soils; therefore, regardless of whether residues are present, even “bare” fields have a higher amount of surface cover in the October image (see Table 4.4.3 for SLA-NDVI derived cover values within bare/residue field types). Weeds and grasses are most likely not present in the October image’s bare fields for the other soil types, as these were not observed during October/November 2002 fieldwork.

Table 4.2.4 Pre-harvest (June) image differences in SLA-NDVI and MSI with residue management by region/soil type

Region	Soil type	SLA-NDVI						MSI					
		Residues		Bare		% Difference[1]		Residues		Bare		% Difference[2]	
n/a	A	.52		.47		+9.9		.117		.128		-8.5	
Northern	RU1	.48	.50	.45	.48	+5.6	+4.0	.145	.141	.150	.144	-3.3	-2.4
	RU2		.47		.44		+7.9		.148		.155		-4.8
Central	RL1	.43		.43		+0.6		.157		.158		-0.5	
Southern	L1	.39		.41		-5.0		.162		.159		+2.3	

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

[1] calculated as (Residues – Bare)/Bare

[2] calculated as (Bare – Residues)/Residues

Table 4.2.5 Seasonal SLA-NDVI differences in fields by soil type

Region	Soil type	October SLA-NDVI		June SLA-NDVI		Difference[1]	
n/a	Alluvial	0.118		0.490		+0.372	
Northern	RU1	0.066	0.064	0.458	0.478	+0.392	+0.414
	RU2		0.067		0.445		+0.378
Central	RL1	0.039		0.422		+0.383	
Southern	L1	-0.009		0.395		+0.404	

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

[1] calculated as June – October

4.3 SOIL SPECTRA AND QUALITY PREDICTIONS

In general, spectral variation is greatest between the intervals of 350 – 450, 550 – 900, 1350 – 1450, 1850 – 2000, and 2400 – 2500 nm, as shown in Figure 4.3.1. Absorptions in the 400 – 550 range are associated with the presence of iron oxide and ferric minerals. However, iron oxide has more pronounced signature absorptions in the range 700 – 870 nm, which are not apparent in samples (Ben-Dor et al., 1999). The VNIR is also the spectral region where organic matter content can be distinguished; it appears as strong reflectance in direct proportion to the amount of non-decomposed matter present in soils, and, when soils are organic dominated, they exhibit a convex shape from 750 – 1300 nm (Stoner and Baumgardner, 1981). Since most soil samples' spectra exhibit a steady rise over this region, without iron oxide absorptions or marked convexity, these samples appear to contain intermediate iron and organic matter content.

In the MIR region, soils appear to be comprised of several phyllosilicate clay minerals, namely kaolinite $[Al_2Si_2O_5(OH)_4]$ and, perhaps to a lesser degree, vermiculite $[(Mg, Fe^{2+}, Al)_3(Al, Si)_4O_{10}(OH)_{2.4}H_2O]$. Both minerals are associated with weathered tropical soils of volcanic origin (Churchman, 2000) and are distinguished by absorptions at 1400 and 1900 nm, due to the presence of OH^- radicals, and, in the case of kaolinite, strong absorption at 2200 nm (also due to OH^-), (Ben-Dor et al., 1999). A plot comparing a soil sample to these two minerals' spectra appears as appendix. Spectral variation in the range 2450 – 2500 nm is due to textural (i.e., grain size) differences among soil samples (Ben-Dor et al., 1999).

Spectral variation among samples and averages

Figures 4.3.2 and 4.3.3 show stacked, averaged reflectance spectra by soil type and land use type. For each soil type in Figure 4.3.2, spectra have been averaged within land use types (bush, graze, maize, wheat) before being averaged for the soil type so as to remove any land use bias that could occur from unequal distribution of soil samples (e.g., if one soil type has a greater proportion of 'bush' samples than other soil types, then its spectra would plot more similar to that of 'bush' spectra than a soil with a greater proportion of 'maize' samples). For each land use type in Figure 4.3.3, spectra have been averaged within soil types (Alluvial, RU1, RU2, RL1, L1) before being averaged for the land use type so as to remove any soil type bias (e.g., for the 'maize' plot, all maize fields in the RU1 soil type were averaged, all maize fields in the RU2 soil type were averaged, etc. and then these averages were averaged to generate the 'maize' plot). As can be seen in Figures 4.3.2 and 4.3.3, spectra exhibit greater variation by land use type than by soil type (also evidenced by greater, average standard deviations in first derivative spectra: 0.008 for land use versus 0.004 for soil type); since soils are defined primarily by physiographic (i.e., elevation, slope, and stoniness) rather than compositional features, this should be expected. Most variability in the village's soil spectra can therefore be explained by land use, which in turn, has effects on soil composition (as described below).

Figures 4.3.4 – 4.3.7 show that there is a high degree of spectral variation within each land use type in addition to that which already occurs among different land use types (Figure 4.3.3). Overall variability is lowest among wheat fields (Figure 4.3.7), as the majority of wheat fields are located in the Northern region (93% of samples) and are ploughed by tractors (67% of samples). Maize fields, by contrast, grow and were sampled throughout the village's regions and exhibit greater variability in terms of their agricultural management practices, which seem to influence their spectral variability (Figure 4.3.6). Variability appears greatest among lands used for grazing, which may be related to visible signs of grazing intensity (as suggested by Figure 4.3.5); a larger sample size would be necessary to test this hypothesis. Variation in soils from areas of dense bush (Figure 4.3.4) is likely associated with the type(s) of vegetation present above the soil and the amount of