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RESEARCH ARTICLE

GEOSPATIAL ANALYSIS OF RURAL ENERGY: A CASE STUDY OF KERALAPURAM VILLAGE, ANDAMAN NICOBAR

V Madhava Rao[1], Abha Chhabra[2], N Bhaskara Rao[1*], R R Hermon[1], R Lavanya Sudha[1], MD Shaik Hussain[1]

[1]Centre on Geoinformatics Applications in Rural Development, National Institute of Rural Development & Panchayati Raj, Hyderabad, Telengana India

[2]Earth, Ocean, Atmosphere, Planetary Sciences and Applications Area, Space Applications Centre ISRO, Ahmedabad, Gujarat India

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ABSTRACT

This study presents an estimation of net energy balance resulting from primary production vis-à-vis energy consumption through various components in a semi-arid rural ecosystem of Keralapuram village of Andaman Nicobar, India. An end use energy accounting for input-output analysis of various anthropogenic energy flows with in the village .Rural areas in India offer significant environmental contributions through primary energy production by vegetation in the form of crop biomass which include agricultural lands, along canals, roads, homestead plantations etc. Livestock keeping has also been a major resource and an integral part of rural livelihoods in India as animal energy is a renewable and sustainable source of energy. Livestock convert energy stored in biomass unsuitable for human consumption to useful products in form of milk, meat, eggs etc. Besides, human power, animal power and wood have been the three most widely used sources of energy in rural environment.

INTRODUCTION

Energy generally has been simply defined as "the ability or capacity to do work". Energy is one of the important factors in the functioning of any civilized society needed to improve better life style and socio-economic development of the country. In the heart of Bay of Bengal lies a cluster of scattered Islands is known as Andaman & Nicobar Islands (A&N Islands). The location of these Islands are strategically important on the eastern side of India from the view point of defense. With the generous assistance of Central Government these Islands have taken a large stride on all-round developments in last few decades, which resulted in the tempo of socio- economic transformation. To achieve the above goal, the energy input will be a vital factor. The A&N Islands have a total area of 8249 sq.kms. Out of which the forest cover is about 7589 sq.kms. (92%). These Islands enjoy a thick forest, rich environment, abundant sea wealth, which boost a high tourist attraction.

As per recent census 2011 overall Island's population estimated at 3.81 lakhs (Census, 2011), whereas 2.37 lakhs (62.30%) population lives in 555 villages (Census India, 2011). The current population growth rate in rural areas is estimated at 1.19%. Across the Islands, the villages vary in population density, geographical location, availability of resources, agricultural practices, tree plantations, livelihood patterns etc. The energy use in the rural areas largely depends on the population size, cropping practices, crop production, level of agricultural mechanization, livestock keeping, food habits, domestic energy needs, availability of resources and economic conditions of the population. Rural ecosystem is a thrust area of research for more than half of the world's population lives in rural areas. The rural energy supply includes all commercial and noncommercial sources, both renewable and nonrenewable (Demirbas *et al*, 2007). Rural energy demand refers to energy used by both households and producers. Household energy consumption includes energy used for cooking, heating, cooling, hot water, lighting, and home appliances. Energy consumed for production includes that used for agriculture, forestry, husbandry, fishing, and the transport and initial

Corresponding author:* **N Bhaskara Rao
Centre on Geoinformatics Applications in Rural Development, National Institute of Rural Development & Panchayati Raj, Hyderabad, Telengana India

processing of the resulting goods, as well as for farmer-owned township enterprises.

The energy balance of rural areas through quantification of energy production vis-à-vis energy use through consumption by rural livelihoods, imports (fossil fuel use in agriculture, human energy, draught energy) and exports (food in form of dairy products and crop produce, timber in form of wood etc.) are rarely assessed at the national scale (Abha Chhabra *et al*,2014). In order to study on these aspects a detailed energy balance study was carried out in Keralapuram village of north Andamn. The major objectives of the study are as follows:

STUDY AREA

Keralapuram is a Panchayat. The village is located on the northern side of Diglipur tehsil (6 kms) in Mayabandar district (80 kms) of Andaman & Nicobar Island. The first settlers were from Kerala and the settlement was made in 1956 under Colorization scheme by the Government of India. The Govt. of India allotted five acres of paddy land and five acres of hilly land. Each farmer household has access to a loan of Rs. 1,530/- from the government under colonization scheme. A total of 42 households were there. The first Gram Panchayat was formed in 1962.

