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# Studies on Energy efficiency of Non-agricultural subsystem (Animal Husbandry and Domestic) of two villages in Sub humid, dry agroecological zones of U.P., India.

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**Abstract:**

The energy efficiencies of animal husbandry and domestic subsystem have been studied in two villages of Faizabad district in U.P with the aim to assess human labour energy utilization in these subsystems, their food intake, fuelwood consumption pattern so that a better planning can be made for sustainable development of village ecosystems function. It has been observed that among the two villages the labour energy distribution pattern is governed by economic status of farmer's families, fuel wood consumption pattern also governed by same factors. Energy efficiency of animal husbandry subsystem is found to be 0.10 and 0.08, respectively for Masodha and of Biraulizham village. Domestic subsystem energy efficiency does not show any difference and is 0.04 for both the villages. These findings can be utilized for better energy planning of these two subsystems.

Key Words: Energy consumption, Energy efficiency, animal husbandry sub system, Domestic sub system.

## Introduction

In both social and natural sciences, the use of energy flow models as research tools for the study of human ecology has grown in popularity. Because of the complexities of economic development and humanitarian crises, energy science and technology should be a part of practically every major activity that addresses ecosystem health and sustainability. Energy is the lifeblood of the global economy and the lifeblood of ecosystems, and it has a significant impact on global warming (Chou *et.al*.,2018). The energy crisis, pollution, abuse of natural resources, water scarcity, global climate change, and deteriorating ecosystems are all key issues that must be addressed in order to meet the United Nations Sustainable Development Goals (SDGs). Energy efficiency of animal husbandry and domestic subsystems are considered as important components of village ecosystem function study to determine overall sustainability of any village ecosystem. There are numerous such studies in the fields of agriculture and animal husbandry linked with animal husbandry and domestic subsystems are available specially from north-eastern India (Ramakrishnan,1992; Maikhuri and Ramakrishnan,1990). Such studies on energy efficiency and energy flow not only provide a picture of a system's long-term viability, but they also represent the system's economic condition (Rappaport,1971). As a result, these studies on animal husbandry and domestic systems are critical to the village ecosystem's functioning. Farmers with less land or unproductive land in the tropics have been found to place a greater emphasis on on animal husbandry systems. Animals give not just milk and meat, but also dung, which is either burned as dung cake or used as organic fertiliser. In the absence of a successful market for eucalyptus wood, Eucalyptus is frequently grown and its wood is used as fuel in residential systems. As a result, the purpose of this study is to analyse the impact of eucalyptus plantations and their ecological implications in villages as part of a village ecosystem function study. As part of a village ecosystem function assessment, the current research aims to analyse the impact of eucalyptus plantations and their ecological implications on animal husbandry and domestic subsystems in the villages of Faizabad district under Hot sub humid moist conditions.

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

| Sr.No. | Aspects | Biraulizham (Without Eucalyptus Plantation) | Masodha (With Eucalyptus Plantation) |
|---|---|---|---|
| 1 | Total No. of family | 70(480.9)* | 65(535.3)* |
| 2 | Cow | 162(59)** | 64(59)** |
| 3 | Buffalo | 115(40)** | 113(41)** |
| 4 | Bullock | 60 | 61 |
| 5 | Poultry | 115 | 62 |

* number of family units, ** number of milking animal

**Method of Study**

Labour hour expended for each category of work was recorded. The total food energy consumed was apportioned to each activity (Leach,1976) according to relative duration on the basis of groupings, involving either sedentary, moderate or heavy work. Per hour energy expenditure of 0.418 MJ for sedentary work, 0.488 MJ for moderate work and 0.679MJ for heavy work for an adult male and 0.331 MJ for sedentary work,0.383 MJ for moderate work and 0.523 MJ for heavy work for an adult female, were used to calculate the labour energy input in the sub-systems (Gopalan et.al.,1978).

