Energy Policy and Micro-planning for Participatory Farm Energy Management: The Issues and Understanding

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Abstract—*Farm energy emission, a huge emission from 120 million holdings of Indian Agriculture covering 143 million ha of land, can be held responsible for holding a marginal energy balance between energy trapped in and energy emitted. The 'cooling of farm soil' may be one of the reasons why do Indian farms cannot scale up productivity of crops, comparable at the global level. The huge pull up of ground water, burning of crop residues and indiscriminate mechanization of farmers may be held responsible for a negative energy balance. The present study includes a set of dependent variables related to energy consumption, cattle energy balance, farm metabolism etc.,to be estimated through a set of 19 exogenous variables. It has been depicted through a Discriminant Function analysis that irrigation has got the highest potential to characterize nature, text and emission of farm energy. The principal component analysis has isolated 8 factors through operationally conglomerating 19 explanatory variables responsible for farm energy balances. The factors extracted there from can generate strategic component for participatory micro planning towards ushering an energy efficient farm management. This will ultimately lead to a sustainable production function in agriculture and allied sectors with ecological implications as well.*

Keywords*: Discriminant function analyses, Energy emission, Farm energy and Farm soil cooling.*

1. INTRODUCTION

Socio-economic systems depend on a continuous throughput of materials and energy for their reproduction and maintenance. This dependency can be seen as a functional equivalence of biological metabolism, the organism's dependency on material and energy flows and we therefore, employ the concept of "social metabolism". Contrary to the biological notion, however, the socio-ecological paradigm links the material and energy flows to social organization; recognizing that the quantity of economic resource use, the material composition and the sources and sinks of the output flows are a function of socio-economic production and consumption systems. These systems are highly variable across the time and space. We describe the social systems according to their metabolic profiles in relation to their economic and technological structures, as well as, their demographic governance and information patterns.

2. ENERGY: THE PRIME MOVER

Energy is involved in all life cycles, and it is essential in agriculture as much as in all other productive activities. An elementary food chain already shows the need for energy: crops need energy from solar radiation to grow, harvesting needs energy from the human body in work, and cooking needs energy from biomass in a fire. The food, in its turn, provides the human body with energy.

Intensifying food production for higher output per hectare, and any other advancement in agricultural production, implies additional operations which all require energy. For instance: land preparation and cultivation, fertilizing, irrigation, transport, and processing of crops. In order to support these operations, tools and equipment are used, the production of which also requires energy (in sawmills, metallurgical processes, workshops and factories, etc.). Ulf Renborg (1979), a Swedish agricultural economist, describes in detail the development of this methodological approach in the case of agricultural biomass. Advocates for this method of energy accounting essentially distrust the measure of relative value provided by prices formed in markets or even by legislative intervention in markets (political shadow pricing or administered prices) for that matter.

Major changes in agriculture, like mechanization and what is called the "green revolution", imply major changes with respect to energy. Mechanization means a change of energy sources, and often a net increase of the use of energy.

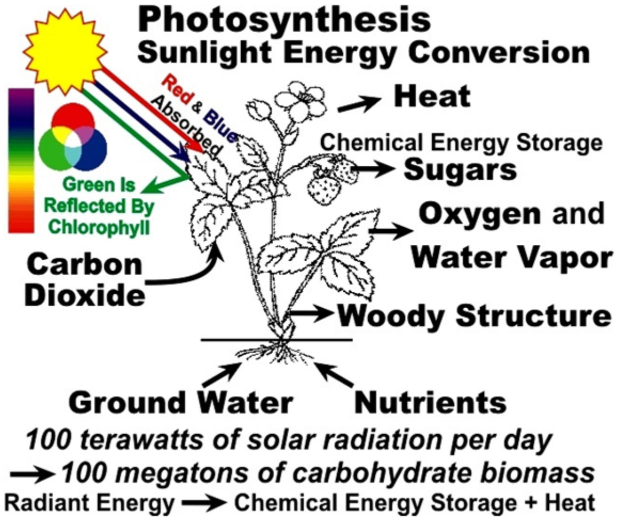

Fig. 1: Energy conversions in plant (Source: wikipedia)

The green revolution has provided us with high yield varieties. But these could also be called low residue varieties (i.e. per unit of crop). And it is exactly the residue which matters as an energy source for large groups of rural populations.

Other sectors of rural life require energy as well. The provision of shelter, space heating, water lifting, and the construction of roads, schools and hospitals, are examples. Furthermore, social life needs energy for lighting, entertainment, communication, etc. We observe that development often implies additional energy, and also different forms of energy, like electricity.

