Man is naturally prone to spoliation, and dreads nothing so much as to have to exert his mental faculties in the acquisition of what he needs [...]. Necessity is the only compulsory agent that will ever make him move, and this will come soon enough (Justus von Liebig, 1859, ‘Letter X’ in Letters on modern agriculture: with addenda by a practical agriculturist. Embracing valuable suggestions, adapted to the wants of American farmers, J Wiley, New York, p. 196).

5.1. Input Usage Patterns
In this chapter, our objective is to explore the usage patterns of inputs. In particular, it is for the manures of both organic and inorganic origins, that accounted for the bulk of inputs in energy terms in either scale A or C. To begin with, we may note the distribution of inputs in absolute terms against farms grouped together on the basis of GCA (figure 5.1.1).1 Predominance of organic manure is obvious, notwithstanding the fact that for no less than 13 of the 59 tehsils,2 the 2004-05 dataset did not include data on this input. Further, figure 5.1.1 also shows that for the fifth size-group, there was a sudden rise in the use of organic manure, more than the rise due to increase in GCA. In fact, in figure 5.1.2 that plots per hectare input components, such a rise is more clearly visible.3

Figure 5.1.1: Distribution of different Inputs, scale A (in MJ) against size-class (in ha)

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1 The category rest in figure 5.1.1 includes seed and soil nutrients.
2 Most of which was located in zone-II, terai, as had been reported in chapter 2.
3 This is the reason for the sudden rise in the input of scale C as well, as was captured in figure 4.1.7 earlier.
Inorganic manure, on the other hand, appears to be of some significance only in the last four of the 12 size-groups. Further, in the last two size-groups some substitution appears to have been taken place of the organic manure by the inorganic one. Similarly, machine use was of significance only in the last two size-groups. Interestingly, human labour use was also of some significance in absolute terms for the higher size-groups: it had increased along with all other inputs. However, in per hectare terms it remained almost invariant to size-group (figure 5.1.2).

In figure 5.1.2, we may notice the sudden rise in the organic manure per hectare use for the fifth size-group, as stated above. Animal labour per hectare remained almost uniform, like use of human labour per hectare. On the other hand, overall use of organic manure per hectare shows a negative relationship with the land size. In contrast, per hectare inorganic manure use shows a rise only in the last size-group, while maintaining an almost invariant pattern across the size-groups.

Further, from figure 5.1.2 it may appear that the input per hectare had reduced for the last but one size-group. In fact figure 5.1.3 reveals that per hectare input

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4 The category rest in figure 5.1.2 includes seed, pesticides and soil nutrients.
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had started falling from the ninth size-group (2.02-2.31 ha), and had increased only in the last size-group. In fact, figure 5.1.3 also shows that for a range, from the fifth (1.21-1.50 ha) till the tenth size-class (2.71-3.30 ha), per hectare surplus was constant even on the face of falling input per hectare. Obviously, for such a phenomenon, output per hectare had to fall at the same rate, as shown by figure 5.1.3.

Figure 5.1.3: Per hectare input, output and surplus, scale A (in MJ/ha) against size-group (in ha)

Figure 5.1.4: EROI, scale A, against size-group (GCA) (in ha)

Figure 5.1.4 reflects such a constant surplus per hectare through a uniform EROI of scale A across size-groups. Further, for the last four size-groups, EROI marked a rise; from figure 5.1.3 shows the corresponding input per hectare and output per hectare along with the changes. Notably, from figure 5.1.2 we may also note that
these are the size-groups that had used lesser organic manure per hectare in contrast to all the other eight. Notably, the last two size-groups had shown an increase in the inorganic manure per hectare. Given the average GCA or the total area under cultivation in absolute terms, the use of organic manure in absolute terms (in MJ) for the last size-group was more than most of the other size-groups (column 11 of table 5.1.1), notwithstanding the highest use of inorganic manure in per hectare terms as well in total (column 12).

