International Journal of Agricultural Engineering, Vol. 2 No. 2 (October 2009 to March 2010) : 207-211

Research Paper :

Energy flow pattern of micro-watershed based farming systems in hills

K.K. SATAPATHY, **K.N. AGARAWAL AND** T.D. LAMA

Accepted : *June, 2009*

See end of the article for authors' affiliations

Correspondence to:

K.N. AGARAWAL

Central Institute of Agricultural Engineering, Nabi Bagh, Berasia Road, BHOPAL (M.P.) INDIA

ABSTRACT

The farming system of north eastern hills is complex due to practice of shifting cultivation prevalent in the region. Alternative farming systems to native shifting cultivation system were evaluated in long term evaluation to check viability, vulnerability and profitability of these farming systems. Among the eight alternative farming systems three *i.e.* agro-pastoral (FSW_4), agri-horti-silvi-pastoral ($FS\text{-}W_5$), horti-silvi-pastoral ($FS\text{-}W_6$) were evaluated during 1999-2004 for five consecutive years. Input supplied and output obtained or recycled were converted into energy equivalents and analyzed for profitability. Agri-horti-silvi-pastoral system was found to be highly remunerative with regards to output: input energy ratio.

Key words : Farming system, Hill farming, Micro-watershed, Energy flow

Energy is key component of every work. There is a need to look into all energy demanding sectors for efficient allocation and utilization of the energy. Agricultural sector in India involves more than 70 per cent of the population. In this sector sun energy could be harnessed to produce crop with higher energy efficiency. However, during this process also some amount of energy is being invested in the form of inputs (seeds, fertilizer, farm yard manure, irrigation, labour etc). The energy efficiency of the crop depend upon it characteristics, growth and environment

At the Experimental Farm of ICAR Research Complex for NEH Region, Umiam, Meghalaya, micro-watershed based land use systems was evaluated for their self sustainability and *in situ* conservation of natural resources such as soil and water (Anonymous, 2000-2004). Eight different types of land use systems namely dairy based ($FS\text{-}W_1$), mixed forestry ($FS\text{-}W_2$), silvi-pastoral (FSW_3), agro-pastoral (FSW_4), agri-horti-silvi-pastoral ($FS\text{-}W_5$), horti-silvi-pastoral ($FS\text{-}W_6$), natural forest ($FS\text{-}W_7$) and timber forestry (FSW_8), were conceptualized and evaluated for their suitability to farmers of the region and to sustain a family on these systems. Over the years a set of improved land use practices, livestock rearing practices etc have been tested for their performence and economic returns to farming community for sustaining a family along with livestock if any by recycling of produce and utilizing resources in more efficient ways. The resource allocation pattern although analyzed in terms of economic returns, their utilization and flow pattern needs to be assed.

METHODOLOGY

Among the eight farming systems tested over the years, agro-pastoral system (FSW_4) and agri-horti-silvi-pastoral (FSW_5) was found to be highly remunerative as per the economic analysis is concerned. These two systems were monitored for five years from 1999- 2004 to access the resource and energy flow pattern of the micro- watersheds. All the resources allocated for growing crop, livestock raising, jungle cleaning and other maintenance activities were recorded daily for last five years. The production and by product recirculation/selling etc were also recorded. The different resources were converted into energy equivalent using the energy constants recommended by Mittal and Dhawan (1989) for various agricultural, livestock products and by products. The input energy was estimated using the energy supplied for maintaining individual crop/trees, livestock rearing etc while the output energy was estimated using the similar energy equivalents for useful products and by products.

RESULTS AND DISCUSSION

The results obtained from the present investigation are presented below :

Agro-pastoral –system:

The agro-pastoral system (Fig. 1) was developed for mid altitude areas in which the upper reaches were having natural forest of about 33 per cent and areas were converted into terraced beds. The terraced beds are utilized for growing crops while the risers were utilized for growing grasses. The grasses on risers were helpful in not only stabilizing the risers, but also acted as additional production which led to keeping one cow and one calf in

