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Energy budgeting of coffee for sustainable development

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Abstract
In today's world for any development, energy is a pre-requisite. Any property, which can be produced from or converted into work, may be defined as Energy. In other words, energy is the capacity to do the work. Those sources of energy, which are being accumulated in nature from a very long time and cannot be replaced if they are exhausted, are called non-renewable sources of energy. Energy use is not an end in itself. It is an input into the productive sectors of the economy *viz*., agriculture, industry, as well as the infrastructure (transport, etc.) Water scarcity has been one of the main causes for the reduction in the profitability from the Robusta coffee plantation. This is because of higher investment on coping strategy and profits are reinvested and used to pay the debts. The research findings further reveal that, the factors of production in agriculture are becoming dearer and the cost economy is inevitable in future. Innovations directed towards economizing the input usage is the need of the hour. With the implementation of effective measures to cope with the seasonal water scarcity in Robusta coffee plantation and increased use of fertilizers in the cultivation of Robusta coffee the economy is being forewarned by the study about the future catastrophes. If the economy of Kodagu has to sustain, water resources has to be sustained. At present, more energy is used to earn one rupee without coping strategy, i.e., without the consumption of energy (investing) of water. Rupee is becoming costly in terms of energy (0.93 MJ to earn 1 rupee). By consuming an additional energy of water (11630 MJ) in Robusta coffee plantation, it could earn a rupee with just 0.84 MJ. If water becomes costly in future, it is impossible to think of earning a rupee in Kodagu by Robusta coffee plantation. Hence the study found the necessity of conserving this energy of water by preserving the total volume of rainfall. If failed, the cost of water exacerbate for the production of Robusta coffee, which is the mainstay of Kodagu's economy.

Keywords: Coping strategy, energy, mega joules, Robusta coffee, water scarcity

Introduction
Indian's coffee is the world's best shade - grown mild coffee. It holds a remarkable place in the list of beverages, for their stimulating intensity. Among all the coffee producing regions, India is the only country where coffee is grown under shade. India withstands this great position among all the countries because of its taste, aroma, mild and less acidic nature. Since the journey of Indian coffee production holds a long journey of around 400 years, it holds a very special place in the historic flavor. This unique journey has been started from the hands of Yemen who has handed over seven magical beans to Bababudan, who planted it in the Chandragiri hills of Karnataka. This magical beginning paved the way for the coffee with aroma, flavour, body and acidity which we are experiencing today. Since every Indian coffee grower spend his whole time to produce coffee, it's not a miracle or a wonder that India produces an extraordinary variety of coffee and exports it to the various parts of the world over hundred and fifty years [2]. The goodness and the freshness of the Indian coffee are obtained from a fine organised two tier mixed shade canopy of evergreen leguminous trees. There are about 50 different varieties of shade trees in coffee plantations. The main reason for the development of Indian coffee lies in the specialty of shade trees which outstands in its work of soil erosion on sloping terrains, soil enrichment by recycling nutrients from the underground layers and prevention from seasonal fluctuations due to temperature, humidity. They also play a host to diverse flora and fauna. Coffee plantations also support for the cultivation of spices and fruits, such as cardamom, pepper, vanilla, orange, banana which are grown alongside of coffee plants.

India's diverse climatic conditions paved a great way for the cultivation of different variety of coffee. The regions with high elevations are best suited for the growth of Arabica of mild quality and the regions with warm humid conditions are best suited for the growth of Robusta.

Over the last few decades, the consumption of energy in agriculture and allied activities has been rising consistently. Going by the additional need for higher productivity, and bringing additional area under cultivation, it is inevitable that the share of energy use would increase further considerably. In the production of any crop, energy is derived from a number of sources like animate (manpower, draft power), chemical (fertilizer, pesticide) and commercial (diesel and electricity). There are however, wide variations in the level and pattern of energy use among various crops.

