Energy and Environmental Sustainability: Some Key Issues in Rural Kolar, Karnataka, India

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Abstract:

The term sustainable development was coined by the UN Bruntland committee to describe a development, which satisfies the needs of the present without compromising the ability of future generations to meet their own needs. It has birth to cope with the development related environmental degradation. When development takes place keeping environmental consideration in mind we follow the concept "sustainable development". But unfortunately shortsighted developmental planning and overlook over environmental damages has severely affected the ecological balance of the region making the very existence of Planet earth unstable. Burgeoning population and resource scarcity demands maintaining environmental quality and economic progress too. Now with growing awareness, knowledge about causes and effect of environmental degradation, changing attitude and technologically advanced skills, we can arrest further damage to our resources. Though the process is difficult, the world leaders have decided to achieve the goal of Sustainability. The progress in this direction is seen in the form of spreading awareness, which is clearly seen in the form Earth Summit (Rio '92), taking up voluntary program for sustainable development in poor rural countries, developing and practicing strict legislation and tools to control further environmental degradation.

Kolar district in dry arid zone of Karnataka is chosen to develop an Integrated Regional Energy Plan considering the resource availability, present consumption patterns and developmental priorities. Suitable methodology is proposed to implement the energy plan taking in to consideration the present administrative structure of the district. Kolar district is one of the drought prone areas and is worst hit by natural calamities. These situations arise mainly due to unplanned resource use and growing population. Scarcity of water and

bioresources has necessitated an integrated approach in natural resource management in order to ensure the sustainability. The district at present is plagued with many environmental problems such as soil erosion, deforestation, water scarcity, tank siltation, changing climate, energy scarcity, etc..

This district depends on agricultural economy, in recent years, sericulture has become major activity in taluks such as Sidlaghatta. Sericulture processing is an energy intensive process and further stress is expected on bioresource base in the district. Energy survey carried out in 2500 households covering all zones of the district indicates that Kolar district mainly depends on bioresources, and the dependence is of the order of 80-82%. Energy intervention through biogas program in villages with sufficient organic residues (animal residues) has shown success in recent years. Resource assessment shows that biogas can cater to the domestic needs of 30-40% of the total population. Biogas has helped in improving the indoor environment as well as cutting down drudgery involved in fuelwood collection, etc..

Two ecologically distinct cluster of villages – Anthragange (Kolar taluk) and Andarhalli (Chickballapur taluk) were chosen to explore the criteria and indicators of sustainability and role of non-conventional energy interventions such as biogas, solar, etc. on sustainability. The paper also brings in relationship between energy and related environmental degradation and tries to focus on sustainable energy technologies

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Introduction:

Energy is a basic necessity for survival and a critical factor affecting economic development and employment. Energy crisis has drawn attention of planners, on the impact of energy costs on economic growth, industrial production, employment, etc. Most of the regions in the developing countries depend on bioresources. Deforestation and desertification are threatening traditional energy sources and subsistence pattern of agriculture, thus starving the rural sector of biomass fuels at the same time more efficient energy sources are needed for the sustainable development of a region.

The term sustainable development was coined by the UN Bruntland committee to describe a development, which satisfies the needs of the present without compromising the ability of future generations to meet their own needs. The sound environmental policy focuses on the environmental aspects and is a part of wider concern aimed at well being and living standards of human species. Sustainable development demands the clean and pollution free environment and enshrines the good quality natural resources for both present and in the future. Energy, biodiversity and physical space are the critical resources for present and future human demands. The international community has espoused the objective of sustainable development in various agreements, which includes- Agenda 21 (Rio '92), Convention on Biological Diversity and the Climatic Conference at Kyoto recently.

The seeds of sustainable development were sown during 1972 Stockholm Conference, but unfortunately it turned out to be a dialogue of the deaf between rich and poor. And subsequent twenty years has seen environmental degradation that was never taken before. Rivers were foamed with pollutants, cities were invisible with smoke and smog, forest were degraded to large extent, many of our tanks and lakes were filled with silt, desertification was a common phenomenon. Every moment many invaluable species are on the verge of extinction and more importantly the synergetic effect of all these local problems was visible in the form of global problems - ozone depletion, green house effect and global warming. Therefore, in order to clean up the world, in which we were living, government of the industrialized and wealthy world wanted all the nations and industries to agree to act together.[1] This led to the debate on the need of environmental soundness to arrest further environmental degradation. The major steps towards this goal was in the form of educating world people about need and importance of environmental soundness which came in the form of "Earth Summit '92" at Rio De Janeiro in1992. Environmental education played very

crucial role in conserving resources and promoting ecologically viable technologies which the key for sustainable development.

