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INTEGRATION OF LANDSLIDE SUSCEPTIBILITY INTO LAND USE PLANNING (LUP) IN MAI CHAU DISTRICT, HOA BINH PROVINCE, VIET NAM

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ABSTRACT

Land Use Planning (LUP) plays the vital role in social economic development, especially in land use. Therefore, improving quality of LUP is of great concern in Viet Nam, especially in regions that are influenced by climate change. The objectives of the research were to answer the following questions: (1) How to integrate landslide susceptibility into LUP? and (2) What benefit from the integration do the local people get? GIS applications were used to carry out the research in Mai Chau District. The results show that 6.30% area of the district was estimated as lowly suitable or unsuitable for some land use types proposed in LUP. If the integration was conducted in 2000, some land use types would be changed to others that were more suitable in comparison with actual land use types in the areas of high landslide susceptibility.

Keywords: Landslide susceptibility, Land Use Planning (LUP), landslide integration.

Lồng ghép nguy cơ lở đất trong quy hoạch sử dụng đất tại huyện Mai Châu, tỉnh Hòa Bình, Việt Nam

TÓM TẮT

Quy hoạch sử dụng đất có vai trò quan trọng trong phát triển kinh tế xã hội, đặc biệt là trong lĩnh vực sử dụng đất. Vì vậy, nâng cao chất lượng quy hoạch sử dụng đất rất được chú trọng tại Việt Nam, nhất là tại các vùng là chịu sự tác động lớn của biến đổi khí hậu. Mục tiêu của nghiên cứu nhằm trả lời hai câu hỏi sau: Lồng ghép nguy cơ lở đất trong quy hoạch sử dụng đất như thế nào? Người dân địa phương được hưởng lợi gì từ quá trình lồng ghép trên. GIS được sử dụng trong quá trình nghiên cứu tại huyện Mai Châu, tỉnh Hoà Bình của Việt Nam. Kết quả chỉ ra rằng 6,30% diện tích của vùng nghiên cứu được đánh giá là ở mức thích hợp thấp hoặc không thích hợp với một số loại hình sử dụng đất được đề xuất trong phương án quy hoạch sử dụng đất. Nếu việc lồng ghép này được tiến hành vào năm 2000, thì một số loại hình sử dụng đất trong phương án quy hoạch phải chuyển đổi sang các loại khác cho thích hợp hơn tại các vùng có nguy cơ lở đất cao.

Từ khóa: Nguy cơ lở đất, lồng ghép lở đất, quy hoạch sử dụng đất.

1. INTRODUCTION

Land Use Planning (LUP) is a systematic assessment of the potential of land and water resources subject to economic and social conditions in order to select suitable land use options. It should account for current land use needs, as well as safeguarding resources for future use (FAO, 1993). Therefore, LUP can be considered as one of the most important approaches for long-term sustainable development at both the regional and national levels. Based on different development scenarios, LUP shall help groups of stakeholders to organize the utilization of land resources in a way that fosters socio-economic development (Counsell & Haughton, 2006). LUP is understood as the planning for the allocation of activities to

land areas to benefit human kind (Crowley et al., 1975). In this regard, LUP can contribute significantly to economic development in the future, by systematically shaping industrialization and urbanization, both of which are major driving forces contributing to land-use change (Long et al., 2007). In addition, a systematic LUP is able to contribute positively to sustainable development within agricultural landscapes, particularly in frontier landscapes. This is particularly important in the rural areas of developing countries where the population depends mostly on agricultural income (Counsell & Haughton, 2006). Moreover, LUP needs to form a "bridge" connecting different scales from the national to commune level to facilitate sustainable development in public administration hierarchies (Bristow, 1981; Kelly, 2004).

