



BASIN PROFILE OF THE UPPER SESAN RIVER IN VIETNAM

December 2013

*MK3
Optimising cascades
of hydropower*

BASIN PROFILE

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1 SUMMARY

The Sesan catchment covers 19,250 square kilometres, of which about 11,620 km² are in Viet Nam. The Sesan River is 237 kilometres long and runs through all of Kon Tum province and five districts in the Gia Lai province (Figure 1).

Given its topography, the catchment is ideal for developing step hydropower and small hydropower projects. However, all such projects should be linked to broader economic and social benefits across sectors such as agriculture, fisheries, industry and tourism. Their impact on the environment and their contribution to climatic changes should also be considered. Most studies have so far ignored these aspects.

The rapid development of hydropower on the Sesan basin has led to unsustainable exploitation of forests, deforestation, soil erosion and run-off, as well as sedimentation of basin streams. The existing projects are also solely responsible for generating electricity and cannot be used for other purposes such as regulating water supplies, flood control or irrigation.

Sustainable development of the basin requires close coordination between nations sharing the Sesan River. Within Viet Nam, the managers of the river basin should help local governments manage land resources, forests and the water catchment area, and help improve the lot of ethnic minorities who rely on the river.

The MK3 research group at the Western Highlands Agriculture & Forestry Science Institute (WASI) has received support from ICEM – International Centre for Environmental Management, the Executive Board of WASI, and the Gia Lai Research and Experimental Center for Irrigation and Agriculture and Forestry.

The data in this report were collected from the Yaly Falls Hydropower Company and relevant departments in Gia Lai and Kon Tum provinces: the Department of Agriculture and Rural Development (DARD), Department of Planning and Investment (DPI), Department of Natural Resources and Environment (DONRE) and Department of Trade and Industry (DOT).





2 OVERVIEW OF THE SESAN RIVER

The Sesan River flows through the Gia Lai and Kon Tum provinces^{2,36,38,44} in Viet Nam before entering the Ratanakiri and Stung Treng provinces in Cambodia (Figure 2).

The river's main run-off originates at the Tion Mountain at an elevation of 2,010 metres in the upper north of the Kon Tum province. From there, it flows south to the Yali waterfalls. It then winds towards the southwest to the Vietnam border and enters Cambodia. It joins the Mekong River in Stung Treng, Cambodia.

The average height of the basin is 737 m, with a slope factor of 14.4 percent. The river net density of entire region is 0.38 km/km², with a meandering factor of 1.45. The Dak Bla, Dakpsy, Sa Thay and Lagrai tributaries all branch from the river⁴⁴.

The headwaters flow through the mountains and high lands west of Truong Son and form the main tributaries Dak Bla and Krong PoKo. The smaller Sa Thay River also forms. Where the river flows through deep canyons and high mountain ranges, there is little inhabitation or agriculture.

In the Gia Lai province, the Sesan catchment occurs west of the districts of Chu Pah, Ia Grai, Duc Co and north of Dak Doa. The river in this part has enormous hydropower potential and already supports the Yali, Sesan 3, Sesan 4, Sesan 3A and Sesan 4A dams.

The Krong PoKo basin is vast and occupies 30 percent (3,530 km²) of the total catchment area. It occurs in the northwest between the Krong PoKo and Dak Bla Rivers, and covers the districts of Dak Glei, Dak To, Dak Ha, Ngoc Hoi, a part of the Sa Thay district and Kon Tum town. About 121 km of the river flows through this region.

The Dak Bla region is on the northeast side and includes most of the districts of Plong Kong, Kon Ray and most of Kon Tum town. It covers 3,226 km² and accounts for 27.9 percent of the river basin.

The lower Sesan River catchment area consists of the Sesan River, downstream of the confluence of Krong Poko and Dak Bla Rivers. The river passes on its right bank the Sa Thay district of the Kon Tum province. The left bank includes the Chu Pah, Ia Grai, Duc Co, Dak Doa districts and Pleiku city of the Gia Lai province.

The coordinates of the Sesan catchment area in Vietnam are 107⁰36'50" to 107⁰40'58" east longitude and 13⁰45'35" to 15⁰15'38" north latitude^{36, 38, 44}.