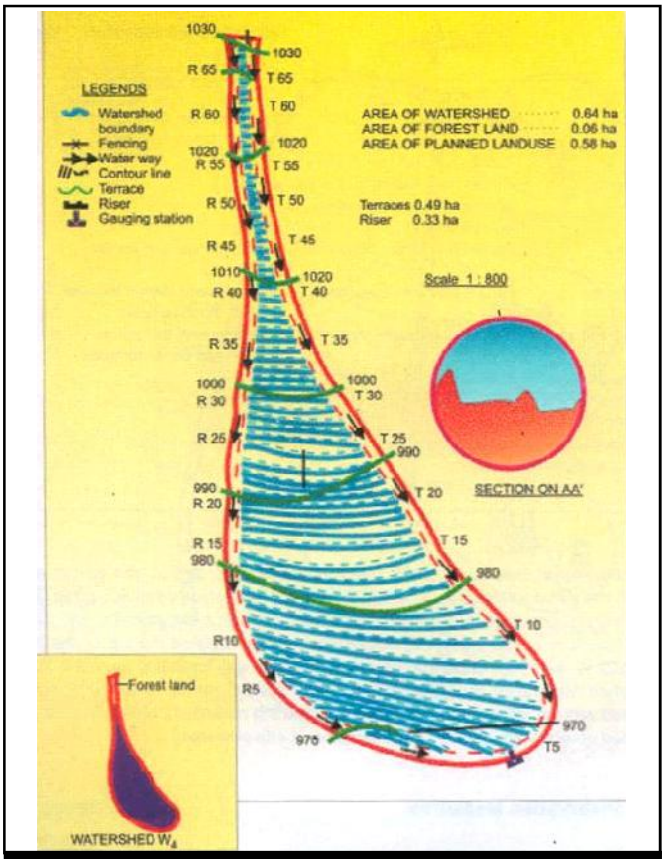

Fig. 1 : Agro-pastoral system (FSW4) of farming system

Table 1: Energy constants of various products/by-products (after Mittal and Dhawan, 1989)

Sr. No.	Particulars	Energy constants
1.	Human	1.96 MJ/man-hr
2.	Animal	14.2 MJ/pair –hr
3.	Diesel	56.0 MJ per litre
4.	Seed (intrinsic energy)	Equivalent to energy value of crop
5.	Fertilizer	
	i) Nitrogen	60.6 MJ/kg
	ii) Phosphorous ($P_2 O_5$)	11.2 MJ/kg
	iii) Potash (K_2O)	6.7 MJ/kg
6.	Crop	
	i) Cereals	14.7 MJ/kg
	ii) Oilseed	25.0 MJ/kg
	iii) Tuber (high value such as ginger, turmeric)	5.6 MJ/kg
	iv) Tuber (low value such as potato)	3.6 MJ/kg
7.	By-product	
	i) Straw	14.7 MJ/kg (dry weight)
	ii) Crop residue	14.7 MJ/kg (dry weight)
8.	Chemical	120 MJ/kg (a.i.)
9.	Farm yard manure	0.3 MJ/kg
10.	Farm machinery	62.7 MJ/kg weight of the machinery distributed over life of machinery

the system to recycle the grass and agricultural waste generated. All together terraces were developed with width varying from 0.6 m to 2.7 m. the terraces were located at an altitude of 975 to 1032 m above msl. The total area under crop is 0.33 ha while balance 0.13 ha is under forest. Over the last five years a number of crops were grown in the terraces during *rabi* and *kharif* seasons. The crops grown and its output – input ratio for crops grown during last five years is presented in the Table 2. It can be observed from the table that over the years terraces of upper reaches mainly utilized for growing maize during *kharif* and mustard during *rabi* season. The terrace no. 47 to 60 were kept fallow during *rabi* season since severe moisture stress was observed in these terraces during *rabi* season since all the terraces are rainfed. However, in lower terraces a number of other crops such as soybean, ragi, ginger, groundnut etc were tried while crops such as rajmash, raddish etc were tried in *rabi* season. The crops such as soybean, ragi, rajmash

