CHAPTER V

DISCUSSION

In this chapter, concentration is focused on how the results described in the preceding chapters can help to discuss the importance of individual factors. Additionally comparison was made for the landslide hazard map derived from this study in the Nan study area with that performed earlier by the Department of Mineral Resources. A comparison was also performed for landslides of the Nan study area in northern Thailand with those of the Phang Nga in the south (by Akkrawintawong et al., 2008).

5.1 Relationship between Landslide Occurrence and Controlling Factors

As shown in Chapter IV, there are 8 factors that control the occurrences of landslide including lithology, lineaments, land use, elevation, slope angle, slope aspect, flow direction and NDVI.

5.1.1 Landslide Occurrences and Lithology

It is quite likely as illustrated in the hazard / scar maps (Figure 4.11) and the lithological map (Figure 4.13) that the compatibility of lithology with scars. The weighting of past landslide locations is much more than the other kinds of weighting and that among the rocks involved in the scar occurrence, the interbedded sandstone and alternated sandstone and other clastic strata seem to be the most likely environmental factors. It is quite clear that several of the large scars occur in the coarse-clastic region (Figure 5.1). This can be explained by the fact that the sandstone sequences are prone to be chemically disintegrated due to intensive weathering process and becoming unstable chemically through times. Weathering of some silicate and feldspathic minerals to clays can help to the instability of mass in the steep and high-altitude mountainous areas.

As reported for landslides in southern Thailand, the most favorable rocks which tend to posses landslides are granites with strongly weathered surfaces and fractures (Tantiwanit, 2005 and Akkrawintawong et al., 2008). However such situation is unlike that in the north because most landslides in the north usually occurred in area dominated by clastic rocks (Kosuwan, 2005; Teerarungsigul, 2004 and this study)

5.1.2 Landslide Occurrences and Lineaments

As shown in Figures 4.14a and 4.15, both lineament and buffer zone maps seem to show no spatial relationship with the past landslide occurrences. However, it is indicated in the statistic analyses (Table B2 in Appendix B) that the past landslides mostly occurred near the lineaments (faults & fractures) within the buffer zone of 100 meters. It seems likely that some landslides occurred in areas dominated by crossed lineaments (Figure 5.2), for instance those located in the mountain sides of the eastern Pua Basin and the eastern Nan Basin, respectively. Figure 5.3 shows the relationships between landslide occurrences and major active faults proposed by Khaowiset (2007). It has been observed that both large and small landslides occurred nearby active faults and, in several cases, between two major active faults. Earlier studies, for examples Kosuwan (2005) and Akkrawintawong et al. (2008), reported that landslide scars in Tak and Phung Nga areas, respectively, are situated nearby and immediately at the Mae Ping and Ranong Faults.

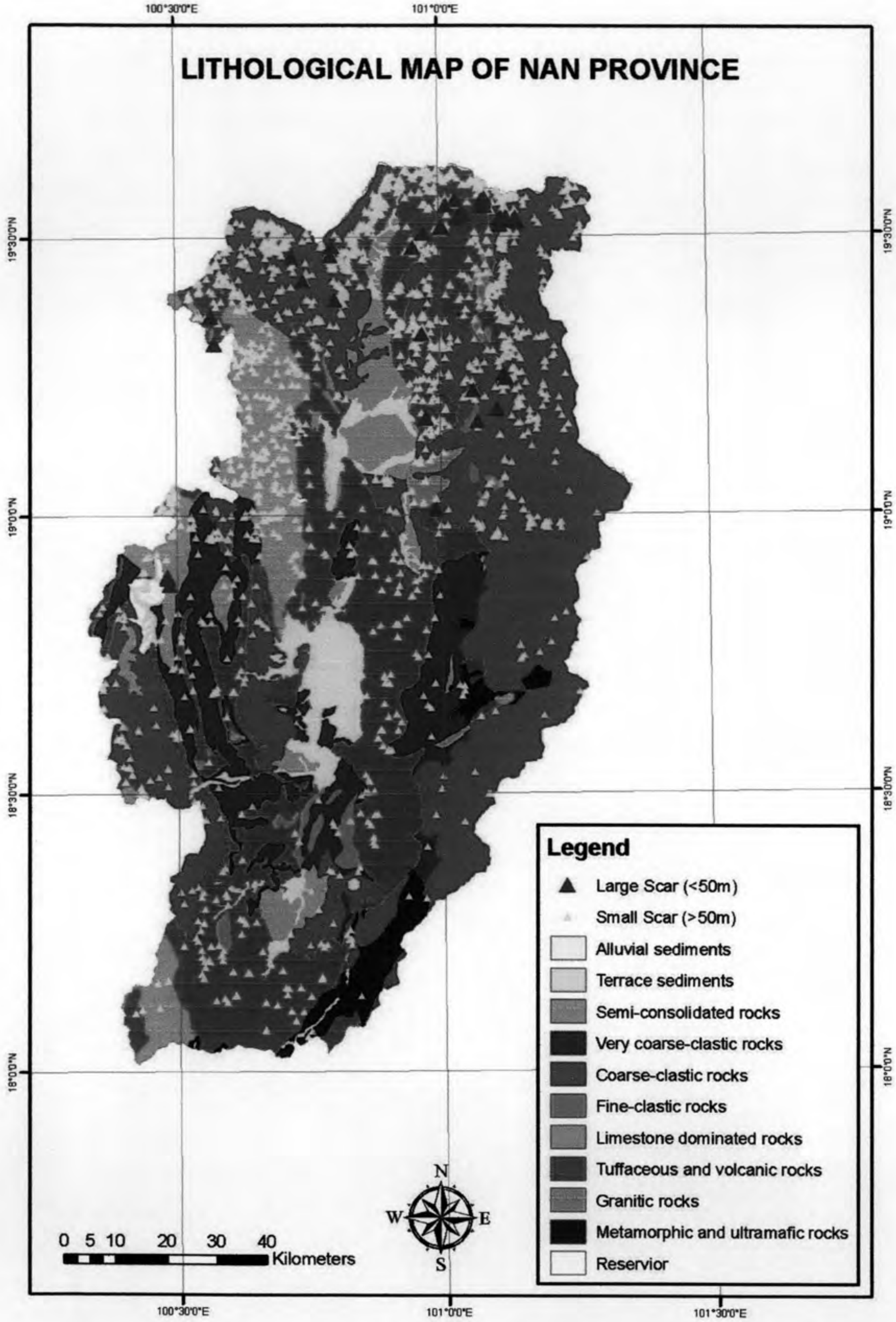

Figure 5.1 Lithological map of the Nan study area show large and small landslide scars.

