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Energy Flow Model and Village Ecosystem Function in Hot Sub-Humid Area of Faizabad District of Uttar Pradesh, India.

Dr Anil Kumar
Associate Professor and Head, Department of Botany, Feroze Gandhi College, RaeBareli (U.P.), India.

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Corresponding Author:
Dr. Anil Kumar

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ABSTRACT

Energy flow model have been prepared to assess the intricate relationship between various sub-systems of village ecosystem viz; the agroecosystem, animal husbandry sub-system and domestic sub-system in the village where Eucalyptus plantations are maintained on bunds for improving the economic and ecological conditions of the rural communities. Energy flow model were used to assess the sustainability of villages ecosystems and its ecological implications. It has been observed that in presence of sufficient irrigation facilities / resources, inputs of occasional heavy rainfall the Eucalyptus plantations on bunds may be a boom for the village farmers as it is more energy efficient and economically viable to make the system viable and sustainable.

Introduction

Over the years Eucalyptus has been grown in association with agricultural crops, as a wind break around orchards, as avenue tree on farm houses, cattle shed and as roadside avenue on farm approach road. Raising of Eucalyptus on field boundaries under different pattern of plants is a common practice adopted by farmers throughout India). Plantation of Eucalyptus have been raised on the bunds of the agricultural fields by the farmers owing largely to its versatility in adaptation to a wide spectrum of climatic conditions and soil conditions and providing short rotations of normally 5 to 6 years. Eucalyptus planting on the boundaries of agricultural lands in U. P (Kumar et.al,2003) India has attracted a great deal of controversy.

Whereas, the environmentalist has criticized this (Chandrasekhar et.al.,1987; Roy, 1986) on the ground that it draws down the water table, thus causing negative effect on the crops, foresters have denied any excess drawl by Eucalyptus (Tiwari and Mathur,1983; Davidson, 1985; Srivastava and Lal,1989). Much of the debate is polemical, and each side has adducted scientific evidence in favour of their stand taken largely from laboratory results. Neither environmentalist nor foresters seems to have thoroughly studied eucalyptus plantations under agro-forestry systems in context of socioeconomic and ecological web of villages in U.P. of northern India. Energy flow models have often very effective method to assess the sustainability of village ecosystems (Kumar and Sinha, 1997). It is in this context present study is presented.

Objective of the Study

The present study was undertaken to analyze energy flow in the different subunits of village ecosystem function. Most of the studies are limited to cost benefit analysis that too without measuring its impact on village economy. Therefore, the present study is aimed at the village ecosystem function study of villages associated with eucalyptus plantations and energy flow analysis.

Materials and methods

Study area and climate

Masendha and Biraulizham village of Faizabad district were selected for the present study. The region falls under hot subhumid moist condition. The agroclimatic of the region is characterized by hot summers and cool winters. The region receives mean annual rainfall of 1000-1200mm 70% of which is received during the summer monsoon period i. e. July to September. The rainfall covers about 70%of annual PET demand of 1400 to 1800mm and leaves an annual water deficit of 500 to 700mm. The region has an LPG of 150 to 180 days in a year. According to the water balance diagram the region experiences dry period from February to June with an annual mean temperature of more than 22°C and thus qualities for ustic soil moisture and hypothermic soil temp. regimes. The areas adjacent to foot hill are relatively cooler and experience thermic soil temperature regime.

Methods of study

Energy flow model have been prepared on the basis of earlier studies on effect of eucalyptus plantations on agriculture, animal husbandry system and domestic sub-systems in Masendha and Biraulizham villages of Faizabad district of U.P (Kumar, 2021a,2021b). All the households were surveyed for their land use and cropping patterns as well as for cattle and human population data (Table 1). All the activities in the village were closely monitored and quantified over a period of one year time during 2019-2020 from selected farmers family of each category i.e. large farmer, middle farmer and poor farmer family. Detailed methodology for the present study was described in those papers. Most of the energy values were considered on the basis of values given by Mitchel,1979 and Gopalan et.al.,1978.

