Sustainability of Agriculture: exploring the labour and livelihood dimensions

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Abstract

Sustainability of agriculture or agricultural practices can only be defined with respect to specific contexts. In reference to well-being of the living labour in question, for this paper a practice is deemed to be sustainable when it can ensure adequate Calorie intake for the living labour. Alternately, sustainability of agriculture has been defined in terms of whether the farm household in question is able to yield an energy surplus, when its members and the animals in its possession are obtaining an adequate Calorie intake.

For evaluating 590 households engaged in 3432 plot season crop combinations in the State of West Bengal, India, four alternative and stricter scales of sustainability had been proposed, defined, and applied. Such an evaluation was carried with the method of energy balance analysis and against two paths of enquiry, with all the measurements in terms of energy units: first, the surplus during the cultivated period, against gross cropped area (GCA), gross output (O) (cultivated period), and second, the annual surplus, against GCA, and net area sown (NAS).

One of the several conclusions of this paper includes identification of threshold area under cultivation (both in terms of GCA and NAS), land/household size and land/earners, for ensuring sustainability of the practices.

Keywords: Scales of sustainability, labour, energy balance analysis, surplus, small farmer

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The New Oxford Dictionary of English defines sustainable as ‘able to be maintained at a certain rate or level’. Merriam-Webster defines ‘sustainable’ as (1) capable of being sustained and (2) of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged. Other dictionaries provide multiple meanings of ‘sustain’: ‘keep going’, ‘maintain’, ‘support’ or ‘endure’. Sustainability or ‘the ability to sustain something’, has been applied to many situations and contexts over multiple scales of time and space, from total carrying capacity of the planet earth to a very local one like that of a farm. Perhaps, due to its multiple applications and meanings in different contexts, it is often perceived as nothing more than a feel-good buzzword with little substance. It follows that any use of this term need to be preceded by its precise contextual meaning.

This paper conceptually defines sustainability of agriculture in general terms in section I, followed by the more specific four alternative scales in section II. Section III shows the evaluation for the sustainability of agricultural practices by an illustrative farming household. Section IV will summarise the results of analysis of sustainability of agricultural practices of state of West Bengal, India, in 2004-05, a normal year, using field-level data collected by a government agency. Section V will contain summary and conclusions.

I. Sustainability of Agriculture: some conceptual issues

> […] As a destination, sustainability is like truth and justice—concepts not readily captured in concise definitions. Nor can sustainable farming practices be defined easily, simply because no one can ever know precisely and finally which farming practices may be the most sustainable in every location and circumstance. (Schaller 1993: 91–92)

Schaller (1993: 91) argued that popularity of the term ‘sustainable agriculture’ arises from its general appeal ‘not only to people interested in an environmentally beneficial and healthful farming but also to those concerned with its economic and social dimensions’. At the same time, as a concept, this phrase pointed towards ‘not only a destination for agriculture but particular farming practices that could move agriculture toward that destination’. Undoubtedly, such a definition is not only imprecise, nevertheless it helps us in recognising the ambiguity and controversy accompanying similar terms that capture some of the dimensions of sustainability, as commonly understood, namely, 'organic', 'biological', 'ecological', 'reduced-input', 'low-input', 'regenerative', or 'alternative’ agriculture.

A detailed critical engagement with the multiple notions of sustainability of agriculture is beyond the present scope, but we may list some of the issues central to this debate: profitability of ‘sustainable farming’ howsoever defined; adequacy of food production; matters of scale neutrality; supply of adequate non-chemical inputs, and price of such products; certification programmes; crop rotations that can break pest cycles and restoration of soil nutrients; supply forage and harvest feed; raising livestock for supply of manure and power; biological, mechanical, and other non-chemical methods for controlling insects weeds, and diseases; soil and water conservation techniques with better scientific knowledge, to name a few.

Surprising human labour/labourer has not been its due importance here, even while it holds the key in ‘abstraction of energy fro nature, […] and [t]his material process of “metabolism” between society and nature is the fundamental relation between environment and system, between “external conditions” and human society’ (Bukharin 1921/1969: 108). Arguably, such contact takes place through the process of human labour: ‘[b]y work, energy is transferred from nature to society; and it is on this energy that society lives and develops (if it develops at all)' (Bukharin 1921/1969: 89–90). Clearly, the higher is the amount of such appropriation, the greater will be the societal growth.

A typical contribution from the agro-ecological side includes biodiversity, resource efficiency, productivity and economics, resilience, etc. as well as ecologically based soil nutrient management and participatory plant breeding with focus on livestock, livelihoods and innovation (see, for example, Snapp and Pound 2008). On the other hand, those who focus on labour concentrate on the labour intensity, livelihood, displacement due to high-yielding variety (HYV) technology, market for off-farm employment, etc. (see, for example, Tripp 2006). To illustrate, Index of *The Earthscan Reader in Sustainable Agriculture* (Pretty, 2005) does include a variety of terms but not labour or labourers.[2]

Perhaps, today Red and Green perspectives are at loggerheads for being too close to each other along with myopic visions. There is hardly anyone connecting the labourer and the soil, despite it occupying the very central place in the early literature on the question of sustainability of agriculture (see, Foster 2001).

> […] As one observer has put it, when you consider the energy inputs and costs in the distribution as well as production of food, you must ask harder questions. [...] To what extent does sustainable farming increase the well-being of rural people and communities? Do rural communities and institutions enhance or impair the ability of farmers to adopt sustainable practices? Beyond that, what is the connection between agricultural and rural sustainability and the rest of society? (Schaller 1993: 96)

We may limit our scope to only the first question that links well-being of the farming household with the agricultural practices. Within this particular context, a practice is deemed to be sustainable when it can ensure adequate Calorie intake for the living labour. Alternately, sustainability of agriculture can be defined in terms of whether the farm household in question is able to yield an energy surplus, when its members and the animals in its possession are obtaining an adequate Calorie intake.

It may, however, be noted that, due to the assumption of appropriate Calorie norms, their fulfilment being is just a necessary and not a sufficient condition for the generation of surplus. Indeed, this route does not allow us to look into the magnitude of the actual surplus or its distribution, as the latter is based on the property relations, which can be extremely exploitative in nature.[3] Thus, the results of this paper show only the upper bound of the number of households producing a surplus, or being engaged in sustainable agricultural practices, without the consideration of the factor incomes.

The method employed in such an evaluation is the energy balance analysis, which takes into account not just the economic but the ecological dimension as well. In fact, it is independent of the prices of inputs and outputs altogether. Energy is taken as the standard. Surplus, conceptually speaking, has undergone significant changes in the past two and half centuries of economic thought. The standard in terms of which both inputs and output are measured moved even in early years of economics from corn to embodied labour. Certainly, a logical

[2] It includes terms like agroecology, biodiversity, genetic modification, intercropping, monocropping, organic crop production, energy consumption, environment, farmers, farming systems, fertilizers, health, insecticides, pesticides, soil erosion, water supply and, even network.