During this period of strong economic growth, LUP was mainly used to facilitate economic development (Trung et al., 2004). This focus resulted in damages to the environment, such as erosion in the uplands and soil degradation in the low lands. The Viet Nam Land Law regulated that land use should be in accordance with Land Use Planning (Article 11) (Anonymous, 2003). This means that land use change in Viet Nam should be proposed in LUP, and then implemented by land users. In addition, some climatic factors, such as, temperature, rainfall, and humidity have increasingly fluctuated affecting largely the land use and human activities not only in Viet Nam, but also all over the world. Thus, associated with a great contribution to economic development, current LUP practice in Viet Nam is still limited by the environment (SEMLA, 2009). Actually, with three-quarters of Viet Nam's territory being mountainous with high rainfall, landslides occur frequently. Therefore, actual landslides should be investigated to see if current LUP practice in Viet Nam can be improved if the susceptibility of landslide risks is incorporated into LUP.

Mai Chau District is a mountainous area with a complex terrain. Relatively close to Viet Nam's capital Hanoi, it was conveniently selected to serve as a case study region. The district's LUP was made in 2000 without analysis of landslide susceptibility although landslides happened frequently in the past and damaged the local living conditions. The question is that whether or not the land use types in LUP are suitable to protect the environment in long term? Which trends of land use change can be supported in the future period? If landslide susceptibility is integrated into LUP, will local land users in the district gain the benefit? This result can consult local land users and planners to improve quality of LUP in the future.

2. METHODS

GIS (Geographic Information System) is basically understood as a computer-based system of storage and a manipulation of data which is organized by area or location. This location can be identified by a grid of cells (cell-based or raster systems), or information can be stored by means of the boundaries of mapped areas, e.g. land units or administrative units (polygon-based systems). A GIS enables different kinds of information to be recalled and combined, for example, areas that are both suitable for export crops and within a specified distance of an all-weather road could be overlain and mapped (FAO, 1993). Furthermore, the GIS functions help in managing spatial data and visualizing the results.

A good LUP requires adequate input data and supports for its implementation (Son et al., 2008). In Viet Nam, integration of environmental factors into LUP has been limited because of policies, knowledge of planners, and especially inadequate input data (Anonymous, 2006: p36). From 2006 - 2009, with the help of Viet Nam - Sweden program, the integration of some environmental factors into LUP has been experimented in three provinces and some districts. The results are the significant reference documents to planners, in particular to decision-makers in contributing

a suitable process of LUP in Viet Nam. The integration of landslide susceptibility into LUP is meaningful to find out some limitations of LUP which is the object of this research.

GIS was used to overlap the map of landslide susceptibility and the map of LUP, as Figure 1.

Fig.1 shows that the overlapping was conducted on the layers, including: Map of landslide susceptibility (layer one) and map of LUP (layer two). Based on the alternatives of the integration in table 1, the results are shown in the integrated LUP map (layer three).

Table 1 indicates that three categories were proposed in the integration, including: low, moderate and high suitability. This suitability is defined as a suitability of land use types in LUP in comparison with landslide susceptibility. Actually, LUP made in 2000 ignored the landslide component, so some areas with land use types were not suitable with landslide susceptibility, even though, these areas were probably suitable for other purposes of development. Each land use type in the LUP map was overlapped with different categories of the landslide susceptibility map. Accordingly, the overlapping was carried out for different land use types, such as: agriculture, residence, infrastructure and forest, in which, only two categories of integrated LUP map were proposed for forest, including: moderate and high suitability because of the forest's ability to prevent the occurrence of landslide (Sidle & Ochiai, 2006).

