# 4. RESULTS

## 4.1 FARMER SURVEYS

Village averages for wheat and maize productivity in 2003 were 5.60 bags/acre and 6.06 bags/acre, respectively. Table 4.1.1 shows variations in wheat and maize productivity that occur over the village's soil types that are highly suitable for cultivation. As wheat is only grown in the Northern region and at the highest altitudes in the Central region, a productivity value is not given for wheat grown in the Southern region. Fields in the alluvial soil type reported the highest productivity for both crops, which is significant for wheat against soil types RU1 ($p < 0.005$, $n = 11$) and RU2 ($p < 0.0001$, $n = 15$) and for maize against RL1 ($p < 0.0001$, $n = 17$) and RU2 ($p < 0.0001$, $n = 26$). RU1 soils reported higher productivity than RU2 soils for both crops (significant only for maize: $p < 0.0005$, $n = 26$), as was also the case in 2002 (see appendix). RU1 also had significantly higher productivity than RL1 for maize ($p = 0.0001$, $n = 17$). L1's maize productivity is significantly higher than RL1's ($p = 0.0005$, $n = 17$) as well as RU2's ($p < 0.005$, $n = 26$). For crop population sizes (n) for each soil type, please refer back to Table 3.1.2.

**Table 4.1.1** 2003 average crop productivity by region/soil type

| Region | Soil type | Wheat (bags/acre) | | Maize (bags/acre) | |
|---|---|---|---|---|---|
| n/a | Alluvial | 9.3 | | 9.7 | |
| Northern | RU1 | 5.3 | 5.8 | 6.5 | 8.1 |
| | RU2 | | 4.9 | | 6.0 |
| Central | RL1 | 6.1 | | 5.3 | |
| Southern | L1 | n/a | | 7.7 | |

*only soils highly suitable for cultivation are included in this table.

Table 4.1.2 shows variations in wheat and maize productivity that occur with respect to field age and the management factors included in the survey (tillage method,

manure usage, residue grazing, and presence of contour ridges). The "rating" factor, as described in section 3.1, indicates productivity based on a field's usage of *all* management factors. For crop population sizes (n) for each management factor, please refer back to Table 3.1.3.

**Table 4.1.2** Crop productivity for wheat and maize by field age and management practices

| | | Wheat (bags/acre) | Maize (bags/acre) |
|---|---|---|---|
| Field age | Cleared in or before 1976 | 5.4 | 5.8 |
| | Cleared after 1976 | 7.3 | 6.5 |
| Tillage | Ox-plough | 7.2 | 5.5 |
| | Tractor | 5.2 | 6.3 |
| Manure | Used | 5.6 | 6.4 |
| | Not used | 5.4 | 5.5 |
| Residue grazing | Not allowed | 5.6 | 6.3 |
| | Allowed | 5.0 | 5.8 |
| Contour ridges | Vegetated | 5.7 | 6.8 |
| | Bare/none | 5.3 | 5.6 |
| Rating | Highest third | 5.7 | 7.2 |
| | Lowest third | 5.1 | 5.4 |

* Values in red are above the village averages of 5.60 and 6.06 bags/acre of wheat and maize, respectively.

In all but one case, use of positive management practices is accompanied by significantly higher crop productivity (Table 4.1.3) and, in that one case, the higher maize productivity reported for fields tilled by tractor is only marginally significant ($p < 0.1$, $n = 32$). Significance values are not reported for the "rating" factor, as this factor is derived from the relative significance of each individual management factor. Similar trends are apparent in the 2002 data (see appendix), although their significance was not assessed.

The two wheat and six maize fields that utilized all positive management practices reported an average of 10.4 bags/acres and 7.3 bags/acre, respectively. By contrast, two wheat and two maize fields did not utilize any positive management

practices: the wheat fields had an average 4.5 bags/acre, while one of the maize fields reported 1.6 bags/acre and the other reported a crop failure.

**Table 4.1.3** Significance of younger field age/positive management practices and higher productivity

| Age/management practice | Wheat | | Maize | |
|---|---|---|---|---|
| | Significance | n | Significance | n |
| Cleared after 1976 | $p < 0.025$ | 5 | $p < 0.1$ | 26 |
| Tillage by ox-plough | $p < 0.01$ | 9 | n/a | n/a |
| Manure used | $p < 0.025$ | 20 | $p < 0.005$ | 37 |
| No residue grazing | $p < 0.025$ | 17 | $p < 0.1$ | 33 |
| Vegetated contour ridges | $p < 0.025$ | 22 | $p < 0.005$ | 30 |

Demographic data were used in part to develop socioeconomic groupings, as described in section 3.1. Demographic data for each socioeconomic group and for the entire village appear in Table 4.1.4 and Table 4.1.5. Table 4.1.4 shows that the vast majority of fields, independent of socioeconomic status, are owned by farmers who do not have income other than crops and have only received a primary education. Table 4.1.5, however, indicates that there exists substantial inequity in terms of livestock head and crop surplus income: group A farmers make more than 8 times the amount per field and have over 30 times the number of head of livestock per field than a farmer of group D. In both tables demographic data are indicated as *values for fields* for compatibility with subsequent tables (values for individual farmers appear as appendix); this means that a farmer's demographics are counted twice if he owns two separate fields but, more importantly, that, e.g., a field owned by a farmer of group B generates an average surplus of $335 per harvest. Equations for crop surplus income, family size, and livestock number are in section 3.1.