[3] That is, even while producing an adequate energy surplus for the members and the animals in the sense defined here, a household can end up with a negative surplus because property relations are such that it gets expropriated.

extension is the embodied energy measured with the units of Calorie (kcal) or Mega-joule (MJ).[4]

Well Being

It may be argued that the process, which is to be sustained, for ensuring the sustainability of agriculture, is the *life* or the level of living of the human labourer in farming operations on the land under assessment. A few qualifications shall be in order, however. First, the farming operations under consideration are limited to those taking place within the farm-gate. The labour involved in activities within the management of the household, but not connected with farming are not included. Further, activities outside the farming household have been considered only indirectly, in extending some of the calculations. Second, while the land units under evaluation in this paper had greatly varied characteristics and qualities, they have been taken as given and no attempt has been made to explain the differences in terms of past practices, ecosystem stress, and so on. Indeed, it is impossible to know about the past contributions of nature and labour separately towards the quality of land: '[i]t is indeed difficult to draw the line between the so-called endogenous soil differences and man-made differences especially since it is past investment in land which influences today's quality of soil' (Bharadwaj 1978: 15). Finally, while property relations are not taken into account in an energy balance analysis, it may be noted that of the 2279 parcels or contiguous land (827.25 ha) cultivated by the 590 households under evaluation here, 2243 were 'owned and managed' (814.37 ha), while 20 were 'leased in' (5.01 ha) and 16 were 'leased out' (7.87 ha). Thus, for an overwhelming 98.5% of land was cultivated by its owner.[5] It may also be noted also that, owing to land distribution programmes of the State government and the fragmentation of land due to succession, there had been as many as 178 households (30% of the total) with less than 1 ha of net sown area.

Level of Living

Arguably, it is possible for the human beings to have various levels of living or 'lifestyle support'.[6] Consider the contrasting examples of having a healthy life resulting from the consumption of recommended doses of food in balance with the intensity and duration of activity engaged in and a 'solitary, poor, nasty, brutish, and short' life, following *Leviathan*. However, the resulting choice over the particular level of living and its attainment requires a few disclaimers.

[4] Apart from its being a convenient standard, there also exist a number of arguments, supporting such a development, of which a few may be listed here. First, price or wage or income, and in the process, the problems related to imputation can be avoided altogether. After all, in agriculture, for most of the inputs and outputs, the markets either do not exist or are heavily distorted. Second, the use of 'energy income' or food calorie for the human labourers certainly has served as a norm for identifying the productive capacity of their labour power, as manifested in the construction of poverty lines in India. The third reason is the impending crisis facing the present mode of energy use which is exhausting the non-renewable low entropy ones at a much faster rate than they could be produced. Clearly, there is a need to combine appropriately the non-renewable and renewable sources of embodied energy in the inputs, excluding the living labour, for the sustainability of the surplus.

[5] These percentages are based on net area sown. However, with such a distribution for NAS, the one based on gross cropped are is unlikely to be very different.

[6] These two phrases are often used synonymously. There can be many elements in the commodity basket that define level of living, which may appear to be without any corresponding support in *physical* terms. However, such mental or emotional support, always require indirect expenditure in physical terms.

Consider the distribution of food by the female members of the household favouring those working outside home and/or belonging to male gender across ages. There is well-documented evidence of these sacrifices.[7] This paper will not take into account these favouritisms and its consequences on the sustainability of the life of each individual member of the household.[8] Rather, consumption of the labourer household has been taken at the aggregate, using the norm of recommended age-sex-activity based dietary intake in food calorie terms. The purpose of this paper is to locate those households who are being able to meet these norms, though notionally, under different scales of sustainability, to be defined shortly.[9]

It is well established that many of the farming households do not have profit maximization as their objective function (Bharadwaj 1978: 5) but aspire to lead a 'decent' life. This is especially true for the small and medium farmers, primarily engaged in food crop production on the land under the management of the household, while supplying labour to cultivation managed by others, to make both ends meet. Stated differently, one of the intentions of this work is to assess the farming households in terms of meeting this rather simple goal.

Index of Measuring the Level of Life

This work takes food-calorie intake at the household level as the indicator for measuring the level of living. Indeed, it has been a common practice, to link mean per capita consumer expenditure by the household to food intake (NSSO 2007). However, for many, if not most of the farming households, the bulk of consumption originates from the farm itself, which is not fully captured by the expenditure route. Food-calorie, on the other hand, does not suffer from similar disadvantages.

Understandably, analyzing the level of living on the basis of a single ingredient of the basket of commodities may appear to be reductionist in approach. The term commodity here means not just the 'commodity space' but also the 'capability space' following Amartya Sen and Martha Nussbaum, and thus includes all the goods, services, associations, freedoms, dignity, social supports, and so on. We maintain that food is a necessary, if not the chief ingredient of such a basket, defining and deciding the level of living.[10] Thus, it would not be unrealistic to let the basket be represented by food itself due to the position that food enjoys. Admittedly, the assumption held here is that the food and other requirements of life do maintain a strong and positive relationship with each other. Further, rather than taking food, we have taken Calorie as the unit of measurement. This assumption finds support from the *Nutritional*

[7] It is possible to link this distribution to the notions of fairness on the part of the women, which is a function of generations of custom, constructs and controls that the society has transposed into their moral positioning. Monetary earnings and their earners are only valued, be it those at present or the ones having future potentials.
[8] Such a position, however, does not challenge the assumption of rationality that we maintain on the part of all economic agents: altruism is just one manifestation of rational behaviour.
[9] Actual consumption data could have made the analysis more robust. Though this remains as a possible area of extension of this work, one must qualify that getting individual household member's consumption data is difficult if not impossible, even through the field observations. It is precisely for these difficulties, *Nutritional Intake in India* (National Sample Survey Organisation, Ministry of Statistics and Programme Implementation, Government of India), collects and publishes data on the basis of household, defined as 'a group of persons normally living together and taking food from a common kitchen'.
[10] Consider Pachauri and Spreng (2004) for an alternative view: in 'Energy Use and Energy Access in Relation to Poverty', while criticising the conventional approach to poverty line on household income or consumption (total or food), as a 'static concept', the study had offered 'energy poverty line' or 'fuel poverty line' as an alternative. However, such standards were exclusive of access to food by human beings, but included only biomass, electricity, kerosene and LPG as energy needs of a household determining the well-being.

Intake in India: 2004–2005 (NSSO, 2007, NSS 61st Round) for the period July 2004–June 2005, which exactly corresponds to the period under study here. For the three lowest MPCE (Monthly Per-capita Consumer Expenditure) classes in the rural West Bengal (Table 3R) the percentage of expenditure on food varied between 70.2% and 71.8% while that on cereals was between 35.5% and 38.2%. Further, the consumption of cereals alone was responsible for 74.92–77.75% of Calorie intake (Table 4R), suggesting that the focus on the particular food crops that provided the bulk of the calorie intake in the state of West Bengal may be justifiable. Within this understanding, food consumption is a necessary and important component of the human well-being.

Food-calorie has also been used as a measuring unit for the estimation of poverty line in India. Similarly, scientific studies on human metabolism (rate by which the human body produces and consumes energy and calories to sustain life) use it as the unit for calculating the chemical energy that human body releases per unit of time. Finally, a person's Basal Metabolic Rate (BMR) is also defined in terms of the minimum calorie requirement needed to sustain life, when at rest.

II. Alternative Scales of Sustainability

We propose four alternative and progressively stricter scales of sustainability. It may be noted that this variety is applicable only for the human labourers and the animals, and not for any other input. For the latter, the analysis is identical across the scales. The per acre algebraic expressions corresponding to these scales together with a numerical example to elucidate them has been presented, in table 1.

Consider a certain practice on a land of a given area of 1 ha that involves engagement of only one labourer for 56 days during the Kharif season of 120 days. The male household labourer, aged 29, provides the requisite labour and he is not engaged in any other crop cultivation managed by others during the season.[11] Dependents include two female members, aged 26 and 17 respectively, who are not engaged in any farming activity, within or outside.[12] The cultivation also involved 10 active days of labour from the animal in the possession of the household. The household is not engaged with cultivation beyond the Kharif season.