With continuous changes occurring in the farming methods and dynamic technology situation, it is inevitable that important farm resources have to be conserved on priority. The farm practices in the present context demand a higher quantum of energy. The crop enterprises within the farm sector have wide-ranging demand pattern for energy, which ultimately brings out competition during scarce situation.

Water scarcity has been one of the main causes for the reduction in the profitability from the Robusta coffee plantation. This is because of higher investment on coping strategy and profits are reinvested and used to pay the debts. The research findings further reveal that, the factors of production in agriculture are becoming dearer and the cost economy is inevitable in future. Innovations directed towards economizing the input usage is the need of the hour. With the implementation of effective measures to cope with the seasonal water scarcity in Robusta coffee plantation, and increased use of fertilizers in the cultivation of Robusta coffee and ginger, the economy is being forewarned by the study about the future catastrophes.

Over the years, there has been a substantial increase in the demand for commercial energy due to sprinkler irrigation. To be under a cost effective zone in the production process, it is required to reduce the energy utilized per unit of output. It is thus appropriate on the part of farmers to use energy at a judicious level to avoid higher economic loss. Robusta coffee, paddy and ginger are the pivotal enterprises, which have within them many activities needing attention for conservation of their valuable input *viz*., energy. To arrive at a conclusion, the elicited data pertaining to unit consumption (physical units) of different inputs in the production of major crop enterprises of the region are further quantified into their respective energy units.

The measurement of energy is done by expressing the equivalent energy unit in Mega Joules. Because, different forms of energy are equivalent and all can be expressed in same units. In the international system of units, amounts of energy are expressed in Joules (J) or multiples of the Joules. A kilo Joule (KJ) equals 1,000 J, and a Mega Joule (MJ) equals 1,000,000 Joules. One joule is equal to the amount of energy in one watt of electricity used for one second. It is the unit energy or work in the Metric System of units equal to the work done by a force of one Newton magnitude, when the point at which the force is applied is displaced to one meter in the direction of the force. Symbolized 'J' is also known as Newton-meter of energy. All the inputs covered under the study were converted into equivalent units of energy and expressed in Mega Joules (MJ). Hence, the energy equivalents (conversion factors) reported in this study is given by the Co-ordinating Cell of the All-India Co-ordinate Research Project on Energy Requirements in the Agricultural Sector [3]. They are used nation-wide to convert various sources to energy. The energy equivalents are given in the Table 1.

Table 1: Energy Equivalents

Sl. No.	Source of Energy	Energy in Mega Joules (MJ)
1.	Electricity	11.93/kwh
2.	Diesel	56.31/liter
3.	Petrol	48.23/liter
4.	Tractor 32 HP	394.1/hour
5.	Draft power of one bullock	6.19/hour
6.	0.5 HP Motor	6.19/hour
7.	Nitrogen (N)	60.60/kg
8.	Phosphorous (P2O5)	11.10/kg
9.	Potash (K2O)	6.70/kg
10.	Insecticide	140.75/liter
11.	Straw	12.50/kg
12.	Rice (paddy)	14.7/kg
13.	Farm Yard Manure*	(39.09/100 kg) 0.39/kg
14.	Human Labour	1.96/hour
15.	Stalk (plant material)	18/kg
16.	Implements	62.70/kg

Note: * For the computation of energy units for Farm yard manure, the yard stick used is the content of N, P and K status. It is reported that (Jayaram H.*et al*.-2002) the contents of Nitrogen in farm yard manure ranges between 0.3 to 0.5%, phosphorous content ranged between 0.15 to 0.4% and potash to an extent of 0.3 to 0.5%. That is in every 100 kgs of manure 500gms of N, 400gms of P2O5 and 500gms of k is found as nutrients. Hence, these quantities of NPK is converted to MJ which is equal to 30.30(N) + 4.44(P) + 3.35(K) = 38.09 MJ for 100 kgs of farm yard manure. Therefore 1kg of farm yard manure = 0.39 MJ.