Detailed field surveys and ground truth data collection was carried out at Keralapuram village of Andaman Nicobar Island, the location map of the village is shown in figure - 1. The village occupies an area of 615Ha. The area lies between "13^0 $17^{'}$ $22^{''}$, 13^0 $14^{'}$ 30" N Latitude and "93^0 0' 4", 93^0 1' 36" E Longitude.

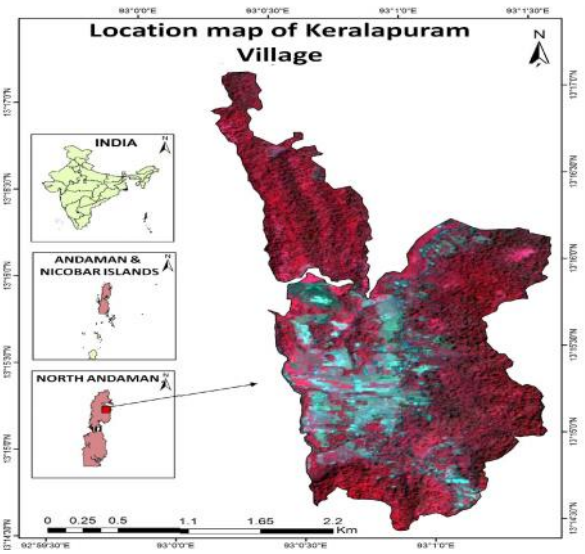

Figure 1 Location map of the study area

As per 2011 Census of Keralapuram had a total population of 647 living in 192 households. The ratio is being 319 females per 328 males. The village has higher literacy rate with 78.2 %.The literacy of male is 81% and female is 75.2%. The poverty line of the village is at Rs. 10,000/-. The numbers of APL households are 171 and BPL households are 21.The demographical, population and residential details of the villages are depicted in table 1.

Table 1 Details of demographical, population and residential of the study village

Sl.No.	Particulars		
1	Area of the village		615 Ha
2	No. of occupied residential houses		192
3	Population	Male	328
		Female	319
		Total	647

METHODOLOGY

To gather primary information on the energy production and consumption patterns and other related issues, two techniques were adopted; i.e. Participatory Rural Appraisal for availability of resources, need of villagers, perception and priorities of various renewable and non-renewable energy resources and a stratified random sampling approach based on occupation, social and economic status of rural households was adopted various energy uses at household level using structured schedules and questionnaires, with these two techniques an in depth study was carried out in the respective village by interviewing hundred households. We collected overall village information from government offices like Panchayat Office, Revenues Office and Block Office as secondary data.

Participatory Rural Appraisal (Pra) Methodology

A Participatory Rural Appraisal (PRA) exercise was carried out to understand the priorities and needs of the people of Keralapuram village.

Figure 2 Social Map of Keralapuram Village Explanation of resources available in the village

It involves interacting with local different communities, developing rapport with villagers and learning their problems and potentials. We also analyzed socio-economic conditions, problems and challenges faced by the farmers. The principle and methods of PRA was adhered for gathering information on nine PRA tools.

Sampling Method

A household survey of energy balance of rural India project using geospatial inputs has been conducted in Keralapuram village of Diglipur Tehsil of North and Middle Andaman District of Andaman and Nicobar Islands state, India. A set of variables have been used to get information related to energy consumption of the village. A sample of 100 households with different occupations and casts has been selected based on the methodology (Figure.3).

