Table 3.3.14: Summary of indicators for analysis of sustainability of cultivation by the selected household

<table>
<thead>
<tr>
<th>Description</th>
<th>Scale A</th>
<th></th>
<th>Scale B</th>
<th></th>
<th>Scale C</th>
<th></th>
<th>Annual Scale</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In MJ</td>
<td>%</td>
<td>In MJ</td>
<td>%</td>
<td>In MJ</td>
<td>%</td>
<td>In MJ</td>
<td>%</td>
</tr>
<tr>
<td>Total Input</td>
<td>42139</td>
<td>100.0</td>
<td>436010</td>
<td>100.0</td>
<td>528104</td>
<td>100.0</td>
<td>554208</td>
<td>100.0</td>
</tr>
<tr>
<td>Human Labour</td>
<td>21014</td>
<td>5.0</td>
<td>35630</td>
<td>8.2</td>
<td>39733</td>
<td>7.5</td>
<td>42839</td>
<td>7.7</td>
</tr>
<tr>
<td>Animal Labour</td>
<td>5701</td>
<td>1.4</td>
<td>5701</td>
<td>1.3</td>
<td>93693</td>
<td>17.7</td>
<td>116691</td>
<td>21.1</td>
</tr>
<tr>
<td>Organic Manure</td>
<td>208800</td>
<td>49.5</td>
<td>208800</td>
<td>47.9</td>
<td>208800</td>
<td>39.5</td>
<td>208800</td>
<td>37.7</td>
</tr>
<tr>
<td>Inorganic Manure</td>
<td>85657</td>
<td>20.3</td>
<td>85657</td>
<td>19.6</td>
<td>85657</td>
<td>16.2</td>
<td>85657</td>
<td>15.5</td>
</tr>
<tr>
<td>All Manure</td>
<td>294457</td>
<td>69.9</td>
<td>-294457</td>
<td>67.5</td>
<td>294457</td>
<td>55.8</td>
<td>294457</td>
<td>53.1</td>
</tr>
<tr>
<td>Machine*</td>
<td>89923</td>
<td>21.3</td>
<td>89923</td>
<td>20.6</td>
<td>89923</td>
<td>17.0</td>
<td>89923</td>
<td>16.2</td>
</tr>
<tr>
<td>Rest^</td>
<td>10298</td>
<td>2.4</td>
<td>10298</td>
<td>2.4</td>
<td>10298</td>
<td>1.9</td>
<td>10298</td>
<td>1.9</td>
</tr>
<tr>
<td>Gross Output</td>
<td>872026</td>
<td>100.0</td>
<td>872026</td>
<td>100.0</td>
<td>872026</td>
<td>100.0</td>
<td>872026</td>
<td>100.0</td>
</tr>
<tr>
<td>Main product</td>
<td>452436</td>
<td>51.9</td>
<td>452436</td>
<td>51.9</td>
<td>452436</td>
<td>44.8</td>
<td>452436</td>
<td>42.9</td>
</tr>
<tr>
<td>By product</td>
<td>419590</td>
<td>48.1</td>
<td>419590</td>
<td>48.1</td>
<td>419590</td>
<td>41.6</td>
<td>419590</td>
<td>39.7</td>
</tr>
<tr>
<td>Dung</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>137700</td>
<td>13.6</td>
<td>183600</td>
<td>17.4</td>
</tr>
<tr>
<td>Surplus</td>
<td>450632</td>
<td>-</td>
<td>436016</td>
<td>-</td>
<td>481621</td>
<td>-</td>
<td>501418</td>
<td>-</td>
</tr>
<tr>
<td>EROI</td>
<td>2.07</td>
<td>-</td>
<td>2.00</td>
<td>-</td>
<td>1.91</td>
<td>-</td>
<td>1.90</td>
<td>-</td>
</tr>
<tr>
<td>Labour/ha</td>
<td>3198</td>
<td>-</td>
<td>5423</td>
<td>-</td>
<td>6048</td>
<td>-</td>
<td>6520</td>
<td>-</td>
</tr>
<tr>
<td>Output/GCA</td>
<td>132728</td>
<td>-</td>
<td>132728</td>
<td>-</td>
<td>153687</td>
<td>-</td>
<td>160674</td>
<td>-</td>
</tr>
<tr>
<td>Surplus/GCA</td>
<td>68589</td>
<td>-</td>
<td>66365</td>
<td>-</td>
<td>73306</td>
<td>-</td>
<td>76319</td>
<td>-</td>
</tr>
<tr>
<td>Surplus/NAS</td>
<td>148724</td>
<td>-</td>
<td>143900</td>
<td>-</td>
<td>158951</td>
<td>-</td>
<td>165484</td>
<td>-</td>
</tr>
<tr>
<td>Rate of Surplus Value</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12.122</td>
<td>-</td>
<td>11.7</td>
<td>-</td>
</tr>
<tr>
<td>No of members of household</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No of earners</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Calorie for members</td>
<td>34.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Calorie for animals</td>
<td>250.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAS</td>
<td>3.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCA</td>
<td>6.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAS/number of household</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCA/number of household</td>
<td>1.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cropping intensity</td>
<td>2.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note
* includes material used directly and for maintenance, depreciation and labour for maintenance
^ includes seeds, pesticides, micro- and macro-nutrients
The discovery of the *net product*, wrote Mirabeau, 'which we owe to the venerable Confucius of Europe, will one day change the face of the world [...]. The whole moral and physical advantage of societies is [...] summed up in one point, *an increase in the net product*; all damage done to society is determined by this fact, *a reduction in the net product*. It is on the two scales of this balance that you can place and weigh laws, manners, customs, vices, and virtues'. (1932, *Correspondance Générale de J.-J. Rousseau*, T Dufour, ed., Vol. XVII, pp. 171–2, quoted in Meek 1962: 19–20; emphasis as in original)

In this chapter, the results of the energy balance analysis of West Bengal agriculture will be presented for the agricultural year 2004–05. As noted in the previous chapter, the indicators selected for the present purpose will mainly be surplus, under the four alternative scales of sustainability of this thesis. Other indicators will be used towards explaining its variability, as its augmentation is a necessary condition for the sustainability of agriculture.