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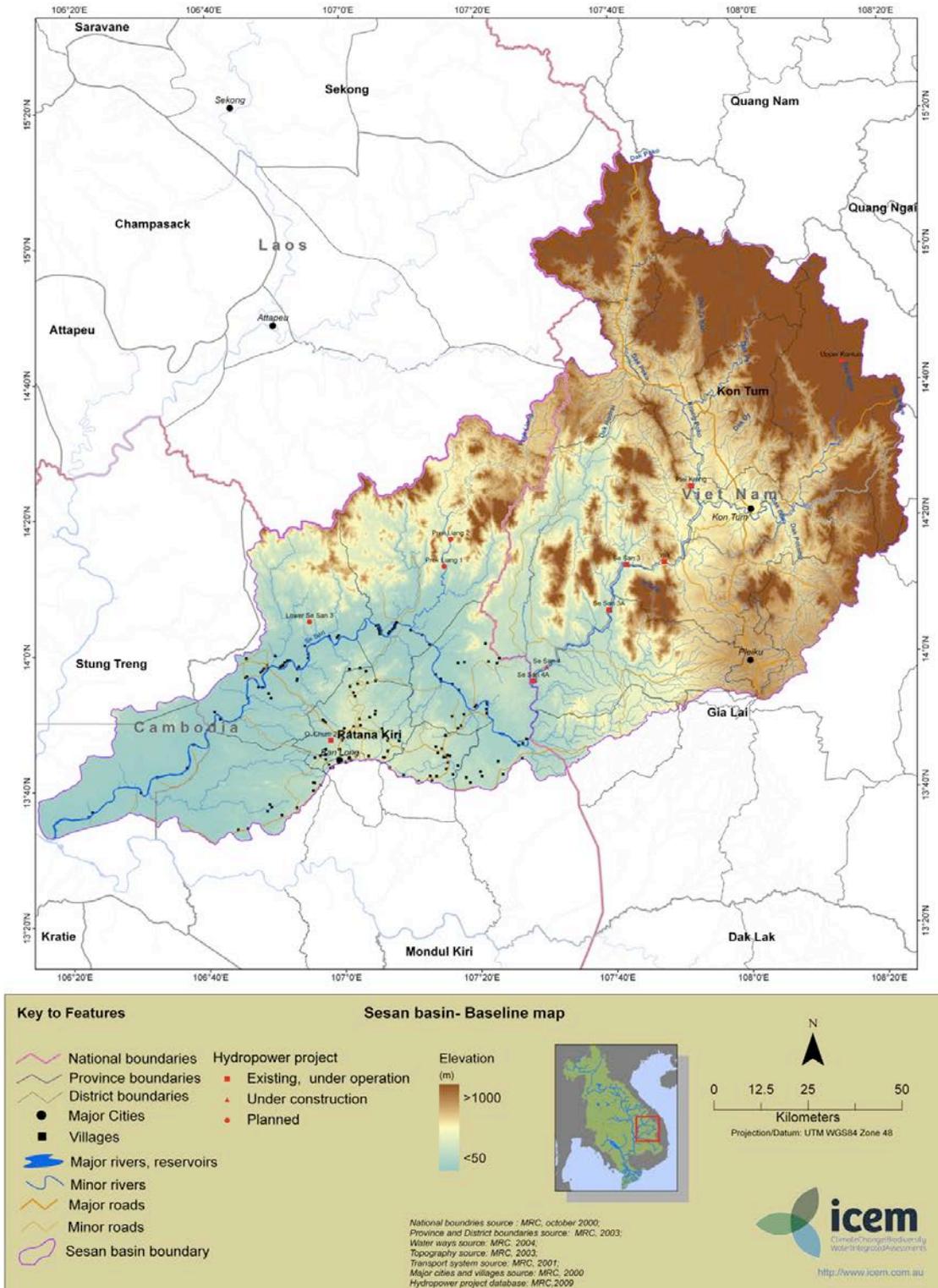


Figure 1: Baseline map of the Sesan basin



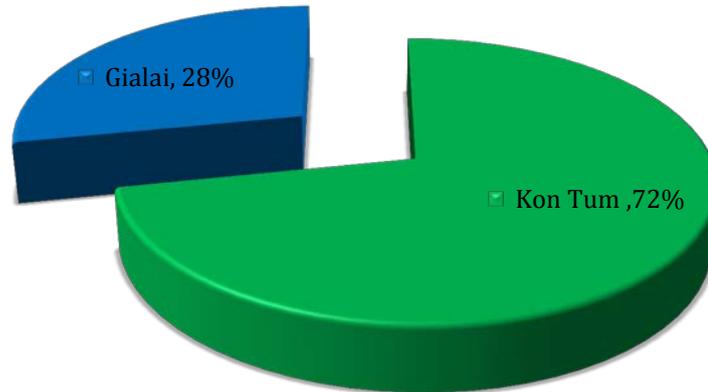


Figure2: Distribution of Sesan catchment area in Viet Nam

Source: DARD of Gia Lai and Kon Tum, 2010, Pham Tan Ha, Water Resources University, 2006⁴⁴