Energy output for per kg of meat of each category was calculated on the basis of 17.2 MJ for cattle,4.56 MJ for poultry, 7.2 MJ for eggs (Gopalan et.al.,1978). These values were multiplied by 1.149 to calculate the heat of combustion of meat and egg (Mitchell,1979).

For cost benefit analysis input and output cost in terms of money earned or expend were taken into consideration, the economic output/input analysis were done to get economic efficiency of animal husbandry system. Estimation of actual amount of food/ fuelwood consumed by humans was based on regular measurements made in the village and the energy equivalents of the food items were calculated on the basis of values given by Gopalan et.al,1978 and 19.7 $MJkg^{-1}$ for fuel wood (Mitchell,1979).

**Table 1: Energy Value (MJ/kg dry wt.) of different components considered in the Study**

| 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

For calculation of energy of grazing and scavenging by animals it was assumed that the energy equivalent for this would be equal to the values obtained after subtracting the energy values of the actual feed consumed from their standard requirement (Ranjhan,1977).

For calculating standard food energy of humans, the total consumption units (adult male values) for the whole village was calculated from the energy consumption scale as suggested by Gopalan et.al.,1978. One adult male, 1 unit; one adult female0.9unit;Children aged 5-7 years,7-9 years,9-12 yearsas 0.6,0.7,and 0.8units, respectively. The total consumption units was then multiplied by food enegy equivalents of an adult (1unit) of 10.042 MJ day$^{-1}$ (Gopalan et.al.,1978) to calcu;ate daily food energy of different categories of humans. To find energy required for one adult (1 unit) would be 15.76 MJ (Mitchell,1979). This was then multiplied by total units obtained for the whole village (Table1).

**Animal Husbandry System**

SC population in both the villages give more emphasis to animal husbandry subsystem as compared to general cast population. Poultry birds are maintained by SCs of both the villages, whereas OBCs maintain maximum number of cattle per family.

Grains, green fodder, and crop by-products (straw are the main food items consumed by animals of the villages (Table 2). More than 60% of energy intake by animals come from the crop by-products. Energy input through grains as food are very insignificant.

**Table 2: Annual food consumption pattern (q/yr.) by animal husbandry sub system**

| S.No | Item | Village | |
|---|---|---|---|
| | | Biraulijham | Masauda |
| 1 | Straw | 6270.8 | 10164.7 |
| 2 | Green Fodder | 2903.8 | 5031.4 |
| 3 | Grain | 143.8 | 281.0 |
| 4 | Total | 9318.4 | 11187.1 |
| 5 | Energy value (MJx$10^3$) | 8668.8 | 15477.1 |

Child labour and females have the responsibility for maintaining animal husbandry sub system among landless and poorer people whereas among middle and upper middle category farmers adult males take care of their animals. Maximum labour energy expended in animal husbandry system is by SC community followed by OBC and general cast expend least energy in this subsystem. (Table 3). Among category childe labour used most for animal husbandry system in SC communities.

**Table 3: Labour Energy Input (MJ/yr.) used in animal Husbandry Sub system**

| S.No. | Category | Biraulizham | | | Masodha | | |
|---|---|---|---|---|---|---|---|
| | | SC | OBC | Gen. | SC | OBC | Gen. |
| 1 | Male | 917 | 3326.6 | 5006.8 | 613 | 3642 | 4114 |
| 2 | Female | 5699.7 | 5725.4 | 2732.8 | 5351.4 | 6234 | 383 |
| 3 | Child | 15020 | 2078.7 | 424.5 | 8054 | 2228 | 287 |
| | Total Energy | 21636.7 | 11130.7 | 8164.1 | 14018.4 | 12104 | 4784 |

Annual milk and dung production in both the villages are given in Table No.4. About 25 to 30% dung is lost while collection or in fields while grazing in Masodha village, losses are more about 35% in Biraulizham village.