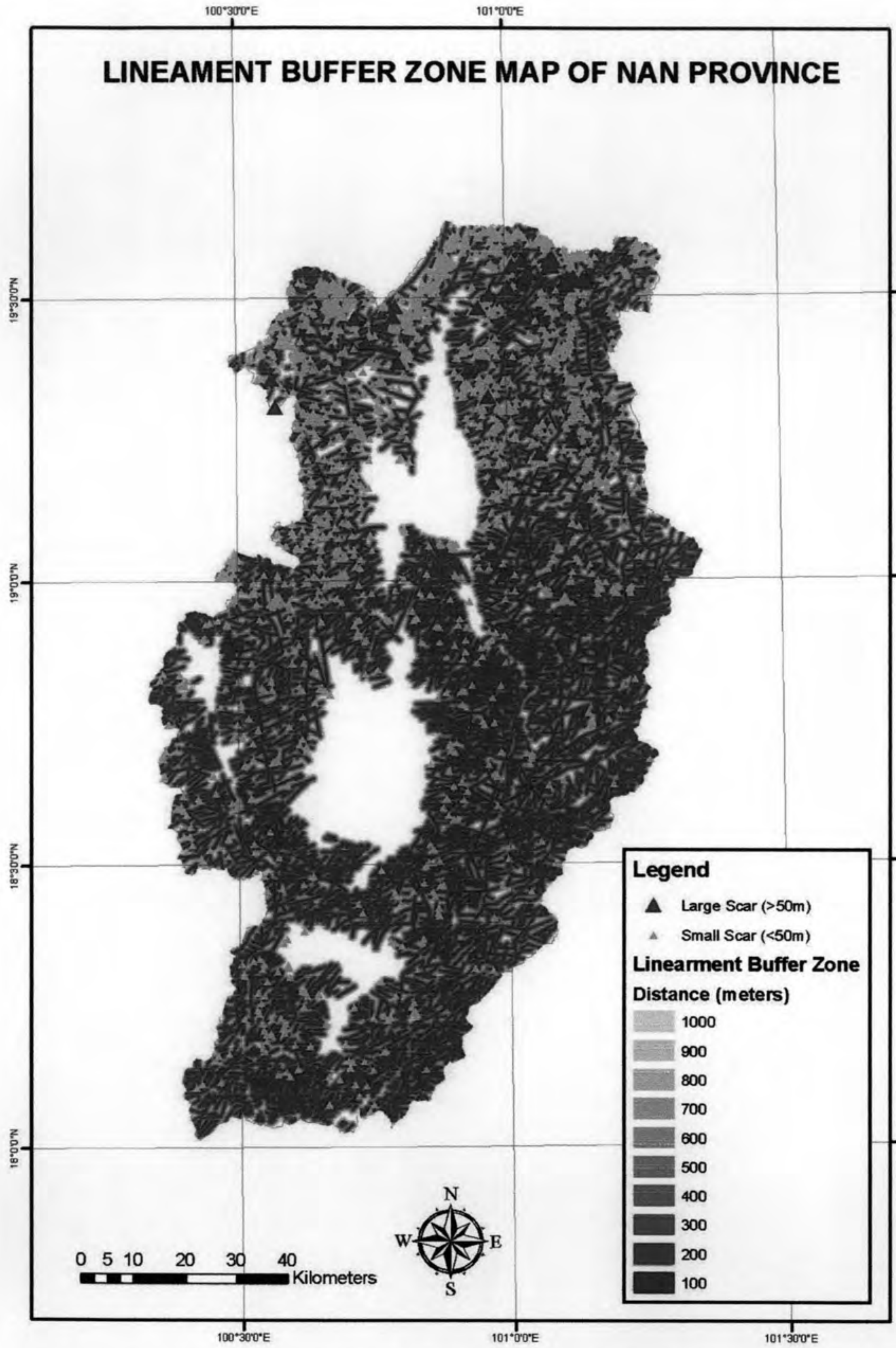

Figure 5.2 Lineament buffer-zone map of the Nan study area show large and small landslide scars.