<table>
<thead>
<tr>
<th>Gross Cropped Area (in ha)</th>
<th>No. of households</th>
<th>Average GCA</th>
<th>NAS</th>
<th>GCA</th>
<th>Cropping intensity</th>
<th>Input</th>
<th>Output</th>
<th>EROI</th>
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<table>
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<tr>
<th>Gross Cropped Area (in ha)</th>
<th>Human Labour</th>
<th>Animal Labour</th>
<th>Organic Manure</th>
<th>Inorganic Manure</th>
<th>Machine</th>
<th>Rest*</th>
<th>Share of Manure in total input</th>
<th>Share of organic manure in total manure</th>
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</tr>
</tbody>
</table>

Notes:
1. * Rest includes Seeds, Pesticides and Micro- and Macro-nutrients

The importance of manure among the inputs can be seen from the column 15 of table 5.1.1: the lowest share was more than 65% (eleventh size-group). On other hand, barring the two largest size-groups, share of organic manure in the total
manure (column 16) had remained over 80%. Incidentally, it is these two size-groups that had yielded a much higher per hectare surplus than all the other size-groups. It appears that this association of a higher per hectare surplus and the use of inorganic fertilisers holds some importance towards augmentation of the surplus, in absolute terms or on a per unit area basis.

It may be noted further that barring one, all the other 589 households had used inorganic fertiliser. Admittedly, many plots did not have any such use, but at the household level, it was not so. On the other hand, among the 460 households, only 368 had reported use of organic manure. We may classify these two type of manure use among those households from the 46 tehsils with organic manure data: those which used both inorganic and organic manure (type 1), and the ones which used only inorganic manure (type 2).

Figure 5.1.5: Per hectare manure, output and surplus (in MJ/ha) of scale A among households of type 1, against GCA (in ha)

5 Leaving aside the 13 tehsils (6, 7, 10, 11, 13, 14, 15, 18, 19, 41, 44 and 60) for which dataset did not include data on organic manure, as stated in 3.2.3.6.2 above.
Figure 5.1.6 in the previous page shows per hectare manure use (both organic and inorganic), output and surplus in scale A (in MJ/ha) for the farms using both types of manure (type 1). Besides the obvious higher energy associated with per hectare organic manure in contrast to the inorganic types, we may also notice the households with negative surpluses. In contrast, all of the 92 households which had used only inorganic manure (type 2), yielded a positive surplus per hectare in scale A.

Among all the 590 households, 388 had used both type of manure. We may observe some of the features of these mixed manure use farms from figure(s) 5.1.7 - 5.1.14 that shows per hectare use of manures of both types, per hectare output and per hectare surplus of scale A, with the additional identifiers of CCS size-groups and agro-climatic zones.
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Fig. 5.1.7: Per hectare Organic manure, scale A (in MJ/ha) in relation to GCA (type 1 farms), across size-groups

![Graph showing the relationship between Organic manure and GCA across different size-groups.]

- Group 1 (0-1 ha)
- Group 2 (1-2 ha)
- Group 3 (2-4 ha)
- Group 4 (4-6 ha)
Fig. 5.1.8: Per hectare Inorganic manure, scale A (in MJ/ha) in relation to GCA (type 1 farms), across size-groups.
Fig. 5.1.9: Per hectare Output, scale A (in MJ/ha) in relation to GCA (type 1 farms), across size-groups.
Figure 5.1.10: Per hectare Surplus, scale A (in MJ/ha) in relation to GCA (type 1 farms), across size-groups.
Fig. 5.1.11: Per hectare Organic manure, scale A (in MJ/ha) in relation to GCA (type 1 farms), across Zones
Fig. 5.1.12: Per hectare Inorganic manure, scale A (in MJ/ha) in relation to GCA (type 1 farms), across Zones.
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Fig. 5.1.13: Per hectare Output, scale A (in MJ/ha) in relation to GCA (type 1 farms), across Zones
Figure 5.1.14: Per hectare Surplus, scale A (in MJ/ha) in relation to GCA (type 1 farms), across Zones