For the moment, we also assume that the said plot is the only land in possession of the particular household. In the actual calculation for surplus under all the four scales, the one made against every plot will be aggregated at the household level. Results will be derived from the latter for the purposes of analysis in section IV.

a) Scale A, asks the following question—what are the input used, output yield and the resulting surplus in energy terms for this particular plot of land in a particular season? In this scale, human and animal labour input is defined exclusively in terms of the Calories to sustain these inputs according to the number of days for which they are employed/engaged. Alternatively, this scale evaluates the surplus of only the agricultural operations, and thus considers only the 'on farm' labour. Agricultural engineers usually follow this scale (for example, see, studies done under ICAR-AICRP), which reflects a rather mechanistic framework, like the mainstream economics. Agriculture is treated as

[11] Some modification will take place in these assumptions later, to incorporate the wage-labour and hired out days.

[12] Specific ages were assumed *only* for the purpose of identification. Corresponding Calorie values have been included in table A.1.

an activity, in this scale. Indeed, for highly mechanised operations, results of this scale of sustainability will not be different from the other ones.

b) In scale B, the question is as follows: what are the input, output and surplus in energy terms, when the input must include the sustenance of the human labour, during not only the active days but also the days in which it is not employed during the season.[13] In other words, here, sum of the 'on farm' and 'off farm' labour of the labourer involved in the cultivation on the land during the entire cropping season, say, Kharif, is under consideration. Difference between the working time and production time in agriculture (Marx 1956: 242—244) necessitates this scale. In contrast to the previous one (scale A), agriculture is considered as a livelihood, and includes contributions from the labour in its non-active days as well. Certainly, for more labour intensive operations, there will be considerable difference between the results of this scale with the previous one. Indeed, for a labour force mostly dependent on agriculture as a source of livelihood, or alternatively, without many other occupational opportunities, this scale is more relevant than the previous one. Further, following the difference between the terms activity and livelihood, in this scale, the farmer himself or herself is the designer, tiller, planter, cultivator, herder, harvester, picker, thresher, transporter, marketer, and so on; in the other case, different persons could have performed each of the activities.

c) The following question is asked in scale C: what is the surplus in energy terms, when the input include the sustenance of the human labour and the animal during the active and unemployed days of the season, along with the dependents of the labourer within the household for the duration of the season,[14] and the output include dung from the animal besides the main product and the by-product? In other words, scale C, considers the replacement of the labour-power. Even if scale B had considered agriculture as a livelihood, many other 'supporting' activities had not been considered, which take place outside the farm boundary, in a spatial sense. For the sustenance of the labour force as such, these 'non-activities' are necessary. Alternatively, while scale B had considered agriculture as a livelihood, it was still for the labourer alone and hence rather individualistic, and certainly not social.

Quite obviously, through the application of these three scales, we arrive at the progressively lower quantities of social surplus or the *produit net*, against given units of land cultivated by the household in question. In one of the variations of the fourth or annual scale, we shall incorporate hiring out of the household labour as well as the animal in possession of the household. Subsequently, we will extend the illustration to incorporate wage labour.

[13] Unemployed or inactive days for the animal during the season will be considered in scale C. Needless to state that, the nomenclature of 'active' and 'inactive' concerns only the direct involvement with the crop production.

[14] All animals in the possession of the household are considered in this scale and also in the annual one. For reasons of simplicity, in the illustration, only one animal was assumed, which could be engaged in the cultivation. In reality, one additional animal will be required (either hired out or in cooperation with the neighbour) for such an engagement. Further, milch animals do not usually participate in the cultivation, and inclusion of their Calorie requirement in scale C will loosely correspond to the reproduction of animal labour-power.

Table 1: Numerical example for per acre input and output under alternative scales of sustainability (without wage labour)					
Scales Inputs and Outputs	A	B	C	Annual, without hired-out labour	Annual, with hiring-out labour
No. of active days of household human lab (nourishment @ 2,879 Cal/day)	56	56	56	56	56
No. of inactive days of household human lab (nourishment @ 2,424 Cal/day)	n.a.	64	64	304 (240+64)	154 (240+64-150)
(Total) No of days for other household members (nourishment @ 1872 + 2061 Cal/day)	n.a.	n.a.	120	360	360
No of active days of household animal lab (nourishment @ 17,624 Cal/day)	10	10	n.a.	n.a.	n.a.
Total no of days for household animal labour (nourishment equals actual consumption)	n.a.	n.a.	120	360	340 (360-20)
No of days for all other inputs, main product and by product (actual Calorie value)	120	120	120	120	120
No of days for dung	0	0	120	360	360
Note 1: All the number of days follows the specific assumption taken, which, needless to say can be altered. All Calorie values follow the established and accepted norms. Note 2: Surplus in scale i = Gross Output in scale i – Total Input in scale i, i=A, B, C, annual Note 3: Animal nourishment follows Rao (1984).					

d) The fourth or the annual scale asks the following question: what is the surplus in energy terms, when the temporal boundary for the 'inputs' and the 'outputs' is beyond the cultivating periods of the year? Here, the input not only includes sustenance of the household labour, the dependents and the animals during the entire season, but also during the non-cultivating period of the year as well. Similarly, the output includes dung produced during the non-cultivating period besides the cultivating period (the latter was considered in scale C), besides the seasonal main product and by product. This scale necessitates from the fact that the Calorie requirements of a particular cultivating household, must originate from the surplus produced by the same household during the only season when cultivation takes place.[15]

Let us now consider two possibilities, so far as the engagement of the labour (both human and animal) is concerned. The first corresponds to a situation where no hiring out takes place, for either of the two. In the other possibility, the labourer in question hires out labour, say, for 150 days in the crop cultivation managed by others, and in plots of land in someone else's possession.[16] In the remaining 90 days, he has no direct involvement with any crop cultivation.[17] Likewise, hiring out of animal takes place for 20 days outside the Kharif season. In both the above cases, with all the remaining assumptions remaining unchanged, we may define the annual surplus, as the difference between the 'full and final annual gross output' and the annual 'input'. It may be noted that the 'full and final output' is different from the

[15] Conceptually speaking, an alternative way to conceive this surplus as the ability of the farming household to support others in every occupation other than crop cultivation, during the same agricultural year when cultivation is taking place.

[16] For the hired out days, it has been assumed that the Calorie 'earned' is just sufficient to maintain the energy balance of the household labour or the animal in possession of the household.

[17] But, can be engaged with some work involving crop produced in the past. For example, weaving basket.

sum of seasonal outputs. This is due to the fact that even if a household can be engaged in crop cultivation in as many as three seasons in the same plot of land, latter may remain fallow for some days within an agricultural year.[18]

Table 2: Numerical example for (only) per acre human labour under alternative scales of sustainability (with wage labour)			
Scales Inputs	B, without hired out labour, with wage labour	B, with hired out labour, with wage labour	Annual, with hired out labour, with wage labour
No. of active days of household human lab (nourishment @ 2,879 Cal/day)	40	40	40
No. of inactive days of household human lab (nourishment @ 2,424 Cal/day)	80 (120-40)	50 (120-40-30)	170 (360-40-150)
No. of active days of hired-in human lab (nourishment @ 2,822 Cal/day	16	16	16
No. of inactive days of hired-in human lab (nourishment @ 2400 Cal/day	32 (16 x 2)	32 (16 x 2)	32 (16 x 2)
Note: All other inputs and outputs remain the same as in the last two columns of table 1, respectively.			