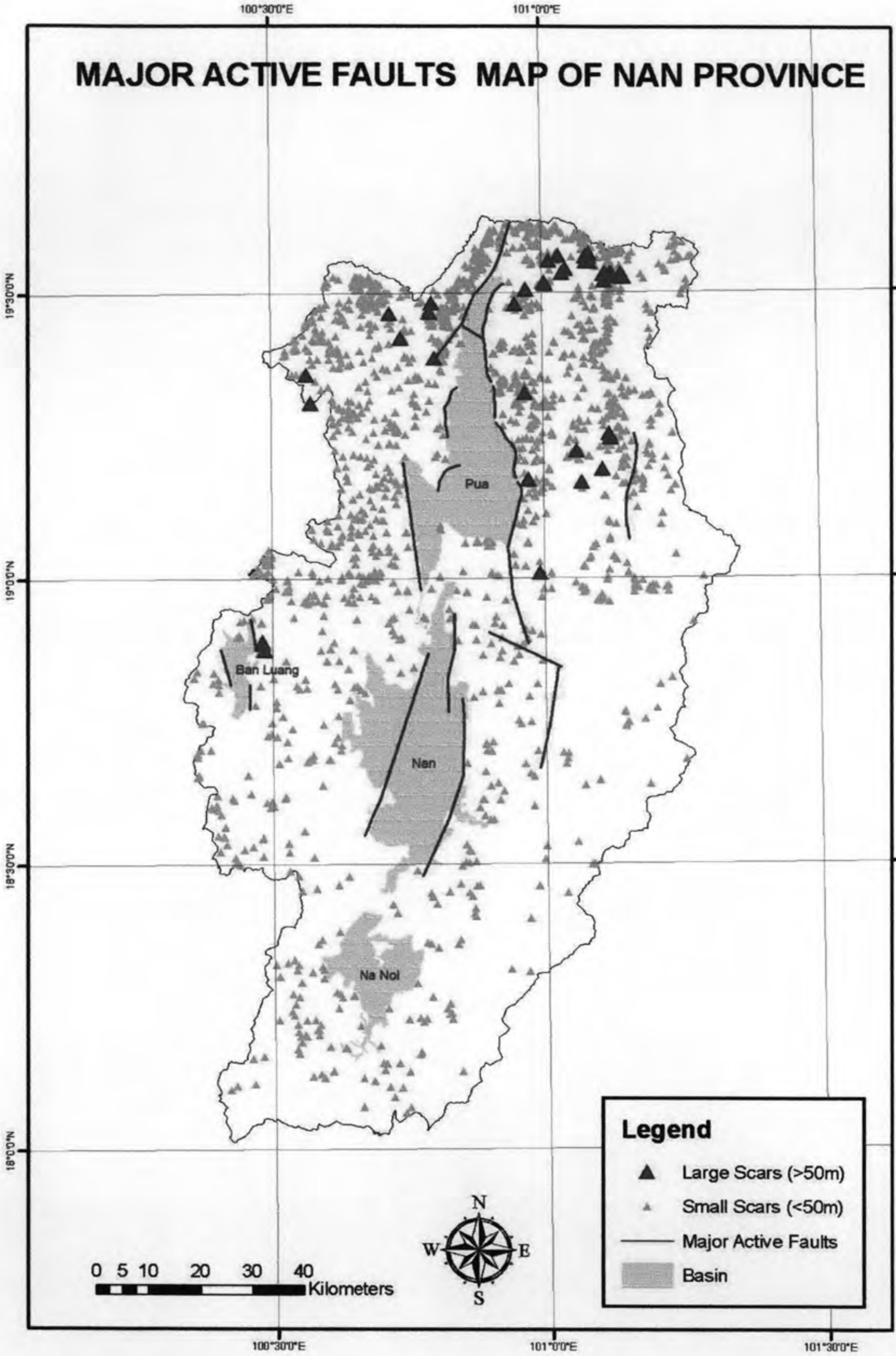

Figure 5.3 Major active faults map of the Nan study area based on the work of Khaowiset (2007) show large and small landslide scars.

5.1.3 Landslide Occurrences and Elevation / Slopes

As shown in Table B4 and C4, more than 40% of the landslides of the Nan study area in the elevation ranging from 400 to 800 meters (see also Figure 5.4). This suggests that elevation frequently plays an important role in the landslide occurrence. Similar situation was also recognized for the past landslides in Phang Nga, southern Thailand (Akkrawintawong et al., 2008) and Tak, western Thailand. The scar map shown in Figure 4.11 is overlain onto the slope angle map and the result map is displayed in Figure 5.5, it is discovered that most of both small and large scars occurred in the zone of immediate to high slope angles (10° - 30°). Therefore apart from high elevation, slope or steepness also plays an essential role in the landslide occurrence.

5.1.4 Landslide Occurrences and Flow directions / Slope Aspects

Flow directions and slope aspects are also important factors for landslide hazard analysis. As shown in Figure 4.19 and 4.20, it is likely that the slope aspects with the major reliability is south, southwest and west direction and attain up to 38% and that the majority of flow direction has no clear direction with the maximum of 25% and the minimum of 10% of the total area. In fact, these two parameters show contrasting results; i.e. the flow in the east to southeast but the slope aspect is to the south to southwest. Maps shown in Figures 5.6 and 5.7 are relationship between landslide occurrences and flow directions / slope aspects. It is therefore concluded that there is no relationship between landslides and flow direction / aspect analysis of the Nan study area.

