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Land Use Zones and Land Use Conflicts in the Liwagu-Labuk River Basin, Sabah, East-Malaysia

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Abstract

In the Liwagu-Labuk River Basin, eight different landuse zones have been identified. They cover areas beginning in the highlands close to the Mt. Kinabalu National Park (ca. 1400 m a.s.l.) and ending at the highly productive waters of the Labuk estuary. Land use along the the river basin changes from intensive vegetable production and tourism in the upper catchment, followed by areas with more extensive mixed agriculture and ending in the low lands with increasing areas of large scale oil palm plantations. The observed land use conflicts along the upper part of the river basin are attributed largely to competition for water by agriculture, tourism, recreational and municipal uses; with inherent risks of water pollution by pesticides, fertilisers, waste water. Copper mining activities in adjoining watershed further aggravate the risk of water pollution by suspended sediment and heavy metals. The proposed 120 MW Liwagu HEP Dam at the middle section of the river basin will flood agricultural land and may result in relocation and intensification of land use in the remaining areas therein. Along the lower part of the river basin, land use conflicts are due to increasing conversions from extensive small/medium scale agriculture and forest to intensive monocultures dominated by oil palm plantations. This intensification with a growing input of agrochemicals increases the risk of water pollution and soil erosion. Socio-economically, people are becoming increasingly dependent on these oil palm plantations, which are owned largely by private companies. Loss of social structures is an anticipated consequence of this development. A future project shall further investigate the reasons for land use conflicts in this area and develop sustainable land use concepts.

1 General Description of the River Basin

1.1 Geography

The Liwagu/Lauk River Basin is situated in the northeast of the state of Sabah, Malaysia. It drains an area of about 4,000 km^2 from Mount Kinabalu in the west to the Sulu Sea in the east. The river basin is located between latitudes 5°30'N and 6°05'N and longitudes 116°25'E and 117°30'E.

The Western part of the Liwagu basin is characterised by mountainous topography comprising the Crocker and Trusmadi Ranges with peaks generally rising to 2,500 m. The highest peak is

Mount Kinabalu (4,101 m). The mountainous terrain is jungle covered in its natural state although there have been clearings for cultivation of rice, vegetables and grazing ground along parts of the hillspurs. Hill slopes are very steep in some places and landslides occur frequently in areas where the natural vegetation has been disturbed, particularly during wet season. To the east, the terrain is still rolling and undulating but falls gently towards the Sulu Sea. The lower part of the river reaches are relatively flat. Extensive logging has taken place in the basin and over wide areas the primary forest has been replaced by secondary forest and lalang.

Near Tampias, Liwagu is joined by its main tributary, the Kegibangan River, whose source rises in the Trusmadi Mountains to the south-west. Other major tributaries in the upstream area are the Kenipir and Melaut Rivers. Downstream, important tributaries include Ensuan, Meliau, and Tungud Rivers.

The vegetation of the watershed is primarily tropical rain forest which has given way to dense areas of secondary growth subsequent to timber harvesting activities or shifting cultivation. This has resulted in the increase of the sediment load of the river.

The Labuk River catchment area discharges into the Labuk Bay through the Kuala Labuk and Klagan estuaries. Although the channel of Kuala Labuk estuary is much bigger, both of these estuaries are interconnected by a network of upstream tributaries (Murtedza et al., 1984).

1.2 Climate

The climatic condition of the Labuk River basin can be generally described as hot and wet, similar to other equatorial monsoon regions supporting tropical rain forests. The temperature and humidity are relatively uniform throughout the year (approximate average of 27°C and 85%, respectively). Published records of the temperatures indicate mean annual daily for maximum and minimum temperatures are 32°C and 22°C respectively.

Annual rainfall is generally greater than 2,000 mm and at a maximum of over 4,000 mm on Gunung Kinabalu (4,101 m). Rainfall is well distributed over the Liwagu Basin. There is a steep orographic rainfall gradient on Gunung Kinabalu. The rainfall decreases sharply southward, but this affects only an insignificant portion of the catchment area. The rainfall increases again eastwardly in the downstream direction of the river. There is no regular and distinctly dry season and it is rather rare for no rainfall to be recorded for more than 25 days. The forest evaporation is between 900 and 1,100 mm. The average annual open water evaporation is about 1,600 mm (SEB, 1989).