Table 2 : Crop grown during 1999-00 to 2003-04 and its output-input in FSW_4

Sr. No.	Crop	Year				
		1999-00	2000-01	2001-02	2002-03	2003-04
1.	Maize	1.82	1.86	3.09	1.536	1.99
2.	Groundnut	3.11	1.96	-	-	3.54
3.	Ginger	1.61	4.35	10.07	-	1.82
4.	Soybean	-	-	1.16	1.61	-
5.	Ragi	2.36	1.98	0.74	-	3.12
6.	Rajmash	1.74	1.56	-	-	-
7.	Mustard	0.74	0.89	1.02	1.31	1.99
8.	Popcorn	-	-	1.10	1.45	1.86
9.	Paddy	-	-	2.05	1.84	-

could not give better results while the crops such as ginger, groundnut, maize during *kharif* season performed very well with output input ratio ranging from 3.11-3.54 for groundnut, 1.61 – 10.07 for ginger, 1.34 –3.09 for maize, etc. The guinea grass grown on the risers has a good yield throughout the year with average yield of 59.6 to 60.29 q/ha/cutting and helped in supplementing 54± 4.2 % of the feed requirement of the livestock system. The material and energy flow pattern of the micro watershed based agro-pastoral system is depicted in Fig. 2. Perusal of the figure shows that output- input ratio of the crop production had been higher as compared to output-input ratio of the livestock component. Although, over the years with recycling of wastes and fodder, etc. within the system has resulted in higher output-input ratio of the livestock component in the land use system. The crop selection and agro-climatic conditions has played a significant role in overall output-input ratio of the cropping system. Many newly introduced crops such as soybean, rajmash etc could not perform to the desired potential resulting in lower yield and subsequent poor return.

Agri-horti-sivi-pastoral system:

The agro-horti-silvi- pastoral system (Fig. 3) was developed for mid altitude areas in which apart from having lower reaches were utilized for agriculture, mid altitude areas for horticultural crops and upper reaches of watershed was utilized for forest. Grasses are grown on risers and in the horticultural block. The terraced beds are utilized for growing crops during both *rabi* and *kharif* season. The horticultural trees are planted on half moon terraced and chiefly contain trees of assam lemon, oranges and guava. The grasses on risers were helpful in not only stabilizing the risers, but also acted as additional productions, which were utilized for livestock system in the other watershed. All together 15 the terraces were developed with width varying from 1.45 m to 3.0. The terraces were located at an altitude of 975 to 990 m above msl. Over the last five years, ginger, groundnut and maize were grown during *kharif* season while mustard and raddish were grown during *rabi* (winter) season. The crops grown and its output –input ratio for crops grown during last five years is presented in Table 3. It can be observed from the table that over the years terraces of