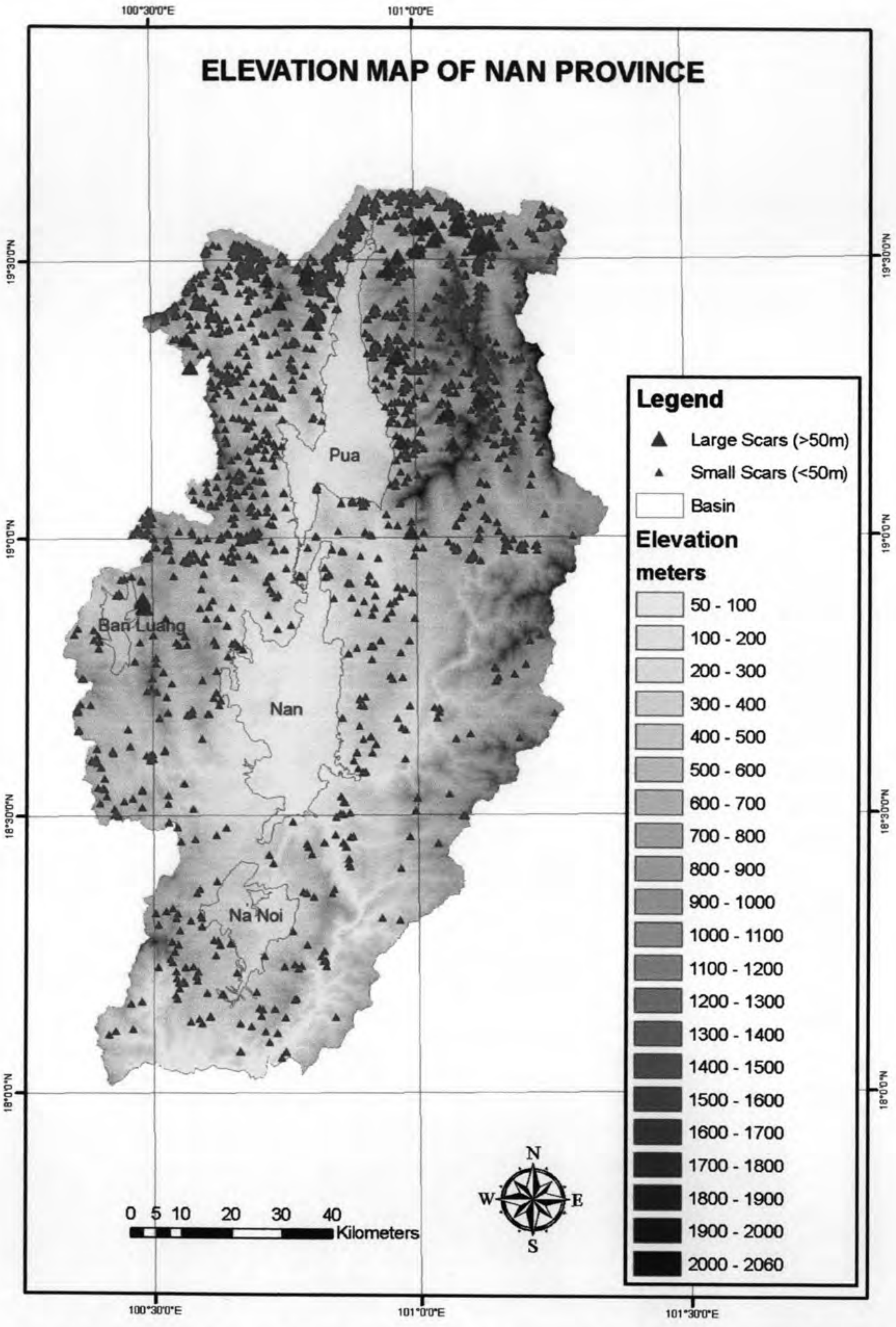

Figure 5.4 Elevation map of the Nan study area show large and small landslide scars.

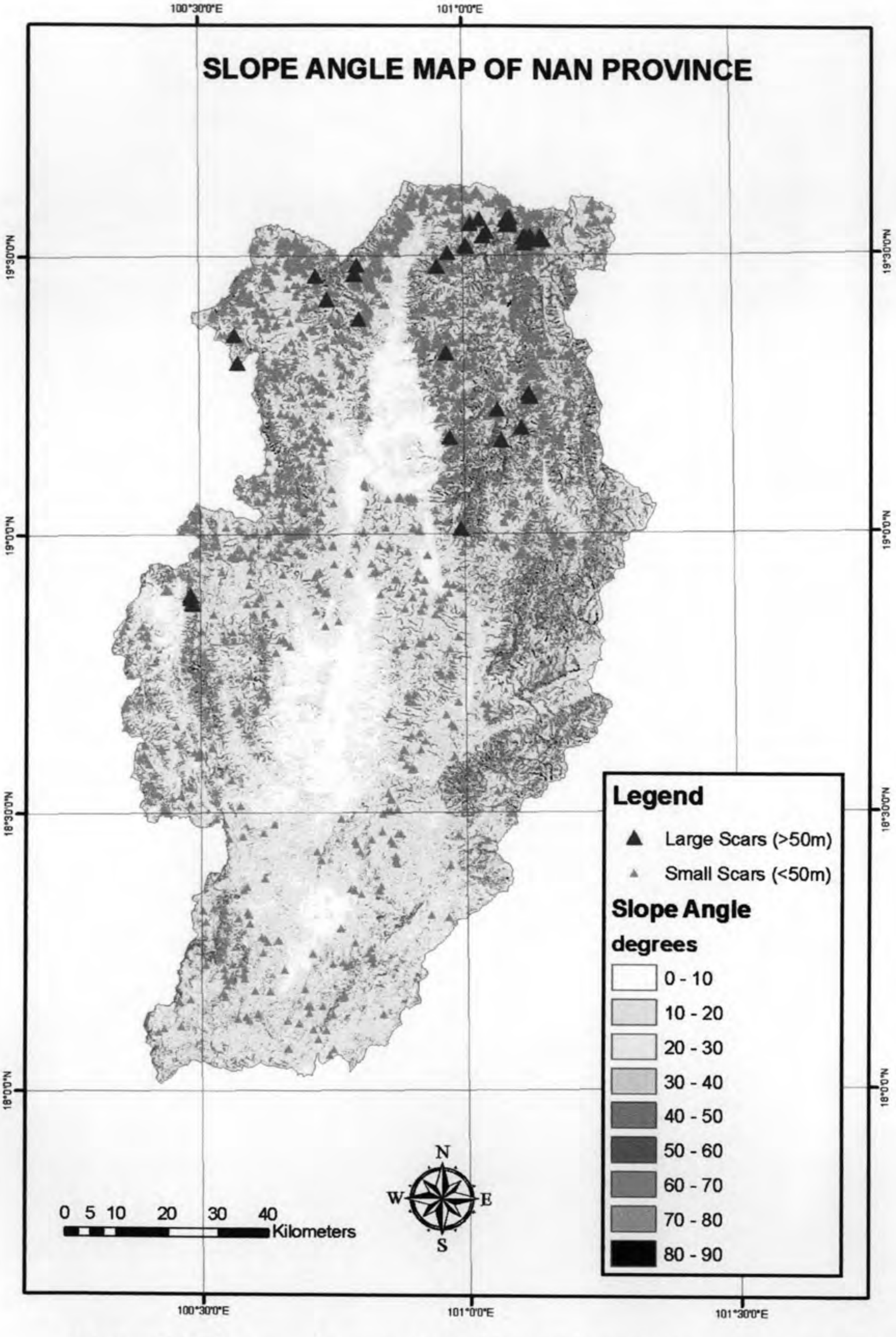

Figure 5.5 Slope angle map of the Nan study area show large and small landslide scars.