1.3 Geology

1.3.1 General Geological Features

The Liwagu Basin is underlain by various rock types ranging from Recent Alluvium to adamellite and granodiorite pluton of Gunung Kinabalu. In the upper part of the catchment, the Liwagu flows from the adamellite and granodiorite of Gunung Kinabalu to the Trusmadi Formation which consists of mudstone, shale, phyllite and sandstone. At Kagibangan confluence the river flows over the Crocker Formation consisting mainly of flysch type of deposits – sandstone, shale and siltstone.

At Lipaso, the river flows through a narrow gorge consisting of basalt of the chert-spillite. On the left bank of the Liwagu, basalt has been replaced by dolorite and ultra basic at some places. The soil cover at Lipaso is rather thin and ranges in thickness from 1.5 m to 3.4 m. Below the soil is either fresh basalt or gabbro. Basalt has been encountered in several boreholes at depth less than

6 m. Seismic survey carried out at the proposed Liwagu Hydropower damsite, shows that the soil has an average thickness of about 2.5 – 3.6 m.

From Telupid to Porog, the river traversed through ultrabasic rocks consisting of peridotite, dunite and gabbro. In the lower part of Labuk after Porog, the rocks consists mainly of a mixture of argillaceous and arenaceous sediments with conglomerates of Oligocene – Middle Miocene age. In most part of the Labuk valley these rocks is overlained by Recent Alluvium (SEB, 1989).

1.3.2 Rock Formations

Within the Basin, the important sedimentary rock formations are the Crocker, the Trusmadi and the Chert-Spillite Formations.

The Trusmadi formation are predominantly agrillaceous rocks, of middle to lower Eocene age. The formation comprises strongly folded and faulted alternating bands of siltstones, mudstones and shales in which the generally thinly bedded siltstones are subordinate to the more massive mudstones. The regularly alternating siltstones and mudstones are considered to be transition rocks and are located close to the contact boundary with the Trusmadi Formation. Minor occurrences of conglomerate, grits, tuffs and cherts have been reported in other areas outside the basin. Regional metamorphism has given rise to the formation of argillites and sub-phyllites, the latter being responsible for landslipping where steeply dipping beds occur. Quartz veining cutting across bedding planes is commonly associated with the occurrence of argillite bands.

The Crocker Formation comprises the sedimentary rocks of upper Eocene age that dominate the geology and topography of the central portion of project area as far as the Lipaso gorge. The Formation comprises massive sandstone and closely bedded sandstone siltstone, shale and mudstone. The sandstones and siltstones which generally consist of fine but poorly graded grains of quartz, lithic fragments and feldspar, are usually massively bedded with well developed jointing. The formation also exhibits various sedimentary structure and has been described as an arenaceous “flysch” deposit.

The Chert-Spillite formation comprises rocks of cretaceous to Tertiary age, which extend over the eastern part of the basin from south of Ranau following an arc to the south-east, crossing the Liwagu in the vicinity of the Lipaso gorge and forming the prominent Gunong Mentapok range. The rock types represented by this formation comprise pillow basalt, spilite, basaltic agglomerate, tuff and volcanic breccia with associated sedimentary rocks of sandstone, siltstone and some tuffaceous sandstone, red and grey shale and mudstone. Chert outcrops are uncommon and are not considered to be represented in the basin area.

Recent deposits are found throughout the study area both as relic terraces on hillsides and as fan deposits on the Ranau plain. The terraces comprising illsorted gravel and cobbles in a silty clay matrix result from the denudation of Gunung Kinabalu and the Crocker Range and this is related to sea level changes and rejuvenation of the area. The Ranau plain comprises fan deposits associated with a massive accumulation of gravel to boulders in a silty clay matrix overlying sand, silt and clay (SEB, 1989).

1.4 Land and River Uses

Most parts of Liwagu Basin are covered by primary and secondary forests and thus giving cover against soil erosion. However, certain areas of the basin have been subjected to logging activities and the exposed areas in the logging concessions are highly susceptible to soil erosion. Aerial photographs of 1975 and 1986 showed distinctly the extensive logging activity in the basin.

Some areas has been utilised for agriculture and cultivated tree crops. In the upstream part of the basin a wide variety of crops have been planted. These include fruit trees (Durian, mangoes etc.), padi (including hill padi), maize, various kinds of vegetables, rubber, cocoa and coffee. In the Ranau-Kundasang area, significant agricultural development has taken place. Besides irrigated rice, the cool climate of the area has encouraged widespread plantation of vegetables such as cabbage, tomatoes and lettuce.