Table 1: Details of Village selected in Faizabad District for Study

Sr.No.	Aspects	Biraulijham (Without Eucalyptus Plantation)	Masauda (With Eucalyptus Plantation)
1	Total family	70(480.9)	65(535.3)
2	Total Land(ha.)	128.87	207.3
3	Land/family	1.84	3.19
4	Cow	162(59)	64(59)
5	Buffalo	115(40)	113(41)
6	Bullock	60	61
7	Poultry	115	62

Labour hours expended for each activity was recorded separately. The total energy consumed was apportioned to each activity (Leach, 1976), according to the relative duration or the basis of grouping, involving sedentary, moderate or heavy work. Per hour energy expenditure was calculated as (i) 0.418 MJ for sedentary work, 0.488 MJ for moderate work and 0.679 MJ for heavy work for an adult male and (ii) 0.331 MJ for sedentary work, 0.383 MJ are moderate work an 0.523 MJ for heavy work for an adult female (Gopalan et. al., 1978). Energy input through chemical fertilizers was calculated on the basis of fossil fuel energy that is required to manufacture that fraction of the fertilizer (Table No.2). The fossil fuel equivalents are given in Table No. 1 were used to calculate the replacement cost of organic manure in terms of fossil fuel energy.

Table 2: Energy Value (MJ/kg dry wt.) of different components

S.No.		Items	Energy value
1.	**Crops***	Grains	16.17
		Pulses	17.03
		Oil Seed	22.64
		Leafy vegetable	15.8
		Tuber & Rhizome	3.94
		Sugarcane	16.65
		Milk	2.9
		Green Fodder	3.9
2.	**Cost of Production****	N2	76.98
		PO	55.80
		KO	9.66
		Pesticides	101.25
3.	**Replacement cost*****	Fire wood	19.69
		Straw	13.82
		Organic manure	8.75
		Eucalyptus wood	20.42
4.	**Transportation cost(MJ/hr)*****		133.7
5.	**Irrigation cost (MJ/hr)*****		47.75
6.	**Bullock (MJ/hr)*****		3.031
7.	**Labour (MJ/hr.)*-Male(female)**	Moderate work	0.418(0.331)
		Sedentary work	0.488(0.383)
		Heavy work	0.679(0.523)

Gopalan et.al.,1978 ; **Pimental et.al.,1973; * Mitchell,1979*

Results and Discussion

In both the villages i.e. Masendha (with Eucalyptus) and Biraulizham (without Eucalyptus) have energy efficiency of village ecosystems is 8.15 and 3.34 respectively (Fig.1). The schematic presentation of energy flow model through a village ecosystem having Eucalyptus plantation (Masendha) and through another village ecosystem having no Eucalyptus plantations (Biraulizham) emphasize the intricate relationship between agriculture, animal husbandry and plantations (both with and without Eucalyptus plantation) and human energy production and consumption system. Both the village ecosystem studies were made to observe the ecological and socioeconomic impact of Eucalyptus plantations and its intricate relationship with village ecosystem function (Fig.2 and Fig.3).