We may start with noting the definitive and positive relationship between the annual output (in MJ) and the GCA (in ha) in figure 4.1.1. Figure 4.1.2 plots the annual output (in MJ) and output in scale C (in MJ) against GCA (in ha), aggregated over size-groups.

![Figure 4.1.1: Annual output (in MJ) in relation to GCA (in ha)](image-url)
In figure 4.1.2, corresponding to every size-group, we may observe the difference between the annual output and the output in scale C; as the former takes account of the non-cultivating period apart from the cultivating one, while the latter considers only the cultivating period. The difference arises, due to the inclusion of dung from the animals in possession of the household.

With emphasis on this basic monotonic relationship, which had implications on the question of scale of production, we may proceed further with the rest of the results. We shall begin with the surplus of scale C, in absolute as well as in per hectare terms (4.1), followed by an analysis of the annual sustainability through an analysis of the annual surplus (4.2). Subsequently, the EROI in the four scales of sustainability will be looked into (4.3). Finally, we will analyse the rate of surplus value and per hectare labour under scales of A, B and C (4.4).

1 The size-group ranges have been delineated with the intention of having a near uniform density. See, table 4.2.1 below for the number of households in each size-group.

2 See, <annual sustainability.xlsx> in the attached CD.
4.1. Surplus
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. We may first note the relationship between the surplus of scale C and the gross output of scale C in figure 4.1.3. One may note the negative surplus in some of the farms corresponding to as high output as 700,000 MJ in the figure.

Figure(s) 4.1.4 and 4.1.5, represent figure 4.1.3 along with the two additional markers, as stated earlier: CCS size-group and agro-climatic zones. Former represents the area under the command of the household (see, 3.1.3 above), while the latter serves as a proxy for the bio-physical framework, within which crop cultivation took place.

From figure 4.1.4, we may note the obvious concentration of the two lowest CCS size-groups corresponding to a negative surplus.\(^3\) Further, some of the households with a cultivable area within a range of 2–4 ha, also had reported with

\(^3\) 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.
a negative surplus. Given the fact that two uppermost size-groups consisted only 8 households, we have found the phenomenon of negative surplus rather universal, so far as CCS size-groups are concerned. In sum, we may state that the minimum output for ensuring a positive surplus during the cultivated period, differs across size-groups. There is, however, a certain size of output at the household level, above which there is no negative surplus.

In terms of agro-climatic zone, as in figure 4.1.5, such negative surpluses could be located in all the five zones. However, the minimum output, beyond which there was no negative surplus differed across zones. For instance, the households belonging to the new alluvial zone, in general, had a positive surplus, barring a few with a very low level of output. On the other hand, those in the old alluvial zone had shown a rather extreme variation: some of the farms have yielded very high output associated with a very high surplus, while some others have reported a negative surplus with as high output as 370,000 MJ. Output from the farms located in the red laterite zone (zone V) was concentrated within a range of 60,000 and 400,000 MJ; nearly half of which had reported a negative surplus. Further, in general, the surplus in zone V was less in comparison to the farms in the coastal saline zone (VI), in spite of producing a similar range of output. Again, like zone V, many farms in zone VI also had reported a negative surplus. Farms in zone II terai, did not reveal any definite relationship. However, of note is the negative surplus associated with relatively higher levels of output, for many farms in this zone. In sum, we may reiterate that the critical minimum output for yielding a positive surplus differed across the bio-physical framework.

Assocation 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 (see, figure 4.1.6). This was obvious though, given the relationship between output and GCA in figure 4.1.1.
Figure 4.1.4: Surplus (in MJ) against Output (in MJ) in cultivated period (scale C), across CCS size-groups.
Figure 4.1.5: Surplus (in MJ) against Output (in MJ) in cultivated period (scale C), across Zones
Figure 4.1.7 plots input, output and surplus against GCA with farms grouped into size-classes: one may notice that the increase in the total input was relatively uniform unlike that of the output. Consequently, surplus recorded a steep rise for the two of our highest size-groups. We may note the slight fall in the surplus against the size-group, namely 1.21 -1.5 ha, due to a steep rise in the total input (figure 4.1.7).

Figure 4.1.6: Surplus (in MJ) in cultivated period (scale C) against GCA (in ha)

Figure 4.1.7: Input, output and surplus (all in MJ) during cultivated period, (scale C) in relation to GCA (in ha), aggregated over size group

* In chapter 4 we shall discuss composition of inputs in a greater detail.
Figure 4.1.8 shows the same relationship as in figure 4.1.6 with CCS size-groups, as the marker; figure 4.1.9 does the same with agro-climatic zones. We may note the minimum gross cropped area for generation of a positive surplus during the cultivated period was around 3 ha (see, figure 4.1.6). Figure 4.1.8 shows it more clearly: most of the households, belonging to the lowest two CCS size-groups, could cultivate a GCA of less than 3 ha, and consequently, several of them produced a negative surplus. For the other three size-groups the relationship between GCA and surplus is identical to figure 4.1.4; among the farms belonging to the third CCS size-group (2–4 ha) there were only a few with a negative surplus while all the 8 households in the other two, as expected, produced a positive surplus.

In figure 4.1.9, like in figure 4.1.5, one may notice the differences in the critical minimum GCA across the agro-climatic zones for ensuring a positive surplus. For the new alluvial zone, as complemented by figure 4.1.5 on the relationship between surplus (scale C) and output (scale C), the minimum GCA (around 0.5 ha) for ensuring positive surplus was lower than that for the old alluvial, that includes districts of Hooghly and Burdwan (see, figure 3.1.1). For the households in the latter zone, indeed, such a minimum GCA is much higher (more than 3 ha). Together these results imply that while the bio-physical framework, could be an important factor towards the generation of a positive surplus, there are other equally important factors as well. For example, the rate at which surplus could increase with a rise in the GCA in the old alluvial zone was higher than that of the new alluvial zone, which cannot be explained by the natural factors alone. The relationship between GCA and the surplus, for the agriculturally less developed red laterite and coastal saline zones, was identical to the one plotted in 4.1.5; so was for the terai zone as well.