Clearly, the difference between the two cases in the scale of annual sustainability arises due to the hired out labour: 150 days for human labourer and 20 days for the animal. Employment elsewhere will also reduce the input in scale B and C as well. Assume that of the 150 hired-out days in the entire year, 30 falls within the Kharif season. The modified human labour input in scale B, will be as follows:

56 active days of nourishment for the adult male labourer @ 2,879 Cal per day
+ 34 (=64–30) inactive/unemployed days of nourishment for maintenance of adult male labourer @ 2,424 Cal per day.

Further, consider the possibility of wage labour, during the Kharif season cultivation. For simplicity, let us assume that only one hired adult male labourer had contributed 16 days, and as a result it was 40 (=56–16) active days for the household labour. 2004–05 dataset had shown that on average, among the members of the households with crop cultivation as the occupation, an adult female and male labourer were engaged with 44 and 32 days of work respectively during the Kharif season with an average length of 120 days. Thus, on average, of the duration of the season, the number of active days was one-third, while the remaining two-third days were without employment. It follows that for every active day, there were two inactive days, within the season. Per active day Calorie requirements for the hired adult male labour was taken as 2,822 Cal; for unemployed days, 2,400 Cal per day was assumed.[19] In scale C, or in the annual one, due to the modifications in the assumption on hired in and hired out labour, except for the changes as shown above for the labour engaged on the plot of land in question, every other component of the input will remain the same, and so will be the output. The corresponding numerical illustrations have been shown in table 2.

[18] This fact is based on the CCS 2004–05 dataset of West Bengal, which this paper has used.

[19] Following table A.1, Calorie requirements per non-active days for male of 18-30 years and 31-59 years were 2,424 and 2,376 Cal respectively. The average Calorie value taken approximates to the nearest hundred.

III. Sustainability of Agricultural Practices through Energy Balance Analysis

Sustainability of agricultural practices through energy balance analysis of agriculture will be carried out through two paths of enquiry, with all the measurements in terms of energy units:

1. The surplus during the cultivated period, against gross cropped area (GCA), gross output (O) (cultivated period).
2. The annual surplus, against GCA, and net area sown (NAS).

We shall be using two categories for exploratory purposes: first, the size-group characteristics as defined by the Comprehensive Scheme for Studying Cost of Cultivation/production of Principal Crops (CCS), the agency responsible for collecting the data used in this paper[20] and second, the agro-climatic characteristics of the land in question. There are five size-groups based on the area in possession, or the upper bound for the NAS: 0–1 hectare (1), 1–2 hectare (2), 2–4 hectare (3), 4–6 hectare (4) and more than 6 hectare (5). The size-group will serve as a proxy for the NAS; due to the possibilities of land lying fallow, NAS may be lower than the lower boundary of a particular size-group. The relevant agro-climatic zones were also five: terai (II), new alluvial (III), old alluvial (IV), red & laterite (V) and coastal saline (VI) (see, figure 1).[21]

The dataset used here belongs to a series which has not been made public, but since 1986–87, it had been released only for research purposes, under certain conditions (Sen and Bhatia 2004: 328). 2004–05 was the latest normal year as the yield data revealed.[22]

The choice of West Bengal results from its significantly long history of food crop production. Further, the average farm sizes are smaller in comparison to most parts of the country, while a part of the farm is usually kept for cultivation of food crops for self-consumption. Indeed, it is important to evaluate the efficacy of the land to the tiller policy of the erstwhile governments in the state of West Bengal belonging to the Left Front (comprising Communist Party of India, Communist Party of India (Marxist), Forward Block and Revolutionary Socialist Party), 1977--2011, in terms of its ability to sustain the agricultural practices. Finally, this State is one of the top producers of paddy, the cereal consumed by the majority of people in the state. It is also a well accepted physiological fact that this cereal contributes the most in the 'energy income' of the people.

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[20] It was obtained from Bidhan Chandra Krishi Vishwavidyalaya (BCKV), Kalyani University, West Bengal with due permission from Department of Economics and Statistics, Ministry of Agriculture, Government of India, Krishi Bhavan, New Delhi.

[21] CCS in West Bengal presently covers 600 households, 10 each for 60 *tehsil*s (A.k.a., *taluk* and *mandal or* sub-districts, which is usually is an administrative unit, comprising several blocks). It follows three stage stratified random sampling, with *tehsil* as the first stage sampling unit, a cluster of villages as the next stage and an operational holding in the cluster as the final and ultimate sampling unit. For the purpose of providing representation to all the areas in the states, samples were selected from all the agro-climatic zones, as defined by ICAR (see, Ghosh 1991). The state falls under six agro-climatic zones, offering diversity, apart from various types of soil, variety of farm sizes, and irrigation practices. Data are collected from the same households for every three years. For the 'crop complex' during 2002–05 cycle, selected *tehsil*s were distributed against five agro-climatic zones as the following: 9 (II—terai), 14 (III–old alluvial), 17 (IV–new alluvial), 10 (V–red and laterite) and 10 (VI–coastal saline), leaving zone I (hill) unrepresented.

[22] In 2004–05, West Bengal stood sixth in the state-wise yield rank for paddy at 2574 kg/ha, and accounted for the highest share in total area under paddy in the country (13.79%) and production (17.9%) (Table 4.6 (b) in DES 2007).

Dataset had shown that the harvested percentage was at least 95% for 90.29% (3099) plots, with 86.97% (2985) recorded 100%. 6.17% of plots reported harvested percentage between 75% and 94%, while only 7 plots had recorded complete loss.