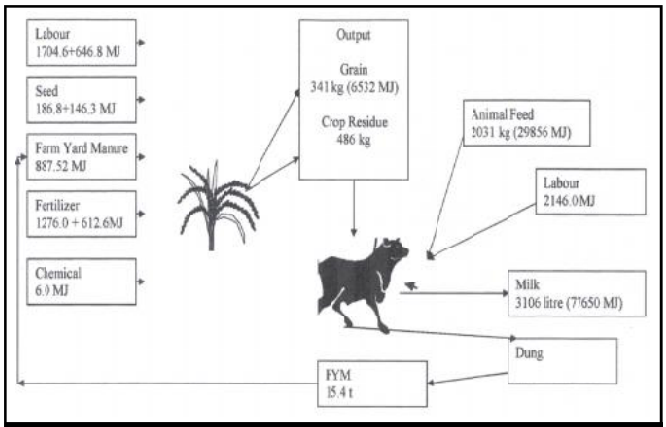

Fig. 2 : Energy and material flow pattern of agri-pastoral system

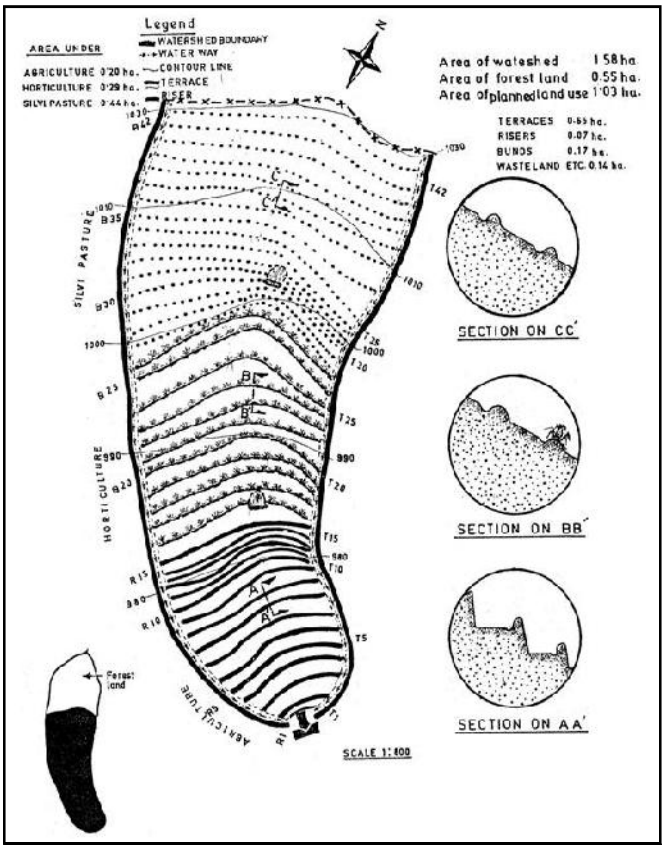

Fig. 3 : Agri-horti-silvi-pastoral system(FS W5) in hills

Table 3 : Crop grown during 1999-00 to 2003 –04 and its output –input ratio in FSW_5

Sr. No.	Crop	Year				
		1999-00	2000-01	2001-02	2002-03	2003-04
1.	Maize	1.34	1.36	3.09	2.05	2.06
2.	Radish	4.65	4.96	8.36	6.34	4.39
3.	Ginger	1.61	3.65	9.40	-	0.86
4.	Soybean	-	-	1.10	0.85	-
5.	Mustard	0.70	0.87	0.89	-	-