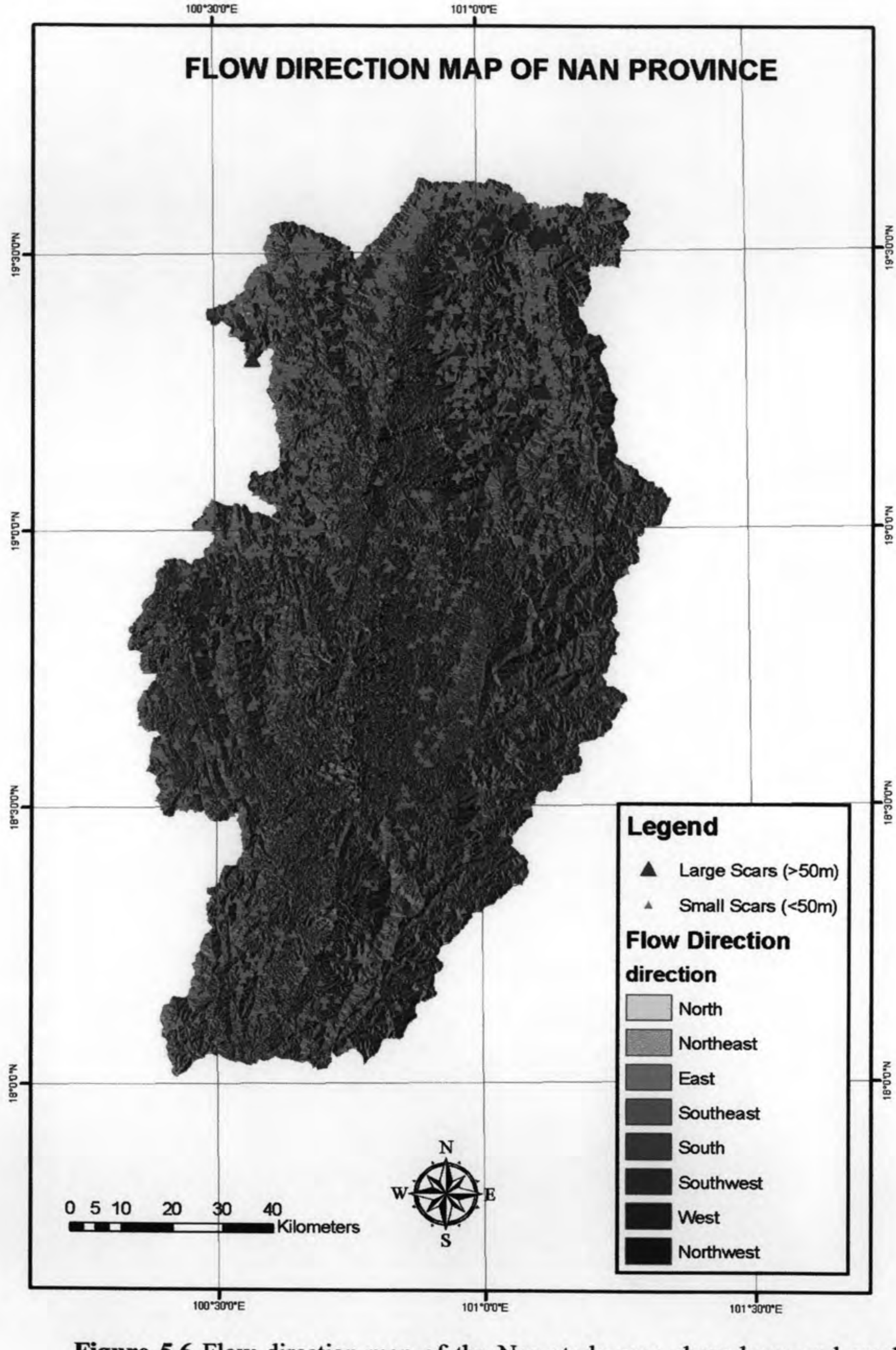

Figure 5.6 Flow direction map of the Nan study area show large and small landslide scars.