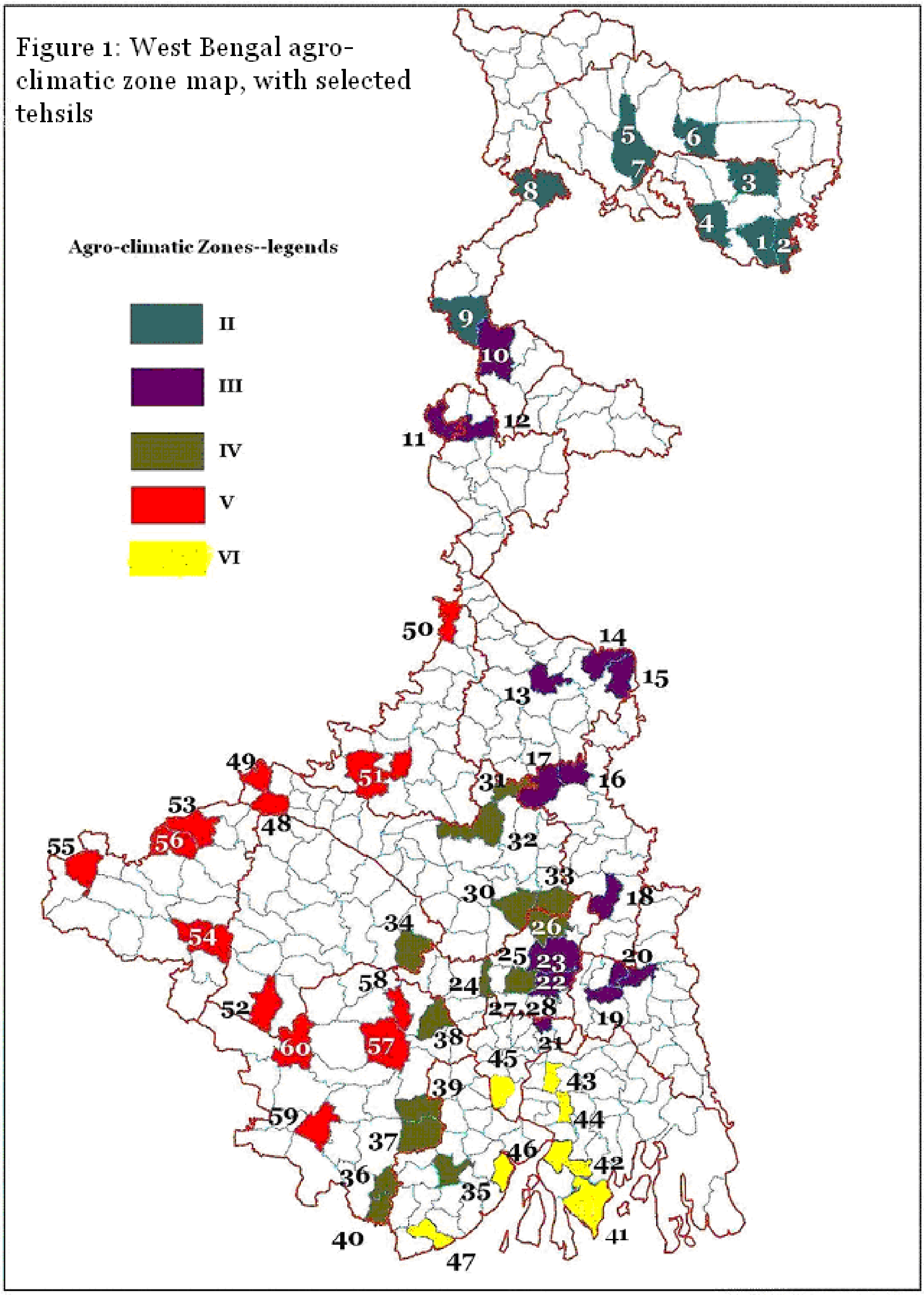


Figure 1: West Bengal agro-climatic zone map, with selected tehsils

<u>An Illustrative Household</u>

For the analysis, a data point (TTFFRRPS-C) represents the unique combination of tehsil, farm, parcel, plot, season, and the crop. First two digits represents the tehsil number (1–28, 30–60),[23] third and fourth are for farm number within the tehsil (1–10), fifth and sixth correspond to the parcel number (1–11), seventh, the plot number (1–4), while eighth depicts season (1–3), and final one represents the crop code (for instance, 20 for paddy). A household

[23] Excluding no. 29, which was not considered due to data problems.

has been represented with TTFF. Each TTFF managed multiple PSC, a shorthand identifier for TTFFRRPS-C.

The selected household for illustration was the 9th farm in the 30th tehsil (TTFF: 3009). We shall be mainly referring to TTFFRRPS-C 30090111-20, or the paddy cultivation during the season 1, carried out in the first plot of the first parcel, of the household. This farm belonged to one of the more prosperous blocks of Memari-I in Burdwan district, the paddy belt of the State. Its choice arose primarily from the 7 plots under its management, the fact that it derived benefits from canal irrigation and that it undertook cultivation in two seasons, besides certain other distinct characteristics.[24] The village belonged to zone IV (old alluvial).

The members of the selected household included 2 adult 'earner' males, aged 67 and 38. Dependents included an adult female and a girl child, aged 27 and 12 years respectively. While all the four members lived at home throughout the year, only the adult male members were engaged with the crop cultivation. Accordingly, Calorie norms were set.

Human Labour in scale A
Calorie value against the use of human (physical) labour for 30090111-20 in scale A has been stated in table 3.

Table 3: Measurement of Energy Expenditure by Human Labour in Cultivation of the selected household's sample plot in one season for paddy.

Type of Labourer	No of hours	No of days	Calorie/day	Total Calorie	Total MJ
	(1)	(2) = (1)/6	(3)	(4) = (2) x (3)	(5) = (4)/1000 x 4.18
Household Head	91	15.17	2347	35,596	148.79
Family Men	59	9.83	2822	27,750	116.00
Casual Men	378	63.00	2822	1,77,786	743.15
Casual Women	231	38.50	2280	87,780	366.92
Total	759	126.5	N.A.	3,28,912	**1374.85**

Source: CCS WB 2004–05.
Note:
(1) We have assumed a working day to consist of six working hours, both for animals and human labour.
(2) Column 3 follows table A.1 (age-sex-activity-wise Calorie per day).
(3) While the energy content of food and feed is usually expressed in Calorie, for materials it is Mega Joule or MJ. 4.18 MJ = 1000 Calorie.

[24] None of the parcels were divided and thus for this household, parcels were identical to plots.

The informational/managerial inputs resulted in an addition of 44.5 hours of labour (or, 89.45 MJ of energy) following recommendation of GoI (1990).[25] Thus, the total energy value of human labour was 1463.30 MJ.

Animal Labour in scale A

The cultivation involved a total 28 hours of family draught cattle labour. Animals included two cattle, in the age-group 3 (mature), with both being managed as under 'herding, own land'. As by construction, under scale A only the activity was to be considered, following our assumptions, per day Calorie requirements was considered as 73.67 MJ. Given the involvement of 4.66 days of bullock-pair labour, total energy cost was 687.59 MJ.

Material Inputs, in all scales

The items included seed, main product, by product, organic manures, chemical fertilisers, pesticides, materials for operation of machines, human labour and material for maintenance of machines, all flows, alongwith the depreciation of the machines. Energy coefficients of some of the selected materials have been taken from the literature and will be made available by the author on request, while depreciation followed a straight line method.[26] Result of the energy balance analysis in scale A, for the selected PSC has been shown in table 4.

Table 4: Energy balance analysis for the selected PSC, scale A (all energy values in MJ)

Input groups	Human Labour	1467
	Animal Labour	689
	Pesticides	127
	Fertiliser	5891
	Machines	4609
	Rest of the inputs	578
	Total	13361
Output	Main Product	31816
	By-product	28794
	Total	60610
Surplus (Output-Input, both in MJ)		**47249**

Human Labour in Scale B

For both the earners in the selected household, there was no hired out labour. In the selected PSC, the season was of 150 days duration. Thus, by construction, the necessary Calorie for the maintenance of labour was required for the unemployed days during the season of 150 days. The total amount was to result from all the seven plots of land under cultivation within the season. Plot-wise analysis necessitated apportionment of this requirement of Calorie. We had used area under cultivation for this purpose. Identical method of apportionment was

[25] For the convenience of using numbers of lower magnitude, all energy units will be expressed in MJ, subsequently. Exception will be food and the feed.

[26] Let the value in construction/purchase of the asset be V_o as calculated from above and at year t, it is V_t, with t taking the value from 1 to n. Considering uniform rate of depreciation r, $V_t = (1-r)^t \times V_o$. As t becomes large, $(1-r)^t$, and consequently V_t approach zero. Typically, use of the machine ceases much before V_t equals or even becomes close to zero. Doering III (1980: 11) assumed reliable life for farm machinery and buildings to be 82%. V_t/V_o attained 19% with r = 0.08, at t = 20. Such value of r gains strength as the average life span of all machines in the dataset was roughly 19 years, as captured by table A.3.1.7. Therefore, with t obtained from the dataset against individual machines, depreciation or the change in capital stock due to wear and tear for the i[th] year was measured with the expression:

$V_{t-1} - V_t = 0.08 \times (1-0.08)^{t-1}.V_o$

followed for Calorie requirements for the dependents in scale C, feed for animal in scale C as well attribution of dung output in scale C.

