dioxide emissions and stocks				
Total (Mt CO2)				
1990	681.7	55.3	0.6	
2004	1342.1	177.5	3.0	
Annual change (%) -1990-2004	6.9	15.8	27.3	
Per capita (t CO2)-1990	0.8	3.0	.	
2004	1.2	7.5	0.1	
Carbon intensity of growth CO2 emissions per unit of GDP (kt of CO2 per million 2000 PPP US$)				
1990	0.48	0.56	0.03	
2004	0.44	0.76	0.08	
Carbon dioxide emissions from forest biomass (Mt CO2/year)				
1990-2005	-40.8	3.4	-26.9	
Carbon stock from forest biomass (Mt Carbon) 2005	2343.0	3510	485.0	
Energy sources				
Total primary energy supply (Mt of oil equivalent)				
1990	319.9	23.3	5.8	8757.71
2005	527.3	62.3	9.2	11432.9 1
Share of TPES				
Fossil fuels %				

Indicators	**India**	**Malaysia**	**Nepal**	**World**
Coal				
1990	33.2	4.4	0.8	25.3
2005	38.7	9.6	2.0	25.3
Oil- 1990	19.6	55.8	4.5	36.8
2005	23.9	43.3	9.2	35.0
Natural gas				
1990	3.1	29.2	0.0	19.1
2005	5.4	41.8	0.0	20.7
Renewable Hydro, solar, wind and geothermal Energy				
1990	1.9	1.5	1.3	2.5
2005	1.7	0.8	2.3	2.6
Biomass and waste				
1990	41.7	9.1	93.4	10.3
2005	29.4	4.5	66.6	10.0
Other Nuclear				
	0.5	0.0	0.0	6.0
	0.8	0.0	0.0	6.3
Technology: diffusion and creation				
Research and development expenditure (% of GDP) 2000-05	0.8	0.7	0.7	2.3
Researcher in R&D (per million people) 1990-2005	119	299	59	
Gender related development index				
GDI- Rank	113	58	128	
Value	0.600	0.802	0.520	
HDI rank minus GDI rank	0	1	-4	
Gender empowerment measure-Ratio of estimated female to male earned income	0.31	0.36	0.50	
Gender inequality in economic activity				
Female economic activity aged 15 and older				
Rate% 2005	34	46.5	49.9	52.5
Index (1990=100) 2005	94	105	104	101
As % of male rate 2005	42	57	64	67
Employment by economic activity % Agriculture				
Women	..	11	..	

Indicators	**India**	**Malaysia**	**Nepal**	**World**
Men 1995-2005	..	16	..	
Industry				
Women	…	27	…	
Men 1995-2005	…	35	…	
Services				
Women	…	62	…	
Men 1995-2005	…	49	…	
Contributing family workers				
Women	…	..	…	
Men 1995-2005	…	..	…	

Source: UNDP HDR 2007/2008 Fighting climate change: Human solidarity in a divided world

Annex B

BIOGAS DESIGN PARAMETERS

Parameter	Value
C/N Ratio	20-30
PH	6-7
Digestion temperature	20-35
Retention time	40-100 days
Biogas energy content	6 kWh/m^3
One cow yield	9-15 kg dung/day
Gas production per kg of cow dung	0.023 - 0.04 m^3
Gas production per kg of pig dung	0.04 - 0.059 m^3
Gas production per kg of chicken dung	0.065 - 0.116 m^3
Gas production per kg of human excreta	0.020 - 0.028 m^3
Gas requirement for cooking	0.2 - 0.3 m^3/ person/day
Gas requirement for lighting one lamp	0.1 - 0.15 m^3/ person/ day

Source: Warner, Stohr, and Hees, 1989

ACKNOWLEDGMENTS

This report has been prepared by Professor Bishwambher Pyakuryal from Nepal under contract with UNAPCAEM. Valuable comments have been offered by a number of persons including Professor WANG Maohua from China, Dr. S. K. Tandon from India, Professor G. Gantulga from Mongolia, Dr. S. K. Adhikary from Nepal, Dr. Kwang-Jae CHOE from ROK, Dr. Nguyen Quoc Viet from Vietnam, Professor Ping Chang and Ms. Zhaorui Meng of UNAPCAEM. Their comments have been incorporated where applicable.