***Source* [4]**

1. Devasenapathi P., R. Balasubramanian and K.R. Swaminathan, 1991, Saving Energy in Crop Production, in Journal of Indian Farming, p 16
2. Jayaram H., C. Umadevi, R.G. Geetha Devi, 2002, Energitics of Mulberry Sericulture under Rice Based Farming System - An Analysis, in Advances in Indian Sericulture Research (eds), Dandin S.B and V.P. Gupta, Central Sericulture Research and Training Institute, Mysore (compiled)

Energetics of Robusta Coffee - An Analysis

The energy requirements for the production of Robusta coffee, paddy and ginger are calculated by applying the energy equivalents. Where there is no direct conversion factor, the cost is converted to Mega Joules in terms of diesel as, 1 litre diesel = 56.3(at the time of the study) MJ = Rs.24 at current prices. Hence one rupee is equal to 2.35 MJ.

Robusta coffee production is the main source of income to the economy of Kodagu. The economic scarcity of water is reflected by the degree of investment in the total production cost. This production cost is converted to the energy units in MJ with the conversion factors from the Table 1. The energy required in the production of Robusta coffee per acre per year is summarized in the Table 2.

In an attempt to study the level of resource use and the energy output relationships, water is found to be the most important source of energy in terms of contribution to total energy. In the study area, the production of Robusta coffee is consuming 42730 Mega Joules to produce 2700 kgs of coffee cherry in one acre of plantation in a year. Coping strategy (i.e., the combined energy of sprinkler irrigation with its source of water, accessories, diesel and human labour to operate) is the major source of energy followed by the fertilizers, interest on credit and human labour. Coping strategy accounts for 27.21 percent of energy followed by fertilizer (23.71%), interest on credit (12.19%) and human labour (7.40%). In addition to this, share of energy used for the establishment of plantation includes energy of human labour as a major portion followed by fertilizers and plant material. Energy of human labour is used for clearing the vegetation, making 480 to 500 pits per acre, planting the seedlings, providing shade if necessary, weeding and manuring twice a year including replacing the withered plants. These operations are under taken for 10 years, which is considered to be the establishment period as the plant starts bearing average yield only after 10 years. Hence, the total establishment cost is spread out equally for 10 years. This apportioned cost on establishment of coffee accounted to 28.07 percent of energy per acre per year.

Coping strategy constitutes a major share of 27.21 percent of energy. Water, which is an important input to Robusta coffee plantation is no more the free gift of nature but has entered the economic scarcity because of investment on it. This share of energy use has made way to use the rest of the energy, in terms of fertilizer and human labour. Because, if coping strategy is not adopted, the crop will fail due to lack of shower for blossom and backup. That leads to no further farm activities for the year like application of fertilizer and other weeding, pruning and harvesting activities. In turn there will be loss of income and employment.

Table 2: Energy Used in the Production of Robusta Coffee (per acre per year)