In the downstream part of the basin, there are major agricultural schemes (114 oil palm estates). Besides the public trunk road and the plantation roads, the Labuk River and the Kuala Labuk estuary provide a means of communication between these schemes and the downriver towns of Beluran and Sandakan. For the Pamol and Sabapalm plantation especially, the Kuala Labuk is of extreme importance since the waterway is used by barges for the transportation of supplies and produce to and from the plantation. The Kuala Labuk waterway is also used by logging companies for the movement of logs from the Tungud logging concessions to Sandakan. The various rivers in the estuarine system also serve as fishing grounds to the locals, and the freshwater giant prawn *Macrobrachium rosenbergi* is an important catch in the upper rivers.

Because of the low elevation of the terrrain of the Lower Labuk reaches, the palm oil and cocoa trees do not require water abstraction from the river for irrigation. Irrigation is by sluiced canals. These areas, however, are prone to flooding.

Urban and associated areas are localised around Ranau, Telupid and Beluran. Small villages are scattered around the river flood plain and the East-West Ranau-Sandakan highway.

1.5 Labuk Estuary

The Kuala Labuk estuary is funnel-shaped, with an orientation of east to west. From its mouth in Labuk Bay to its head at the confluence of Labuk and Sapi rivers, the estuary is about 29.5 km long. Its width at the mouth is about 7 km while at the head it is about 1 km. The main rivers feeding the Kuala Labuk estuary are the Labuk, Sapi and Muanad rivers. The area between the Kuala Labuk estuary and Klagan River form a sort of delta with small streams dividing the land area into small islands. In the Kuala Labuk estuary itself a few small islands are present, together with sand banks between the mouth and Beluran. These sand banks and streams behind the islands are exposed at low tide.

The banks of the Kuala Labuk estuary are muddy and, except for the township of Beluran and Kampung Kolapis, and have not been developed. On the south bank, the dominant flora is *Nypa* palms, while on the north bank mangroves are more common. The estuarine sediment is made up of a mixture of silt and fine sand. Closer to the mouth and in the sand banks, the sediment is coarser, being made up of sand particles with an average particle diameter of *ca*. 0.2 mm.

Kuala Labuk is a shallow estuary, especially close to the mouth where the depth is generally less than 5 m deep during high tide. The northern side of the river mouth is very shallow, while on the southern side there exist deep channels of up to 10 m. These channels coincide with high salinity regions, and are used for navigation purposes. Upstream of Pulau Sulok, the depth of the estuary is more uniform, averaging 7 m.

Labuk Bay itself is also shallow, with a large part being less than 2 m deep. However, deep channels also exist in the southern side of the Bay, with depths of between 5 – 8 m. The coastline of the Bay is vegetated by mangroves and *Nypa* palm.

Based on salinity measurements made at several points in the estuary, the Kuala Labuk can be classified as a well-mixed estuary. At the river mouth, the distribution of salinity from the surface to the bottom is fairly uniform (~15 ppt). However, lateral variations in salinity values exist, with higher values recorded on the south side, corresponding to deeper waters. The longitudinal variation is gradual, with a difference in salinity of about 12 parts per thousand over a distance of about 30 km from the mouth to the head. The whole water column in the estuary moves as a single water mass according to the state of the tide. This was shown by current measurements which showed the same direction of movement from the surface to the bottom.

The river banks in this part of the estuary were mostly more than a metre in height above high water level, except at the lower reaches of the rivers. Measurements of bank height were made between Tungud and the mouth of Terusan Sapi at Perenchangan, and the distribution was approximately as follows:

0.5 – 1 m	20%
1 – 1.5 m	35%
1.5 – 2 m	30%
> 2 m	15%

Buns of 1.5 m high have been constructed around boundaries and on low banks at Pamol and Sabapalm Plantations and the KPD padi schemes to keep out flood water.

In most part, the original vegetation on river banks has been cleared. Thus one can see collapsed banks together with their palm trees, bamboo clumps, and even houses. Erosion is particularly evident where meanders occur. Erosion takes place on the concave bank while deposition occurs on the convex bank. The river banks are made up of fine particles with median diameters of 100 – 200 μm (SEB, 1989).

1.6 River Flow and Estuarine Hydrodynamics

Flow records are available at four gauging stations within the Labuk River basin. These are at Bedukan, Tampias, Tomboloi and Porog for the year as early as 1963. However, the records are not complete and regression method has been used to infill the missing data and also for extension of records at some stations (SEB, 1989). The mean flow at various gauging stations are shown in Table 1.

Table 1: The mean flow recorded at four DID gauging stations in the Sg. Liwagu/Labuk catchment

Station	*Catchment area (km^2)*	*Mean Flow (Cumec)*
Bedukan	197	7.1
Tampias	2070	93.2
Tomboloi	2397	123.3
Porog	3244	177.0

2 Land Use Zonation

The watershed has been divided into to 8 zones reflecting the land-use and the topography.