The selected PSC accounted for 16.83% of the cultivated area under the management of the household in season 1, as shown in table 5. Thus, for the ‘non-active’ days or the days of ‘rest’ within the season, this plot was expected to generate 16.83% of the Calorie required, so as to sustain the labour working on it.

Table 5: Distribution of area under cultivation in season 1 for selected household

Parcel	Plot	Season	Area under crop (in ha)	Share
1	**1**	**1**	**0.51**	**16.83**
2	1	1	0.46	15.18
3	1	1	0.38	12.54
4	1	1	0.26	8.58
5	1	1	0.51	16.83
6	1	1	0.4	13.20
7	1	1	0.51	16.83
Total			3.03	100.00

For the selected household, one of the earners (household head) had spent 331 hours, or 55 days in 7 plots together, during the season 1. Thus for this labourer, the representative PSC was to ‘supply’, albeit notionally, 16.83% of the Calorie requirements for the remaining 95 days of sedentary activity. The other earning member of the household was engaged with 396 hours or 66 days or work. Thus in his case, the representative PSC was to provide 16.83% of the Calorie requirements of 84 days of sedentary activity. Given 94.83 days of sedentary activity for the household head, 84 days for the other male member, and respective calorie values from table A.1, the total additional energy for their maintenance was found to be (94.83 x 1976 + 84 x 2376 Calorie=) 3,86,975 Calorie. Results of the energy balance analysis in scale B have been presented in table 6.

Table 6: Energy balance analysis for the selected household, scale B, season 1

TTFFRRPS	Input in scale A (in MJ)	Additional MJ in scale B	Input in scale B (in MJ)	Output, scale A (& B) (in MJ)	Surplus, scale A (in MJ)	Surplus, scale B (in MJ)
	(1)	(2)	(3)=(1)+(2)	(4)	(5)=(4)-(1)	(6)=(4)-(3)
30090111	13361	2127	15488	60610	47249	45122
30090211	11551	1918	13469	55214	43663	41745
30090311	9932	1585	11517	41723	31791	30206
30090411	6229	1084	7313	30305	24076	22992
30090511	12905	2127	15032	55214	42309	40182
30090611	10246	1668	11914	44422	34175	32507
30090711	12602	2127	14729	59358	46757	44630
Total	**76827**	**12637**	**89464**	**346846**	**270020**	**257383**

Based on the duration of the season, and the unit Calorie values from table A.1, total Calorie requirement for the dependents in season 1 was found to be 2,448 MJ. On the basis of the share of the plot area under selected PSC (16/83%) of the total area under cultivation in season 1, the corresponding Calorie requirements were calculated. The energy values of annual feed and the labour for the upkeep of animals, in accordance with the seasonal duration of 150 days, was added in this scale C. Results have been presented in table 7.

Table 7: Energy balance analysis for the selected household, scale C, season 1								
TTFFRRPS	Input, scale A (in MJ)	Input, scale B (in MJ)	MJ for depen-dents, scale C	MJ for animals, scale C	Input, scale C (in MJ)	Output, scale A (and B) (in MJ)	Output, scale C (in MJ)	Net addition due to animals (in MJ)
	(1)	(2)	(3)	(4)	(5) = (2)+(3)+(4)	(6)	(7)	(8) = (7)–(6)–(4)
30090111	13361	15488	412	8736	24636	60610	73486	4140
30090211	11551	13469	372	7886	21727	55214	66828	3728
30090311	9932	11517	307	6481	18305	41723	51318	3113
30090411	6229	7313	210	4657	12180	30305	36869	1908
30090511	12905	15032	412	9227	24672	55214	68090	3649
30090611	10246	11914	323	7391	19629	44422	54521	2708
30090711	12602	14729	412	9178	24319	59358	72234	3698
Total	**76826**	**89462**	**2448**	**53556**	**145468**	**346846**	**423346**	**22944**

Note:
(1) Energy value of dung in season 1 was 76,500 MJ, shown as the difference between column total of (7) and (6).
(2) Duration of the season was taken as 150 days. Accordingly Calorie values for the maintenance of dependents and animals during the unemployed days was calculated only for 150 days.

Annual Sustainability

The selected household had carried out cultivation in all the plots in season 2, like in season 1. In season 3, there was no cultivation or any hired out of household labour or animals in its possession. It follows that, the annual surplus will consist of three terms: (a) surplus of scale C, in season 1, (b) surplus of scale C, in season 2, and (c) the Calories necessary for the members of the household and the animals for the agricultural year as a whole over and above what has already been provided for in scale C. Quantification of the input, output and surplus in season 2 was done in an identical manner as illustrated above for season 1. It may be mentioned here that while all of the scales corresponding to only the cultivation period, it is only in the annual calculation, non-cultivation period was accounted for.

Table 8: Seasonal and annual sustainability of the selected household (input, output and surplus are in MJ)				
Description	Season 1	Season 2	Non-active period	Annual
	(1)	(2)	(3)	(4)
Length in days	150	120	90	360
Input	145468	382636	25650	553754
Output	423346	586379	45900	1055625
Surplus	277879	203743	20250	501872
Area under Cultivation (in ha)	3.03	3.54	Nil	6.57

Note:
(1) In column 3, input is obtained by multiplying per day Calorie requirement of members and animals in possession of the household by the number of days, i.e. 285 MJ/day x 90 days = 25650 MJ.
(2) Output in column 3, was consisted of only dung, with an energy value of 45,900 MJ.

IV. Sustainability of Agricultural Practices by 590 households

While we had calculated surplus in all the four scales, for analytical purposes mainly two will be used: of scale C, corresponding to the cultivated period, and the annual one, for the entire agricultural year. The important results are the following, in brief:[27]

(1) Some of the farms have reported a negative surplus (scale C) corresponding to as high an output as 700,000 MJ. Besides the obvious concentration of the two lowest CCS size-groups, of such farms, some of the households with a cultivable area within a range of 2–4 ha, also had been found with a negative surplus.[28] Thus, the phenomenon of negative surplus was rather universal, so far as CCS size-groups are concerned. While negative surplus could be found in all the five agro-climatic zones, the threshold output, for ensuring a non-negative surplus differed across zones.

(2) Such association, as in (1) above, of a negative surplus with a range of output—differentiated with respect to economic, social, technical, and biophysical characteristics—was also evident from the relationship between surplus and GCA. The minimum GCA for generation of a positive surplus during the cultivated period was around 3 ha: most of such households, belonged to the lowest two CCS size-groups. However, even among the farms belonging to the third CCS size-group (2–4 ha) there were only a few with a negative surplus. The critical minimum GCA across the agro-climatic zones for ensuring a positive surplus also varied.

(3) The 'full and final' annual surplus, that considers both cultivating and the non-cultivation period was non-negative only beyond a GCA of 4 ha. Roughly half of the households belonging to the lowest two size-groups, were having a negative surplus along with a few from the third size-group (2–4 ha), as in the case of surplus in scale C. In terms of the net area sown (NAS), such minimum was around 2.5 ha. This differed across agro-climatic zones, as expected. In the least developed red laterite zones it was 2.5 ha, while in a relatively better (and certainly not in absolute terms) coastal saline, it was around 1.2 ha. Further, while only a handful of households in the old alluvial zone reflected such a negative annual surplus, there was none from the new alluvial zone (the one with the healthiest bio-physical framework).