Sl. No.	Inputs used	Units	Quantity			Energy equiva-lent (mj)	Energy units (mj)			Percentage to the total energy		
			With Coping Strategy (n=37)	Without Coping Strategy (n=11)	Total		With Coping Strategy (n=104)	Without coping Strategy (n=14)	Total	With Coping Strategy (n=104)	Without Coping Strategy (n=14)	Total
1	Apportioned cost on establishment of coffee plantation	Rs.	2486.00	2618.00	5104	2.35	5842.10	6152.30	11994	20.39	43.68	28.07
2.	Operation and Maintenance of Plantation Human labour	Man hours	1037.00	576.00	1613	1.96	2032.52	1128.96	3161	7.10	8.02	7.40
3	Manure	Kg	840.00	716.25	1556	0.39	327.60	279.34	607	1.14	1.98	1.42
4	Fertilizer									(21.14)*	(28.93)*	(23.71)*
	Nitrogen	Kg	67.60	45.48	113	60.60	4096.56	2756.09	6853	14.30	19.57	16.04
	Phosphorous	Kg	54.08	36.40	90	11.10	600.29	404.04	1004	2.10	2.87	2.35
	Potash	Kg	202.80	136.44	339	6.70	1358.76	914.15	2273	4.74	6.49	5.32
5	Interest on credit	Rs.	1174.00	1042.00	2216	2.35	2758.90	2448.70	5208	9.63	17.39	12.19
6	Interest on fixed cost	Rs.	598.66	0.00	599	2.35	1406.85	0.00	1407	4.91	0.00	3.29
7	Depreciation on Coping Strategy	Rs.	1324.00	0.00	1324	2.35	3111.40	0.00	3111	10.86	0.00	7.28
8	Operation cost of Coping Strategy	Rs.	3026.20	0.00	3026	2.35	7111.57	0.00	7112	24.83 (40.60)**	0.00	16.64 (27.21)**
Total Energy units		MJ					28646.55	14083.57	42730	100	100	100
Quantity of production		Kg	1850	850	2700							
Gross income		Rs.	34097	15215	49312							
Total area		Acres	8313	304	8617		8313	304	8617			
Energy required to generate one rupee income							0.84	0.93	0.87			

Note: n value denotes the number of respondents * and ** Figures in the parenthesis denotes total percentage of fertilizers and coping strategy to the total energy units

***Source*:** Tabulated from the primary data and Table 1

This analysis reflects that, 11630 extra units of energy (MJ) are used by the coping strategy to earn the extra sustainable gross income of Rs.18,882 (Gross Income with coping strategy Rs.34097 minus Gross Income without coping strategy Rs.15215). The increase in gross income is thus due to the additional energy used for coping strategy. The energy required to generate one rupee income (total energy / total income) is 0.87 MJ. According to the study, energy required to earn one rupee without adopting coping strategy is higher than with adopting coping strategy, i.e., 0.93 MJ against 0.84 MJ. This is because the gross income earned without coping strategy is less to the tune of Rs.15,215 compared with income earned by adopting coping strategy to the tune of Rs.34,097 per acre per year. There is an additional consumption of energy in adopting coping strategy to the tune of 11630 MJ. Hence, the total energy consumption increases. What can be noticed here is, energy units of human labour is almost half the proportion in Robusta coffee plantation without adopting coping strategy when compared to adopting coping strategy. If there is adoption of coping strategy even when rainfall fails during critical growth period, employment is generated for application of fertilizers. Otherwise, only minimum work of application of manure and harvesting the little quantity of coffee which the plantation yields will take place. Thus, the significance of water either by natural availability through rainfall or artificially by high investment, is reflected. Without which, there cannot be employment and income to sustain the economy of Kodagu.

If the economy of Kodagu has to sustain, water resources has to be sustained

At present, more energy is used to earn one rupee without coping strategy, i.e., without the consumption of energy (investing) of water. Rupee is becoming costly in terms of energy (0.93 MJ to earn 1 rupee). By consuming an additional energy of water (11630 MJ) in Robusta coffee plantation, it could earn a rupee with just 0.84 MJ. If water becomes costly in future, it is impossible to think of earning a rupee in Kodagu by Robusta coffee plantation. Hence the study found the necessity of conserving this energy of water by preserving the total volume of rainfall. If failed, the cost of water exacerbate for the production of Robusta coffee, which is the mainstay of Kodagu's economy.

Conclusion
The issues discussed so far clearly indicate the problems related to water and its scarcity. This, however, is not a new phenomenon. The importance of water, need to collect, preserve and protect the rain water, and measures towards rain water harvesting have been taken up since time immemorial. With all techniques and procedures, by the time coffee is had as a beverage, the energy used is immense which can be further measured in mega joules. Meeting future demand for coffee under climate change is a challenge. Approaches that can inform where coffee may grow best under current and future climate scenarios are needed.

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