2.1 Zone 1:

This area is located on the southeastern flanks of Mount Kinabalu, which is the highest mountain in South East Asia (4101 m. a.m.s.l.). The uppermost town is Kundasang comprising approximately 20 villages, *kampongs*, which are spread over the entire area. Infrastructure consists of a few paved roads in the area close to Kundasang town and unpaved roads in the more remote areas; all kampongs can be reached by road with a four-wheel driven vehicle. The number of persons living in the Kundasang area is estimated to be 6000-8000. Most of the people are Dusuns, an indigenous ethnic group, but there are many Chinese, Indonesian and Malay settlers (AUR, 1984).

The area is generally very hilly, with slopes ranging from 5-60 % at an average of 20% (Lim, 1995). Lying at an altitude of 1200-1800 m.a.s.l. the area is characterised as having a temperate climate. The hottest month is May the coolest is January with mean daily maximums of 25.7 $^{\circ}$C and 22.6 $^{\circ}$C respectively. Mean night temperatures are between 16.6 $^{\circ}$C in June and 14.6 $^{\circ}$C in February. Because of the "shadow" effect of Mt. Kinabalu the area has the lowest recorded average rainfall in Sabah. Mean evapotranspiration of 1248 mm leaves only 1001 mm available for surface-runoff and deep percolation and therefore the area is the driest in Sabah. Soil conditions vary and include Lithosols, Acrisols, Cambisols, Gleysols and Podzols. The natural vegetation is mountain rain forest. This vegetation is conserved within Mt. Kinabalu National Park, which was gazetted in 1964 and covers an area of 700 sq. km (AUR, 1984).

The temperate climate allows for intensive vegetable production, few tea plantations and dairy farms. It is also an area with important tourist activities especially in and around the Mount Kinabalu National Park.

Water is a natural resource used as drinking water, irrigation water, or process water for mining and industrial production. On the other hand, waste-water from private households, industrial production and mining is disposed into the water streams without a sufficient pre-treatment. The education of the farmers is poor and they are not supported by a functioning advisory system. Therefore, pollution of the water with nutrients and pesticides origin from the intensive agricultural activity is a potential risk. Increasing tourism in the catchment area is a chance for economical development. However, it requests more clean water and produces more waste and waste-water. This may be a challenge for future development programs.

Preliminary studies in Kundasang (Andersen *et al.*, 1998) showed that competition for the water resources by agriculture, tourism and private households, and disposing of waste-water creates problems concerning water quantity and quality. Insufficient administrative structures and unclear responsibilities have been found to be responsible for missing regulations concerning water supply and waste-water treatment.

The extensive use of fertilisers and pesticides for vegetable production in this area leads to potential risks for the people living downstream. On the way to Ranau, logging activities, a pulp-mill, mining activities and urban settlements create further problems for the downstream water quality. Heavy metals, organic compounds and pathogenic agents are potential pollutants of the river water. Strong heavy metal pollution of the downstream river sediments has been detected in earlier investigations.

2.1.1 Zone 2:

Below Ranau, the valley becomes more narrow and the hillsides steeper. The land-use is not intensive and many fallow fields can be observed. There may be shifting cultivation. In the valley, some paddy fields are found. The hillsides are mostly covered with secondary forest with interspersed fields. The river in this area is rather wide (20m+) and calm. A few old rubber-plantations can be found, some hill rice and also some orchards with durian, banana and cassava. Upstream from Kg. Na Lapak a cowshed and cocoa plantations are situated.

At Tampias a bridge (484922,632110) crosses the river that now has changed its name to Labuk. A few km downstream of this bridge is the site for a proposed 1200MW hydroelectric dam (Liwagu Dam). This dam has been planned for several years (EIA dates 1989) but is at present suspended.

From the bridge a few oilpalm plantations are replacing the old rubber plantations. (489011,627679). Paddy rice becomes more important in the widening valley.

Some landslides close to the road can be observed. Several small villages prior to the bridge are suitable for case studies of this zone.

2.2 Zone 3

Zone 3 is the Dawiu Forest reserve. Here no exploitation has been observed. The reserve is relatively small.

2.3 Zone 4

Zone 4 is the area east of the forest reserve. This is a kind of transition zone in between the upland areas with extensive cultivation and the intensive palmoil plantations in the lowland. The valley is rather wide and the hillsides not so steep compared to zone 2 and 3. Kg. Tabiu could be a case of this more populated area with more agricultural land available. Kg. Wonod (506622,625600) has some rubber-plantations. Some newly established oilpalm plantations can be found at 511972,621305.