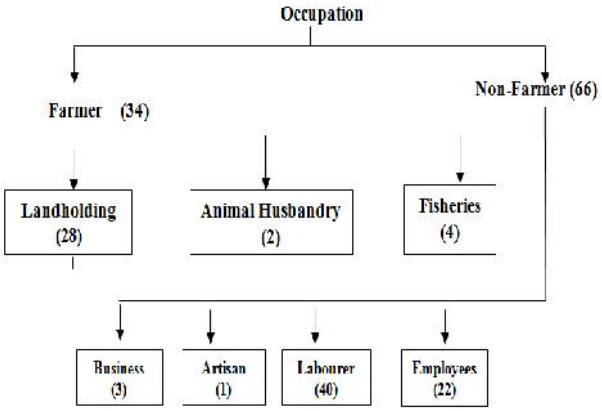

Figure 3 Sampling methodology for household data collection in Keralapuram village

The distribution of the various occupational classes revealed that the farmers constituted 26.5%, livestock keeping 1.04%, fisheries 4.167%, labourers 41.67%, business 1.56%, employees 24.48%, artisans 0.52% of the total households of 192. The sample to be selected is to be proportionate to the percentage distribution of the category of the occupation; this can also be interpreted otherwise as the weights. Farmers of Keralapuram are mostly comes under the category of Small, Marginal and Semi Medium group with limited land holding. Thus, as a total number of 100 samples were drawn based on the proportionate distribution of the occupation randomly. The selected households have been interviewed through structured schedules. The data collected has been analyzed with the help of SPSS tool.

Land Use / Land Cover Categories In The Study Area

Land use refers to 'man's activities and the various uses which are carried on land'. Land cover refers to natural vegetation, water bodies, rock / soil, etc. Although land use is generally inferred based on the cover, yet both the terms are related and interchangeable. In the present study, one season (Rabi) satellite data is used for land use/ land cover mapping of Keralapuram village. For Rabi season IRS-P6 Resourcesat-2 satellite data of 1st March 2013 data is used. Supervised classification technique has been implemented using the maximum likelihood algorithm and classifications procedure is applied on each scene separately using spectral reflectance and field knowledge (NRSC 2007). Before classifying the images using supervised classification technique, unsupervised classification was done to attain spectral signature of real land use and land cover (NRSC 2006). The maximum likelihood algorithm is used for different class segments with separate training data set. To assess the accuracy of the classified image, ground truth surveys have been carried out, and pure signatures were collected using ground truth points obtained from the field. Ground truth locations along with GPS readings. The entire study area is broadly divided into six categories; namely crop land, fallow land, plantation Builtup land water bodies and canal given Table 2.

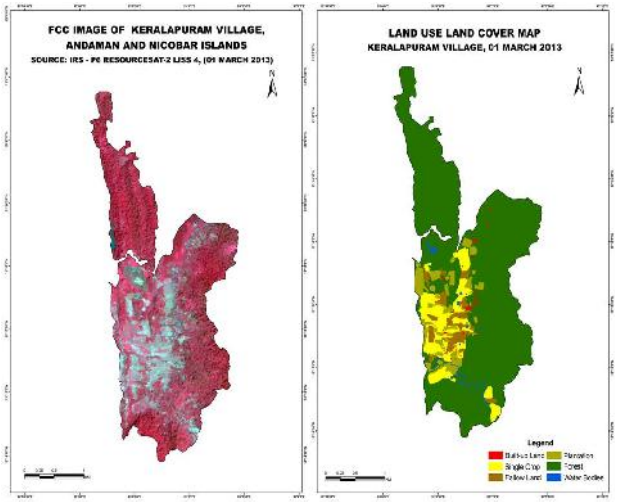

Figure 4 Land use / land cover map derived using High resolution satellite data

Table 2 Land use / land cover categories

S.no	Land use class	Area(Ha)	Area in %
1	Crop	56.30	9.16
2	Fallow	24.21	3.94
3	Water	5.01	0.82
4	Forset	486.60	79.16
5	Plantation	39.33	6.40
6	Built-Up-Land	3.28	0.53
	Total	**615**	**100**

Cropland: These are the areas with standing crop as on the date of Satellite overpass. Cropped areas appear in bright red to red in color with varying shape and size in a contiguous to noncontiguous pattern. They are widely distributed indifferent terrains; prominently appear in the irrigated are as irrespective of the source of irrigation. It include rabi crop land along with areas under double or triple crops total area 56.30 Ha.

Fallow: An agricultural system with an alternation between a cropping period of several years and a fallow period. (Ruthenberg, 1980). In another terms these are the lands, which are taken up for cultivation but are temporarily allowed to rest, un-cropped for one or more season, but not less than one year total fallow land area 24.21 Ha.

Water Bodies: This category comprises areas with surface water in the form of ponds, lakes, tanks and canal in the village area 5.01Ha.