Zone
- II. Terai
- III. New Alluvial
- IV. Old Alluvial
- V. Red Laterite
- VI. Coastal Saline
For the 101 households (excluding those which reported no use of organic manure), inorganic manure per hectare, output per hectare and surplus per hectare have been plotted against GCA (like in figure 5.1.7) with additional markers of CCS size-group and agro-climatic zones in figure(s) 5.1.15-5.1.20.
Fig. 5.1.16: Per hectare Output, scale A (in MJ/ha) in relation to GCA (type 2 farms), across Size-groups
Fig. 5.1.17: Per hectare Surplus, scale A (in MJ/ha) in relation to GCA (type 2 farms), across Size-groups.
Fig. 5.1.18: Per hectare Inorganic Manure, scale A (in MJ/ha) in relation to GCA (type 2 farms), across Zones.
Fig. 5.1.19: Per hectare Output, scale A (in MJ/ha) in relation to GCA (type 2 farms), across Zones

- Zone I: Terai
- Zone II: New Alluvial
- Zone III: Old Alluvial
- Zone IV: Red Laterite
- Zone V: Coastal Saline
Fig. 5.1.20: Per hectare Surplus, scale A (in MJ/ha) in relation to GCA (type 2 farms), across Zones
5.2. Output Composition

We may recall that for the selected household, the energy value of by-products were higher than that of the main product (table 3.3.14). This was not an exception. Figure 5.2.1 and 5.2.2 show main product and by-product against GCA for all the 590 households; both of them show this across size-class or GCA.
In fact, this is one of the literally fertile areas, in which newer methods can assist in towards the return of nutrients back to the soil without any use of materials/inputs that are ecologically harmful. In this process, certainly, the necessity of inorganic sources of manure may reduce use of which-though effective towards yield-is associated with many problems. These facts of enormous quantity of by-products and its potential in returning the nutrients to the soil taken away are well established. In fact, indiscriminate burning of by-products adds to the atmospheric pollution rather than making a positive ecological impact. Certainly, there remain ample possibilities of effectively using this ‘free gift’ and improving the human society-nature metabolism. Further, the average cost of preparing composts using the by-products will be lower if farmers organisations can bring its members together for a common facility. Finally, use of scientific principles can improve the quality of such composts and the impact on the yield.

This is not a novel idea. Call by the Scottish ‘practical capitalist farmer and an advanced agronomist for his time’, James Anderson (see, Anderson 1776, 1777) towards adoption of ‘rational and unsustainable agricultural practices’ (see, Foster 2000: 124) or that of ‘rational principles’ by the American Josse Buel (see, Buel 1847: 26-27) or by the Scottish agricultural chemist James F W Johnston for ‘a rational system of culture, capable of being carried on for an indefinite period without injury to the land’ (see, Johnston 1851: 355-58, v.1) or by the American political economist Henry Carey’s to halt the practices that ‘rob [...] the earth of its capital stock’ (Carey 1858: 210-215, v. II; also see, Foster 1999) can be summed up as the following: ‘Every act of the farmer which violates the laws of nature must justly be branded as an act of spoliation’ (Liebig 1859: 175; emphasis is in original). The ‘rational principle’ could best be expressed in ‘the law of compensation, which makes the recurrence or permanency of effects dependent upon the recurrence or permanency of the conditions which produce them [...] the most universal of the laws of nature’ (Liebig 1858: 254-55). Certainly, rather than robbing the soil its capital stock, its continuous replenishment can ensure the conditions which are more conducive towards a sustainable agriculture.
We may conclude this chapter by stating the following:

1. Organic fertilisers has a larger use-value than the inorganic fertiliser for a given level of output. The respective uses are determined by the size-group as well as the agro-climatic zones.

2. Use of only inorganic fertilisers has resulted in a positive surplus. On the other hand, there were many farms with a negative surplus which had used both organic and inorganic manure.

3. Finally, in order to 'compensate' the soil for the nutrient losses, it is important to return to it the by-products which has very little use given the reduction in the number of animals in the recent times. Further it is also important to take steps so as to improve the efficiency of organic manures in improving the yield per unit of its use.