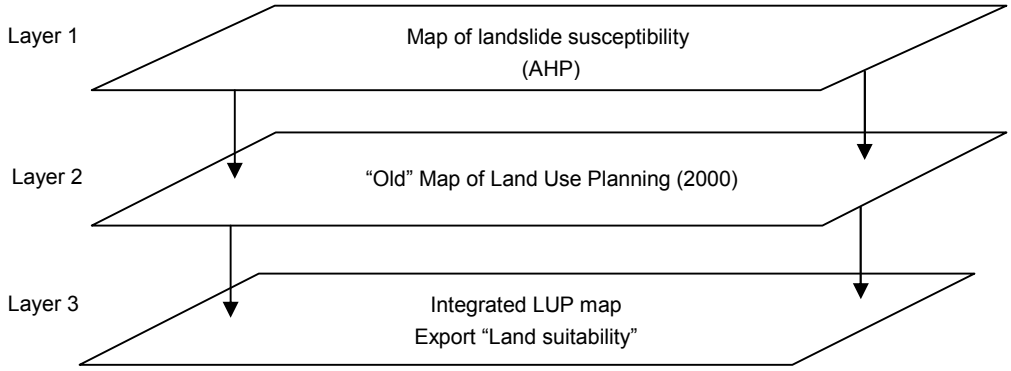

Fig. 1. Overlapping thematic maps

Table 1. Alternatives of integration of landslide susceptibility into LUP

Land use planning in 2000	Landslide susceptibility	Suitability rating
	High susceptibility	Low suitability
Agriculture	Moderate susceptibility	Moderate suitability
	Low susceptibility	High suitability
	High susceptibility	Low suitability
Residence	Moderate susceptibility	Moderate suitability
	Low susceptibility	Highly suitability
	High susceptibility	Low suitability
Infrastructure	Moderate susceptibility	Moderate suitability
	Low susceptibility	Highly suitability
	High susceptibility	Moderate suitability
Forest	Moderate susceptibility	Moderate suitability
	Low susceptibility	High suitability
	High susceptibility	Low suitability
Unused land	Moderate susceptibility	Moderate suitability
	Low susceptibility	High suitability

Moreover, the integration between unused land and all three categories of landslide susceptibility was also conducted. This assessment based on the ability of unused land to trigger landslides. Specifically, result of overlapping between unused land and high level of landslide susceptibility was low suitability. Similarly, moderate and high suitability was result of overlapping between unused land and moderate and low levels of landslide susceptibility, respectively. The assignments were based on the suitability of the location of unused land proposed in LUP to trigger a landslide, actually, not on the use of this land.

3. RESULTS AND DISCUSSION

3.1. Results of old land use planning (2001-2010)

A summary how LUP 2000 envisioned the changes to the main land use types are shown in fig.2. Several land use types should increase gradually. For instance, agricultural land was to rise by 347 ha from 2001 to 2005 and 399 ha from 2006 to 2010, forest land was to increase by 3,281 ha from 2001 to 2005 and 4,121 ha from 2006 to 2010, non-agricultural land also was to rise by 128 ha from 2001 to 2005 and 100 ha from 2006 to 2010. On the contrary, unused land was planned to decrease dramatically by 3,757 ha from 2001 to 2005 and 4,621 ha from 2006 to 2010.

Table 2. Results of land use planning implementation from 2000 - 2010

Land classification	LUP 2010 (ha)	Actual land use (LU) 2010 (ha)	Difference (ha)	Comparison (%)
1. Agricultural land	5,749.50	6,853.39	1,103.89	119.20
1.1. Land for cultivation of annual crops	4,393.93	6,421.54	2,027.61	146.15
Rice	1,265.89	1,244.51	-21.38	98.31
Others	3,128.04	5,177.03	2,048.99	165.50
1.2. Land for cultivation of perennial crops	1,355.57	431.85	-923.72	31.86
2. Forest land	46,176.61	42,833.77	-3,342.84	92.76
2.1. Land for production forest	27,798.23	14,384.61	-13,413.62	51.75
2.2. Land for protection forest	12,857.08	23,500.97	10,643.89	182.79
2.3. Land for special-use forest	5,521.30	4,948.19	-573.11	89.62
3. Residential land	821.42	861.08	39.66	104.83
4. Land for construction of offices, public service delivery institutions	28.59	12.68	-15.91	44.35
5. Land for national security and defense purposes	26.00	7.82	-18.18	30.08
6. Land for non-agricultural production and business	27.98	28.07	0.09	100.32
7. Land for public use	532.76	496.00	-36.76	93.10
8. Land used for cemeteries and graveyards	215.01	183.91	-31.10	85.54
9. Land with rivers, canals, streams and specialized water surface	1,921.71	1,921.71	0.00	100.00
10. Unused land	1,350.80	3,651.95	2,301.15	270.35
Total area	56,850.38	56,850.38		