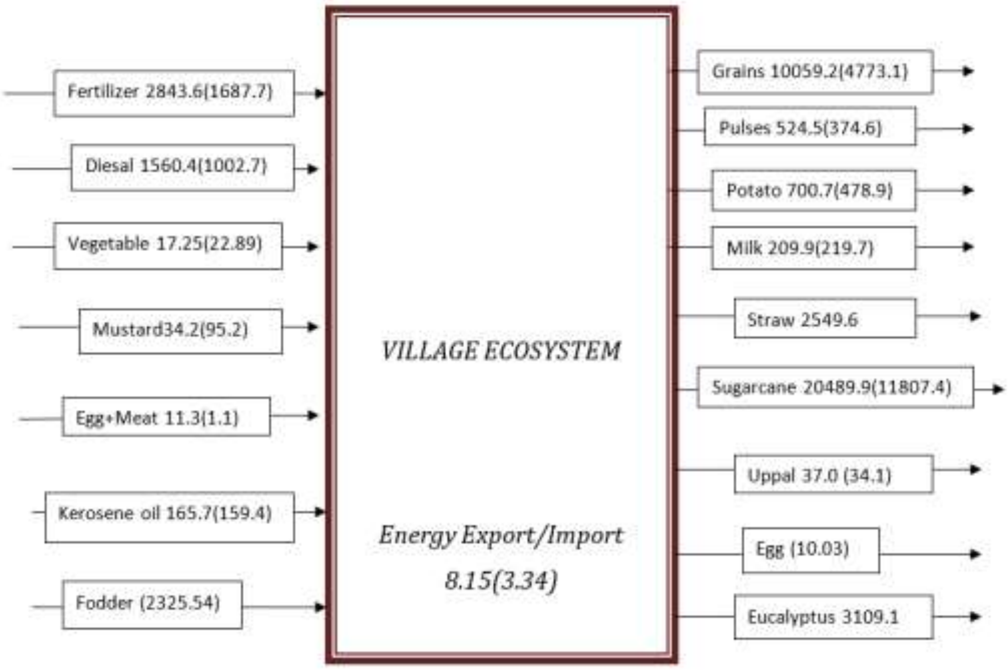

Fig. 1: Energy (MJx103) Export /Import Pattern through Masendha village Ecosystem (Value in parentheses is for Biraulizham Village)

The dependence on private orchards and woody vegetations for fuelwood requirements, for domestic subsystems and animals for grazing though less emphasized. In return the dung produced from these animals are recycled for agricultural systems as organic manure, dung cake for fuel wood requirement and part of it for sale. Both the social and scientific sciences are now using energy flow models as a tool for the study of human ecology (Kumar and Sinha, 1997). These studies may also be linked to methods in agriculture, animal husbandry, agroforestry, or human nutrition (Dufour, 1983 and Leslie et.al. 1984). According to Loucks and D'Alessio (1975), such energy flow models employ complete metrics to characterize ecological features. According to Briscoe (1976) connections between village ecosystems and plantations and the forest resource base are particularly important for the functioning of ecosystems in many traditional communities (Doufour 1983, Rappaport, 1971).Due to the high calorific content of both rice and maize, small farmers in the wet tropics focus more on growing rice to meet their basic dietary demands (Fink,1970). Numerous research conducted throughout the globe have demonstrated these on Over to conventional systems, based on technologies created over many generations to be energy efficient (Schultz, 1964). (Steinhart and Steinhart, 1974; Thomas, 1976; Kumar and Ramakrishnan, 1990).

Animals in traditional civilizations are grazers and consumers of agricultural products unsuited for human use. They have cheap maintenance costs while also supplying power for numerous farm operations, recycling valuable nutrients, and serving as a significant source of nutrition for the general population (Odum,1971). Small farmers priorities rice more in the rainy tropics. Farmers are now focusing on the growing fodder crops in their farms in addition to stressing crop by-products for animal feed. Therefore, in this village ecosystem study in the hot sub-humid dry zone, the animal husbandry system does not seem to increase rivalry for food between mankind and animals. This contrasts with the tribal societies in north-east India and other regions of the world, where man and animals battle for food since there are less agricultural grounds available. (Reid, 1973).

The per capita fuelwood consumption pattern in both the village ecosystem is about one and a half times (1.4 to 1.6) higher than the standard requirements. Fuelwood consumption patterns are determined by resource availability, the energy efficiency of cooking stoves (chulhas), and the need for winter heating. Because cooking stoves are not as energy-efficient, there is a high fuel consumption. In general, fuelwood use per person in developing nations works out to be roughly 1.5 times higher than consumption in the west. (Leach1976). In the study, eucalyptus twigs, which have little commercial value, are used to supplement the need for burning wood. Eucalyptus wood is not typically utilised as fuelwood. Nevertheless, declining traditional orchards are being forced to use fuelwood from the eucalyptus trees. Usually Mahua *Madhuka indica, Mangefera indica , neem, Babool wood is used for the purpose.