In sum, we may emphasise on two types of thresholds for the sustainability of the labour: one is related to the gross output during the cultivated period (scale C), and the other is to the GCA. Given the relationship between Output, Surplus and GCA (figure 4.1.1 and 4.1.7), these thresholds are connected no doubt. Further, the agro-climatic environment of the crop production system was found to be influencing both these thresholds, along with the other factors.
Figure 4.1.8: Surplus (in MJ) in cultivated period (scale C), against GCA (in ha), across CCS size-groups.
Figure 4.1.9: Surplus (in MJ) in cultivated period (scale C), against GCA (in ha), across zones

[Graph showing data points scattered across a grid, with zones labeled as II. Terai, III. New Alluvial, IV. Old Alluvial, V. Red laterite, and VI. Coastal Saline.]
4.1.1. Impact of Cropping Intensity on Surplus, Scale C

We may look at the surplus in the cultivated period in relation to the nature of agricultural production, through cropping intensity (GCA/NAS) (figure 4.1.10).

As expected, the highest surplus of scale C was associated with a cropping intensity of around 1.5. With households grouped together on the basis of a range of cropping intensities, the one between 1.5 and 1.8 will correspond to highest average surplus. On the other hand, a cropping intensity of 2.2 and above was associated with a rather low surplus.

Indeed, figure 4.1.11 reveals an interesting picture. Irrespective of the cropping intensity, lower surpluses were associated with the lowest CCS size groups. With a rise in the area of land in possession (as revealed by different CCS size-groups), the surplus increased, notwithstanding the changes in cropping intensity. For example, for the third size-group (2–4 ha), one may notice the initial rise in surplus with cropping intensity, followed by a fall. Similarly, for the second lowest CCS size-group (1–2 ha) the level of surplus across cropping intensities also showed an inverse-U pattern. Interestingly, for a range (1–1.7), against a given cropping intensity, one can notice farms belonging to the second lowest CCS size-group (1–2 ha) with a lower surplus than those from the lowest size-group (0–1 ha). On the other hand, cultivation by the two highest CCS size-groups could yield
a distinctly high surplus with cropping intensity range of 1.2–1.8, with the highest corresponding to 1.5. The association of high surpluses with the two highest CCS size-groups irrespective of the cropping intensity shows the benefits of economies of scale. In sum, we may add that, a very small area, irrespective of the cropping intensity (including very high ones) was associated with a very low or even a negative surplus. This is particularly true for lowest two CCS size-groups (0–1 ha and 1–2 ha).

Importance of the agro-climatic environment in the crop cultivation, once again, was shown by figure 4.1.12. Farms in the red laterite and coastal saline zones mostly recorded a cropping intensity of 1, but with a range of surplus ranging from −100,000 MJ to around 300,000 MJ. Figure 4.1.11 (along with 4.1.18), on the other hand, revealed that these were the farms mostly belonging to the three lowest CCS size-groups; those with the negative surplus belonged to the two lowest CCS size-groups (0–1 ha and 1–2 ha). On the other hand, other farms in the same size-group but located in the two alluvial zones (as revealed by figure(s) 4.1.11 and 4.1.12 together), could not only increase cropping intensity, but also yield more surpluses.

In general, one may find that the farms located in red laterite and coastal saline zones could achieve the same amount of surplus with a lower cropping intensity than both the alluvial zones (figure 4.1.12). Further, while the cropping intensities against the farms in the new alluvial zone were greatly varied, the surplus was within a rather narrow band, barring a few exceptions with a very high cropping intensity. On the other hand, for the old alluvial zone, no such range exists: both cropping intensity as well as surplus varied greatly. Once again, for terai, no conclusion could be drawn.

It seems that higher surpluses in the locations with a poor agro-climatic environment and also with a lower cropping intensity, may have resulted from relatively higher contributions from the other inputs, in contrast to the other zones. On the other hand, farms belonging to the lowest CCS size group but located in the new alluvial zone recorded a very low surplus, associated with a very high cropping intensity.

Figure 4.1.8 plots per hectare surplus with cropping intensity, across CCS size-groups.
Figure 4.1.11: Surplus (in MJ) in cultivated period (scale C), against Cropping Intensity, across CCS size-groups.
Figure 4.1.12: Surplus (in MJ) in cultivated period (scale C), against Cropping Intensity, across Zones.
In sum, we may state the following: an association between higher cropping intensities and higher surpluses existed only for a land size beyond a threshold (certainly higher than 2 ha, the upper bound of the second lowest CCS size-group). This association was strengthened by the relative superior bio-physical framework of both alluvial zones. Thus, for a household located in other zones and having a small land, even with a high cropping intensity, could yield only a low or a negative surplus. Only an elimination of either of the conditions can increase the surplus. While the alterations in bio-physical framework, other than land quality is beyond the human control, the only option for augmenting the surplus is to increase the area under cultivation, in operational terms.

4.1.2. Per hectare Surplus

Figure 4.1.13 portrays the per hectare surplus, against the gross cropped area. Certainly, there had been rather wide variations against the lower area of land under cultivation. The extent of such variation can be seen from table 4.1.1. On the other hand, figure 4.1.14 portrays per hectare surplus against GCA, aggregated over size-groups. We may note once again—like in figure 4.1.7 for surplus—of a fall in the surplus/hectare, against size-group 1.21–1.5 ha.

---

Analysis of per hectare surplus excludes TTFF 0201 (GCA=0.01 hectares, per hectare surplus = -869,873 MJ/ha).
Table 4.1.1: Per hectare surplus (in MJ/ha), its variance in relation to GCA (in ha), aggregated over size-groups

