The Crop Energy Metabolism: An Agro-ecological and Socio-economic Analysis

Kabita Mondal[1] and S.K. Acharya[2]

1. Ph.D. Scholar, 2. Professor, Department of agricultural Extension, BCKV, Nadia, WB.

Corresponding author email: kabita.mondal@rediffmail.com

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ABSTRACT

The study was undertaken in two districts of West Bengal namely Hooghly and Nadia with 100 beneficiaries as respondents to assess an innovative idea by including energy as the most important input to sustain and support productivity as well as ecological balance. The study depicted that the variables Age and Innovation index have made highest and substantive contribution to the crop energy metabolism in coefficient of correlation analysis. The other variable Gender ratio has recorded a significant association with crop energy metabolism in regression analysis.

Keywords: *Crop energy, Emission of energy, Metabolism, Gender ratio etc.*

The ecology and the universe, the matter and the energy are all combined, integrated, interactive and keep growing exponentially. In the physical ecosystem the two prime movers are *matter and energy*; more complicated, a system thereafter, is the biological ecosystem wherein the prime movers are *genetics and metabolism*. And thereafter, comes the next and most important ecology i.e. Social ecology wherein the prime movers are, *intelligence and motivation*. So this is a hierarchy exposition of matter and energy and energy comes as the basic instigation to earn dynamism, transmission and transformation.

So far and so on the extension paradigm is basically based on the transfer of technology. It is basically linear and monolithic approach, as yet to cherish a denial to the existence of the non-linear functioning of the system and its cybernetics. "Energy flows of the universe are organized in an energy transformation hierarchy. The position in the energy hierarchy is measured with transformities."(5th Law Of Energy, Odum, H.T. 1988). The decline of agricultural productivity cannot only be relegated to a genetic degradation of variables or levels of impurities in fertilizer. As usually as we are doing, we seldom delve into the complicated interaction between matter and energy which deciphers the instincts and inspiration of farmers for the productive function of factor production. A productive farm is always energy wise, balanced, composed, agile and resilient. This means the factor production in a farm have been well audited and accentuated in terms of energy input and energy output quotient. If the factor production of a farm is so constantly extravagated i.e. more of energy emission and less of energy trapping, then it is sure to lose its energy balance and the system will turn 'cooler' with the loss of farm's energy and in no way, the present level of productivity can be retained or upgraded.

Fisher-Kowalsky and Haberle (1998), described Social metabolism as "the particular form in which societies establish and maintain their input from and output to nature; the mode in which they organize the exchange of matter and energy with their natural environment". According to Haberl,-H; Geissler,-S (2000), the utilization of currently unused biomass residues for energy generation could contribute some 76 PJ in Austria, i.e. 6% of the current primary energy consumption, without increasing NPP appropriation.

So, the new age extension science will increasingly be aiming at energy auditing, energy designing and energy management. Even with plenty of fertilizer and fertility of genomes cannot usher in the productivity unless the energy backup has been properly maintained. With this background, the present study envisages to generate a model on farm metabolism; ultimately the metabolic function of farm can be audited, estimated and esteemed. The transformation of agriculture and its mellifluent behaviour is the common nature for the new age agriculture. There is a clear swing from per hectare biological production to per hectare value generation with ecological pursuits and dimensions.

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. And, the present study has selected the topic **"**The Crop Energy Metabolism: An Agro-ecological and Socio-economic Analysis" with following Objectives-

i. To conceptualize the analytical form of farm metabolism.

ii. To elucidated and estimate the operational interaction through coefficient of correlation and regression as well as strategic interaction through path analysis, canonical covariates and canonical discriminant amongst and between the causal and consequent variables i.e. X_1..........X_{19} and Y.

iii. To generate a micro level policy on crop energy metabolism that can be replicated in both the similar and exotic situation.

METHODOLOGY

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.

RESULTS AND DISCUSSION

Table 1. Descriptive statistics of dependent variable, Crop Energy Metabolism with respected to Mean, Standard Deviation and Co-efficient of variance

Dependent variable	Mean	SD	CV%
Crop energy metabolism	-4.24	8.50	-200.47

The mean value of this variable is -4.24 and the standard deviation is 8.50 for the total distribution taken for the study. The coefficient of variation of this variable is -200.47 per cent which shows that the variable has got the very low level of consistency.