Forest: these are the areas bearing an association predominantly of trees and other vegetation types (within the

notified forest boundary) capable of producing timber and other forest produce. Two forest categories; deciduous (open) forest , forest plantations are included in this class. The total forest aerial extent in this area 486.60 Ha, which is 79.16% in the study area.

Plantations: These are the areas under agricultural tree crops planted adopting agricultural management techniques. Depending on the location, they are exhibit a dispersed or contiguous pattern. Use of multi-season data will enable their separation in a better way. It includes agricultural plantation, horticultural plantation (like coconut, citrus, ornamental shrubs and trees, vegetable gardens etc) and agro-horticultural plantation total area under this class 39.33 Ha.

Built-up land*:* It is an area of human habitation developed due to non-agricultural use and that has a cover of buildings, transport and communication, utilities in association with vegetation and vacant lands.

Rural: **-** These are the lands used for human settlement of size comparatively less than the urban settlements of which the majority of population is involved in the primary activity of agriculture. These are the built-up areas, smaller in size, mainly associated with agriculture and allied sectors and non-commercial activities. They can be seen in clusters non-contiguous or scattered total area under in this area 3.28Ha.

Village Profile

The goal of the Village GIS is to depict the comprehensive picture of Village. The Keralapuram village spatial spread with households, panchayat office, canal, temple, church, rural roads, wells, school building, Anganwadi, Health Sub Centre etc are shown below (Figure 5,6,) .

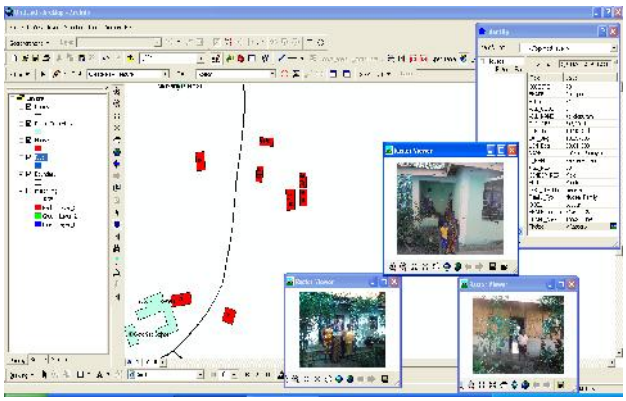

Figure 5 Household Information with Photographs

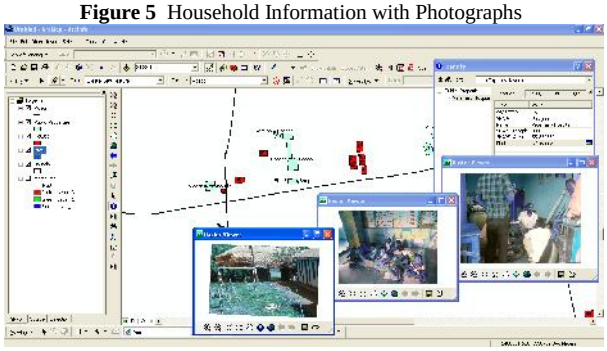

Figure 6 Information on Public Properties

Household Survey

The household survey covered heterogeneous population belonging to different income, educational and social groups. There was more availability and utilization of solid biomass fuels as energy resources in domestic sector as compared to the commercial fuels. Dung cakes, crop residues and firewood were found to be the three main fuels used for cooking, though LPG was also used along with biomass fuels (Zhao L, 2011). Income was an important factor determining the choice of fuel for cooking, but there were some socio-cultural factors which were equally important in making fuel preferences at household level. The rural energy survey was carried out by the team with the structured questionnaire (Agrawal R.K, 2001). The questionnaire contains the following information:

- **Personal information:** Information about the respondent age, gender, educational qualification, social status, occupation, economic background, annual income, type of house and family type will show the influence of various energy sources.
- **Electricity / Fossil Fuel use for Household:** Status of electricity supply, source of drinking water, quantity of water used per day and household assets shows the energy consumption(IEA, 2009). In rural India majority of the energy consumption is met from the noncommercial energy sources like dung cake, crop biomass waste, wood, biogas, gobar gas, charcoal and coal, however, commercial energy uses like petrol, diesel, kerosene, LPG gas and electricity were also used minor due to rising of prices (Abha Chhabra, 2015). We studied about biofuel, fossil fuel usage for household activities like cooking, lighting, water heating and other uses. These were measured across seasons, per day.
- **Renewable Energy Consumption:** The need for renewable energy sources is real and pressing today simply because our current dependence on conventional petro -based fuels and energy sources cannot be sustained due to increasing prices. In this context it is understood that renewable energy sources like solar, wind, etc are promising solution not only in meeting the ever increasing demand of energy but also in mitigating the adverse environmental effects. Hence, our study focused on this component and information gathered about renewable sources like solar, wind and other sources which are available in the village, their usage in houses, number of units installed, power usage in watts and energy consumed (Mahiri I.O, 2003).
- **Food Basket Estimation:** There is interregional difference in energy intake in rural India, of energy this component was classified in to food grains, pulses, milk & meat, cooking oils, fruits, vegetables and processed food. The consumption of these items were measured per month and in units (Wijayayunga *et al*, 2002).
- **Agriculture details:** To carry out the study of different energy consumptions, primary data was collected for farmers land holdings, crop input details like usage of seed, fertilizers, insecticides, labour, production cost and crop output details like yield, self-consumption, sold in the market, price per acre per cycle (Subramaniyam *et al*, 1998). Information about crop residue which is used

as biofuel, burnt on site, animal feed and sold in market. Machinery used for farming, irrigation sources and equipments used for irrigation were also taken into the consideration to measure the usage of fuel consumption (Singh S, 1998).

- **Livestock details:** livestock, livestock produce, fish production, crop biomass consumption as human food, biofuel consumption in rural households, agricultural machinery like (tractors, thrashers etc), livestock feed/fodder consumption, livestock products consumption, animal dung production and consumption as biofuel in residential households/industry (Bari M.N *et al*, 1998).

Results of The Study

To carry out the study of different energy consumptions, primary data was collected for crop statistics viz. total cropped area, crop wise gross sown area, net sown area, crop production at village level, livestock, livestock produce, fish production, crop biomass consumption as human food, biofuel consumption in rural households, agricultural machinery like (tractors, thrashers etc), livestock feed/fodder consumption, livestock products consumption, animal dung production and consumption as biofuel in residential households/industry.

Agriculture

Agriculture is the mainstay for majority of the people of the village. The village is mainly paddy cultivating village. The village produces Banana, commercial crop like Areca nuts. The data collected for the crop holds the variables such as seed, fertilizer, insecticides, yield (energy input), consumption, sold in market, residue production, burnt in farms and animal feed (energy output) have been analyzed and discussed as follows (Janakarajan S, 1993).

The results of the study on the source-wiseenergy input-use on sample farms for paddy, moong, urd dal, banana, coconut and areca nut crops in the village have been presented in Table 3. The energy inputs usage was very high in urd dal, moong and banana crops. For the paddy, coconut and areca nut crops consumed less energy input. Agriculture not only consumes energy but produces also in the form of crop outputs.

As depicts in the above table residue production, burnt, animal feed and residue sold in market are as out puts of the crop. Production of residue per acre was 1608.3Kg. Residue burnt onsite per acre was 466.67 Kg. Villagers are using 641.67 Kg for animal feeding. The rest of the residue is sold in the market on an average of 501 Kg.

Livestock

In Keralapuram village the livestock observed was cow, bullocks and sheep. A set of parameters have been used for calculating energy consumptions andthe parameters used to calculate energy are water, oil cakes, crop residue, gazing hours, dung produced, milk produced, etc. The analysis of livestock is as follows.

The total number of livestock is 139. A total of 104 cows are held by the respondents from 100 samples. The parameters shown in the above table is water, oil cakes, crop residue, grazing hours, other feed and other fodder are energy inputs and dug produced, dung self-consumption, milk quantity produced, milk self - consumption and milk sold in market are as energy outputs. Water consumption of each cow is an average of 6.8 liters per day and each bullock is an average of 7.1 liters. Input of energy in animal food for the cows, bullocks and sheep came from crop residue from the paddy, moong, urad dal, other feed like banana leaves. The oil cakes are imported from the market.