<table>
<thead>
<tr>
<th>Gross Cropped Area (in ha)</th>
<th>No of households</th>
<th>Per hectare Surplus (in MJ/ha)</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01–0.33</td>
<td>54</td>
<td>8596</td>
<td>112240</td>
</tr>
<tr>
<td>0.34–0.66</td>
<td>51</td>
<td>35052</td>
<td>74179</td>
</tr>
<tr>
<td>0.67–1.00</td>
<td>48</td>
<td>56593</td>
<td>6790</td>
</tr>
<tr>
<td>1.01–1.20</td>
<td>46</td>
<td>57453</td>
<td>10561</td>
</tr>
<tr>
<td>1.21–1.50</td>
<td>48</td>
<td>30544</td>
<td>8961</td>
</tr>
<tr>
<td>1.51–1.80</td>
<td>52</td>
<td>40495</td>
<td>8414</td>
</tr>
<tr>
<td>1.81–2.01</td>
<td>50</td>
<td>39524</td>
<td>5942</td>
</tr>
<tr>
<td>2.02–2.31</td>
<td>48</td>
<td>52868</td>
<td>7302</td>
</tr>
<tr>
<td>2.33–2.70</td>
<td>51</td>
<td>43449</td>
<td>5549</td>
</tr>
<tr>
<td>2.71–3.30</td>
<td>52</td>
<td>48372</td>
<td>4741</td>
</tr>
<tr>
<td>3.31–4.25</td>
<td>50</td>
<td>65527</td>
<td>5327</td>
</tr>
<tr>
<td>4.26–9.30</td>
<td>40</td>
<td>73901</td>
<td>4747</td>
</tr>
</tbody>
</table>

Figure 4.1.14: Per hectare Surplus (in MJ/ha) in relation to GCA (in ha), aggregated over size-group

Figure 4.1.15 and 4.1.16 portrays figure 4.1.13 with CCS size groups and agro-climatic zones as the respective markers. Former shows that variations are much higher for the lower size groups. On the other hand, latter shows greater variability for farms located in the agro-climatic zone of V (red laterite) and VI (coastal saline). Variations are expectedly least in both the alluvial zones. For the farms in the terai zone, while variability could be observed against the lower levels of GCA, it reduced with an increase in GCA, as captured by table 4.1.1 for all farms.
Figure 4.1.15: Surplus per ha (in MJ/ha) in cultivated period (scale C), against GCA (in ha), across size-groups

size group
- 1 (0-1 ha)
- 2 (1-2 ha)
- 3 (2-4 ha)
- 4 (4-6 ha)
- 5 (>6 ha)
Figure 4.1.16: Surplus per ha (in MJ/ha) in cultivated period (scale C), against GCA (in ha), across Zones
In sum, we may state two things on the per hectare surplus. First, variations in it are higher for lower size-groups as well in agro-climatic zones with a relatively inferior bio-physical framework. Second, despite the variations, there seems to be an upper bound on the per hectare surplus; notably, it is associated with the farms cultivating a very small area, which is even higher than the largest farms. Even otherwise, such an upper bound is visible for farms with GCA higher than 2 ha as well. This certainly demands an intense scrutiny.

Figure 4.1.17 presents the relationship between per hectare surplus during the cultivating period with the cropping intensity. If we take only the positive numbers, per hectare surplus, shows a negative relationship with the cropping intensity, bringing the importance of leaving the land fallow for regenerating its ‘power’.

Figure A.4.1.1 shows the relationship as in 4.1.13 with ‘Irrigation types’ as an additional marker. It may be recalled that the presence of an irrigation facility may not necessarily its use. Even without the aid of any structure, through human labour with or without the animals, farms are irrigated. As expected, figure A.4.1.1 did not reveal any particular pattern, except the predominance of farms without any irrigation facility, as noted earlier in table A.3.2.15. However, those farms with canal based irrigation facility, with higher GCA yielded higher per hectare surplus. Such a facility on the other hand for very small farms could result only in a negative surplus and hence a negative surplus per hectare.
Figure 4.1.18 and 4.1.19 portray figure 4.1.17 with the usual markers. The former shows that the highest surplus/hectare was obtained with a cropping intensity in the range of 1-1.2. The latter confirms the result that it is the households with very small land, and located in zone V and VI.

Further, figure 4.1.18, offers an 'scaled up' version of the figure 4.1.11 (with surplus) for farms with a very small area under cultivation. It reveals once again the association of a negative surplus with many households belonging to the lowest size-groups. Indeed, it is these households that yielded the most variable per hectare surpluses. Certainly, located within a not so conducive natural environment (see, figure 4.1.19), such a high per hectare surplus calls for further investigation.

4.1.2.1. Per hectare Surplus and EROI

Figure 4.1.20 plots per hectare surplus in the cultivated period with EROI (scale C). It shows that, while with the increase in the EROI, initially the per hectare surplus increases monotonically, beyond an EROI of around 3, the curve appears flatter, indicating an upper bound. In fact, an increase in EROI and a constant surplus per hectare required input per hectare to fall. 8

---

8 Surplus/ha = O/ha - I/ha
or, Surplus/ha X ha/I = O/ha X ha/I - 1
or, Surplus/ha X ha/I = EROI - 1
or, K x ha/I = EROI - 1 (K= constant)
Exploring Sustainability of West Bengal Agriculture through Energy Balance Analysis: 2004–05

Figure 4.1.18: Surplus per ha (in MJ/ha) in Scale C, against Cropping Intensity, across size-groups
Figure 4.1.19: Surplus per ha (in MJ/ha) in Scale C, against Cropping Intensity, across Zones
Figure 4.1.21: Surplus per ha (in MJ/ha) against EROI, in Scale C, across size-groups

- Size group 1 (0-1 ha)
- Size group 2 (1-2 ha)
- Size group 3 (2-4 ha)
- Size group 4 (4-6 ha)
- Size group 5 (>6 ha)
Figure 4.1.22: Surplus per ha (in MJ/ha) against EROI, in Scale C, across Zones
Figure 4.1.21 and 4.1.22, that plots figure 4.1.20 with markers may provide a few additional insights. To begin with, in figure 4.1.21, one may notice the monotonic relationship between per hectare surplus and EROI of scale C, for three lowest size groups, separately.\(^9\) We may focus only on the farms with a positive surplus or surplus/hectare in energy terms. It appears that for a given rise in the surplus per hectare farms of the lowest CCS size-group required the least increase in EROI, scale C among all the three. For the second lowest size-group (1–2 ha), it required higher rise in EROI and for the third size-group, it was even more. However, given the fact that, for the lowest CCS size-group (0–1 ha), surplus per hectare is higher than the surplus in absolute terms, we may focus on the other two size-groups. While EROI, scale C and surplus per hectare shows a positive relationship, it is important to emphasise here that a very high EROI with a low or a negative surplus means hardly anything substantial. Given the predominance of farms belonging to second lowest CCS size-group (1–2 ha) among the high per hectare surplus ones,\(^10\) it seems reasonable to conclude that there are factors other than the land size or GCA which is having a significant influence on the per hectare surplus yield of higher magnitudes.