Table 9 aggregates the households on the basis of 12 output ranges, and presents some of the characteristics of the farms within each. A few of it has been portrayed in figure 9 (no of days beyond annual sustainability against output groups) and figure 10 (no of members of household along with no of animals in possession of the household against output groups).

Table 9: No of days beyond annual sustenance, in relation to output-groups (in MJ)

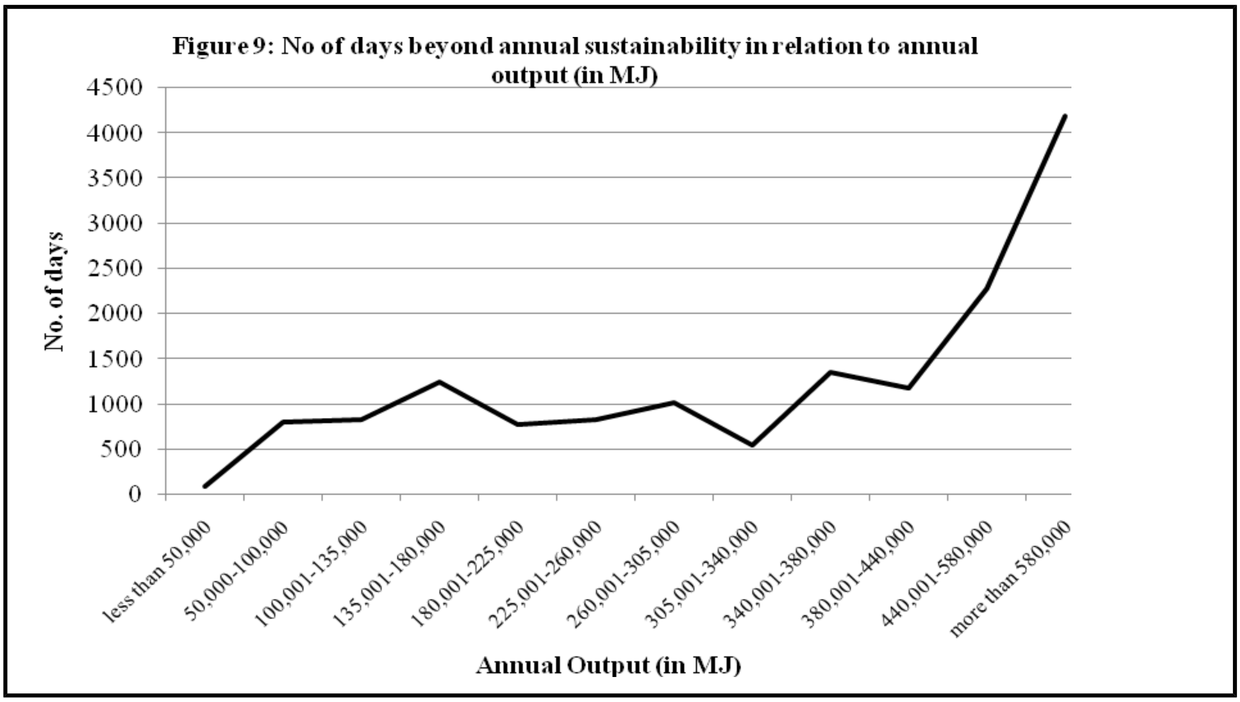
Output range (in MJ)	No of house -holds	Annual surplus (in MJ)	GCA (in ha)	NAS (in ha)	No. of members of household	No of animals	Daily Energy requirement* (in MJ)	No of days ^
Less than 50,000	47	1914	0.28	0.19	4.51	0.08	43	93
50,000–100,000	52	21021	0.61	0.38	5.17	0.84	75	811
100,001–135,000	48	25460	0.97	0.75	6.7	1.18	101	838
135,001–180,000	50	45677	1.11	0.9	5.44	1.74	110	1246
180,001–225,000	48	46602	1.56	1.15	6.81	2.69	156	776
225,001–260,000	47	66018	1.65	1.3	7.04	3.08	172	830
260,001–305,000	54	90432	2	1.54	6.55	3.05	166	1019
305,001–340,000	52	89473	2.21	1.67	6.71	3.92	200	548

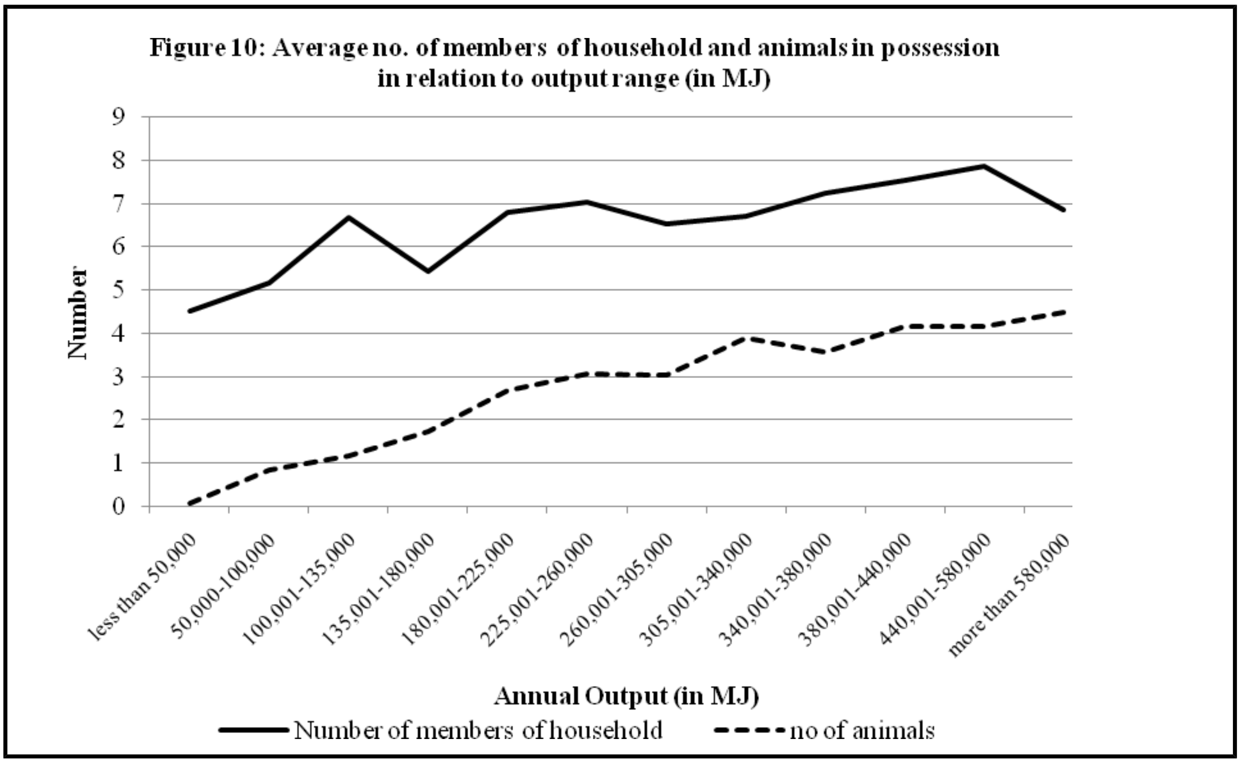
[27] The evidence on which the summary results are based upon can be provided by the author, on request.

[28] Number of households belonging to each of the CCS size-groups is as follows: 160 (0–1 ha), 237 (1–2 ha), 185 (2–4 ha), 7 (4–6 ha) and 1 (above 6 ha). We may add here that as this categorisation had resulted in a very few number of households in the upper two size-groups, we shall be using our own size-classes, in addition to the CCS one.