Table 3 Details of Production and Residue of all crops

Crop name	Total Acres	Seed (Kg)	Fertilizer (Kg)	Insecticides (ltr)	Yield (Kg)	Consumption (Kg)	Sold In Market (Kg)	Residue_ Production (Kg)	Burnt (Kg)	Animal Feed (Kg)
Paddy	76.56	67.71	73.33	1.83	1758.33	452.08	1306.25	1608.3	566.67	741.67
Moong	18.5	29.9	120.3	1.2	2758.33	452.08	2306.25	1650.0	1150	500
Urd Dal	11	28	165	1.26	1800	119.37	1680.63	2900	2400	500
Banana	6	--	150.3	1.65	250.00	119.37	1680.63	2900	--	442.36
Coconut	4.86	--	34.38	--	1405.56	127.78	1277.78	103	103	--
Areca Nut	34.88	--	34.38		439.37	5.47	433.91	50	50	--

Table 4 Details of Energy inputs and outputs of Livestock

Animal Details	Water (lit/Day)	Oil cakes (kg/Day)	Crop Residue (kg/Day)	Grazing Hours (kg/Day)	Other Feed (kg/Day)	Dung Produced (Kg/day)	Milk Quantity Produced (lit/day)	Milk Self Consumption (lit/day)	Milk Sold in Market (lit/day)
Cow	6.8	0.56	4.9	3.9	0.9	5.78	2.337	1	1.337
Bullocks	7.1	0.6	4.5	4	1	6	--	--	--
Sheep	2.71	1.67	1	3	0.73	--	1.21	1.21	--

Out of the total land area in the village (Table 2), about 33.65%is cultivable, but only 15.23% is actually used for cultivation during the monsoon i.e. in kharif, 2.72% isused for rabi (winter) and 6.36% is used for perennial plans. Paddy and moong are the kharif season crops. Banana and urd dal crops are sown in Rabi season. Perennial plants are coconut and areca nut.

The grazing hours per day by each cow is an average of 3.9 hours, bullock 4 Kg per day and per sheep 3 hours per day. Dung produced by the cow was 5.78 Kg per day and 6 Kg by bullocks. Milk produced by the cow was 2.337 liters and 1.21 liters by sheep, villagers are using 1 liter of cow milk and 1.21 liters of sheep milk for self- consumption, 1.337 liters of cow milk selling in the market.

Table 5 Details of Energy Sources usage in Households

Commercial Energy Sources					Non Commercial Energy Sources	
LPG (cylinder)	**Electricity (units)**	**Kerosene (Ltrs)**	**Petrol**	**Diesel**	**Dung Cake (Kg)**	**Collected Wood**
5	896	19.20	31.42	43.08	0	676.80

Usage Of Energy Sources At House Hold Level

Every household uses various energy sources to satisfy the needs of the family. The types of energy sources used for household purposes by the respondents and the influence of locality on the usage of various energy sources in (Jashimuddin M *et al*, 2006) table 5.

The above table shows that among the commercial energy sources electricity was mainly used by the 91 households with on an average of 896 units per annum. On an average 5 LPG using by the 68 respondents for cooking and 19.20 ltrs of kerosene is using by 13 households for lightening purposes. For the transportation purpose villagers are using on an average 34.42 ltrs of petrol by 31 households and 43.08 ltrs of diesel by 7 households per annum. Villagers are using non-commercial energy source like collected wood as cooking fuel on an average of 676.80 kg by 55 households per annum. Villagers are more sentiment using dung cakes because in Hindu tradition bodies are burnt with dung cakes after the death due to this villagers are not using dung cake.

CONCLUSION

The study presents an estimation of net energy balance in a semi-arid rural ecosystem of Keralapuram village, Andaman Nicobar Islands. An end use energy accounting 'Rural Energy Balance Model' is developed to provide a complete assessment of net energy balance of a rural ecosystem. The primary and secondary field data collection of various energies used at household and village level was carried out using structured schedules and questionnaires.

The different energy resources including fossil fuel and electricity are available in the village. The positive energy balance indicates 'an energy sustainable rural ecosystem' of Keralapuram village. However, the availability and awareness about various renewable energy sources and their maintenance need due attention to improve the energy efficiency and meet the future energy requirements of the rural ecosystem together with sustainable development.

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