Energy is a scarce resource, at least for some groups of people in some places and, maybe, for the world as a whole. A rational use of energy is then necessary for economic and environmental reasons. This applies to agriculture as much as to any other sector of the economy. Webb and Pearce (1975) point out that this "introduces the idea that energy as a constraint on economic activity is more important than any other constraint". Thus, policies or options with low energy input may have high total resource costs. A key to the rational use of energy is the understanding of the role of energy. The following sections aim to help understand energy in agriculture and rural development. It should help communication between agricultural planners and energy specialists.

3. OBJECTIVE

- To study social ecology and energy consumption pattern in farm metabolism
- To conceptualize the analytical form of farm metabolism.
- To generate a micro level policy on farm energy metabolism that can be replicated in both the similar and exotic situation.

4. MATERIALS AND METHODS

The deliberation on the methodology has been made to understand the concept, methods and techniques which were utilized to design the study, collection of information, analysis of the data and interpretation of the findings for revelation of truths and formulation of theories. This chapter deals with the method and a procedure used in the study and consists of eight main parts-

a) Locale of Research.
b) Pilot Study.
c) Sampling Design.
d) Empirical Measurement of the Variables.
e) Preparation of Interview Schedule.
f) Pre-testing of Interview Schedule.
g) Techniques of Data Collection.
h) Statistical Tools used for Analysis of Data.

In the present study for the stepwise discriminant analysis, canonical disrciminant function coefficients have been used. Stepwise discriminant analysis, like its parallel in multiple regressions, is an attempt to find the best set of predictors. It is often used in exploratory situation to identify those variables from among a large number that might be used later in a more rigorous theoretically driven study. In a stepwise discriminant analysis, the most correlated independent is entered first by the stepwise program, and then second until an additional dependent adds no significant amount to canonical R squared. The criteria of adding or removing are typically the setting of critical significance level for 'F' to remove. These are un-standardized coefficient (b) and used to create the discriminate function (equation). It operates just like the regression equation.

The present study was conducted in two adjoining districts, Hooghly and Nadia. The village, Ghoshalia of Balagarh block in Hooghly district and the village, Maheswarpur of Chakdah block in Nadia district of the state West Bengal were selected for the study. The total number of respondent was 100. For selection of state, district, block and gram panchayat purposive sampling techniques were adopted and fifty respondents were selected randomly from each village.Before taking up actual fieldwork a pilot study was conducted to understand the area, its people, institution, communication and extension system and the knowledge, perception and attitude of the people towards climate change concept.

5. RESULTS AND DISCUSSION

Table 1: Descriptive statistics of Independent Variables (X_1-X_{19}) in terms of Standard deviation and Coefficient of variation

Sl. No	Variables	SD	CV (%)
1	Age(X_1)	11.30	22.03
2	Education(X_2)	3.65	50.71

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3	Gender ratio(X_3)	0.85	59.53
4	Family size(X_4)	2.57	50.46
5	Family education status(X_5)	2.31	31.66
6	Innovation index(X_6)	18138.29	126.46
7	Occupation(X_7)	0.82	13.33
8	Family MIS(X_8)	1.19	44.52
9	Cropping intensity(X_9)	253.19	106.02
10	Farm size(X_{10})	65.15	86.93
11	Expenditure allotment(X_{11})	7.06	19.80
12	Credit load(X_{12})	3179.28	97.56
13	Annual income(X_{13})	39453.00	73.90
14	Irrigation index(X_{14})	0.21	26.20
15	Crop diversity index(X_{15})	0.07	176.92
16	Crop energy productivity (X_{16})	61.63	89.62
17	Adoption index(X_{17})	0.59	34.46
18	Size of water body(X_{18})	180.70	253.74
19	Cattle holding economics(X_{19})	8395.43	88.04

Table 2: Factor analysis: conglomeration of 19 independent variables(x_1-x_{19}) into 8 factors and renaming

Factors	Variables included	% of variance	Cumulative %	Rename
Factor-I	Family education status(X5) Innovation index(X6) Farm size(X10) Annual income(X13)	14.215	14.215	Family resource potential
Factor-II	Age(X1) Education(X2) Cropping intensity(X9) Crop diversity index(X15) Crop energy productivity (X16)	10.902	25.116	Crop-gender ecology
Factor-III	Credit load(X12) Size of Water body(X18)	9.430	34.547	Credit-water diode
Factor-IV	Gender ratio(X3) Irrigation index(X14)	7.624	42.171	Gender-irrigation diode
Factor-V	Occupation(X7) Family MIS(X8)	7.302	49.472	Occupational communication
Factor-VI	Adoption index(X17)	6.270	62.756	Adoption index
Factor-VII	Expenditure allotment(X11) Cattle holding economics(X19)	4.997	73.312	Livestock entrepreneurship
Factor-VIII	Family size(X4)	4.033	77.345	Family size

In factor analysis, the apparently different variables are operationally conglomerated, based on factor loading, into some factors. That is why they need to undergo a renaming as well. This will help to rationalize the number of variables into some manageable and perceptible count.Based on efficacy to explain variables of each of the factors, the resource can be allocated to them for ushering in a better system functioning.