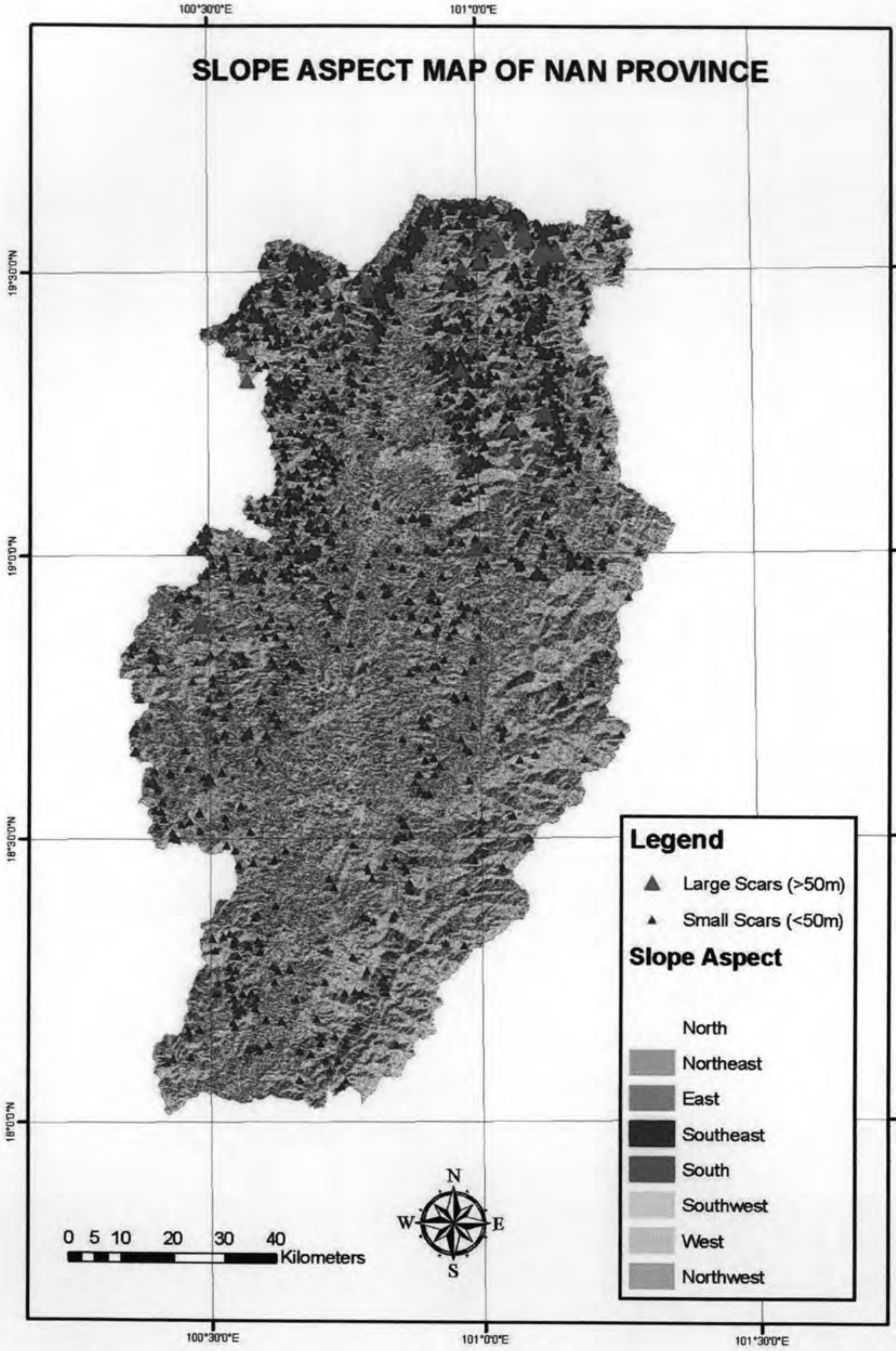

Figure 5.7 Slope aspect map of the Nan study area show large and small landslide scars.

5.1.5 Landslide Occurrences and Land Uses / Land Covers

As displayed in Tables A3, B3 and C3 of the Appendix, there might be some contrast of the range of the landslide percentages of the Nan area with land use as a parameter. It is found that crop and orchard area rank first and open forest and deforestation areas rank second and third, respectively. When probability ratio was taken into account wasteland ranks first, and teak plantation and open forest rank second and third, respectively. However, the result of percent area of land use as a predictor for landslide occurrence become reverse, viz. open forest shows maximum reliability, teak plantation shows lower reliability, but wasteland area shows lowerest reliability. Therefore it can be concluded with some uncertainty that open forest area of high elevation where slope becomes steep can give rise to hazard of landslides.

5.1.6 Landslide Occurrences and NDVI

As shown in Table A8, B8, and C8, it is quite certained that the high values NDVI units, the higher the percentage of landslide occurrences. There are two ranks of the NDVI values which can be compatible with landslide occurrences. They are in the ranges of 0.75 to 1.00 and 0.50 to 0.75. However, reliability of NDVI becomes 1.11 which is quite low rank in comparison with those of the other factors. As shown in Figure 4.21, the low NDVI values are largely located in the Cenozoic basins where villages are concentrated. Perhaps, this leads to the conclusion that many landslides can occur outside the basins.