Table 2. Coefficient of correlation (r) between Crop Energy Metabolism (Y) and 19 independent variables (X1-X19)

Variables	r value
Age(X_1)	0.237**
Education(X_2)	0.024
Gender Ratio(X_3)	0.131
Family Size(X_4)	-0.043
Family Education Status(X_5)	0.049
Innovation Index(X_6)	-0.123
Occupation(X_7)	-0.020
Family MIS(X_8)	-0.053
Cropping Intensity(X_9)	0.001
Farm Size (X_{10})	0.088
Expenditure Allotment (X_{11})	-0.060
Credit Load(X_{12})	-0.021
Annual Income(X_{13})	0.115
Irrigation Index(X_{14})	0.073
Crop Diversity Index(X_{15})	-0.051
Crop Energy Productivity(X_{16})	0.048
Adoption Index(X_{17})	0.072
Size of Water body(X_{18})	-0.142
Cattle holding economics (X_{19})	0.114

* =r>0.167 significant at 10% level of significance
**= r>0.197 significant at 5% level of significance
***= r>0.258 significant at 1% level of significance

Results: The data in Table 2 presents the coefficient of correlation between Crop Energy Metabolism (Y3) and 19 independent variables (X1-X19). It has been found that the variable Age (X1) has recorded a significant correlation at 5% level with the dependent variable Crop Energy Metabolism (Y).

Revelation: It shows that the experienced farmers who have been farming for so many years have a comparative edge over the young new generation farmers who are opting for rampant modernization without thinking of the energy balances that could increase the entropy level in the small farm ecology and add to already increasing ecological imbalances, that could decrease overall productivity in agriculture So, the variable, age, is offering an important consideration so far as energy management is in concern.

Table 3. Multiple Steps down Regression analysis: Crop Energy Metabolism (Y) vs 19 causal variables (X1-X19)

Variables	ß	ß×R	SE of B	t-value
Age(X_1)	0.255	40.082	0.093	2.060[I]
Education(X_2)	0.032	0.517	0.343	0.216
Gender ratio(X_3)	0.119	10.389	1.186	1.003[III]
Family size(X_4)	0.035	-1.012	0.387	0.299
Family edu. status(X_5)	0.113	3.696	0.541	0.770
Innovation index(X_6)	-0.246	20.074	0.000	1.912[II]
Occupation(X_7)	-0.003	05	1.194	0.029
Family MIS(X_8)	-0.006	0.223	0.914	0.049
Cropping intensity(X_9)	-0.081	-0.039	0.004	0.636
Farm size(X_{10})	0.095	5.545	0.019	0.668
Expenditure (X_{11})	-0.092	3.701	0.141	0.790
Credit load(X_{12})	-0.017	0.241	0.000	0.134
Annual income(X_{13})	0.041	0.076	0.000	0.299
Irrigation index(X_{14})	-0.039	1.190	4.754	0.344
Crop diversity index (X_{15})	0.018	0.200	14.008	0.148
Crop energy productivity (X_{16})	0.042	3.483	0.017	0.337
Adoption index(X17)	-0.078	3.776	1.663	0.676
Size of water body(X18)	0.065	1.185	0.006	0.488
Cattle holding economics(X_{19})	0.088	6.629	0.000	0.761

Multiple $R^2 = 0.1509$ F-value = 0.75 with 19 and 80 DFS

Results: The data in Table 3 presents the multiple steps down regression analysis, estimation of the causal effect of 19 independent variables on consequent variable Crop Energy Metabolism (Y). It has been found that the variable Age(X1) (40.082) has recorded the highest causal effect on Crop Energy Metabolism (Y3) followed by Innovation index(X6) (20.074) and Gender ratio (X3) (10.389).

Revelation: Crop energy metabolism (Y) has well been relegated to the variable Age (X1). So, the experienced farmers have more capability for maintaining crop energy balances than younger farmers. Also the farmers who have more innovative proneness can manage the farm energy very well and also the higher participation of female in farm operation can promote better crop energy metabolism.

The R^2 value being 0.1509, it is to conclude that 15.09 percent of variance in the consequent variable Crop Energy Metabolism has been explained with the contribution of these 19 causal variables.

Table 3a: Regression Analysis (Step down): Screening of variables having significant efficacy for character Crop Energy Metabolism (Y)

Variables	ß	ß×R	't'
Age(X1)	0.272	74.736	2.751
Innovation index(X6)	-0.177	25.264	1.791

Results: Through the Step down regression analysis, two prominent causal variables viz; Age (X1) (74.736) and Innovation index (X6) (25.264) have been retained at the last step. So, these two variables have got substantive strategic and operational impact on crop energy metabolism

Table 3.b.