In his research of rural India, Revelle (1976) hypothesised that low energy consumption efficiency is caused by extreme poverty. Rural India uses a lot of energy for residential heating and cooking (Makhijani and Poole,1975). The primary domestic fuels are wood and vegetable waste, crop byproducts, and animal manure. Based on a thorough examination of the ecosystem function of a village in southern India, Sundarraj and Michall (1987) came to the conclusion that this village uses biomass at a high intensity (90%) that is indicative of sophisticated management techniques, operating very close to biological limits for biomass production.

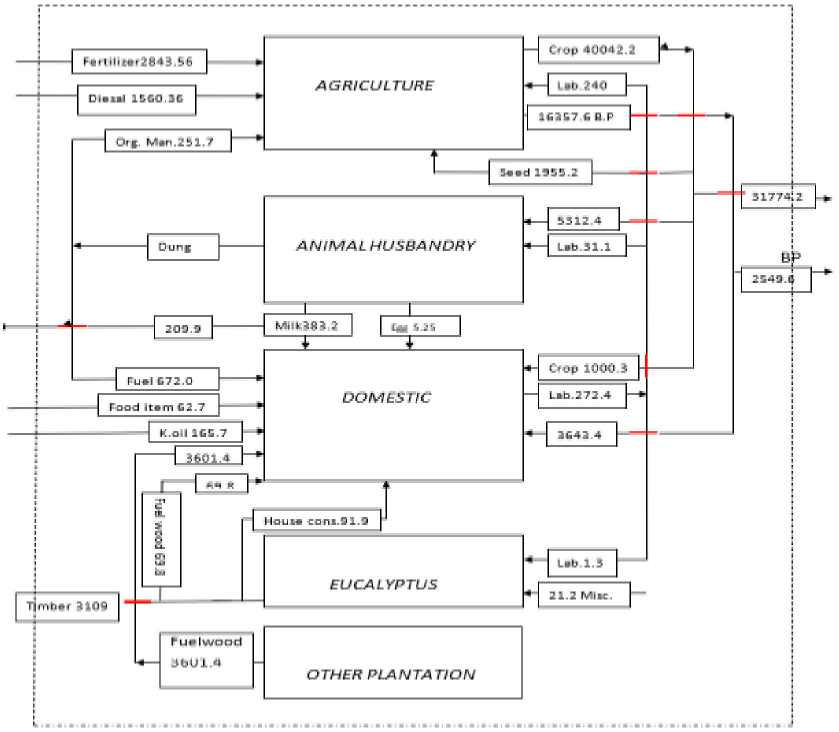

Fig.2. Energy Flow (MJx10^3) model through various sub-systems of Masendha village