In fact, as figure 4.1.22 shows, these high surplus per hectare yielding farms are located in all five agro-climatic zones. While for red laterite and coastal saline, single cropping (see, table 1.7.1) could have played its role, through regeneration of soil capacity, such a possibility does not exist for the both the alluvial zones or terai. We may, but conclude, on the existence of some other important factors beyond land size, economies of scale and the agro-ecological framework.

**4.1.3. Summary**

We may summarise the results of the discussion on surplus. First, the lower size-groups (CCS as well as those taken in this thesis) had shown a negative surplus, as well as wide variations in the per hectare surplus. A number of farms within this size group had been associated with the highest per hectare surplus among all the farms, as well as lowest ones, implying greater variability. Second, while the surplus had shown a monotonic relationship with GCA, like input and output, between 1 and 1.5 ha, there was a sudden rise in input and a consequent fall in the

---

\(^9\) Due to very small number of farms in the two highest size-groups, no definite relationship could be observed, however.

\(^10\) 237 and 185 are the number of households, for CCS size-group 2 (1–2 ha) and 3 (2–4 ha).
surplus. This was reflected in an amplified form in the relationship between per hectare surplus with GCA, giving an inverse-U pattern, if we leave out very small farms. Third, there are factors other than the land size or GCA, scale of production and the bio-physical framework, that can explain the differences in the surplus or per hectare surplus, which may also serve as the key towards augmenting it. It can range from family size per holding or land size (NAS or GCA), to earner-dependent ratio. We will return to it.

4.2. Annual Sustainability
We may recall the primary aim of the thesis: of evaluating the ability of the land under cultivation to sustain the labour working on it. Certainly, it is to be carried out on an annual basis, and the surplus for such a purpose would be the ‘full and final’ annual surplus, that considers both cultivating and the non-cultivation period. We may begin with figure 4.2.1 that shows a minimum of 4 ha as the gross cropped area for a non-negative annual surplus. Figure 4.2.2 shows this minimum, while using CCS size-groups as an additional marker. Following our previous observation over surplus in scale C, we may note that for the lowest two size-groups, roughly half of the households reported a negative surplus; and for the third size-group (2–4 ha), a few.

Figure 4.2.1: Annual surplus (in MJ), against gross cropped area (in ha)
Figure 4.2.2: Annual Surplus (in MJ) against GCA, across size-groups

Gross Cropped Area (in ha)

Annual Surplus (in MJ)

- 1 (0-1 ha)
- 2 (1-2 ha)
- 3 (2-4 ha)
- 4 (4-6 ha)
- 5 (>6 ha)
In terms of net area sown, the more relevant variable in this regard, this minimum is around 2.5 ha, as shown in figure 4.2.3. It implies that it was not just the households in the lowest two size-groups, but for some of the households in the size-group 3 (2–4 ha) as well, cropping intensity was low (less than 1.5). Figure 4.2.4 plots this figure with CCS size-group as the additional marker, and shows more clearly this threshold of 2.5 ha for annual sustainability.

Certainly, of similar interest is the figure 4.2.5, that shows the same relationship as in figure 4.2.3 with agro-climatic zones as the marker. It shows that while the minimum land area that could ensure annual sustainability in the least developed red laterite zones was 2.5 ha, in a relatively better (and certainly not in absolute terms) coastal saline, it was around 1.2 ha. A more intriguing fact is the presence of many households in the terai zone, with a reported negative annual sustainability. Finally, while a handful of households in the old alluvial zone also reflected such a negative surplus, there was none from the new alluvial zone.

Figure 4.2.6 and 4.2.7 show the number of non-active days, that the surplus, if any, could sustain the household members and the animals in their possession, as was done for the illustrative household, against net area sown and annual output. In figure 4.2.7, we may notice the threshold output of around 700,000 MJ for ensuring annual sustainability. Further, while for the higher land sizes, a larger number of days beyond the annual sustenance were expected, what was
Figure 4.2.4: Annual Surplus (in MJ), against net area sown (in ha), across CCS size-groups.
Figure 4.2.5: Annual Surplus (in MJ), against net area sown (in ha), across Zones
Figure 4.2.8: No. of days beyond annual sustenance, against net area sown (in ha), across CCS size-groups.
Figure 4.2.9: No. of days beyond annual sustenance, against net area sown (in ha), across Zones
interesting is the presence of such high numbers against all CCS size-groups (see, figure 4.2.8). Finally, no clear trend could be found as far as agro-climatic zones were concerned (see, figure 4.2.9).

Figure 4.2.6: No. of days beyond the annual sustenance, against net area sown (in ha)

Figure 4.2.7: No. of days beyond the annual sustenance, against annual output (in MJ)
In figure 4.2.7, one may notice the agglomeration of farms closer to the horizontal axis with a few of them with a rather high number of days beyond annual sustenance. Table 4.2.1 aggregates the households on the basis of 12 output ranges, and presents some of the characteristics of the farms within each. Some of it has been portrayed in figure 4.2.10 (no of days beyond annual sustainability against output groups) and figure 4.2.11 (no of members of household along with no of animals in possession of the household against output groups).