Table 3: Canonical Discriminant Function Analyses

Variables	Mean Of Group-I	Mean Of Group-II	L(I) * D(I) value	D Sq Values
Age(X_1)	53.64	48.44	0.246	5.457
Education(X_2)	6.02	8.32	0.384	8.509
Gender ratio(X_3)	1.47	1.38	-0.010	-0.232
Family size(X_4)	4.26	5.88	0.717	**15.883**
Family education status(X_5)	6.58	7.92	0.430	9.518
Innovation index(X_6)	14401.96	14141.18	0.003	0.063
Occupation(X_7)	6.09	6.16	0.0092	0.203
Family MIS(X_8)	2.76	2.56	0.127	2.804
Cropping intensity(X_9)	202.58	272.66	-0.086	-1.907
Farm size(X_{10})	62.57	86.56	0.303	6.707
Expenditure allotment(X_{11})	35.95	34.96	0.060	1.320
Credit load(X_{12})	3566.00	2919.00	0.132	2.931
Annual income(X_{13})	48663.30	57575.32	0.056	1.234
Irrigation index(X_{14})	0.69	0.87	1.204	**26.678**
Crop diversity index(X_{15})	0.02	0.06	0.187	4.146
Crop energy productivity (X_{16})	88.84	48.70	0.502	**11.116**
Adoption index(X_{17})	1.56	1.83	0.132	2.926
Size of Water body(X_{18})	50.96	90.76	0.123	2.714
Cattle holding economics(X_{19})	9155.40	9916.40	-0.003	-0.068
Cattle Energy Balance (Y_1)	6470.52	6470.52	0.000	0.000
Energy Equivalence of Cowdung (Y_2)	42.58	43.68	0.002	3.938
Crop Energy Metabolism (Y_3)	-4.31	-4.16	-0.001	-0.937
Energy Consumption in Farm Family (Y_4)	0.32	0.36	0.034	85.670
Perceived Impact on Energy Consumption (Y_5)	6.78	6.81	0.004	10.380
Farmers' Energy Metabolism (Y_6)	142464.69	142636.23	0.001	0.950

The canonical discriminant function has identified these three variables i.e. Irrigation index (X_{14}) (26.678), Family size(X_4) (15.883), Crop energy productivity (X_{16}) (11.116), contributing substantially to create a difference in terms of social ecological behaviour.

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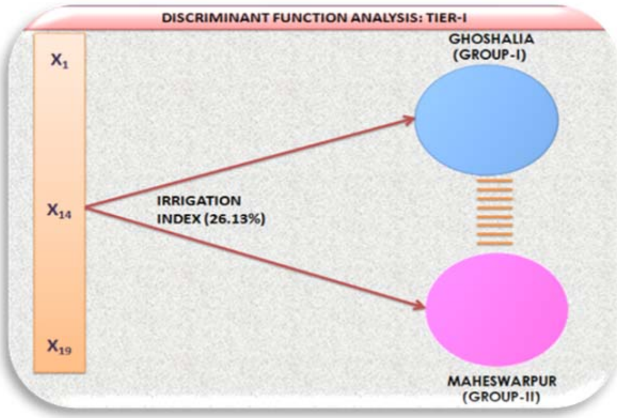

Fig. 2. Discriminant Function Analysis: Tire-I

Canonical Discriminant function has identified the solitary variable, irrigation index(X_{14}), having substantive discriminatory efficacy to make a difference between two research locale with their respective means. This is the single most important intervention which has made a structural as well as functional difference between these two villages i.e. Ghoshalia and Maheswarpur. Irrigation invites application of fertilizer, consumption of electricity and a faster transformation in the character of farm entrepreneurship energy by becoming a polymorphic source of transformation, irrigation can't stay a long way from consuming energy and its relegated change.