R	R^2	Adjusted R^2
0.2940	0.0864	0.0676

Revelation: In compliance with the earlier stated results, these two variables, age and innovation index, have greater impact than others. The result shows that those who are experienced and older and obviously having risk bearing ability to adopt new technologies, quite logically have better maintaining capacity of crop energy metabolism.

Result: The data in Table 4 presents the path analysis to decompose the co-efficient of correlation into direct, indirect and residual effect.

It has been found that the Family education status(X5) (0.1130) has directed highest effect but Innovation index (X6) (0.1229) has rooted the highest indirect effect. The variable Age (X1) has figured up as many as 7 times retaining the highest indirect effect as rooted through it.

Table 4. Path Analysis: Direct, Indirect and Residual effect; Crop Energy Metabolism (Y) Vs 14 Exogenous Variables (X1 to X19)

Variables	Total Effect (r)	Direct Effect (DE)	Indirect Effect (IE)=r-DE	Highest Indirect Effect
Age(X1)	0.2371	0.2551	-0.018	-0.0490(X6)
Education(X2)	0.0245	0.0318	-0.0073	-0.0445(X6)
Gender ratio(X3)	0.1315	0.1192	0.0123	0.0154(X18)
Family size(X4)	-0.0437	0.0350	-0.0787	-0.0306(X1)
Family education status(X5)	0.0494	0.1130	-0.0636	-0.0604(X6)
Innovation index(X6)	-0.1231	-0.2460	0.1229	0.0508(X1)
Occupation(X7)	-0.0203	-0.0033	-0.017	-0.0255(X1)
Family MIS(X8)	-0.0537	-0.0063	-0.0474	-0.0508(X6)
Cropping intensity(X9)	0.0007	-0.0808	0.0815	0.0217(X5)
Farm size(X10)	0.0882	0.0948	-0.0066	-0.1083(X6)
Expenditure allotment(X11)	-0.0605	-0.0923	0.0318	0.0267(X10)
Credit load(X12)	-0.0215	-0.0170	-0.0045	-0.0309(X1)
Annual income(X13)	0.0028	0.0414	-0.0386	-0.1142(X6)
Irrigation index(X14)	-0.0455	-0.0395	-0.006	-0.0226(X3)
Crop diversity index(X15)	0.0166	0.0181	-0.0015	-0.0318(X9)
Crop energy productivity (X16)	0.1265	0.0415	0.085	0.0964(X1)
Adoption index(X17)	-0.0733	-0.0777	0.0044	0.0125(X5)
Size of Water body(X18)	0.0274	0.0653	-0.0379	-0.0444(X1)
Cattle holding economics(X19)	0.1143	0.0875	0.0268	0.0216(X1)

Residual = 0.8491

Revelation: The family education status has impacted on crop energy metabolism decisively and dominantly, while the other variable, innovation index, has rooted the significant indirect effect to reveal that this variable has got ample amount of associating property with other variables. The variable, chronological age, has rooted the highest indirect effect of as many as seven variables to imply that age is still a very important indicator to estimate the respondents' contribution towards creating and maintaining crop energy balances. The high value of residual effect indicates that in the selection of variables and their level of persistence has suffered from inconsistency.

CONCLUSION

This empirical study on energy metabolism offers a new insight and a need to have a paradigm shift in extension researches. The rhetoric of Input use efficiency, as it classically implies in terms of a clandestine application of seed, fertilizer, water, agro-chemicals etc., has to be redefined by including energy use efficiency as well. The variables Family education, Gender Ratio, Innovation Index, as being found to go significantly impacting on energy metabolism of a farm, can generate immense micro level policy implication. The harshness of the reality is imminent, if we don't have a clear energy consumption policy at farm levels, wherein the soil will look like soil as it is, but it won't be productive, no matter how much of fertilizer has been applied. The study rightly reveals that energy prodigal farms are going to be the liability if appropriate energy extension interventions are not made.

Thus, it has led to generate following concluding remarks –

- Energy management for any farm is complex and mutually interactive to form a complete web of interaction.
- Proper planning, execution and management for productive farms shall also lead to the better performance of an energy efficient farm.
- Proper extension strategy and policy at the grassroots level is an essential precondition to steer this huge function of crop energy management to a proper direction otherwise there will be a telling effect on the energy management of farms.

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