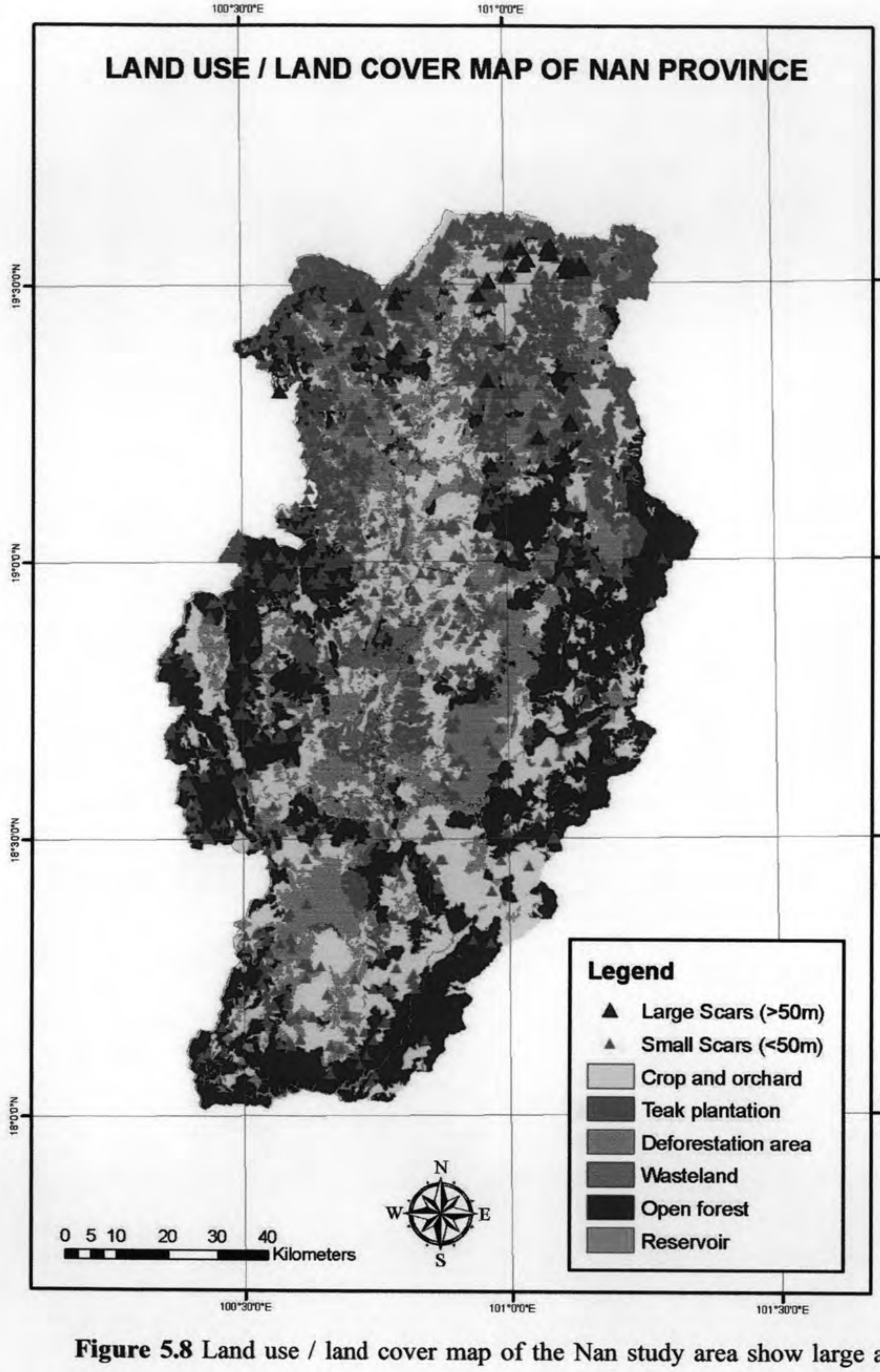

Figure 5.8 Land use / land cover map of the Nan study area show large and small landslide scars.

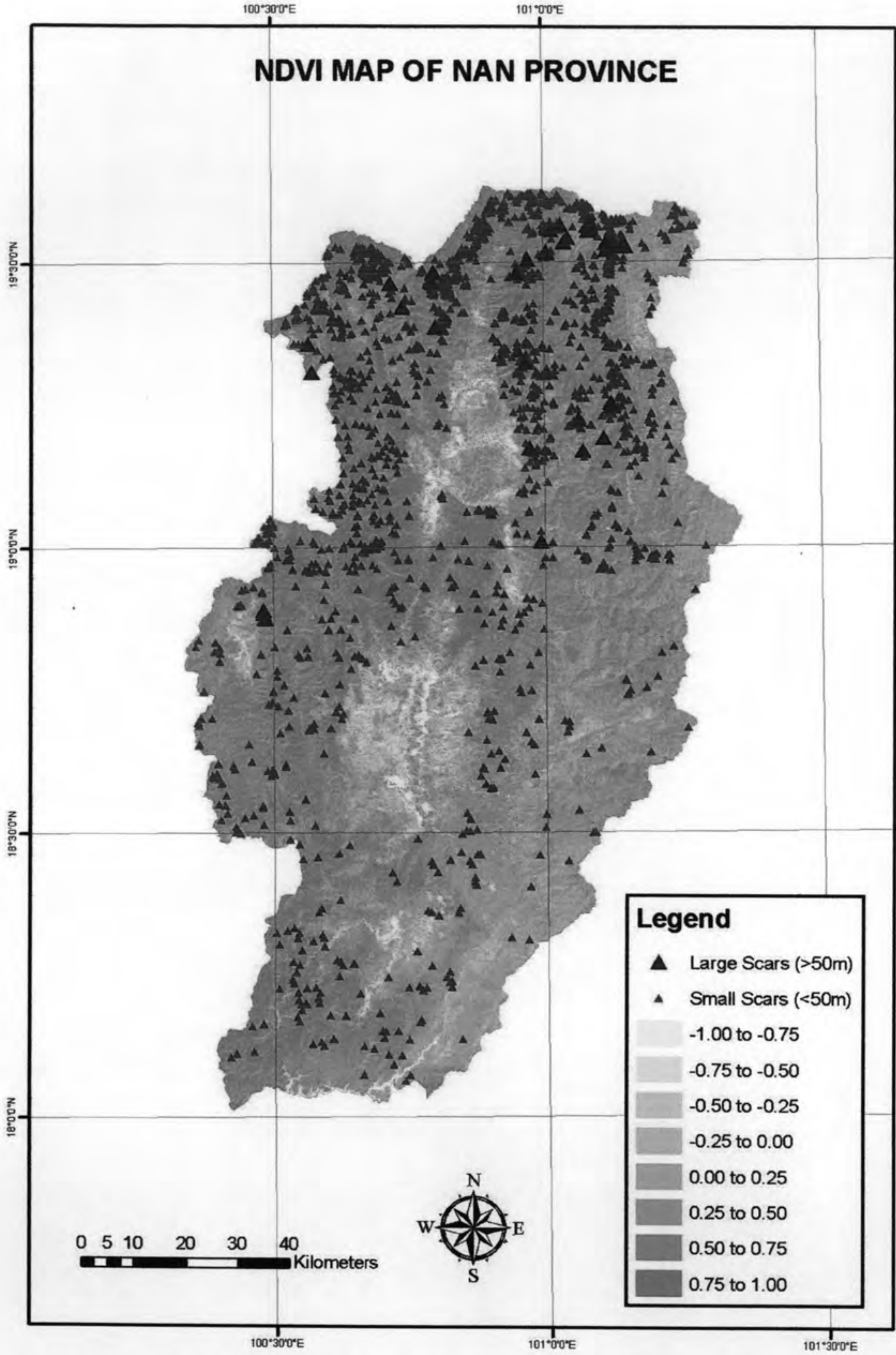

Figure 5.9 NDVI map of the Nan study area show large and small landslide scars.

5.2 Comparison with Previous Hazard Map of the Nan Area

As described earlier in Chapter 1, the Nan study area was studied earlier by Department of Mineral Resources (DMR, 2006) for landslide hazard map (Figure 5.10) which can be downloaded from the website http://www.dmr.go.th. The map was prepared based on the work of Pantanahiran (1994) who applied the equation by using the factors of geology and satellite imagery at the ratio of 0.33 to 0.66. The DMR map displayed that the hazard area is located in the southern and southwestern parts of the Nan study area. The hazard area are granite different from those identified and determined based on the work of Chotikasathien (2004), as well as calculated using Arcview GIS program. Our result indicates that the post landslides and the hazard areas are located in the north and the northeastern parts of the Nan study area has been constructed based upon the data on lithology and lineaments (fault and fractures) as the major factors whereas land use which is an important factor by human activities serves as the minority factor in the case of the Nan study area. The earlier hazard map by DMR must not be used with a great care since the map which points to the prone areas of the future landslide is not compatible with the past landslide locations. In this case, it is considered that the new map (Figure 4.21) proposed in this study becomes better than the earlier map.