Undoubtedly, prior to highly publicized Earth Summit '92, relatively few people had heard of the term sustainable development. Since that time, it is not exactly a household word, there has been rapidly growing interest among international organizations, the research community, environmental groups and professionals, and business to learn about "sustainable development," to promote it and in some cases, to get in on the "next wave" of environmental concern.[2] In order to achieve sustainable development, environmental protection shall constitute an integral part of the developmental process and cannot be considered in isolation from it. Since the importance and need of sustainable development is understood our idea about the 'environment as a constraint' in development has changed to 'environment as a partner' in development, which made the concept of sustainable development practically possible.

Development and environment are inseparably related to each other, though this was overlooked until recent period. Man's greediness to achieve materialistic luxury and his never ending demands has increased resource consumption to the extent which made very existence of the planet earth impossible. Initiation to rapacious resource consumption started after industrial revolution in early eighteenth century. The countries, which could take part in industrial revolution, were able to use the available resources without any restrictions and limitations mainly because of its free access, which made them economically and politically strong. On the other hand, the poorer countries could just strive for their basic survival and remain economically as well as politically behind rich countries. This gap between poor and rich has many implications on resource consumption and environmental degradation, because the rate at which developed countries consume resources was and is too high comparing to other countries. For instance per capita energy consumption for India was 0.214 Tones of oil equivalent (TOE) during early ninety's, whereas the figure for Canada and United State for corresponding year is 9.3 and 7.9 TOE respectively. Similarly as per recent statistics, energy for transportation in United State was 100 times more than that for India. With such disparities in rich and poor countries in resource use it becomes difficult to formulate uniform policy for resource conservation for rich and poor world. Now we are at a stage, where looking back and stopping our developmental activities is not possible, therefore we have to look for other alternatives, which will allow economic development with environmental considerations.

Energy is the key element in the production process, and the lack or shortage of energy has serious impact on the economy. Fossil fuels such as coal, oil and natural gas are the basis of industrial society, but they are disappearing at an increasing and threatening pace. Present fossil fuel potential is unable to meet the growing demand of our society. There is a need to look for viable alternatives to meet the demand and satisfy the needs of society. The development of renewable sources of energy will increase the diversity of energy sources in a region and thereby increase the security meeting energy service needs.

The regional planning machinery could play a leading role in the sensitive development of renewable resources to the benefit of the environment and the local community. However at present the vast majority of region's planning machinery (at state and district level) has little or no knowledge of the renewable energy potential that exists within their boundaries. Therefore need of educating the people (user, supplier as well as administrator) about environment is stressed by many experts if we want to see the growth of newer non-conventional technologies.

It is common knowledge that centralized energy planning exercises cannot pay attention to the variations in socio-economic and ecological factors of a region at local level, which influence success of any intervention. Therefore decentralized energy planning is considered in the interest of efficient utilization of resources. The regional planning mechanism takes into account various resources available and demands in a region. This implies that the assessment of the demand and supply and the intervention in the energy system which may appear desirable due to such exercises must be at a similar geographic scale. Ecologically sound development of a region is possible when energy needs are integrated with the environmental concerns at the local and global levels. For this purpose an integrated planning approach to energy planning is necessary.

Bioenergy continue to contribute significantly to the total energy consumption in Kolar, Karnataka, India and most of the developing world. In domestic and rural industrial sector, they play a critical role. In this context it is necessary that the regional planning exercises formulate policies to develop sustainable bioenergy systems consistent with the objectives of ecodevelopment and environmental conservation. However, lack of adequate relevant information on different bioenergy resources in regional planning framework hamper efforts to develop alternatives to achieve multiple goals set by environmental objectives and the energy demand on the resource. Detailed village level planning would be required, if one has to see the idea of sustainability a dream come true, because the local problems, however small they are finally contributes to the global

problems. The continuing demographic and unplanned economic growths are the major threats to sound environmental policy. The environmental gains achieved by more environmentally efficient production are offset by increased pollution due to growths in the volume of production and consumption. Socio-cultural, administrative (integrated planning approaches) and technological breakthroughs are needed if we are to achieve the objectives of sustainable development.

Present paper highlights many sustainability related energy issues in rural area of Kolar District, Karnataka. Based on one-year field research in energy study some criterions of sustainability have been identified and then indicators to those have been explored in the two ecologically distinct clusters of villages. Anthragange (Kolar taluk) and Andrahalli (Chickballapur taluk) which are the ecologically distinct zones, one remote, situated on hilltop, surrounded by forest and other well accessed, agro-climatically sound village were chosen to explore the criteria and indicators of sustainability. This study constitutes a part of Integrated Regional Energy Planning for Kolar district as a part of Department of Science and Technology, Government of India, Energy initiative under NRDMS-UNDP Program. This paper also brings in relationship between energy and related environmental degradation and tries to focus on sustainable energy technologies.