**Table No. 4: Annual Production of milk and animal dung**

| S.No. | Aspect | Animal | Biraulizham | Masodha |
|---|---|---|---|---|
| 1 | Milk | Cow | 372.74 | 373.21 |
| | (x$10^2$ l/yr.) | Buffalo | 547.75 | 574.91 |
| | Dung (q/yr fresh wt.) | Cow+Buffalo+bullock | 15357.2* | 14476* |

*30-35% Loss from village

Energy efficiency (Energy output/input) for animal husbandry subsystem is more for Biraulizham village compared to Masodha village. Human labour and animal food are major input cost for the subsystem, while milk, eggs and dung are major gain which is either used in village ecosystem or sold in market. (Fig 1).

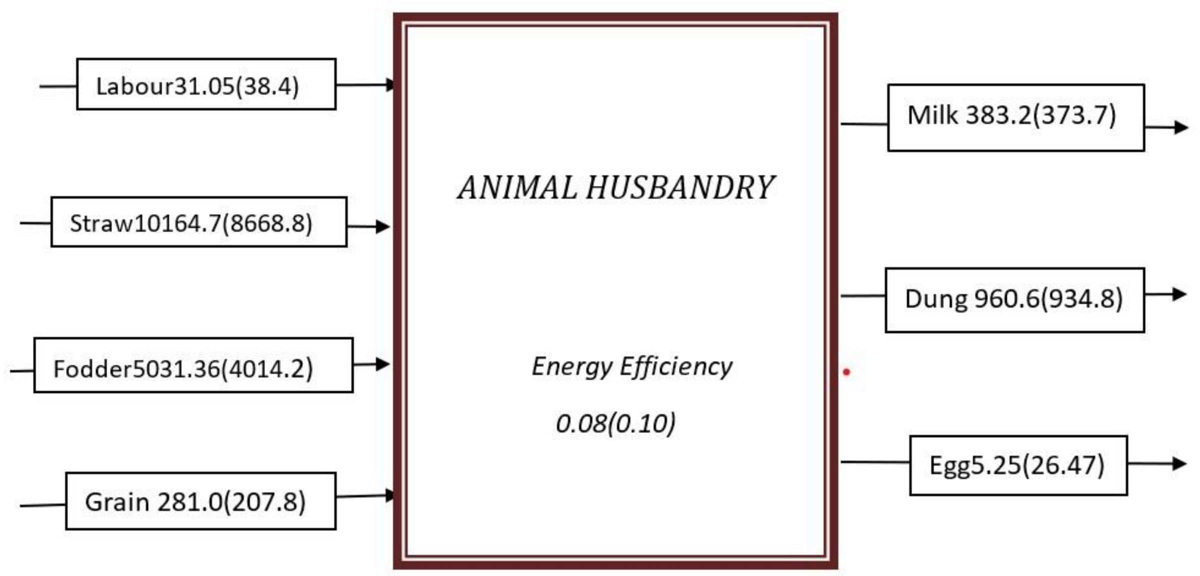


Fig 1: Energy Flow (MJx10$^3$) through the Animal Husbandry Subsystem of Masodha Village (Value in parentheses is for Biraulizham village)

Human food and fuel wood are the major energy input of domestic subsystem, while labour energy is the only output of domestic subsystem which is used for agricultural activity and animal husbandry subsystem. Fuel wood collection does not require extra labour energy input because it is collected during grazing activity of domestic animals. Energy efficiency of domestic subsystem very low in both the villages i.e.0.04 (Fig. 2).