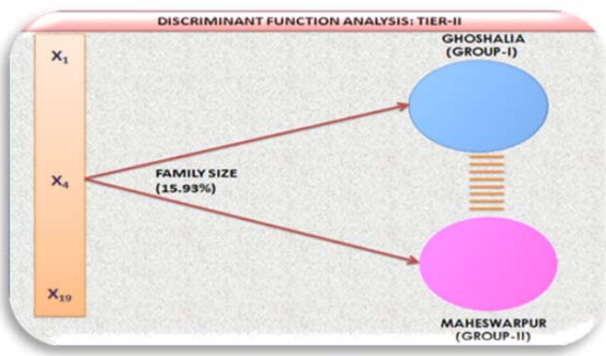

Fig. 3: Discriminant Function Analysis:Tire-II

The Family size in one village is bigger because of its domination of minority population and hence, has offered a socio-cultural distance between these two villages (Ghoshalia and Maheswarpur)

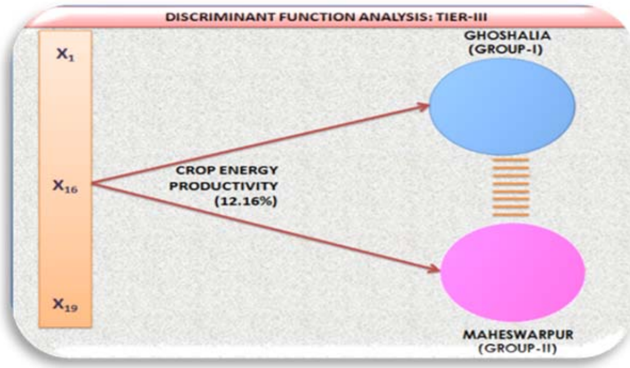

Fig. 4. Discriminant Function Analysis:Tire-III

The crop energy productivity has also been a character of discernible differences between these two villages, which may spear a new research in cataloguing villages with differential crop energy balances.

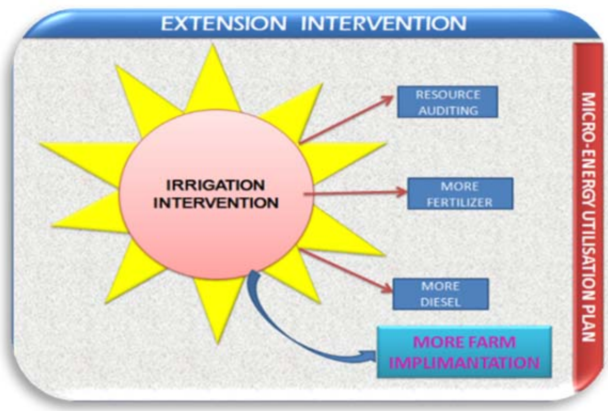

Fig. 4. The Extension Intervention

The most important findings of the study has been its identification of a solitary variable i.e. irrigation index , which have made a perceptible distance between these two villages. Irrigation as an intervention can diverge and begets scores of congenital effects for example Resource auditing, Fertilizer optimization, Consumption of diesel and more mechanization. All these sub-processes may move isochronously to invite further a composite approach of, input-method-concept-planning management. All these having been done, this will generate a micro policy to be applied and adopted in the transforming farm ecology.

6. CONCLUSION

The present study has been a modest attempt to audit on the happening energy metabolism, that is, a subtle balance between energy invested and energy generated from per unit farm functioning. So, the future research has to go further to standardize this energy auditing and energy monitoring while prescribing, what we may call the package of practices. In a redefined regime of farm productivity, quintals per hectare or kilo joules per hectare can go interchangeably to frame of the orchestrations of efficient factor production leading to a sustainable energy echelons, effectively apply with pro energy approach in farm production management. While extension science is having a new mode travel, from material input to energy and from energy to ecological drivers, a new model will be the prerequisites for furthering the *energy extension research*. In the phase of escalating energy crisis scenario, wherein the farm sector is going to be the most vulnerable, the conservation of energy is recycling and cost effectiveness will count the most and in this regard energy economics and the sociology of energy management are going to tantamount to the present fragile interdependence and input versus output interaction.

The new age extension research is better prepared to answer this by following the innovative extension research model, as may humbly be proposed-

1. System behaviour of farm energy dynamics
2. Cataloguing of farms based on level of energy metabolism
3. Farmers capacity building and info of humane skills into the technicality of energy management
4. Hunting alternative source of energy, non-conventional source, solar, bio fuel etc in the process of farm function management and securing energy economy
5. The micro models all developed through small and fragmented farm energy research can be co-integrated to develop a mega level energy saving, heavy load agriculture to feed the millions for the present, and, of course, for the posterity.

Energy Policy and Micro planning for Participatory Energy Management: The Issues and Understanding**.** This empirical study offers policy implications for farm energy management. While there are village to village differences in managing farm energy, deciphering from respective level of technology socialization, there is also farm to farm variability in energy use and trapping as well. The remixing of crop residues into the disturbed soil, clean agriculture, and micro- irrigation bank, scouting on water harvesting and energy stewardship, multilayer crop geometry can go a long way to frame up micro-level policy formulation for village clusters at GP level.

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