Literature Review:

In order to know the trend in levels and types of energy consumption at macro level, the energy consumption at state level was studied before taking up village level studies. The source wise energy consumption in Karnataka[3] reveals that 53.20% of the total energy is met by non commercial sources of energy like firewood (43.60%), cow dung cake (1.40%) and agrowastes (8.20%). While commercial energy like coal (5.80%), oil (11.60%), kerosene (2.60%), LPG (0.70%) and electricity (26.10%) constitutes 46.80%. A significant part of this non conventional energy sources such as firewood, agriculture residues etc. are to cater the heating (domestic) needs of the rural population (about 70 - 80% of the total) and then followed by village industries.

As a first step to understand rural energy problems, ASTRA (Centre for Application of Science and Technology for Rural Areas) of Indian Institute of Science, Bangalore conducted a detailed survey in six villages in Kunigal taluk (Tumkur District) in Karnataka[4] during 1975-76, based on observations discussions, measurements and checks. Some of the findings are: (a) Firewood is a dominant energy source (81.6%), used mainly for household activities, (b) cooking is a major activity consuming human and firewood energy. Efficiencies

of chulahs are in the range of 5-8%, (c) human energy (especially women and children) was inefficiently used in firewood gathering (2.6 hrs/day/hh), cooking (3.68 hrs/day/hh), carrying food to farms (1.82 hrs/day/hh), fetching water (1.53 hrs/day/hh), taking cattle for grazing (5.54 hrs/day/hh) etc. The share of domestic burden between men, women and children is 24%, 20% and 20% respectively, (d) kerosene consumption for lighting is about 4.3 litres/un-electrified house, 78% of the houses being unelectrified, and (e) industrial consumption is very small.

Roger Revelle[5] estimated the total energy utilized in rural India for the year 1971. As per his study and analysis, only 10 per cent (1.2×10^{14} kcal per year) of the total energy (11.42×10^{14} kcal per year) in rural areas was derived from the commercial sources mainly contributed by kerosene, diesel, chemical fertilizer and electricity from hydro sources. The remaining 90 percent is derived from traditional sources of energy viz. Human and animal labour, firewood, crop residues and animal wastes. Revelle concludes that rural people in India are tied to poverty and misery mainly because they use too little energy and use it quite efficiently, and nearly all he energy they use is secured by their own physical effort. Increasing the quantity and improving the technology of energy use, he suggested, can bring about a transformation of rural India.

Gerald A. Leach[6] reviews the major features of residential energy use that have bearing on demand and supply options. Leach also examines the profound changes that have occurred over the past few years in attitudes to wood fuel problems and their implications for energy policies and planning. Data from 15 country assessments show that households account for 30-95% of total energy use, compared to 25-30% for industrialist countries. The highest proportions are found in poorer countries, where households exclusively depend on biomass fuels.

Ramakumar[7] gives conceptual model of an Integrated Renewable Energy System for a Village, wherein available biomass sources are converted to biogas to supplement the output of a sub system designed to integrate the solar radiation and wind resources.

A study of 74 Indian Villages[8] involving more than 5200 households, found that Village average biomass fuel use of 4-6 GJ per capita annually in 30% of the Villages and 2-8 GJ in 65%, but that the complete range was 1.5-20.5 GJ.

Ved Mitra and Ashwin Kumar[9] expressed that global concern regarding deterioration of the environmental conditions is also providing added impetus to the development of energy alternatives in particular renewable sources of energy.

The duo emphasizes on the role played by energy in economic and social development in every society.

J. B. Lal[10] worked on the survey made by Forest survey of India in the late eighties. His study revealed that India consumes as much as 157 million tones of firewood annually against the sustainable level of production of 58 million tones per annum. The enormous gap between demand and sustainable production of firewood is one of the major causes of depletion of forest resources in the country. He further stresses on the chance of reducing demand by increasing thermal efficiency of firewood burning as a means to conserve forest as well as energy resources.

AFPRO (Action for Food Production)[11], an NGO, in collaboration with CHF (Canadian Hunger Foundation) have been involved in promoting biogas in India since 1984. TERI (1997) has worked on how NGOs can help promote renewable energy technologies in Rural India. TERI has documented role of biogas plants in a regional energy situation and importance of monitoring the projects to assess the success rate of the technology and gives way for further improvement in the technology.