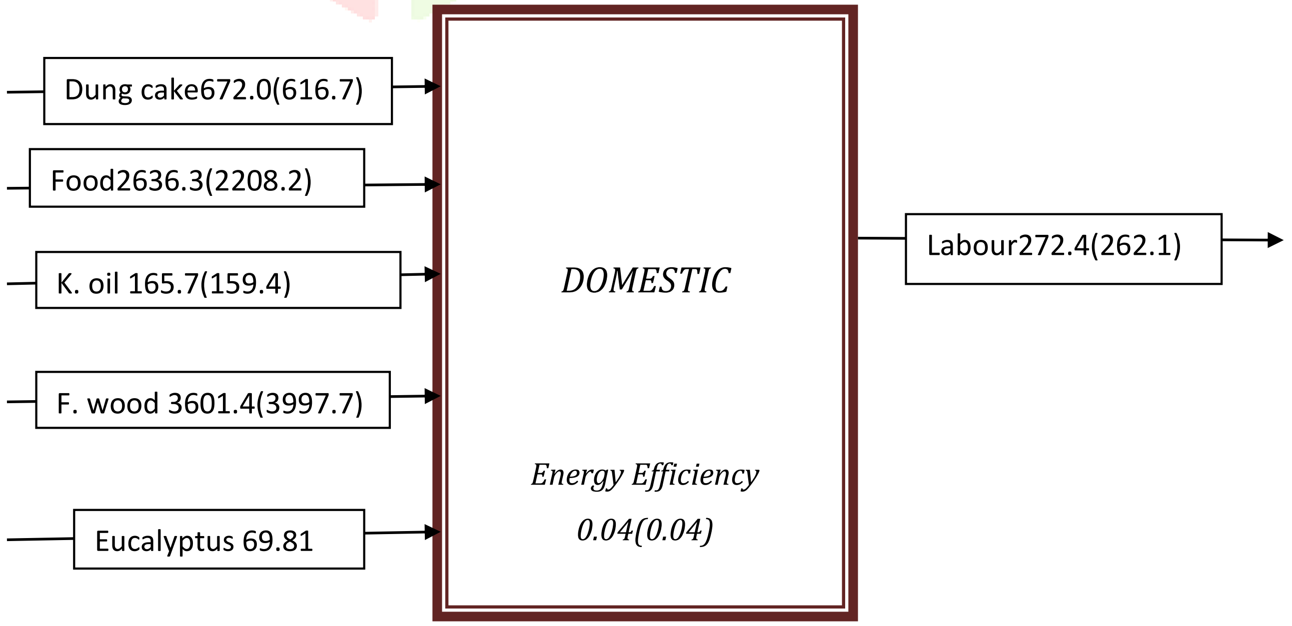


Fig.2: Energy Flow (MJx10$^3$) through the Domestic Subsystem of Masodha Village (Value in parentheses is for Biraulizham village).

**Domestic System**

Human food and fuel wood are the major input of domestic subsystem; labour energy used in agricultural activity and animal husbandry subsystem is the only energy output. (Fig.2). Fuel wood collection does not require extra labour energy because it is collected during grazing activity of animals. The energy efficiency of both the villages are 0.04 which is very less in both the cases.

The annual food consumption pattern of human populations in both the villages consists of more than 90% vegetarian (plant origin) diet, and less than 10% is of animal origin food. (Table 5). Usually per unit consumption of food is less for weaker farmers, though data is presented here represents

Seasonal fuel energy consumption pattern showed both the villages consumed more per capita energy than the standard requirement. Per unit daily fuel wood requirement is more in Biraulizham village than in Masodha village. Non-Eucalyptus wood and dung cake were the major source for fuel energy consumption, contribution of Eucalyptus as fuel wood was not significant even in the village where Eucalyptus plantations were maintained. This reflects Eucalyptus was mainly sold as timber for economic gain (Table 6).

**Table 5: Energy of (MJx$10^3$) annual food consumption in the study villages**

| S. No. | Food | Biraulizham | Masodha |
|---|---|---|---|
| | **Plant origin (Total)** | **2036.63** | **2452.68** |
| 1 | Grains | 1233.56 | 1297.37 |
| 2 | Pulses | 66.63 | 96.49 |
| 3 | Potato | 58.56 | 64.94 |
| 4 | Vegetables | 34.7 | 36.18 |
| 5 | Fruits | 1.32 | 1.52 |
| 6 | Sugar | 633.59 | 947.63 |
| 7 | Oil | 8.27 | 8.55 |
| | **Animal origin (Total)** | **178.58** | **189.64** |
| 8 | Milk | 154.03 | 163.45 |
| 9 | Egg | 16.44 | 24.52 |
| 10 | Meat | 1.11 | 1.67 |
| | **Total Consumption** | **2215.21 (4.61)** | **2642.32 (4.94)** |

