Chapter VI

Comparison of Laboratory and Farmers' Fertility Indices

6.1 Indices of soil fertility and farmers' indicators

6.1.1 Structure of interviewees

In terms of age, 90% of the surveyed interviewees were above 30 years of age and the 10% were inbetween 20 to 30 years of age (Figure 34). Sixty-five percent of the interviewees were females and the rest males. The number of males and females were equal in two age groups above 60 years of age, the number of males decrease as we move to younger age group. This trend suggests that the more males are away for off-farm activities and are not available at the time of interview as interview was done with most experienced available member of a family.

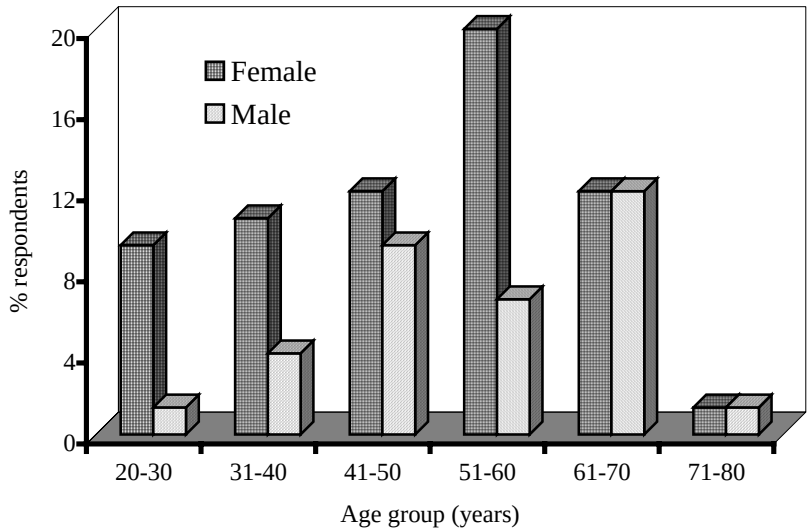

Figure 34. Structure of interviewees.
(Source: Survey, 2005).

6.1.2 Soil fertility indices by laboratory method and farmers' ratings

The farmers' assessment of overall soil fertility based on linguistic scale of poorly fertile, moderately fertile and highly fertile were converted to numeric categorical values by assigning inverse ranks (Stillwell *et al.*, 1981) as in Table 23:

Table 23. Farmers' soil fertility indices.

Farmers' ratings	Index assigned	Number of indices
Poorly fertile	1	18
Moderately fertile	2	41
Highly fertile	3	16
Total		75

(Source: Survey, 2005).

These numeric ordinal values are treated as the farmers' soil fertility indices and are referred to as farmers' soil fertility indices. The soil fertility indicators that the farmers used are presented in Table 25 and degree of importance of the prioritized indicators are presented in Table 26 and data on these two Tables could be used to generate farmers' fertility indices. Due to lack of sufficient information the farmers' fertility indicators and weights for the most important indicators are not used to generate the indices. Indices presented in Table 23 are based on the direct questions of questionnaire survey.

The soil fertility indices obtained by using soil chemical analysis result is presented in Table 24. The total number of indices for point to point statistical comparison is 75, that is, for the same surveyed sites as in the case of farmer assessed sites. The total number of indices for point to overlay spatial comparison is 97, that is the total sampled sites for all agricultural land uses. The reason for using all the 97 laboratory indices for generating prediction surface for point to overlay spatial comparison is to produce the best reflection of the reality in the field on which farmers' assessment is based.

Table 24. Technical or laboratory soil fertility indices.

Fertility category	Index	Number of indices for point to point statistical comparison	Number of indices for point to overlay spatial comparison
Low	1	14	24
Moderate	2	57	62
High	3	4	11
Total		75	97

Soil compactness (13.0% by weight) is an important indicator of farmers' soil fertility as shown by the results of Analytical Hierarchy Process workshop (Table 26) and household survey (Table 25). Therefore it was decided to combine it with the chemical fertility attributes to make soil productivity indices. However, since the bulk density values were low with 88% (66 out of 75) sites having bulk density values of less than 1.4 g/cm^3. This means that most of the sites fell under most favorable categories with high scores (3 or 2) changing all the points to moderate and high soil fertility indices, while categorizing based on Arshad *et al*. (1996) and Handreck and Black (1994).