Energy and Environment Planning

Many environmental problems confronting mankind at present is connected one way or the other, to the extraction, conversion, transformation or use of the energy. This is the reason why a through understanding of energy and environment is a prerequisite for planning and implementing sustainable energy program. Therefore, the role of energy is to be understood from both soci-economic and environmental perspectives. Sustainable energy technology is the one, which brings about socio-economic and cultural development without compromising on environmental quality and future of natural resources. Energy planning process today emphasises on energy conservation as first the best option to arrest energy and related environmental problems immediately. Integrated approach to resource management is suggested in planning process in order to attain the goal of sustainable development

Since the initiation of human civilization on this planet man is dependent on different kinds of energies for his basic survival as well as economic development. In beginning, need was limited to biological energy in the form of food, which extended to wood when use of fire was discovered, then to fossil fuels which made industrial revolution of early eighteenth century possible. Industrialization and urbanization together promoted transportation that was very

energy intensive sector and used mainly fossilized fuels in the form of oils. When man learnt to make life more comfortable, his wants and technological inventions made way for newer materialistic culture, which was very energy hungry. This culture created tremendous pressure on natural resources and existing sources of energy, which allowed newer and cleaner energy sources to sprawl. Only rich world could afford to depend on costly cleaner fuels like electricity or gaseous fuels, but poor world had to depend on unhygienic energy sources like firewood, dung-cakes and agricultural residue etc.

With passage of time, increased standard of living and burgeoning population growth has increased energy consumption rapaciously, which created tremendous pressure on forests. As a result many forests all over the world were degraded, many economies were stand still and entire ecological balance of the planet earth was disturbed. This situation provoked scientist community all over the globe to find way for energy crisis and solve environmental conflict in sustainable manner. As a result, many newer and cleaner non-conventional energy technologies were developed - technologies to extract energy from biomass (biogas, biogassifiers) solar, wind, hydroelectric, geothermal, tidal, etc. The success of these new technologies was mainly influenced by the cost of the fuel and environmental considerations. Of the many newer technologies, solar energy technology is promising and its use can be limited only due to economic and commercial viability. The progress in wind power generation has earned India recognition as a "World Superpower" in the state of the world 1998 Report of the Worldwatch Institute. According to mid-80s estimates the wind power potential of India is around 20,000 MW. The installed capacity of the grid quality power generation has reached 1,300 and the ninth plan aims at the addition of 3000 MW.[12] This shows remarkable progress India made in wind power sector.

Domestic activities such as cooking and water heating are the major thrust areas where energy consumption in the form of bioresource is more in rural areas. Technological advancement, fortunately made way for cleaner energies such as biogas, electricity from biomass even in remote rural region. Of all renewable, non-conventional energy programs, biogas program in India is considered as a successful one, but only 10% of the available potential is harnessed so far. Our study in Kolar district shows that biogas can met 30%-40% of the total energy demand in rural area and solar energy can meet the electrical energy demand, if harnessed effectively.

Growing awareness and knowledge about energy technologies, positive attitude and technologically advanced skills can bring sustainability in all spheres of development. To channelise the goal of sustainability, monitoring the progress

on the path is of first and foremost importance, which can be done by identifying criteria's for sustainable development and then exploring indicators, if any to the identified criteria's. This exercise will help formulate newer policies for sustainable development.

Sustainable Development with regard to Energy

Energy systems are to be consistent with i) *environmental,* ii) *economic* and iii) *social* sustainability aspects to be conducive to sustainable development of a region.

The *environmental sustainability* includes criteria's such as the pollutants related to energy should not exceed the absorptive capacity of environmental media (land, water and air), etc.

The *economic sustainability* includes aspects such as user costs of energy to be considered in determining the economic feasibility of projects.

The *social sustainability* includes aspects such as -the development and use of energy should not harm people's health nor involve involuntary resettlement. The energy projects are required to contribute to poverty alleviation and social equity.

In view of these, sustainability has to be checked "traversally" on the *ecological, economic, social, technological and cultural / political dimensions.* The energy sustainability criteria should address the whole energy life cycle, from extraction to the disposal of wastes. In order to assess the extent to which the energy supply is renewable, an indicator could be the share of solar + wind + renewable biomass + mini hydro in the regional energy budget.

Indicators with regard to environmental and developmental impacts are:

- The amount of land, water and non-renewable resources used;
- The pollutants emission - CO, SOx, NOx, HC, CO_2;
- Liquid effluents including organic waste and heavy metals;
- Solid wastes generated;
- Risk assessment;
- Employment generation;

Distributional aspects

- Transfer of economic resources to the beneficiaries of government subsidies and soft loans for energy production (large, small, decentralised) and type of producers (small groups, private or public)
- Technological self reliance in the energy production
- Diversity of energy sources and technologies available and put to use;

Energy consumption / demand point of view

- Main energy consumers
- Enduse - for what energy is used.

These are strongly correlated to the income distribution, level of education on both personal and spatial basis.

Another crucial indicator is the efficiency of end-use of energy, in different economic sectors and income classes. The ratio of useful energy to the primary energy provides insight in to the degree of wastefulness of energy consumption patterns and of the opportunities for energy conservation..

Methodological approaches proposed in this regard are:

- Choice of indicators (based on selected criteria)
- Estimation of indicators in the region studied
- Comparative analyses of indicators (temporal and spatial analyses)
- Identification of factors responsible for changes
- Recommendations of measures to stop the decrease in sustainability
- Evaluation of factors explaining success stories.