**Table 6: Annual Fuelwood consumption pattern (MJx$10^3$) in the study villages**

| S.No. | Fuel type | Biraulizham | | | Masodha | | |
|---|---|---|---|---|---|---|---|
| | | Summer | Rainy | Winter | Summer | Rainy | Winter |
| 1 | Uppal (dung cake) | 178.85 | 200.2 | 237.66 | 196.55 | 228.41 | 246.99 |
| 2 | Non-Eucalyptus wood | 767.76 | 1083.37 | 1787.86 | 1041.76 | 942.38 | 1617.19 |
| 3 | Eucalyptus wood | - | - | - | 20.73 | 2.96 | 45.85 |
| | Gross total | 4255.7 | | | 4343.82 | | |
| | Daily/unit consumption | 0.026 (0.016) | | | 0.022 (0.016) | | |

**Discussion**

In both the social and natural sciences, the use of energy flow models as a tool for studying human ecology has grown in popularity (Kumar and Sinha, 1997). These investigations could also be linked to agricultural, animal husbandry, and agroforestry techniques (Rappaport, 1971) or human nutrition (Ramakrishnan, 1987, and Leslie et.al. 1984). Loucks and D'Alessio (1975) used comprehensive measures to characterise ecological features in their energy flow models. Ecosystem function in many traditional societies is based on a tight recycling of resources within village ecosystems (Briscoe, 1976, Leach 1976, Sunderraj Mitchell, 1987), and particularly on links between village ecosystems and forest resource base and plantations. (Doufour 1983, Rappaport, 1971).

Animals that rely on grazing and consumption of agricultural produce unfit for human consumption in traditional civilizations have low maintenance costs while also providing power for various farm operations, recycling valuable nutrients, and constituting a critical supply of protein for the people. Odum (1971), Kumar and Ramakrishnan (1990), and Ramakrishnan (1993). Farmers are now focusing on cultivating fodder crops in their farms, in addition to emphasising crop by-products for animal feed. As a result, in this village Sub ecosystem study in the hot sub-humid dry environment, the animal husbandry system did not seem to increase food competition between mankind and animals. This is against the tribal societies of north-east India and some other parts of the world where animals and men compete for food due to availability of less agricultural lands. (Reid, 1973; Kumar and Ramakrishnan, 1990). Fuelwood consumption patterns are governed by resource availability, the energy efficiency of cooking stoves (chulha), and the demand for winter heating. Per capita fuelwood consumption patterns in both the village ecology and the standard requirements are around one and a half times (1.4 to 1.6). Less energy efficient cooking stoves are to blame for the high fuel wood use. In general, per capita fuelwood use in poor countries was around one-and-a-half times higher than in developed countries. (Leach1976). The fuel wood demand is augmented in the study by the use of eucalyptus twigs with little commercial value. Traditionally, eucalyptus wood has not been used as a source of heat. Traditional orchards, on the other hand, are being compelled to use fuelwood harvested from the forest. However, shrinking traditional orchards forced to use fuelwood extracted from the eucalyptus trees. Usually Mahua (*Madhuca indica*)), neem( *Azadirachta indica*), Babool (*Acacia nilotica*) even mango (*Mangifera indica)* wood is used for the purpose. It is needed to have extensive research and establish working mechanisms that identify and examine issues that are critical to future sustainable development, to offer advice to decision-makers in various public and private social sectors, to secure a shared future for mankind, and to achieve shared prosperity and common interests through international communications and collaborations, in light of the frontiers in energy sciences and disruptive innovation in eco-techonology.(Rives et.al,2012).

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