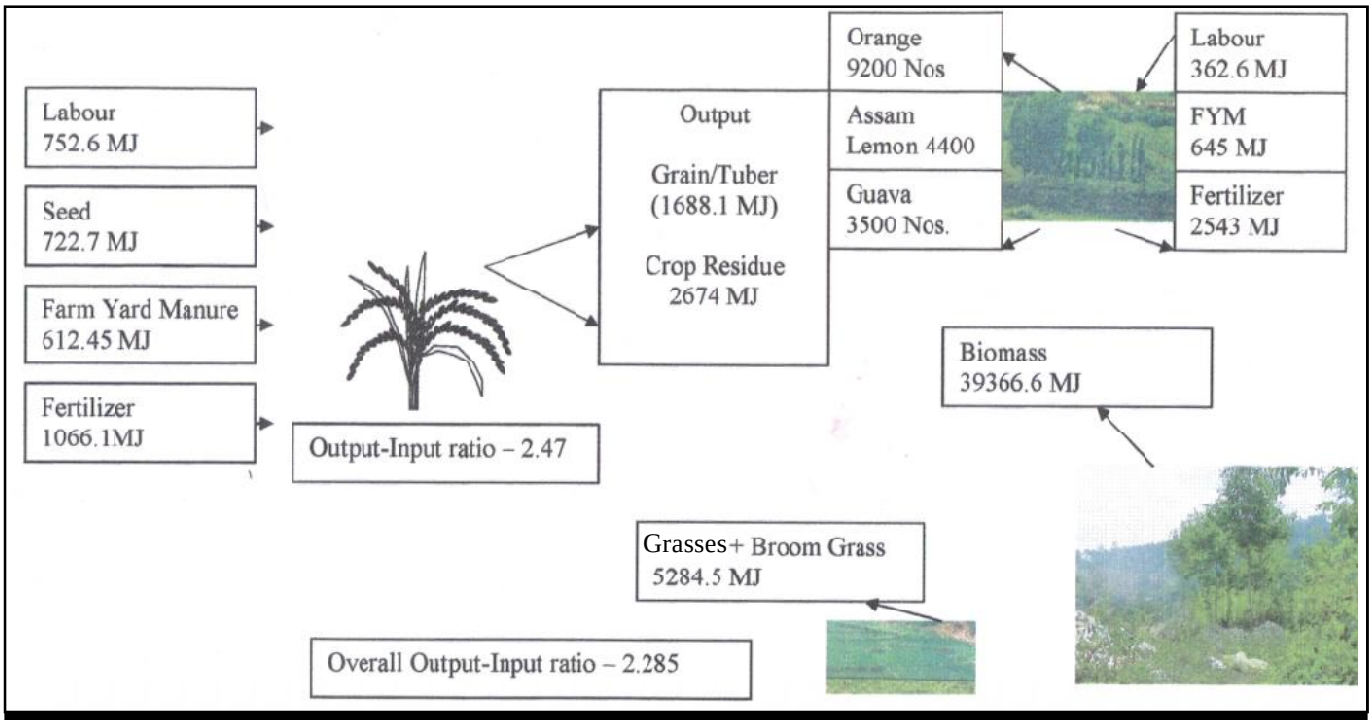

Fig. 4 : Energy and material flow pattern of agri-hoti-silvi- pastoral system

lower reaches mainly utilized for growing ginger during *kharif* and raddish during *rabi* season. However, in upper terraces groundnut or maize were grown in *kharif* and mustard or raddish were grown in *rabi* season. The crops such as ginger, groundnut, maize during *kharif* season performed very well. The guinea grass grown on the risers has a good yield throughout the year with average yield of 59.6 to 60.29 q/ha/cutting and helped in supplementing 54 ± 4.2 % of the feed requirement of the livestock system. The broom grasses grown on bunds also gave total output of 280 ± 80 kg. Apart from that trees planted in the watershed provided additional energy of the micro watershed based agro- horti-silvi-pastoral system is depicted in Fig. 4. Perusal of the figure shows that output-input ratio of the crop production was higher as compared to output –input ratio of the horticultural component. The energy efficiency of the system could have been much better provided horticultural block could have yielded to its potential. Due to disease damage in year 2000–01, the assam lemon plantation were replaced with equivalent. The agro-climatic conditions has played a significant role in output of horticultural block apart from the disease as enlisted above with less consumption of energy. While in agro-pastoral system, the output –input ratio of cropping system was found to be higher, but the energy efficiency of the livestock component reduced below 1.0 for 4 years during last five years of observation. Therefore, a critical look is required in management and optimization of the

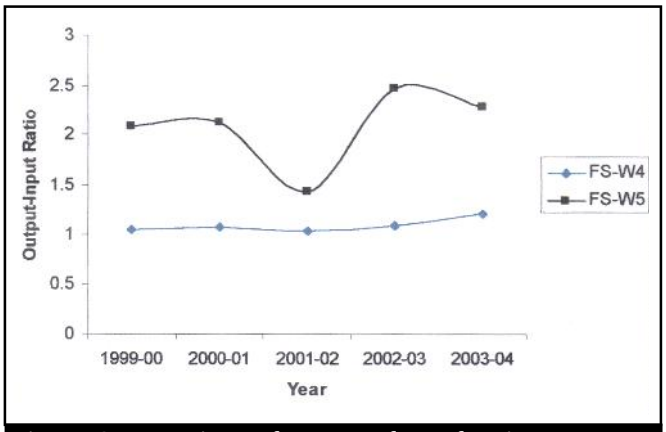

Fig. 5 : Comparative performance of two farming systems

size of herd etc needs to be done to make livestock component more energy efficient.

Comparison of the land use system:

As shown in Fig. 5 the output-input ratio of the agri-horti-silvi-pastoral has got better energy efficiency as compared to agro- pastoral system. This may be attributed to increased contribution from silvi-pastoral component which added more output energy.

Conclusion:

The micro watershed based land use systems have been evaluated for its efficacy in natural resource

management in hilly region, an attempt was made to evaluate these alternative farming systems based on their energy efficiency and identifies the gaps if any in efficiency of the components involved in it. The energy budgeting of various material and resource flow helped in identifying the critical ,which needed higher energy with low returns which needs to be reoriented through proper resource allocation and changed management strategies for higher return to beneficiaries.

Authors' affiliations:
K.K. SATAPATHY, ICAR Research Complex for NEH Region, Umroi Road, UMIAM (MEGHALAYA) INDIA
T.D. LAMA, Indian Institute of Vegetable Research, VARANASI (U.P.) INDIA

REFERENCES

Mittal, J.P. and Dhawan, K.C. (1989). *Research Manual on Energy Requirement in Agricultural Sector*, Punjab Agriculture University, Ludhiana. pp 20-23.

Anonymous (2000 –2004). Annual Report of ICAR Research Complex for NEH Region, Umiam (Meghalaya).

***