Source: LUP of Mai Chau District

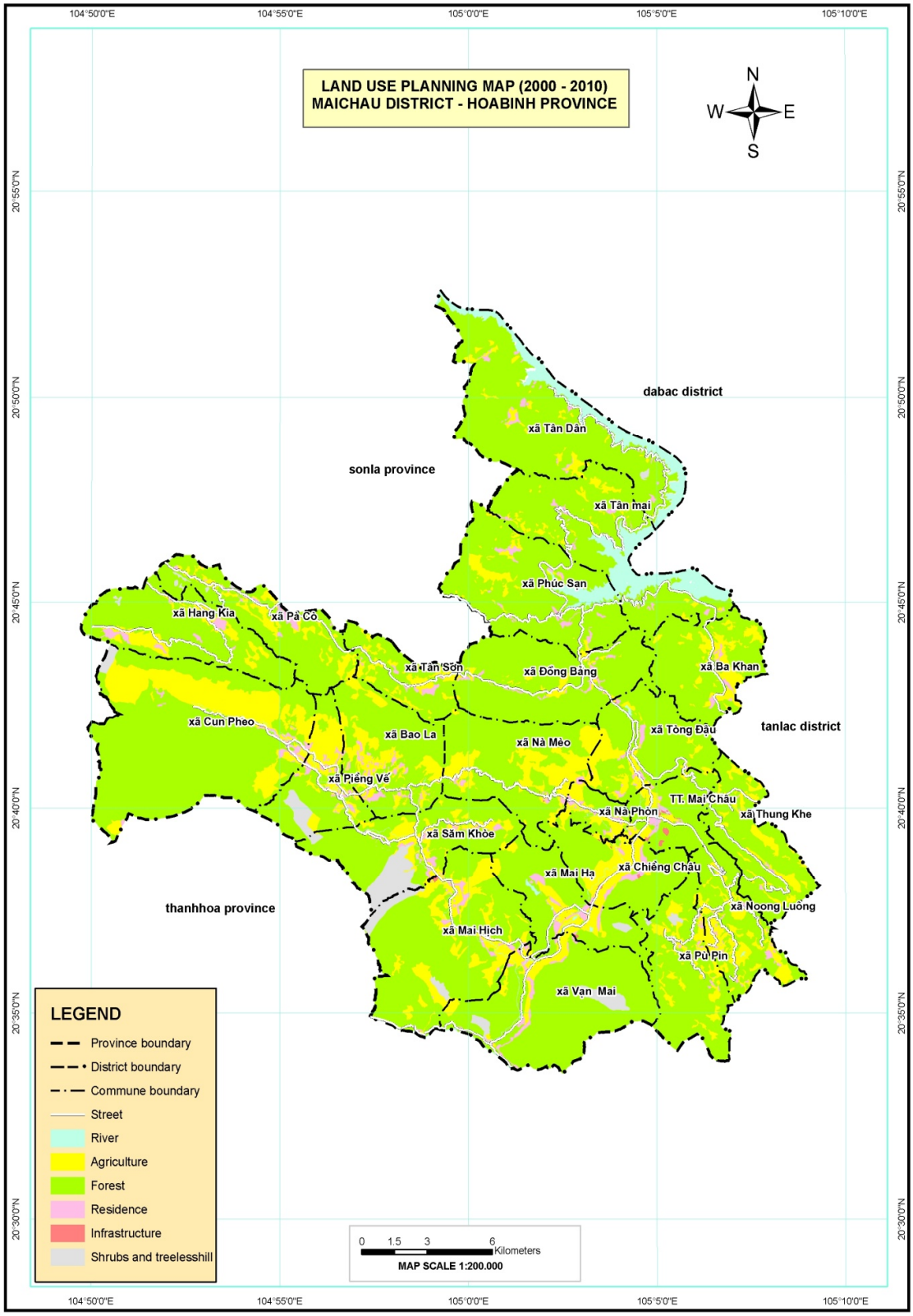

Fig. 3. LUP map in Mai Chau District

Source: Anonymous, 2001

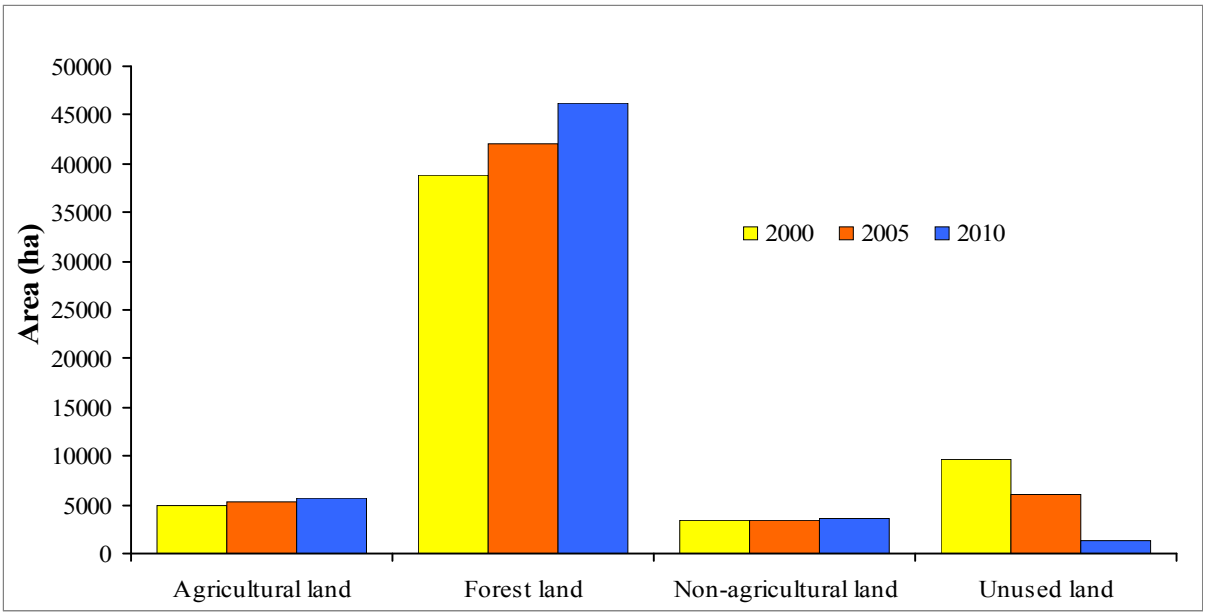

Fig. 2. Comparison between different land use types in LUP in Mai Chau District

Source: Anonymous (2001)

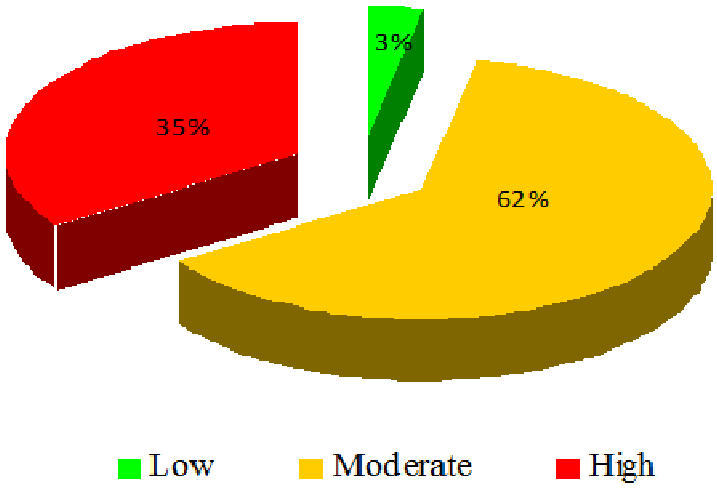

Fig. 4. Landslide susceptibility in Mai Chau (Pie Chart)

Source: Do Van Nha, 2015

3.2. Results of landslide susceptibility

According to Do Van Nha (2015), AHP (Analysic Hierarchy Process) was used to predict the landslide susceptibility with 5 criteria, including: soil type, slope, soil texture, soil depth, and vegetation cover in Mai Chau District, Hoa Binh Province.