Representative indicators

- Supply side - renewability and diversity
- Demand side - amount of energy used in various sectors taking in to account geographical, climatic and cultural aspects and evolve energy intensity indicators.

Criteria of Sustainability:

Based on the suggested methodology and detailed investigations in two ecologically distinct zones, identified criteria's of sustainability are:

- Ø Energy sources, which satisfy basic human needs
- Ø Increased energy efficiency and energy conservation
- Ø Growing awareness about newer energy technologies
- Ø Reduced forest exploitation
- Ø Energy from waste
- Ø Use of locally available bio-manure in agriculture sector and thereby reduced chemical use
- Ø Integrated, decentralised energy system approach
- Ø Reduction in pollution
- Ø Clean and healthy lifestyle
- Ø Energy system which ensures long term economic, social and environmental health of a region over generations
- Ø People's participation.

Indicators of Sustainability:

The above listed criteria were analysed and assessed for indicators of sustainability in the region. Each criterion considered for sustainability is explained in the following section with reference to Anthragange and Andarhalli villages:

Kolar district: Sustainability issues related to Bio-energy

The Kolar District is located in the southern plains region of the Karnataka State, India. It lies between 77^0 21' to 78^0 35' east longitude and 12^0 46' to 13^0 58' north latitude and extends over an area of 8,225 Sq. km. The population was 22.17 lakhs in 1991 (as per census report). For administrative purposes the District has been divided into 11 taluks. There are 15 towns and 3,325 inhabited villages in the District.

Kolar belongs to the semi arid zone of Karnataka. In the semi arid zone, apart from the year to year fluctuations in the total seasonal rainfall, there are also large variations in the time of commencement of rainfall adequate for sowing as well as in the distribution of drought periods within the crop-growing season. Kolar district depends upon the distribution of rainfall during the southwest and

northeast monsoon seasons. Out of about 280 thousand hectares of land under cultivation 35% is under well and tank irrigation. There are about 951 big tanks and 2934 small tanks in the district, which made agricultural prosperity possible in many areas.

The average population density of the district is 2.09 persons/hect (rural) and 2.69 persons/hect (rural+urban). The population density ranges from 1.44 (Bagepalli) to the maximum of 2.55 (Kolar). The population density for Chickaballapur taluk is 1.92.

Current trends in natural resource scarcity, limited energy supply are the major constraints in development of the region. Many times water becomes limiting factor to agricultural output, energy shortage limits agricultural as well as industrial output (in fact region is poorly developed in industrial sector and its growth is restricted mainly due to erratic and intermittent power supply). Environmental problems in the region are linked and related directly or indirectly to each other. For instance, energy scarcity leads to forest degradation, which causes soil erosion, which further causes siltation of tanks and lakes in lowland areas, which ultimately results in reduced storage capacity of the tanks. Forest degradation, on the other hand, causes reduction in carbon sinking capacity of the planet earth and disturbs ecological soundness. These local problems contributes to global problems like- ozone depletion, global warming, etc..

Kolar district is chosen to develop Integrated Regional Energy Plan considering the resource availability and consumption pattern. Energy became scarce resource in this region mainly because large-scale dependency on single type of energy source i.e. Firewood and very low thermal efficiency in burning fuel. Other factors such as exponential population growth, easy and free availability of fuel, made this resource to degrade to a threatening level. In this regard, National Project on Biogas Development of the MNES (Ministry of Non-Conventional Energy Sources) Government of India has initiated biogas dissemination programme to solve energy crisis in the region. Household survey data reveal that many households in the district are operating biogas plants successfully and the success rate of this program is of the order of 70-80%.

Bioresource assessment based on the IRS-1C LISS-III satellite imagery of the two taluks – namely Kolar and Chickballapur has shown that the region is bioresource scarce[13]. The estimates shows that, bioresource (from forest, agriculture and plantations) potential for Kolar taluk is about 768.83 lakh kWh and that for Chickballapur taluk is about 1675.45 lakh kWh. Whereas the estimated demand for respective taluk was 6891.82 and 4105.63, which clearly

shows that the region is scarce in bioresource. Biogas potential of the area(based on present livestock population) can meet an estimated 30-40% of the domestic energy need.

Energy source which satisfy basic human needs

If the world's poor has to achieve decent standard of living, the basic human needs like food, shelter, health, education and employment are to be satisfied. This is a very important criterion of sustainability because it promises survival of human being on planet earth by satisfying his basic needs. Clusters of villages were chosen in two ecologically distinct regions to identify sustainability criteria and then to explore indicators to the identified criteria.