Since, other attributes of available P, available K and organic matter are low in most of the areas, the inclusion of bulk density would deviate the output from reflecting the reality. Many soils in Bhutan are said to have low bulk densities and that the normal correlation between soil texture and available water holding capacity (AWHC) do not hold (BSS/NSSC, 2003). There is weak negative correlation (r = – 0.28) between organic C and bulk density in the study area suggesting that with the increase in organic matter in the soil there is a decreasing trend in soil bulk density.

6.1.3 Farmers' indicators of soil fertility

Farmers' indicators of soil fertility as gathered through the household survey, as presented in Table 25, are: crop yield, soil texture, soil color, soil compactness, soil depth, response to manure/fertilizer, stoniness, weediness, soil workability and land

sloppiness. Crop yield is ranked as top rank by 100 percent of surveyed households as their indicator of soil fertility. This is in line with findings of Norbu and Floyd (2004) that most of the surveyed farmers' used crop yield as an indicator of soil fertility. From looking at the second rank column, texture, color, compactness, depth and stoniness are ranked second by 38.67%, 28.00%, 10.67%, 14.67% and 8.00% of households, respectively (Table 25).

Table 25. Structure of farmers' ranking of their soil fertility indicators.

Farmers' indicator of soil fertility	% households ranking (straight ranks)					Total
	1st	2nd	3rd	4th	5th	
Crop yield	100.00	0.00	0.00	0.00	0.00	100.00
Soil texture	0.00	38.67	21.33	6.67	20.00	86.67
Soil color	0.00	28.00	28.00	21.33	14.67	92.00
Soil compactness	0.00	10.67	25.33	32.00	24.00	92.00
Soil depth	0.00	14.67	0.00	10.67	22.67	48.00
Response to manure/fertilizer	0.00	0.00	6.67	4.00	8.00	18.67
Stoniness	0.00	8.00	0.00	9.33	0.00	17.33
Workability	0.00	0.00	4.00	0.00	8.00	12.00
Weediness	0.00	0.00	12.00	4.00	2.67	18.67
Land sloppiness	0.00	0.00	2.67	12.00	0.00	14.67
Total	100.00	100.00	100.00	100.00	100.00	500.00

n = 75

(Source: Survey, 2005).

6.1.4 Farmers' weight of soil fertility indicators

The weighting of indicators were done by two methods, AHP and ranking. The results of pairwise comparison using AHP and ranking carried out with the GYT members of the *geog* is presented in Table 26. The details of AHP and ranking procedures and consistency ratio calculations are presented in Appendix I. By any three weighting technique the indicators are in order of importance crop yield> texture> color> compactness> soil depth. Since the AHP technique has strong

scientific basis and ranking does not, we could take the weights derived from AHP as more close to reality. Farmers' value crop yield by 49.1% weight followed by three other indicators; texture, color and compactness whose weights are: 16.5%, 14.8% and 13.0%, respectively. Soil depth is weighted at 6.7% by AHP. These weights compared favorably with the results of household survey as 100 percent farmers interviewed used crop yield as their indicator. Moreover, soils' texture, color, compactness, depth and stoniness are ranked at second by 38.67%, 28%, 10.67% and 14.67% and 8% households, respectively (Table 25).

Table 26. Weights of main soil fertility indicators.

Farmers' indicator of soil fertility	Weight by AHP	Weight by ranking	
		Rank sum	Rank reciprocal
Crop yield	0.491	0.333	0.438
Soil texture	0.165	0.267	0.219
Soil color	0.148	0.200	0.146
Soil compactness	0.130	0.133	0.109
Soil depth	0.067	0.067	0.088
Total	1.000	1.000	1.000

(Source: Workshop, 2005).