The data show that roughly 3% area of the total district was predicted as low susceptibility. Area of moderate susceptibility occupied about 62% of the district. The area accounted for 50-70% area of each commune. The most important area of high susceptibility predicted in the research area accounted for roughly 35% and

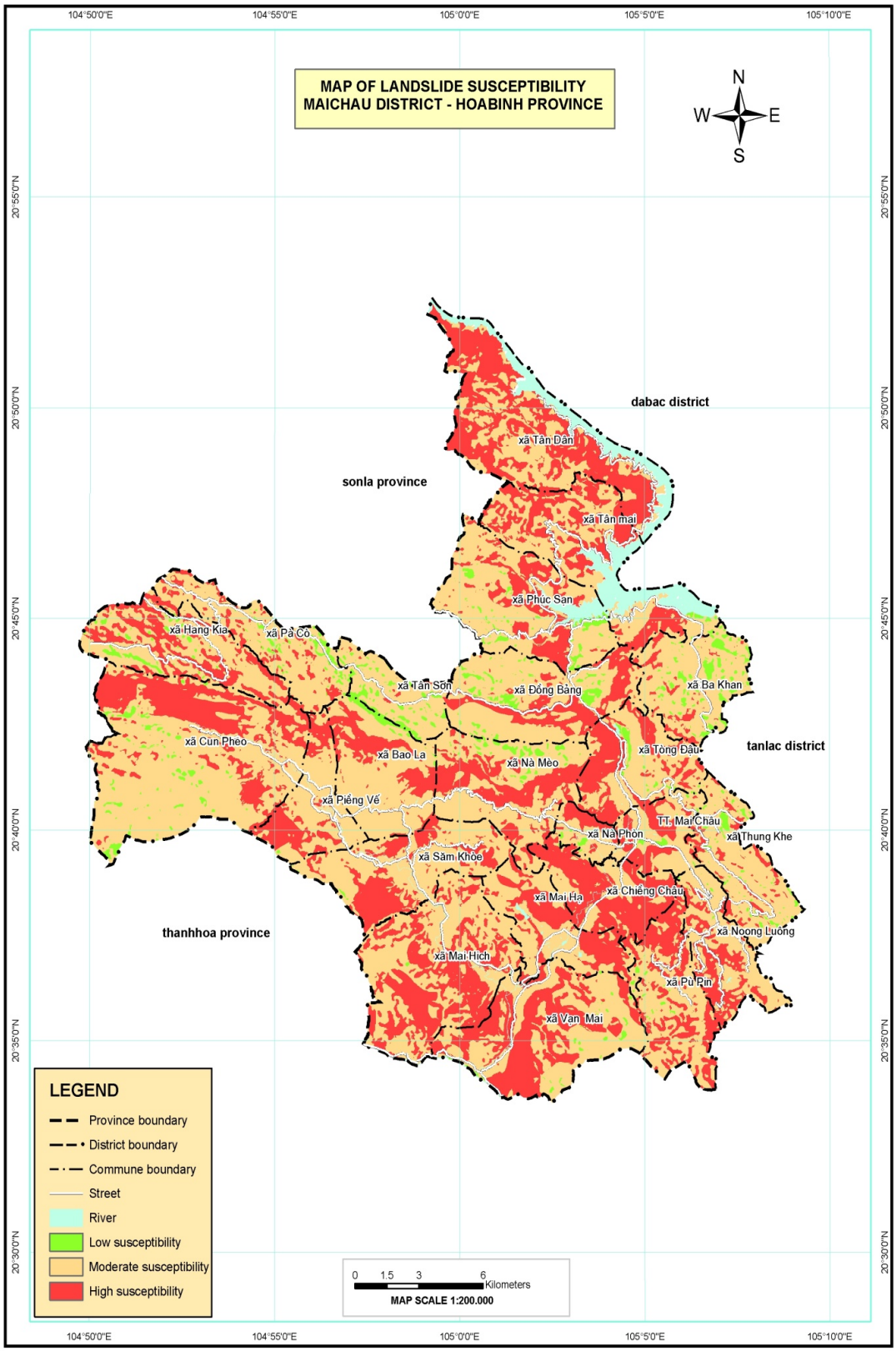

Fig. 5. Map of landslide susceptibility in Mai Chau

Source: Do Van Nha, 2015

was not distributed equally in 22 communes and a town.

3.3. Results of the integration landslide susceptibility into Land Use Planning

ArcGis 9.3 was used to overlap layer one and layer two. The results are shown in fig 6 and fig 7.