Domestic sector: Anthragange, a cluster of six villages is a hilly region in the outskirts of Kolar town is currently an environmentally degraded region and forms part of Anthragange state forest. All the six villages are economically poor, lacks any transportation facility and rely on agricultural economy. In some households sericulture is adopted as a secondary occupation. Anthragange state forest serves as the only source of fuel to 120 families residing there and to the surrounding localities leading to exploitation of forest resources to core extent As a result region lost its ecological balance. Unfortunately, still there is no improvement in energy sector in this region. There is an urgent need to look for alternatives: non-conventional energy technologies in order to improve the standard of living and ecological balance. Energy surveys conducted in these households show high level of dependence on fuelwood. Domestic firewood requirement is about 2.5 kg per person per day, which is much higher than the state average of 1.7 kg/person/day. This high level of consumption is mainly due to inefficient traditional cookstoves. Kerosene and electricity use is restricted due economic and availability constraints and need is 0.72 litre/person/month and 1.16 kWh/person/month respectively. Thus share of non-commercial energy is about 96% and commercial energy contribute only 4% of the total energy use in domestic activities.[15]

Andarhalli, a village in Chickballapur taluk, situated 6 km away from Chickballapur with 200 households was chosen for comparative analyses. Development of sericulture as a blooming activity made agriculture residue available as an alternative to firewood. The energy consumption pattern in the area reveals that the area is rich in bioresources like agriculture wastes (Mulberry, coconut, grape, etc) and animal dung. Though the forest in the area is degraded, the stress on the forest is much lesser than that on Anthragange forest. Of the total

domestic energy needs, 55% need is met by firewood, 20% by agricultural residue, 20 % by biogas and remaining 5% by commercial energy sources like kerosene, electricity and LPG. Survey results show that education has played a pivotal role in the acceptance of energy efficient devices. Apart from this, decentralized planning machinery – Panchayat raj system is instrumental in successful dissemination of biogas systems.

Food: Per capita daily calorie intake is the indicator of food prosperity and food production rely on energy available for agriculture use. Therefore, if the food prosperity is to be achieved one requires enough grain production, which can be achieved only with proper energy supply.

Agriculture: Anthragange area depend on traditional type of energy, mainly animate energy, for agriculture purpose which provides energy only for subsistence, while in Andarhalli, there is rapid transition from animate to machine energy in agricultural activities like tilling, threshing and winnowing. This is a very important as far progress towards commercial energy is concerned. Though the use of commercial energy in agriculture has not made significant contribution to agriculture output, the "opportunity cost" involved in the form of time saved, which is being used for economically productive activities like silk rearing are of immense help to upliftment of people.

Shelter: Shelter is another important need to fulfilled for sustainable survival, which demands for enough per capita dwelling area. Though the matter is not of much serious concern in rural Kolar and Chickballapur, the rate at which urbanization is taking place still demands attention to this factor. Anthragange is more prone to land conversion because of its proximity to Kolar town and its natural beauty which has attracted many business projects like holiday resorts, hotel, etc.. Andarhalli is safe in this regard as there is no such natural factors which influence land conversion in big scale.

Health: Another important sustainability criteria for development of rural areas, is to provide minimum medical facilities to the people, but unfortunately both the region are devoid of this facility and people have to travel 6-8 km to reach to nearest medical center. The prevalence of respiratory tract infections and conjunctivitis are lower in households using improved cook stoves with chimney than in households using the traditional stoves.

Education: Education plays a crucial role in the development of area. Survey conducted in these households show that educated women are more receptive to adoption of energy efficient devices and contribute significantly in the prudent

use of resources. This can be visualized from Andarhalli, where more than 50 % of the people have at least basic and more education, but in case of Anthragange literacy level just 30%. This is the reason for successful dissemination and management of non-conventional energy technologies like biogas in Andarhalli, while in Anthragange not even a single family has biogas plant or any other newer energy technology in use.

Employment: Employment has always been a matter of serious concern to a nation and role of employment in development is of immense consideration. Introduction of non-conventional energy technologies have contributed towards providing the employment in the region – dissemination, service units (to maintain these devices). Apart from these, Andarhalli has good employment opportunities in agriculture as well as business field mainly because of transport accessibility to town. Educated youth have shifted to sericulture, which have contributed to economic improvement. Contrary to this, Anthragange area lacks transportation network and level of literacy, which blocked chances of employment in business field. Employment in agriculture is seasonal and influenced mainly by economic status – lack of finance. Road network for Anthragange is under progress, which is expected to improve employment opportunities in the area.

Increased energy efficiency and energy conservation

Improvement in the efficiencies of enduse devices leads to conservation of energy resources (bio resources etc.). Therefore if energy is used efficiently it automatically leads to conservation, which acts as a catalyst for sustainable development. Shift from firewood based energy system to biogas based energy system brought out substantial amount of energy saving in Andarhalli. This attributes mainly to the increased efficiency in energy use. Firewood is highly inefficient in its use with an efficiency as low as 8-10%, whereas biogas has an efficiency of approx. 60%, which contributes to substantial amount of energy saving in the form of firewood. Estimated 0.7 Tones of firewood can be saved per head per year if use of biogas is practised in rural areas. On the other hand use of biogas only adds to the advantages in the energy sector in the form of non-polluting, easily available energy source and makes energy rich biomanure available for agricultural use. Switching off from conventional energy sources to the non-conventional energy sources is very important indicator of sustainability.