**Table 4.1.4** Survey demographics (n) by socioeconomic group with percentages relative to socioeconomic group size

| Demographic | | n A | n B | n C | n D | n Village |
|---|---|---|---|---|---|---|
| Education | Secondary | --- | 5 (14%) | 2 (12%) | --- | 7 (9%) |
| | Primary | 15 (100%) | 31 (86%) | 10 (59%) | 8 (67%) | 64 (80%) |
| | None | --- | --- | 5 (29%) | 4 (33%) | 9 (11%) |
| Other income besides crops | Yes | 2 (13%) | 5 (14%) | 1 (6%) | --- | 8 (10%) |
| | No | 13 (87%) | 31 (86%) | 16 (94%) | 12 (100%) | 72 (90%) |

* Values are for fields.

**Table 4.1.5** Crop surplus income and survey demographics by socioeconomic group

| Demographic | A | B | C | D | Village |
|---|---|---|---|---|---|
| Crop surplus | $436 | $335 | $170 | $52 | $276 |
| Family size | 12.8 | 10.7 | 7.9 | 8.5 | 9.4 |
| Livestock | 45.6 | 18.1 | 9.2 | 1.5 | 18.9 |

* Values are for fields.

Tables 4.1.6 and 4.1.7 show how land is distributed among socioeconomic groups. The results in Table 4.1.6 indicate that wealthier farmers (A and B) own a considerably greater proportion of the village's land than do poorer farmers (C and D), particularly in terms of wheat. Table 4.1.7 indicates that wealthier farmers also own a greater proportion of land in the more naturally fertile soils of the Northern region than do poorer farmers.

**Table 4.1.6** Distribution of land and field types by socioeconomic group

| Socioeconomic group | n Farmers | Acres wheat | Acres maize | Acres total |
|---|---|---|---|---|
| A | 8 (16%) | 59.0 (7.4) | 55.0 (6.9) | 114.0 (14.3) |
| B | 18 (36%) | 80.0 (4.4) | 106.5 (6.0) | 186.5 (10.4) |
| C | 14 (28%) | 15.75 (1.1) | 44.75 (3.2) | 60.5 (4.3) |
| D | 10 (20%) | 7.0 (0.7) | 27.5 (2.8) | 34.5 (3.5) |
| Village | 50 | 161.75 (3.2) | 233.75 (4.7) | 395.5 (7.9) |

* Parenthetical values represent acres/farmer ratio, except in column 2, where percentages are relative to the village total number of farmers.

**Table 4.1.7** Geographic distribution of land by socioeconomic group

| Region | Soil type | A acres | | B acres | | C acres | | D acres | |
|---|---|---|---|---|---|---|---|---|---|
| n/a | Alluvial | --- | | 13.5 (0.8) | | 4.5 (0.3) | | --- | |
| Northern | RU1 | 110.0 (13.8) | 54.0 (6.8) | 100.0 (5.6) | 23.0 (1.3) | 22.5 (1.6) | 17.5 (1.3) | 18.0 (1.8) | --- |
| | RU2 | | 56.0 (7.0) | | 77.0 (4.3) | | 5.0 (0.4) | | 18.0 (1.8) |
| Central | RL1 | 4.0 (0.5) | | 51.0 (2.8) | | 29.0 (2.1) | | 10.5 (1.1) | |
| Southern | L1 | --- | | 10.0 (0.6) | | 5.0 (0.4) | | 5.0 (0.5) | |

* Parenthetical values represent acres/farmer ratio; only soils highly suitable for cultivation are included in this table.

Table 4.1.8 shows the degree to which positive management practices are utilized by each socioeconomic group. Wealthier farmers reported higher usage of manure, whereas poorer farmers reported higher usage of ox-ploughs and vegetated contour ridges. As wealthier farmers had higher ratings overall, this indicates that they are utilizing to a greater extent conservation measures that have a more positive impact on crop productivity. The distribution of field ages suggests that most fields owned by farmers of groups A, B, and C were cleared before villigization; however, it is quite likely that most of these fields owned by farmers of group B and especially group C were received from villigization, while at least several owned by A farmers were reclaimed after villigization. Half of the fields owned by group D farmers were cleared after 1976 (all of which are located in the Central and Southern regions), providing another indicator of the degree to which they have been marginalized.