Downstream from here, the valley widens further and the forest on the hillsides seems to be degraded with few tall trees standing among low scrub like vegetation. Some agriculture seems to have been taking place recently, but the degraded look of the forest may also be due to the low fertility of soils developed on ultra-basic rocks. Telupid used to be a centre for logging activities and is situated at a small junction.

2.4 Zone 5

Zone 5 is the area east of Telupid where oilpalm plantations become more dominating as the undulating lowland areas take over. This zone can also be described as a transition zone towards the pure oilpalm-plantations, but it contains more monotonous land use than zone 4. The further east the older are the oilpalms, which may indicate an expansion of oilpalm-plantations westwards. (530223, 625614).

At 537079, 626760 a rattan plantation with acacia as shade trees is located. This is the property of the former prime-minister of Sabah, and it is not typical of the region. The plantations observed were established 1996 and 1990-92.

2.5 Zone 6

Zone 6 starts at the rattan plantation and extends eastwards. This zone consists of homogenous oilpalm-plantations. Most of the plantations are owned be large private companies like Sapi, IOI

(553000,630000) and KTS. A small forest reserve, Sunai Sabi, (557400,629200) is one of the few interruptions to the oilpalms. Several small villages housing the plantation workers are scattered in the region and the district has altogether 8 palmoil-mills.

2.6 Zone 7

Zone 7 is distinguished by having a more varied land use some cocoa plantations are found sometimes with coco palms as shade trees. Some orchards can also be found.

2.7 Zone 8

Zone 8 is the remaining area towards the coast. The all-dominating land use is oilpalm-plantation (picture oilpalm view 567900,631336 towards N and picture view with cassava and mill 569964,631890 towards SW). Some cassava fields can be found. Around 4 km further down the road from the picture locations a few small teak plantations can be found. These are also the property of the former prime-minister and are a special case. The plantations do not seem to be successful. A KTS estate is located at 564649,629991.

3 Land Use Conflicts

The observed land use conflicts along the upper part of the river basin are attributed largely to competition for water by agriculture, tourism and municipal supplies; with inherent risks of water pollution by pesticides, fertilisers, waste water. Cultivation of steep sloped land leads to increasing erosion and loss of fertile surface soil. Copper mining activities in adjoining sub-catchment further aggravate the risk of water pollution by suspended sediment and heavy metals. The proposed 120 MW Liwagu HEP Dam at the middle section of the river basin will flood agricultural land and may result in relocation and intensification of land use in the remaining areas therein.

Along the lower part of the river basin, land use conflicts are due to increasing conversions from extensive small/medium scale agriculture and forest to intensive monocultures dominated by oil palm plantations. This intensification with a growing input of agrochemicals increases the risk of water pollution and soil erosion. Socio-economically, people are becoming increasingly dependent on these oil palm plantations, which are owned largely by private companies. However, small forest reserves still exist but are endangered.

4 Conclusion

The Labuk river basin is one of the biggest and most disturbed river basins in Sabah. From the river basin management perspectives, issues to be addressed with respect to the Labuk river are numerous; these include;

- competing water use between the different land uses, which include highland vegetable farming, resort/tourism development, hydropower needs, and the general water supply requirement of the downstream townships and villages;
- land tenureship, water allocation and water pricing issues in the farming sector;
- large scale transformation of land into oil palm estates in the middle and lower catchment;
- use and leaching of agrochemicals in/from both the higland farming and oil palm plantation areas;
- impact of acid mine drainage (pH and heavy metals) from the overburden of an abandoned copper mining on the downstream water quality and aquatic resources;
- possible encroachment into the National Park boundary in the uppermost part of the catchmet due to intensification of agriculture;

- development and potential impacts of a major hydropower plant planned to be installed in the central part of Labuk catchment;
- the occurence of ultrabasic soil in the middle region of the catchment, resulting in the natural leaching of nickel, zinc and other heavy metals; and
- the possible worsening of estuarial channel instability due to changes in stream sediment load and hydraulic characteristics.

The aforementioned land use attributes appear to have resulted in excessive soil loss and deterioration of water quality that can eventually adversely affect the downstream aquatic resources and water use. The worst case scenario would see one of most fertile waters in Sabah, the Labuk Bay, becomes no longer as highly productive in terms of fish yield.

A set of research projects can be initiated for the Labuk River with the aim of producing data and information useful for an integrated approach to river basin management. Investigations will incorporate both scientific and social aspects that embody such management strategy.

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