Growing awareness about newer energy technologies

Awareness is the key for spread of any technology or program. People in the region are aware of energy technologies like solar, biogas etc. What makes people

aware of the newer energy technologies is a kind of education, which people acquires from source like news and print media. It has been seen that, because the education was limited to 'awareness' level there is no further progress in use of these energy technologies as in the case of Anthragange. The basic elements of environmental education such as awareness, knowledge, attitude and skills collectively can bring about the real change in any kind of environmental problem. A wave of such change in the form of 'awareness' is already seen. Once people are aware of any technology they try to know more about such technologies, where comes an element of 'knowledge'. Knowledge brings change in attitude and thinking of people which many times demands skilled personals to promote newer technology. Attitude and skills are two very important components of this system, which plays key role in success of any new technology. Moreover success of any new technology depends on how it is introduced to the people. Andarhalli has shown the indicator of sustainability by acquiring knowledge, attitude and skills to use and promote biogas program. And solar energy technology is in awareness level in both the areas. People are seen to enthusiastic about use of solar technologies but the are handicapped by financial and accessibility constraints. In such case if Government take initiatives to promote such technologies with subsidised price and assured supply and service backup, solar energy can be the energy for future.

Reduced forest exploitation

Shift from firewood to other energy sources like biogas, brings about drastic change in forest degradation. Andarhalli study clearly shows the impact of biogas use over forest conservation. Though extraction of firewood from forest is not completely stopped, it is reduced to significant extent of 0.7 Tones per person per day. Unfortunately Anthraggange area shows no indicator towards such progress where forest is just exploited not just by the local population but nearby localities of Kolar town also depend on this forest for their cooking and water heating needs.

Energy from waste

Sericulture is booming business all over Kolar. Mulberry (*Morus alba*) is the plant species which serve as food for silk warms, therefore much of the agricultural land in the area is under Mulberry plantation. During different activities of silk production different kind of waste is generated which is effectively used as a source of energy in the area. During silk rearing huge amount of waste in the form of small twig and branches is produced, which is effectively used for cooking and water heating needs in the area. Andarhalli has

undergone drastic shift from firwood to agriculture waste, which wastes cater 20% of the domestic energy need. Even the waste cocoons are dumped into the biogas pit along with cattle dung and interestingly it is seen that the biogas production is better with waste cocoon in it. Anthragange area shows no indicator of such prosperity in energy use and depend solely on forest based firewood as an energy source.

Use of locally available bio-manure in agriculture sector and thereby reduced chemical use

Use of cattle dung as a input source for biogas production further improves fertiliser value of dung and makes it much more energetic The output slurry, which has more energy value when compare to fresh dung can met fertilizer demand for agricultural lands effectively. It has been proved that $2m^3$ /day biogas plant yield 109 kg. of urea, 275 kg of super-phosphate and 50 kg of muriate potash. This can meet fertilizer requirement for one acre of land for 2 crops in a year. As a result, use of chemical fertiliser is reduced substantially.

Integrated, decentralised energy system approach

Integrated energy planning – to execute the conceptual scheme to seek the optimal balance between energy efficiency action programs and supply action programs (through renewable sources of energy), having mix of different possible energy sources and by comparing their impacts on the economy and the environment. These impacts in turn influence trends in the development pattern and sustainability. Integrated energy system composed of a mix of energy sources, which can meet the energy demand and has no adverse effect on environmental and human health, has efficiency in burning fuels, can achieve progress in economic as well as socio-cultural development and share the burden on any one energy source. Such approach to energy planning demands for decentralized energy planning. Success story of decentralized energy in the form biogas program in Andarhalli is worth mentioning. Currently, Andarhalli has biogas as the only means to convert biomass into clean fuel, but there are many more options to harness biomass in cleaner way. Biogassification of bioresource can produce electricity, liquid fuels(like alcohol) which can be promoted in the area. Andarhalli follow an integrated approach in energy use, with emphasis on renewable sources. Energy sources like firewood, agriculture residue, biogas, electricity, LPG, diesel, petrol and animate energy, all are in use in different sectors like household, agriculture, commercial and industrial (Household Industry).

Global energy supply policies are generally elaborated at the national level. However, depending on the administrative and political structure of the country, the administrative regions can have considerable degree of autonomy in their energy choices. In our country, district is the most appropriate and quite pertinent to elaborate regional energy management plan, for energy efficiency, renewable energy promotion and local energy development. Panchyat raj system, which is a village level administrative body, has greatly influenced biogas promotion in Andarhalli and set a success example for decentralized energy promotion.