### Table 4.2.1: No of days beyond annual sustenance, in relation to output-groups (in MJ)

<table>
<thead>
<tr>
<th>Output range (in MJ)</th>
<th>No of households</th>
<th>Annual surplus (in MJ)</th>
<th>GCA (in ha)</th>
<th>NAS (in ha)</th>
<th>No. of members of household</th>
<th>No of animals</th>
<th>Daily Energy requirement* (in MJ)</th>
<th>No of days ^</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 50,000</td>
<td>47</td>
<td>1914</td>
<td>0.28</td>
<td>0.19</td>
<td>4.51</td>
<td>0.08</td>
<td>43</td>
<td>93</td>
</tr>
<tr>
<td>50,000–100,000</td>
<td>52</td>
<td>21021</td>
<td>0.61</td>
<td>0.38</td>
<td>5.17</td>
<td>0.84</td>
<td>75</td>
<td>81</td>
</tr>
<tr>
<td>100,001–135,000</td>
<td>48</td>
<td>25460</td>
<td>0.97</td>
<td>0.75</td>
<td>6.7</td>
<td>1.18</td>
<td>101</td>
<td>838</td>
</tr>
<tr>
<td>135,001–180,000</td>
<td>50</td>
<td>45677</td>
<td>1.11</td>
<td>0.9</td>
<td>5.44</td>
<td>1.74</td>
<td>110</td>
<td>1246</td>
</tr>
<tr>
<td>180,001–225,000</td>
<td>48</td>
<td>46602</td>
<td>1.56</td>
<td>1.15</td>
<td>6.81</td>
<td>2.69</td>
<td>156</td>
<td>776</td>
</tr>
<tr>
<td>225,001–260,000</td>
<td>47</td>
<td>66018</td>
<td>1.65</td>
<td>1.3</td>
<td>7.04</td>
<td>3.08</td>
<td>172</td>
<td>830</td>
</tr>
<tr>
<td>260,001–305,000</td>
<td>54</td>
<td>90432</td>
<td>2</td>
<td>1.54</td>
<td>6.55</td>
<td>3.05</td>
<td>166</td>
<td>10.9</td>
</tr>
<tr>
<td>305,001–340,000</td>
<td>52</td>
<td>89473</td>
<td>2.21</td>
<td>1.67</td>
<td>6.71</td>
<td>3.92</td>
<td>200</td>
<td>548</td>
</tr>
<tr>
<td>340,001–380,000</td>
<td>50</td>
<td>115045</td>
<td>2.51</td>
<td>1.9</td>
<td>7.26</td>
<td>3.58</td>
<td>192</td>
<td>1351</td>
</tr>
<tr>
<td>380,001–440,000</td>
<td>48</td>
<td>130339</td>
<td>2.71</td>
<td>1.91</td>
<td>7.54</td>
<td>4.16</td>
<td>214</td>
<td>1187</td>
</tr>
<tr>
<td>440,001–580,000</td>
<td>50</td>
<td>208565</td>
<td>3.42</td>
<td>2.12</td>
<td>7.88</td>
<td>4.16</td>
<td>217</td>
<td>2234</td>
</tr>
<tr>
<td>More than 580,000</td>
<td>44</td>
<td>427278</td>
<td>4.48</td>
<td>2.84</td>
<td>6.86</td>
<td>4.5</td>
<td>221</td>
<td>4138</td>
</tr>
</tbody>
</table>

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

### Figure 4.2.10: No of days beyond annual sustenance in relation to annual output (in MJ)
Along the no of days curve, the first rise corresponding to the fourth output range in figure 4.2.10 is due to the sharp drop in the number of members of the household, as shown in figure 4.2.11. On the other hand, the fall at the eighth output group is due to the increase in the number of animals. In fact, figure 4.2.11 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, stated earlier in chapter 2.

Further, figure 4.2.11 also shows that there was not much variation from the average number of household members (6.58, see, 3.2.3.1), across the output ranges (and hence GCA). As a result, the increase in the daily energy requirements (as in the last column in table 4.2.1) 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.
Figure(s) 4.2.12–4.2.13 shows surplus of scale C against GCA per household size and NAS per household size respectively. Figure(s) 4.2.14–4.2.15 do the same for the annual surplus.

For a positive surplus during the cultivating period or scale C, it seems that a GCA of 0.7 ha per member of household or a little above 0.6 ha of NAS per household member is the threshold. On the other hand, for ensuring a positive annual surplus, the threshold are 0.7 ha per household member as in the case of surplus.
of scale C. However, in terms of NAS per household member, the threshold is close to 0.7 ha. This is one of the significant conclusions of this thesis.

Finally, in terms of number of earners per GCA and NAS, such threshold corresponds to 3 ha and 2 ha per earner respectively, for ensuring a positive surplus in the cultivating period, as shown by figure (s) 4.2.16 and 4.2.17. These
thresholds are not different for ensuring a positive annual surplus as well, as shown by figure(s) 4.2.18 and 4.2.19 respectively.

---

**Figure 4.2.16:** Surplus (in MJ) scale C in relation to GCA per earner in the household (in ha)

**Figure 4.2.17:** Surplus (in MJ) scale C in relation to NAS per earner in the household (in ha)
We may conclude this section with showing the relationship between the surpluses in four alternative scales of sustainability with the number of household members through figure(s) 4.2.20–4.2.23.11 Interestingly, except the very edges (namely with few single member household and the one with 25 members), for every other size, there had been households with a negative surplus. In other

11 Figure A.4.2.1-A.4.2.4 shows the same relationship with CCS size-groups as the marker.
words, household size per se cannot be an explanation to the negative surplus, but it is area under household or cultivation (GCA or NAS) per member of the household or the number of earners in the household.

Figure 4.2.20: Surplus (in MJ) scale A in relation to number of household members

Figure 4.2.21: Surplus (in MJ) scale B in relation to number of household members
Figure 4.2.22: Surplus (in MJ) scale C in relation to number of household members

Figure 4.2.23: Annual Surplus (in MJ) in relation to number of household members
4.3. EROI

EROI was calculated under all the four scales. For all plots together, they were 2.46, 2.25, 1.68 and 1.57 respectively. It may be noted that these numbers were arrived at by taking the ratio of total output and total input in each of the scales. Certainly, these averages did not reflect the variations and the underlying causes for it. Before we explore the patterns of EROI, we may note the total input, output, surplus and EROI under all the four scales, aggregated over our ranges of GCA as presented in Table 4.3.1.