6.2 Comparison between farmers' and laboratory indices

6.2.1 Point to overlay spatial comparison

The total number of soil fertility index points used to generate prediction surface of technical soil fertility indices is 97. The reason for using all the 97 laboratory indices for generating prediction surface for point to overlay spatial comparison is to produce the best reflection of the reality in the field on which farmers' assessment is based. The farmers' 75 indices are overlaid on the technical surface as shown in Figure 35.

What we can see from Figure 35 is that most of points of farmers' index points match with that of laboratory soil fertility surface. We can see that four of the 16

farmers' high fertility indices (green filled circles) are overlain in technical high fertility surface. Most of farmers' low fertility indices (red filled circles) are overlain in low technical surface. But there is clear indication from the spatial distribution of these two classes of indices together is that none of farmers' high fertility indices are overlain in low technical surface and none of the farmers' low fertility indices points are overlain in the high technical surface, except for one point in Lakhu. Soil fertility status is high in the villages of Lakhu and Pakcheykha. Most of lands in Zamdongkha and Khuruguma are in low fertility status by both technical and farmers' method of assessment. The pattern of spatial distribution of these two classes of indices strongly suggests that they are related and that farmers' are to some extend able to assess soil's properties.

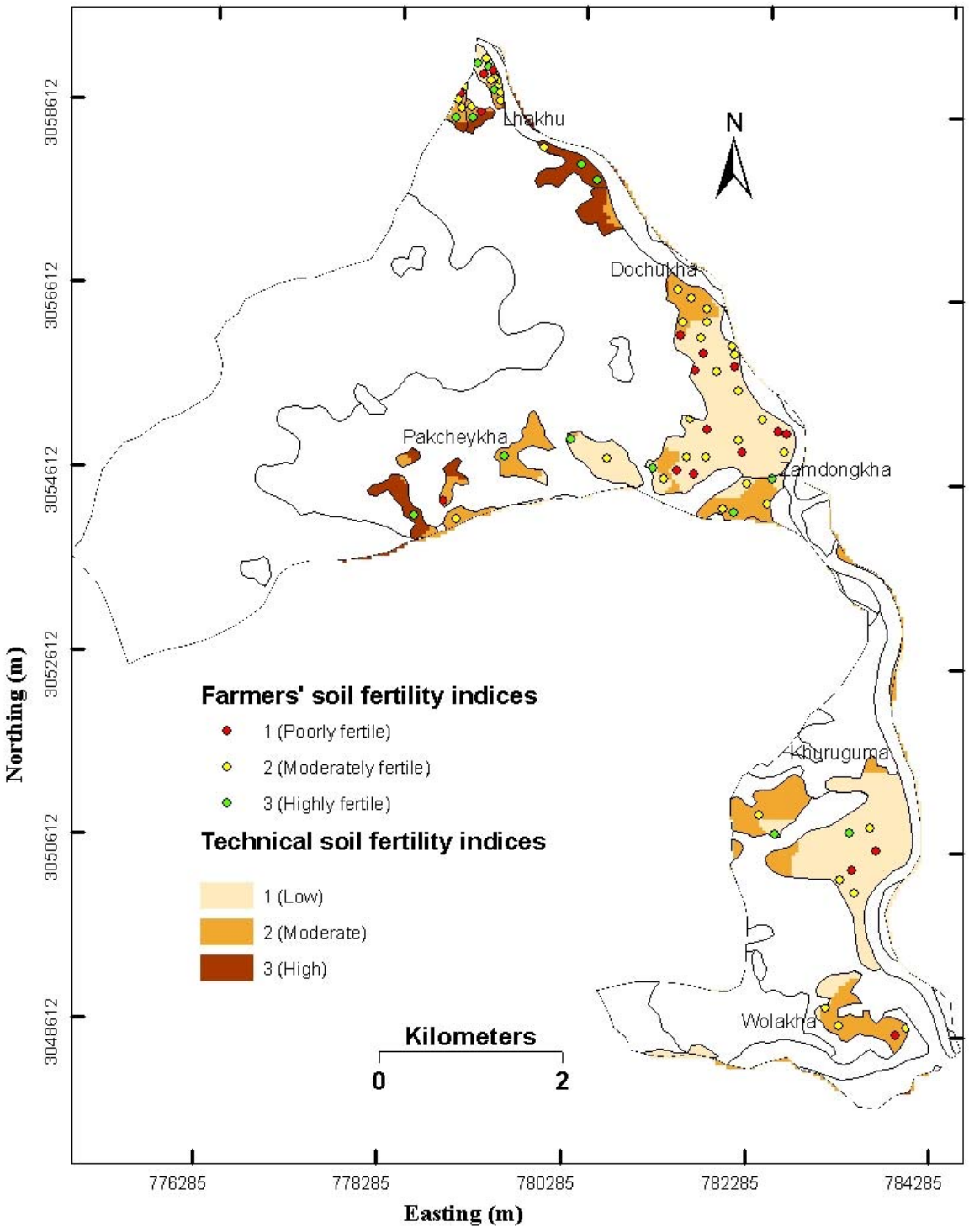

Figure 35. Point to overlay comparison of farmers' and technical soil fertility indices.

6.2.2 Point to point statistical comparison

The crosstabulation between farmers' indices and laboratory indices are presented in Table 27 as done for chi-square tests. From the diagonal cells in shade one can see the percentages within laboratory indices that matched with farmers' indices. Percentages of relatedness within laboratory index 1 to farmers' index 1 is 87.5%, laboratory index 2 to farmers' index 2 is 66.7% and laboratory index 3 to farmers' index 3 is 75%.