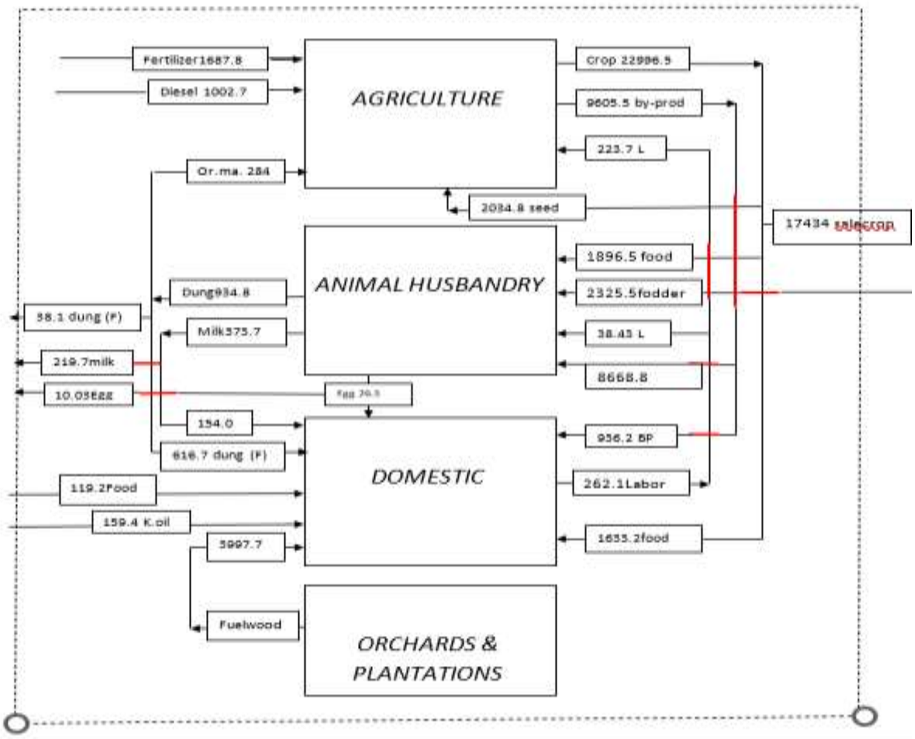

Fig.3. Energy Flow (MJx10^3) model through various sub-systems of Biraulizham village

This study of the village environment follows a similar pattern. Most of the fuelwood used by the village communities are extracted from the private orchards/plantations od the woody vegetations of the area in absence of the natural forest cover. Excessive pressure for the extraction of fuelwood from the traditionally maintained orchards and other vegetations are the major cause of depletion of traditionally maintained vegetation cover. This has compelled the farmers to look for exotic fast growing tree species such as Eucalyptus to meet the domestic and monetary requirements. It is here the Eucalyptus plantations can play a major role in conserving the natural vegetation by contributing a little fuelwood supply and timber demand of the villages.

The village economy is agriculture depends it support from Eucalyptus plantations where ever it is maintained. In this case it is Masendha village. The economic efficiency of this village is high despite fall in crop production due to presence of Eucalyptus trees around agricultural fields, is attributed to sale of excessive crop produce and as well as income generated from the sale of Eucalyptus trees. In case of Biraulizham village the economy is less efficient in absence of timber sale from Eucalyptus trees.The overall energy efficiency of the villages in the hot sub-humid dry region is high compared the tribal villages of north-east India

(Kumar and Ramakrishnan,1989) and the villages of Central Himalaya (Pandey and Singh,1984) because of the better management practices of agroecosystems and animal husbandry sub-systems substituted with Eucalyptus plantations in some cases.

Conclusion
Eucalyptus plantations in the Masendha village is part of every household has got to branch of Sarada Sahayak Canal systems, indicates that availability of cheap water resource is the most important thing for Eucalyptus plantations. The village community is not interested in use of tube wells for irrigation of Eucalyptus plantations as this would cost more for raising the plantations. Biraulizham village has no such type of facility and therefore avoid Eucalyptus plantations in their fields. To minimize the effect of Eucalyptus plantations farmers usually increase the number of irrigations of their agricultural crops and harvest 6 or 7 year old Eucalyptus trees. Sometimes heavy rains naturally sustain such needs. Probably this is the region the energy and economic efficiency of Masendha village did not get affected by the Eucalyptus plantations and has got better energy and economic efficiencies.

If there would have been an adverse impact of Eucalyptus plantations on the village ecosystem on the whole, the Biraulizham village ecosystem would have got better energy and economic efficiency but this has not been observed in this case Not only this the Eucalyptus plantations have contributed to some requirement of the fuelwood of the village ecosystem and that to without affecting the timber economy. The fraction of fuelwood come from the dead twigs and leaves while in the other village (Biraulizham) these benefits are lacking. The total pressure for meeting the fuelwood demand in such village have to come from traditionally maintained private orchards and energy plantations which are basically slow growing tree species.

Considering the above discussions, it can be said that in presence of sufficient irrigation facilities / resources, inputs of occasional heavy rainfall the Eucalyptus plantations on bunds may be a boom for the village farmers as it is more energy efficient and economically viable to make the village ecosystem ecologically sustainable.

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