<table>
<thead>
<tr>
<th>Gross Cropped Area (in ha)</th>
<th>Input, scale A</th>
<th>Output, scale A</th>
<th>Input, scale B</th>
<th>Output, scale B</th>
<th>Input, scale C</th>
<th>Output, scale C</th>
<th>Input, annual</th>
<th>Output, annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01–0.33</td>
<td>12948</td>
<td>22643</td>
<td>15447</td>
<td>22643</td>
<td>34816</td>
<td>38296</td>
<td>48228</td>
<td>51450</td>
</tr>
<tr>
<td>0.34–0.66</td>
<td>24605</td>
<td>52021</td>
<td>28137</td>
<td>52021</td>
<td>54769</td>
<td>73531</td>
<td>67865</td>
<td>83839</td>
</tr>
<tr>
<td>0.67–1.00</td>
<td>39390</td>
<td>88029</td>
<td>43144</td>
<td>88029</td>
<td>68884</td>
<td>116454</td>
<td>89877</td>
<td>138036</td>
</tr>
<tr>
<td>1.01–1.20</td>
<td>52393</td>
<td>122992</td>
<td>57627</td>
<td>122992</td>
<td>99880</td>
<td>166176</td>
<td>130080</td>
<td>196445</td>
</tr>
<tr>
<td>1.21–1.50</td>
<td>82063</td>
<td>145018</td>
<td>88998</td>
<td>145018</td>
<td>161570</td>
<td>202624</td>
<td>190638</td>
<td>233948</td>
</tr>
<tr>
<td>1.51–1.80</td>
<td>78802</td>
<td>164531</td>
<td>85729</td>
<td>164531</td>
<td>155529</td>
<td>227391</td>
<td>190134</td>
<td>248656</td>
</tr>
<tr>
<td>1.81–2.01</td>
<td>95338</td>
<td>197195</td>
<td>102469</td>
<td>197195</td>
<td>185772</td>
<td>262561</td>
<td>218001</td>
<td>291107</td>
</tr>
<tr>
<td>2.02–2.31</td>
<td>98044</td>
<td>204338</td>
<td>106486</td>
<td>204388</td>
<td>182317</td>
<td>295315</td>
<td>217913</td>
<td>322263</td>
</tr>
<tr>
<td>2.33–2.70</td>
<td>114395</td>
<td>242870</td>
<td>123641</td>
<td>242870</td>
<td>203134</td>
<td>314361</td>
<td>231032</td>
<td>334139</td>
</tr>
<tr>
<td>2.71–3.30</td>
<td>122937</td>
<td>284602</td>
<td>133863</td>
<td>284602</td>
<td>224841</td>
<td>370355</td>
<td>252331</td>
<td>389434</td>
</tr>
<tr>
<td>3.31–4.25</td>
<td>104963</td>
<td>375599</td>
<td>117863</td>
<td>375599</td>
<td>225844</td>
<td>474431</td>
<td>249652</td>
<td>483860</td>
</tr>
<tr>
<td>4.26–9.30</td>
<td>145612</td>
<td>604777</td>
<td>159996</td>
<td>604777</td>
<td>278746</td>
<td>722074</td>
<td>325097</td>
<td>733376</td>
</tr>
</tbody>
</table>

While we had noted the pattern of surplus of scale C against GCA, figure 4.3.1 does the same for all the four scales. As we move from a lower (say, A) to a higher (say, B) scale, surplus reduces almost uniformly, across the GCA. Figure 4.3.1 shows the same pattern against output ranges. A closer look reveals a fall in each
of the surplus lines against the GCA range of 1.01–1.2 ha, and a sharp change in
the slope against the GCA range of 2.33–2.70 ha. However, no such distinct
changes can be observed in the surpluses against output ranges in figure 4.3.2.
These two GCA ranges may be taken note of, as a similar pattern will be revealed
by EROI of all the four scales.

Figure 4.3.1: Surplus (in M.J) of four scales, against GCA (in ha)
Figure 4.3.2: Surplus (in MJ) in four scales, in relation to Output (in MJ)
Figure 4.3.3 portrays the relationship between EROI and the GCA in all the four scales. While all four show a similar overall relationship, there are important differences. Overall, the trend shows increase in EROI, with GCA, with a drop in the middle. Indeed, the latter points to the absence of any definite benefits from the opportunities in the increase in the scale of operations due to larger gross area under cultivation. Further, leaving the households of the lowest three size-classes (0–1 ha), the remaining portion of the curve(s) in each of the scales are U–shaped with a long flat portion in the middle; while the extent of fall in EROI with rise in GCA is less, the rise is quite sharp for the last three size-groups. However, as we have noted in the previous section, it is not the absolute land size that is in question but the land with respect to the size of the household that has a significant causal effect on the surplus or the sustainability of the labour engaged in crop cultivation.

Figure 4.3.4 shows the relationship between the EROI in the four scales against annual output (in MJ). We may note the positive relationship beyond the output of 20,000 MJ, in scales C and the annual one. In contrast to figure 4.3.3, the flat portions of all the four scales are longer, implying a more uniform input-output
relationship against scales of production. As a consequence, the 'fluctuation' towards the lower end of the horizontal axis is more concentrated.

Together, we may note the following, besides the average EROI s in the four scales of sustainability, namely, 2.46, 2.25, 1.68 and 1.57: while for the GCA beyond 3.30 ha, EROI of even the annual scale is a decent one, such a threshold corresponds to an annual output of 440,000 MJ.
4.4. Rate of Surplus value

We may reiterate that we had taken the rate of surplus value for scale C, or only the cultivating (active) period. It is the ratio of the surplus in scale C and the value of the labour power in scale C.

![Figure 4.4.1: Rate of Surplus Value, in relation to gross output, scale C (in MJ)](image)

Figure 4.4.2 plots rate of surplus value against gross output of scale C. Besides the rising trend, two other important facts may be noticed. The first is the presence of a considerable number of households with a negative rate of surplus value and the other is the rather high rates of for low levels of output: these points to the greater variance among the smaller land sizes which are associated with lower size of output (table 4.1.1). None of the two is an exception but reflect important characteristics of the agricultural production system. The former results from the negative surplus that we had notice earlier also.

12 For the convenience of visual representation, the following households were not considered in figure(s) in this section 4.4.