Chi-square tests that the two variables are 'not related'. A chi-square probability of 0.05 or less is commonly interpreted as justification for rejecting the null hypothesis that the row variable (laboratory indices) is unrelated (that is, only randomly related) to the column variable (farmers' indices). From chi-square tests we find that significance levels of chi-square is <0.05, leading to reject the null hypothesis and that farmer's soil fertility indices are significantly related to laboratory or technical soil fertility indices. This means that what is measured from soil chemical analysis is related to what the farmers' based their subjective judgments upon. Farmers' weight for yield as an indicator of soil fertility is 49.1% (Table 26) and the yield is directly influenced soil nutrients available for uptake by crops.

Table 27. Crosstabulation between farmers' indices and laboratory indices.

			Farmers' indices			Total
			1	2	3	
Laboratory Indices (Lab)	1	Count	12	2	0	14
		% within Lab	85.7%	14.3%	.0%	100.0%
	2	Count	6	38	13	57
		% within Lab	10.5%	66.7%	22.8%	100.0%
	3	Count	0	1	3	4
		% within Lab	.0%	25.0%	75.0%	100.0%
Total		Count	18	41	16	75
		% within LL	24.0%	54.7%	21.3%	100.0%

6.2.3 Practical relevance of comparing laboratory and farmers' indices

Planning and implementation of development activities are decentralization in Bhutan to the grassroots at the geog level from 9th Five Year Plan (Planning Commission Secretariat, 2002) and it is essential to recognize local knowledge. Research aimed at improving agricultural and natural resources management is likely to be more effective when local people have a voice in their own development and which means that research must embrace 'local' knowledge (Pretty, 1995). Since farmers' are entrusted to their own development activities, their knowledge of soil fertility may be used in relation with scientific finding to address issues and problems of soil management to produce a locally informed development plans and interventions of relevance to local people (Sillitoe, 1998a). Although it is difficult to compare every fertility attributes/indicators by laboratory and farmers' approaches, the indices provide a way forward towards this end. These two indices have significant statistical relatedness, although there are areas of disagreement in farmers' fertility points overlaid on the surface of laboratory indices. Since the indices by the two knowledge systems are related, outcomes can be used complementarily to benefit from the synergy of using both local and scientific knowledge.