340,001–380,000	50	115045	2.51	1.9	7.26	3.58	192	1351
380,001–440,000	48	130339	2.71	1.91	7.54	4.16	214	1187
440,001–580,000	50	208565	3.42	2.12	7.88	4.16	217	2284
More than 580,000	44	427278	4.48	2.84	6.86	4.5	221	4188

Note:
* for both members and animals under sedentary activity
^ Days beyond annual sustenance





Along the no of days curve, the first rise corresponding to the fourth output range in figure 9 is due to the sharp drop in the number of members of the household, as shown in figure 10. On the other hand, the fall at the eighth output group is due to the increase in the number of animals. In fact, figure 10 clearly shows the monotonic relationship between output and number of animals, with the latter reflecting a purposive planning, where number of animals bear a relationship with the output and land size.

Further, figure 10 also shows that there was not much variation from the average number of household members (6.58), across the output ranges (and hence GCA). As a result, the increase in the daily energy requirements (as in the last column in table 9) primarily results from the increase in the number of animals. Given that below 180,000 MJ, average number of animals was less than two, this certainly implies that the power requirements were mostly met by the human labour; given the monotonic relationship between GCA and output, and also the NAS is less than 1 ha, this must have been the case.

V. Summary and Conclusions

> […] [S]torage of energy through work really only takes place in agriculture; in cattle raising the energy accumulated in the plants is simply transferred as a whole to the animals, and one can only speak of storage of energy in the sense that without cattle-raising, nutritious plants wither uselessly, whereas with it they are utilised. In all branches of industry, on the other hand, energy is only expended. The most that has to be taken into consideration is the fact that vegetable products, wood, straw, flax, etc., and animal products in which vegetable energy is stored up, are put to use by being worked upon and therefore preserved longer than when they are left to decay naturally. So that if one chooses one can translate into the physical world the old economic fact that all industrial producers have to live from the products of agriculture, cattle raising, hunting, and fishing—but there is hardly much to be gained from doing so [...]. (Engels 1968)

Indeed, this 'old economic fact' warrants repeated examination in all countries that allows such accumulation of energy through the bio-physical route and more so, in the light of growing food prices across the world and the secular decline of per capita food and nutrient consumption in India, especially among the farming households. It may be reemphasised that it is the cultivators who are responsible as economic agents for exchanges between human society and its environment, the part of the nature that serve as the source of materials, energy and also as a sink for the waste. Even if we leave aside the depletion and/or degradation of natural resource base, groundwater contamination from leaching and competitive withdrawal, pesticide residues in food, vegetables, and breast-milk, and adverse health impacts due to harmful exposure to chemicals, there are enough purely 'economic' reasons for birth of the term 'agrarian crisis' in India and elsewhere.

Sen and Bhatia (2004: 42) had warned that 'economic state of the average farmer, who is generally a small or marginal cultivator in most parts of the country' was far from 'reasonable'. A series of committees and commissions were set up, reports were commissioned, action plans were announced, and occasional aid packages for the distress areas by the State and Central governments were advanced.[29] Together, even intrinsically, these efforts can indicate the nature, extent, and seriousness of such a crisis.

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[29] National Commission on Farmers (2004), Commission of Farmer's Welfare (2004), 'Suicide of Farmers in Maharashtra' (2005–06), Report of Fact Finding Team on Vidharbha (2006), Report of the Expert Group on Agricultural Indebtedness' (2007), 'Farmers' suicide and debt waiver: an action plan for agricultural development of Maharashtra' (2008), just to mention a few.

This paper has shown some of the aspects of the unsustainabilities of the present agricultural practices. We may summarise the findings:

1. There exists considerable number of farms with negative surplus, in scale C or the cultivated period or the annual scale that takes into account the entire agricultural year including the non-cultivating period. Most of these households belong to the two lowest CCS size-groups. Further these farms were mostly concentrated in red laterite and coastal saline zone.
2. The threshold for a positive surplus was around 3 ha of GCA, if we look at the overall data, which however greatly varied with respect to agro-climatic zones. Following were the zone-wise threshold(s) in terms of GCA: 4 ha (terai), 0.5 ha (new alluvial), 3.25 ha (old alluvial), 2.75 ha (red laterite) and 2.9 ha (coastal saline).
3. For the annual sustainability, the threshold net area sown was found to be around 2.5 ha. This minimum area under cultivation varied with respect to agro-climatic zones, which had an influence on the associated cropping intensity.
4. The results of a negative surplus is stronger than the earlier findings of only a negative profit in the Farm Management Studies in late nineteen-fifties and early nineteen-sixties, on which the famous farm size-productivity debate was carried out in India.

Given the land constraint, it is all the more important to take measures for augmentation of the surplus. Perhaps the only option is to incentivise the farmers for adoption of cooperative farming practices so as to exploit the economies of scale. While the ownership of land through land distribution or other reasons may provide a legal security or social prestige, but it cannot ensure economic well-being or livelihood security. Small may be beautiful, but may not be always.

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Appendix:

Table A.1: Recommended daily allowances against sex-age-activity (in Calories)					
Age-group	Age/ age range	RDA^			
		Female		Male	
		Sedentary	Moderate	Sedentary	Moderate
Children	1+	1078	N.A.+	1096	N.A.+
Children	2+	1190	N.A.+	1301	N.A.+
Children	3+	1310	N.A.+	1463	N.A.+
Children	4+	1458	N.A.+	1531	N.A.+
Children	5+	1643	N.A.+	1778	N.A.+
Children	6+	1750	N.A.+	1948	N.A.+
Children	7+	1858	N.A.+	2030	N.A.+
Children	8+	1792	N.A.+	2034	N.A.+
Children	9+	1848	N.A.+	2160	N.A.+
Children	10+	1907	N.A.+	2140	N.A.+
Children	11+	1956	N.A.+	2193	2604*
Children	12+	2032	N.A.+	2248	2670*
Children	13+	2037	N.A.+	2340	2779*
Children	14+	2066	N.A.+	2468	2931*
Children	15+	2065	N.A.+	2354	2795*
Children	16+	2070	2458*	2586	3071*
Children	17+	2061	2447*	2662	3161*
Adult#	18–30	1872	2223	2424	2879
Adult	31–59	1920	2280	2376	2822
Old	>60	1704	2024*	1976	2347*

Source: table 4.2, 4.7, 4.8 and 4.11 of ICMR (1990)

Notes:

^ While recommended dietary allowances is also a function of body-weight of a labourer, in the absence of such information in the either of the datasets, reference weight of an adult male has been adopted as 60 kg and of an adult female as 50 kg, as per ICMR (1990: 70).

* RDA under moderate activity was extrapolated using the 24 hour average of Indian adults, from sedentary activities in terms of BMR. While for the former it was 1.9, it was 1.6 for the latter. Admittedly, this was the formula for adults, and thus for children below 18 years the conversion formula could be different. But for any better alternative route identical conversion factors had been used.

+ Energy values for children aged below 11 were not calculated in moderate activity. Lowest age for persons with crop production as the major occupation (code: 101) was 11 and 17 for boys for girls respectively. However, for crop production as the minor occupation for girls the minimum age is 16.

For persons in the age group of 18 years, table no 4.7 (for adults) puts 2424 against 60 kgs against the sedentary activities for boys while table no. 4.11 (for children) stated 2677 Calories. Persons at 18 years were considered as adults following the legally defined and judicially accepted position in India.