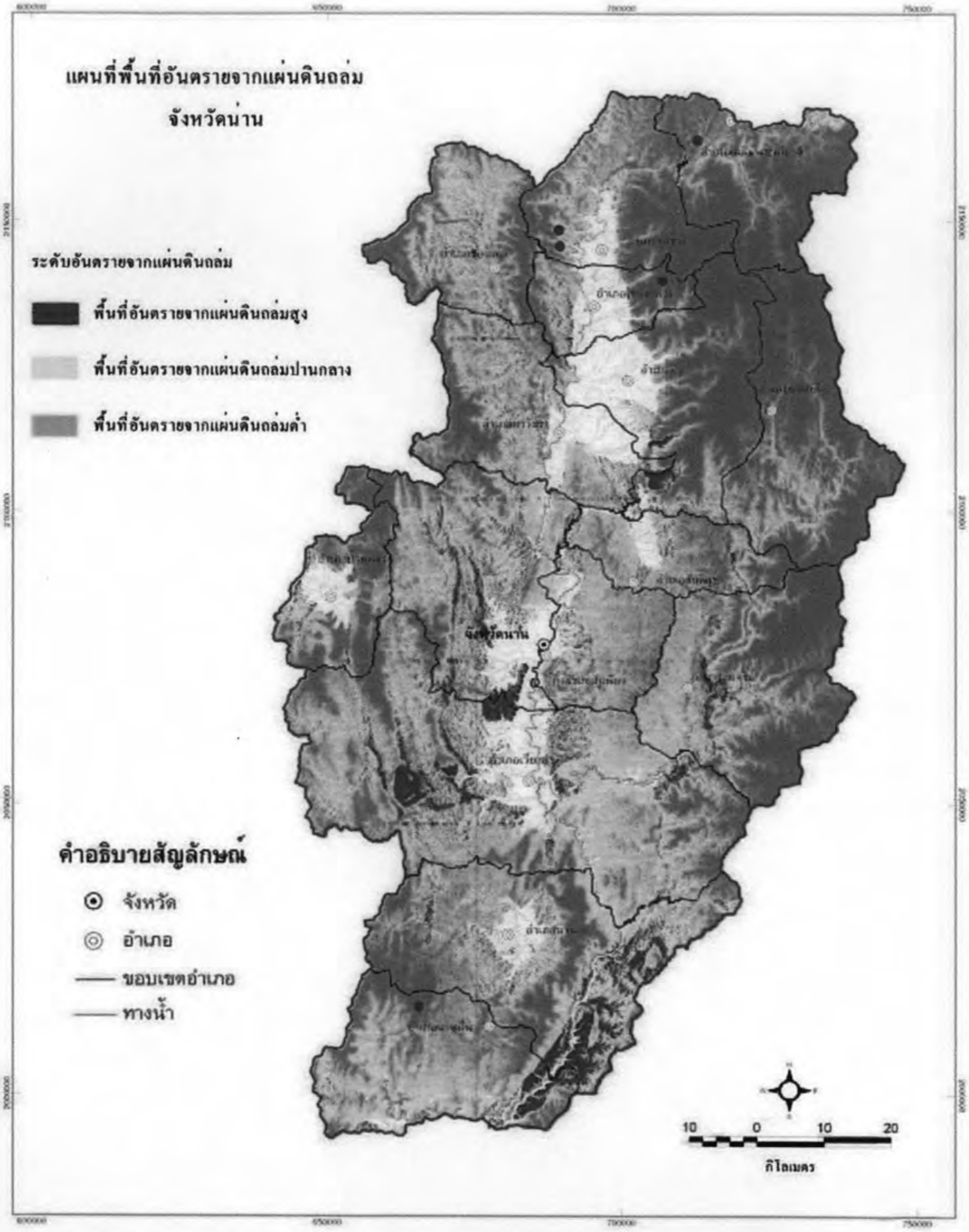

Figure 5.10 Landslide hazard zonation map of Nan Province by Department of Mineral resources (2004) based on the model of Panthanahiran (1994).

5.3 Comparison with Published Hazard Maps of Other Areas.

Akkrawintawong et al. (2008) studied the landslide hazard in Phang Nga region, southern Thailand, using remote sensing interpretation and the equation proposed by Pantanahiran (1994). The result indicates that the main mechanism responsible for the generation of landslide locations (after the 2004 Andaman-earthquake) is not only the heavy and continuous rainfall but also the granite geology and the NW-trending active faults (or lineaments). Similar situation also happened in Kathun area of southern Thailand. Landslide of this area occurred in the strongly and deeply weathered granite of steep-slope terrain after the heavy and continuous rainfall (Tantiwanit et al., 2005). It is also found that the major areas of the landslides are located not too far from the so called "Ranong Fault" which extend northeastward to the Chumporn area (Pailoplee et al., 2008), particularly in the easternmost part of the mapped area. In Mae Ramat district, western Thailand (Kosuwan et al., 2005), landslides where active faults segments have been focused along the Mae Ping Fault zone (Saithong, 2007) after the long period of rainfall. Therefore, it is quite possible that there are two triggering mechanism which control the landslide occurrences.

In the case of the Nan study area for this research, it has been found that the landslides mainly occurred in the deeply weathered sandstone and tuffaceous rocks in areas where steep slope (30°-40°) become dominated. It is quite likely that in term of lithology, the rocks which are scrapped off in the Nan area of the northern Thailand are those of the south are different from one another. They are principally disturbed by present-day seismicity and prolonged precipitation. However, it also considers that both triggering mechanisms must play a role in the generation of past landslides. It is quite different to explain with the present results that which one dominates the other. Therefore in this research both parameters are essential and must mutually happen in the area concerned. In this study, it is ascribed that the steepness also plays an important role for all the landslide areas. These topographic features have been caused mainly by the lithological and structural factors which were formed long times ago but become the dominant factor at present.