Reduction in pollution

Traditional energy sources like firewood, agricultural wastes and dungcakes emit many pollutants which affect ecological balance of the region. These pollutants have many adverse effects on human health, especially women. Women expose themselves to these pollutants every day, which may cause many health hazards. Due to use of biogas for cooking, women's exposure to pollutants is reduced substantially. Outdoor pollution also reduced to the significant extent, though the scale is small, it is positive step towards sustainability. Use of traditional cookstoves with chimney has helped reduce indoor exposure to pollutants to a significant extent, but the amount of released is same as that from traditional cookstoves without any ventilation facility.

Clean and healthy lifestyle

Use of biogas is considered as clean and hygienic energy technologies, which keeps surrounding clean and helps for prosperous human health. Even use of fuel-efficient cookstoves reduces significant amount of exposure to pollutants. Unfortunately the local administration has not adopted the proper strategies for successful dissemination of this technology so far. Proper training and service backups are the essential factors in the success of technologies.

Renewable, non-conventional energy intervention

Renewable energy system ensures long term economic, social and environmental health of a region over generations. Renewable, non-conventional energy intervention with focus on long term health of the ecosystem, economic and social progress has to be given priority to achieve sustainable development. An energy plantation is proposed in wastelands in the form barren hill, which form part of Anthragange state forest. The energy plantation with appropriate indigenous local species can help improve ecological balance of the region and regain degraded

forest wealth. Proposed energy plantation in degraded forest and barren hills which covers an area of 700 Acres can generate substantial employment which can improve economy of the people. Also it is estimated that a hectare of energy plantation provides a job for about seven persons. Energy technologies like biogassifier to generate electricity for lighting are suggested in Anthragange area. The energy plantations with biogasifier would provide required energy for the development of this region.

Even biogas intervention has long term viability in environmental, socio-economic and cultural advancement. Biogas which makes use of available dung (which is currently being used as biomanure) as a row source has real sustainable means. The output slurry, which has more energy value when compare to fresh dung can meet fertilizer demand for agricultural lands. It has been proved that $2m^3$ /day biogas plant yield 109 kg. of urea, 275 kg of super-phosphate and 50 kg of muriate potash. This can meet fertilizer requirement for one acre of land for 2 crops in a year and can save investment on chemical fertilizer, which is usually not affordable by poor farmers. Other benefits like firewood savings and thereby conserving forest, improved health and hygiene, cleaner surrounding are invaluable in protecting environment as a whole and maintaining ecological balance.

Involvement of NGO's in developmental process can help bring changes in socio-economic aspect of the region substantially. A NGO is working on socio-ecomic upliftment of the Anthragange people. Educational institutions in the region can also contribute significantly in managing the environment through involvement of students and teachers in energy and environmental awareness program, afforestation programs, etc.. Indian Institute of Science has taken up the task to formulate and implement a project to introduce renewable, non-conventional energy in Anthragange area. Such a modular development plan of Anthragange area can act as a catalyst and improve awareness and developmental activities in other regions of the district.

People's participation

People's participation holds key for success of any environmental project. Active participation in initiating and controlling development is necessary. It is common observation in the study area that biogas dissemination in villages needs initiative from someone who is knowledgeable in that field, otherwise no one comes foreword to accept such a technology. As in case of Andarhalli, success in biogas promotion was not a instant process, it evolved over a period of time because of initiatives from an individual and now nearly 25% of the population have biogas plants working in the households. In case of Anthragange region no one has taken

initiative to install biogas plant therefore its use is still not practiced. It is increasingly recognised that the success of sustainable development initiatives depends on widespread people's participation and support. People's participation within the sustainability discourse is instrumental. It is seen that only, if people themselves are prepared to 'live sustainably' the necessary economic and social changes be secured. Conscientisation about environmental problems and their causes, information about technologies and their attributes, and training in their use and management are essential for making informed choices. But for true participation, these external initiatives need to be adopted through independent reflective processes of the people concerned, so that they can make these initiatives their own.

Conclusions:

Detailed investigation of two ecologically distinct regions shows that with an integrated approach in energy planning through a decentralised planning machinery it is possible to achieve the goal of sustainability. Education, awareness, people's participation, economic benefits plays a vital role in the adoption of environmentally sound energy technologies. Currently growth of renewable, non-conventional energy technologies is limited only to biogas. In fact the region has potentiality to many other energy technologies like solar, wind, etc which are not in developmental stage mainly because of economic constraints. Energy plantation with species acceptable to local population can be implemented in wastelands available in Anthragange region to sustainablly develop economic, social and environmental system. The criteria and indicators of sustainability which are described in this paper clearly shows that Andarhalli is moving towards sustainability, whereas Anthragange is still far away from the the goal of sustainability.

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