Only 3% area of the district was assigned by LUP 2000 in a way that is classified as "highly suitable". In these areas, the landslide susceptibility is low. Likewise, 90.7% area of the district, equivalent to 49,829 ha, was judged as only "moderately suitable". Of this area, 62% had a "moderate" and 35% a high landslide susceptibility classification (Fig. 4). Specifically, forest use including reforestation planned by LUP 2000 was classified as moderately suitabile even the landslide risk rating was high. Notably, 6.3% area of the district was estimated as lowly suitable or unsuitable for the land use types assigned by LUP 2000. Here, landslide susceptibility was "high".

Therefore, the areas assigned to low suitability are more important for land users and local authorities on land use in the present and future. The significant areas were distributed unevenly in different communes. Indeed, Cumpheo commune was the largest with 693 ha for low suitability, followed by Chiengchau and Maihich communes as the second and third largest communes with 383 ha and 351 ha, respectively. On the contrary, Tanson commune was the smallest for low suitability with only nearly 11 ha. The larger communes were Bakhan and Thungkhe with around 11 ha and 25 ha, respectively. The categories of suitability of each land use type are shown in table 3.

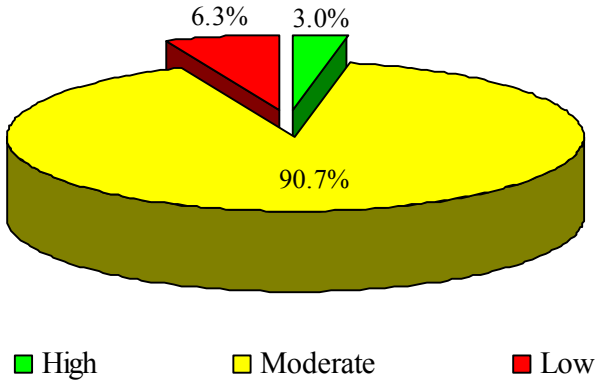

Fig. 6. Export suitability of LUP 2000

Table 3. Suitability category of land use types in Mai Chau District

Land use type	Category of suitability (ha)		
	High	Moderate	Low
Agriculture	476.95	4,801.30	2,018.73
Forest	1,088.31	44,064.03	
Residence	75.35	526.79	480.90
Infrastructure	0.99	27.56	16.94
Unused	1.37	409.58	939.85
Total	1,642.97	49,829.27	3,456.43