**Table 4.1.8** Management practices and field age populations (n) by socioeconomic group

| | | n A | n B | n C | n D |
|---|---|---|---|---|---|
| Field age | Cleared in or before 1976 | 13 (87%) | 22 (61%) | 12 (71%) | 6 (50%) |
| | Cleared after 1976 | 2 (13%) | 14 (39%) | 5 (29%) | 6 (50%) |
| Tillage | Ox-plough | 5 (33%) | 11 (31%) | 13 (76%) | 8 (67%) |
| | Tractor | 9 (60%) | 24 (67%) | 4 (24%) | 4 (33%) |
| Manure | Used | 11 (73%) | 21 (58%) | 6 (35%) | 6 (50%) |
| | Not used | 3 (20%) | 14 (39%) | 11 (65%) | 6 (50%) |
| Residue grazing | Not allowed | 6 (40%) | 18 (50%) | 9 (53%) | 9 (75%) |
| | Allowed | 7 (47%) | 14 (39%) | 7 (41%) | 3 (25%) |
| Contour ridges | Vegetated | 5 (33%) | 16 (44%) | 8 (47%) | 6 (50%) |
| | Bare/none | 9 (60%) | 17 (47%) | 7 (41%) | 6 (50%) |
| Rating | Highest third | 7 (47%) | 13 (36%) | 4 (24%) | 4 (33%) |
| | Lowest third | 6 (40%) | 9 (25%) | 6 (35%) | 5 (42%) |

* Percentages are relative to socioeconomic group size; all values are for fields.

As crop productivity is significantly related to both conservation measure usage and field age (Table 4.1.3), Table 4.1.9 shows their interrelation among socioeconomic groups. For instance, while groups A and B have comparable mean ratings for both

wheat and maize, productivity is higher for both crops in fields owned by farmers of group B. This may be due in part to the younger field ages reported by group B.

**Table 4.1.9** The interrelation of crop productivity, positive management practices rating, and field age by socioeconomic group

| | Crop | A | B | C | D | Village |
|---|---|---|---|---|---|---|
| Productivity (bags/acre) | Wheat | 5.1 | 5.6 | 8.1 | 5.1 | 5.6 |
| | Maize | 6.1 | 6.7 | 6.0 | 3.5 | 6.1 |
| Mean rating | Wheat | 24.0 | 24.8 | 27.7 | 12.3 | 22.5 |
| | Maize | 22.3 | 22.4 | 17.8 | 16.7 | 19.4 |
| Mean field age (years) | Wheat | 48.1 | 37.1 | 37.4 | 60.5 | 41.3 |
| | Maize | 35.2 | 28.6 | 30.9 | 31.4 | 30.7 |

One final consideration is that crop productivity is significantly influenced by field size. For fields less than 5 acres, crop productivity for wheat and maize were reported as 8.4 and 7.4 bags/acre, respectively. For fields 5 acres or greater, these values are 5.0 and 5.5 bags/acre. These differences are highly significant ($p < 0.0001$) for fields of both wheat ($n = 22$) and maize ($n = 32$). Table 4.1.10 shows how field size is distributed among the other factors previously been discussed.

**Table 4.1.10** Distribution of large and small fields by socioeconomic group, soil type, field age, and positive management practices rating

| Field size | Mean field age | Mean | Socioeconomic group | | | | Soil type | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (acres) | (years) | rating | A | B | C | D | A | RU1 | RU2 | RL1 | L1 |
| >= 5 | 36.0 | 19.13 | 60% | 61% | 35% | 25% | 0% | 46% | 58% | 67% | 40% |
| < 5 | 29.8 | 19.62 | 40% | 39% | 65% | 75% | 100% | 54% | 42% | 33% | 60% |

* Percentages are relative to the survey population for each group/type; only soils highly suitable for cultivation are included in this table.

## 4.2 REMOTE SENSING

### *Soil and land use mapping*

A soil type map is superimposed on the post-harvest (October) ASTER image, appearing as Figure 4.2.1. The soil type map correctly classified 85% ($n = 100$) of the georeferenced points taken in the village. Of the 15 points where discrepancies

were found, 8 occurred in intersections of alluvial/valley areas, 3 in intersections of L2/valley areas, 3 in intersections of RU1/2 areas, and 1 in an intersection between RU2/valley. Upon subsequent review of site descriptions, it appears that 9 of the 15 discrepancies resulted from misclassification in the field rather than remotely. The areas of each region/soil type, as calculated from this map, appear in the first column of Table 4.2.1.

A land use map is superimposed on the post-harvest (October) ASTER image and appears as Figure 4.2.2. Figure 4.2.3 shows the same land use map, but subdivides fields into those that were mostly bare and those that had a discernable amount of vegetation (i.e., residues) present in the October image (refer back to methods 3.2 for their derivation). The land use map correctly classified 83% (n = 100) of georeferenced points as a land use type of either dense bush/graze, sparse bush/graze, or fields. Of the 17 incorrectly classified, 9 occurred in alluvial/valley areas and the remaining occurred throughout the village: 7 confused sparse bush/graze with fields and 1 confused sparse bush/graze with dense bush/graze. As the October ASTER image was taken almost a year prior to field work in 2003, a small portion of this error may be due to subsequent changes in land use. Tables 4.2.1 and 4.2.2 show the area of each land use type in the village and relative to each region/soil type.