<table>
<thead>
<tr>
<th>EROI, scale C</th>
<th>Surplus/ GCA</th>
<th>GCA</th>
<th>Cropping intensity</th>
<th>Labour/ GCA</th>
<th>S/V</th>
<th>Zone</th>
<th>Size-group</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.79</td>
<td>-869873</td>
<td>0.01</td>
<td>1</td>
<td>301150</td>
<td>-2.88851</td>
<td>II. Terai</td>
<td>1 (0–1 ha)</td>
</tr>
<tr>
<td>0.28</td>
<td>-247091</td>
<td>0.04</td>
<td>1</td>
<td>163088</td>
<td>-1.51507</td>
<td>IV. Old Alluvial</td>
<td>1 (0–1 ha)</td>
</tr>
<tr>
<td>0.75</td>
<td>-41621</td>
<td>0.05</td>
<td>1</td>
<td>161219</td>
<td>-0.25816</td>
<td>IV. Old Alluvial</td>
<td>1 (0–1 ha)</td>
</tr>
<tr>
<td>0.99</td>
<td>-2340.8</td>
<td>0.05</td>
<td>1</td>
<td>201449</td>
<td>-0.01162</td>
<td>VI. Coastal Saline</td>
<td>1 (0–1 ha)</td>
</tr>
</tbody>
</table>
Figure 4.4.2: Rate of Surplus Value, against Output, scale C, across CCS size-groups"
Figure 4.4.3: Rate of Surplus Value, against Output, scale C, across Zones
We may recollect that the negative surplus results only when the energy value of the difference between the gross output and the inputs is negative (or the value created by the labour is less than the value of labour power). Figure 4.4.1 confirms that these farms mostly belong to the two lowest CCS size-groups. Similarly, figure 4.4.2 shows that they mostly belong to zone V and VI. Certainly, with a tiny land, and a not so conducive bio-physical framework, these households had no other means to produce a surplus.

Figure(s) 4.4.4 and 4.4.5 show the rate of surplus value against GCA per household member and NAS per household member. Arguably, figure 4.4.5 makes it amply clear the positive association between the rate of surplus value and the land in possession per household size.

Further, as expected per hectare labour of scale C for the low levels of output was very high. Small farm sizes, no doubt, had a role in scaling up the number, but such a phenomenon can be witnessed against output levels of 200,000 MJ also.

---

Figure(s) A.4.4.1 and A.4.4.2 shows the same relationship with CCS size-group as marker.
Figure 4.4.5: Rate of Surplus value in relation to NAS per household member (in ha)

Figure 4.4.6: Per hectare labour, scale C (in MJ/ha) in relation to output (in MJ)

Figure 4.4.7 confirms that such high labour per hectare indeed is associated with the lowest two CCS size-groups. With increase in the area under cultivation (or, if we move from lower to subsequently higher size-groups), labour per hectare reduces, an obvious and known fact.
Figure 4.4.8 portrays a more nuanced relationship between labour per hectare and output with agro-climatic zones as the markers. One may observe the association of a very high labour per hectare with all the zones. Further, for a given per hectare labour, say, around 10,000 MJ/ha, lowest output was achieved in red laterite, followed by coastal saline and then by both the alluvial zones. At the same time, for each of the zones, the negative relationship between per hectare surplus and output is visible enough.

Figure(s) 4.4.9 and 4.4.10 shows per hectare labour of scale C against GCA and NAS per number of household members respectively.
Figure 4.4.7: Per hectare Labour (in MJ/ha), against Output, both in scale C, across CCS size-groups.
Figure 4.4.8: Per hectare Labour (in MJ/ha), against Output, both in scale C, across Zones
Besides the obvious negative relationship between per hectare human labour in scale C (in MJ) and the land under cultivation per household size (in ha), be it for GCA or for NAS, we may also note the human labour per hectare in scale(s) of A and B against the GCA per household size in figure(s) 4.4.11 and 4.4.12 respectively.

**Figure 4.4.11: Human labour, scale A per hectare (in MJ/ha) in relation to GCA/no of household members (in ha)**

**Figure 4.4.12: Human labour, scale B per GCA (in MJ/ha) in relation to GCA/no of household members (in ha)**
These figures (4.4.4, 4.4.9–4.4.12) together make it obvious that while rate of surplus value is positively associated with land area per household size, per hectare human labour in the different scales (of A, B and C) is negatively related with land per household size. It appears that per hectare labour against GCA/household size remains relatively static beyond 0.6 ha/no. of members.

4.5. Summary of the Chapter

We may summarise the findings of this section:

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. A positive annual surplus was independent of the number of household members, as for households with very small size (say, 3), as well as very large size (say, 20) was found to be associated with it. On the other hand, 3 ha of GCA/household size and 2 ha of NAS/household size was found to be the critical limits for ensuring a positive annual surplus in energy terms.

5. Highest surplus in absolute terms and also in per hectare terms was found to be corresponding to a cropping intensity of 1.2–1.5. However, both size-class and agro-climatic environment showed varied relationships.

6. Surplus in all four scales of sustainability was found to be monotonically increasing against gross output. Similarly, output and GCA, and consequently surplus and GCA had shown similar patterns.

---

14 Figure(s) A.4.4.3 and A.4.4.4 shows per hectare labour, scale C against GCA per household size and NAS per household size respectively, with CCS size-groups as the additional marker.
7. EROI had shown a monotonic relationship with output, beyond a level of output around 200,000 MJ. With respect to GCA, besides the general rising pattern it had shown a sharp drop in the middle, and a very sharp rise against the largest GCA. EROI curves for the all four scales, be it against GCA or output, had shown a gradual downward movement, with shift from scale B to scale C having the largest shift.

8. Per hectare labour against was found to be relatively static beyond 0.6 ha/household member. A similar threshold (0.7/ha for GCA/household member and 0.6/ha for NAS/household member) was also found towards ensuring a positive surplus in energy terms.

In the end, a few facts stand out: the first is the large number of farms with a negative surplus, and the consequent negative rate of surplus value. Second is the positive relationships between output on the one hand and either the surplus or the GCA on the other. A related matter was a similar pattern for EROI. Third, towards a positive surplus in energy terms, the average threshold per household member land was found to be 3 ha in terms of GCA and 2 ha for NAS. The variations reflected the developments in the means of production and the associated bio-physical framework.

We may finish this chapter by stating that the results of a negative surplus is stronger than the FMS finding of only a negative profit, with a positive surplus in energy terms across the size-groups.15

---

15 We shall return to it in chapter 6.