Source: Own calculation

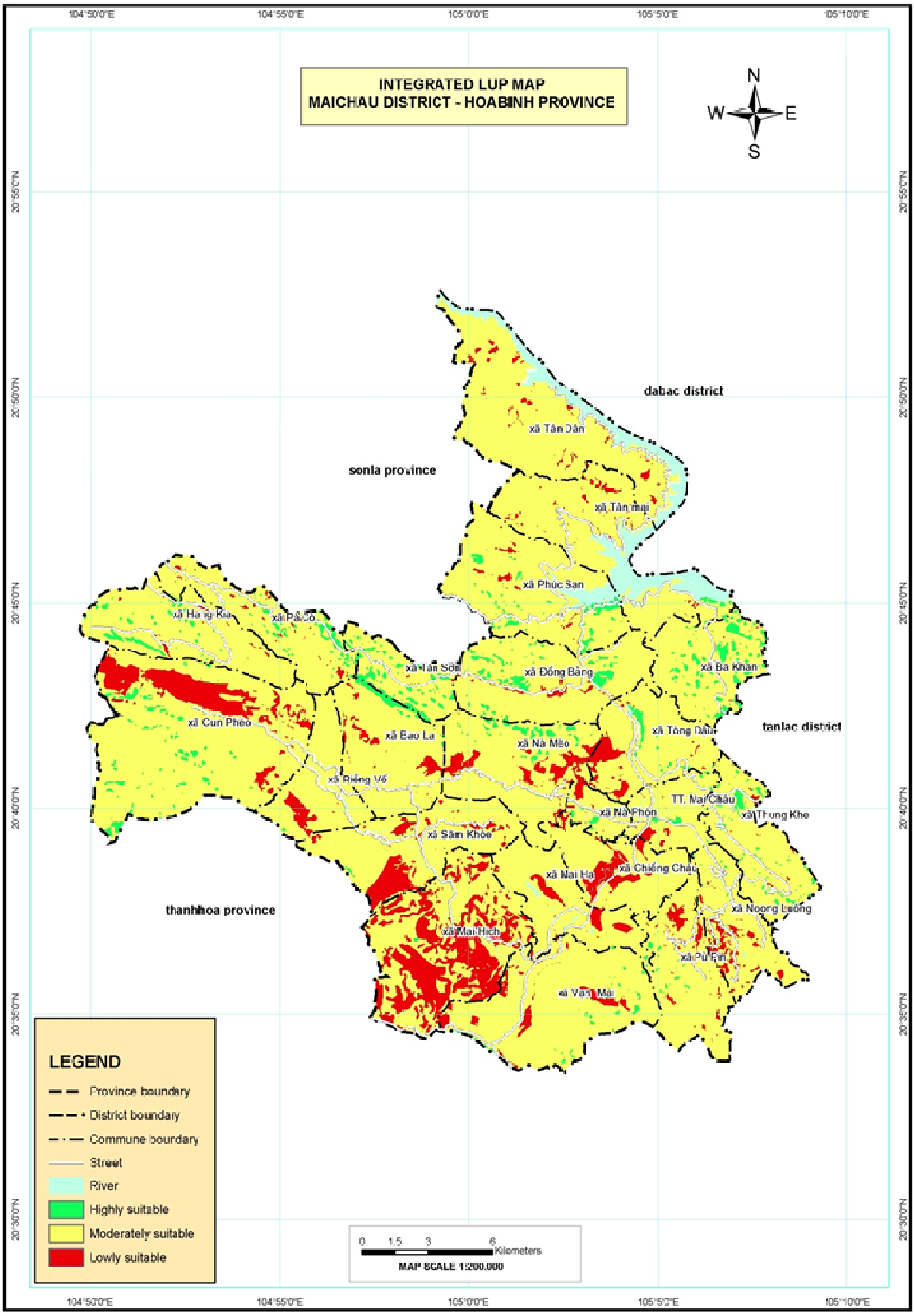

Fig. 7. Integrated map in Mai Chau district, Hoa Binh province, Viet Nam

Table 3 shows that forest and agricultural areas with high level of suitability accounted for the highest position with roughly 1,088 ha and 477 ha, respectively. Conversely, areas of infrastructure and unused land were the smallest, with nearly 1.0 ha and 1.4 ha, respectively. Similarly, on the moderate level, areas of forest and agriculture were continuously largest and area for infrastructure was smallest. Interestingly, on the low level, area of agriculture hit the highest position, with nearly 2,019 ha, after that, unused land stood at the second with 940 ha. Area for residence was nearly the same with moderate level, standing at 480.9 ha. For area of infrastructure, there was around 17.0 ha with low suitability.

4. CONCLUSIONS

The integration between landslide susceptibility and LUP indicates that roughly 6.3% area of the district was estimated as unsuitable for some land use types proposed in LUP which is concerned in the present and future. The change of land use types on the high level of landslide susceptibility to improve quality of LUP was suggested.

Actually, in the rural areas, the living standard and income of local people, in particular, in the mountainous areas, are obviously lower than urban areas. 90% of poor households live in the rural areas with the poorest being in the upland areas (Cuong, 2005: p12). The capital of local farmers is limited and basically relied on the land resources and land use. In addition, local food security depends largely on the areas for agricultural activities (Cuong, 2005: p327; Duong & Izumida, 2002; Mueller, 2003: p85).

Moreover, if the changes of land use from agricultural crops to forest are proposed to diminish the damages of landslides, some social concerns will be possibly emerged, such as food shortage, poverty, education, etc. According to our own investigation, the forest harvest normally begins at the year^{+5} for acacia and year^{+7} for bamboo of their life cycle. Therefore, when the changes of land use are implemented, crucial supports and helps from the government and different organizations will be of great significance at least in the first period of the changes through policies and development programs when the products will be initiated by farmers.

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