3 KON TUM PROVINCE

3.1 GEOGRAPHY AND TOPOGRAPHY

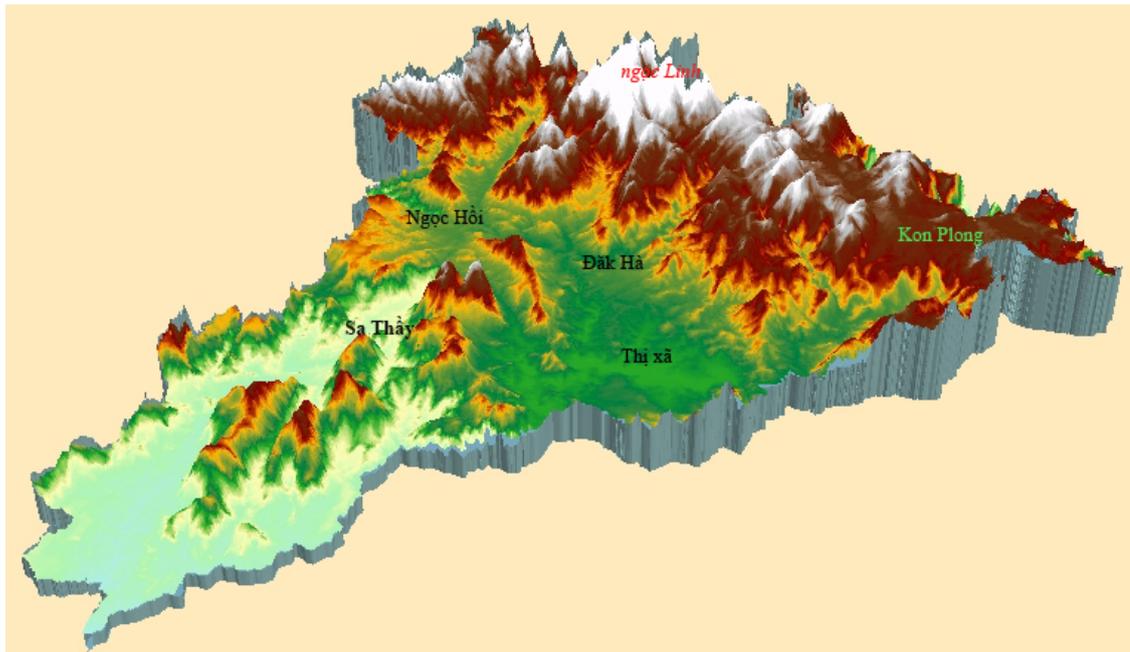
Kon Tum is a high mountainous border province in the Central Highlands covering just 3 percent of the entire country. The provinces of Quang Nam, Quang Ngai and Gia Lai border Kon Tum⁵⁷.

Its topography is diverse, with alternating hills and mountains, plateau regions and lowlands⁵⁷. A mountainous terrain with a slope of at least 15° covers 40 percent of the province. The mountain ranges are the origins of many rivers, such as the Thu Bon and Vu Gia that flow into the Da Nang district and the Tra Khuc River that flows into Quang Ngai (Figure 3).

The Truong Son mountains occur to the east of Kon Tum and the Mount Bon San (1939 m) and Mount Ngoc Kring (2066 m) mountains occur within the province. The region is hilly in the Sa Thay district, where the Chumomray range occurs.

The valley along the Krong PoKo River has a channel shape with less elevation towards the south. Along the valley, there are wavy hills such as Dak Uy and Dak Ha and flat areas such as Kon Tum town.

The Konplong Highlands occur between the An Khe and Ngoc Linh mountains in the Kon Tum province, at an elevation of 1,100 to 1,300 m.



Note:

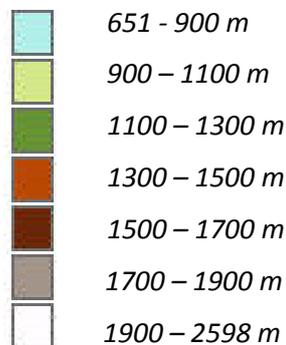


Figure 3: Height distribution of the Kon Tum province

Source: *Institute of Agriculture Planning and Design, 2010*²⁵

3.2 CLIMATE

Kon Tum has a tropical monsoon climate with average annual temperature fluctuating between 22 °C to 24 °C. Within a day, the temperature can change by 8 or 9 °C. The highest temperatures greater than 25 °C occur between March and May (Table 1).

The province's climate is ideal for crops including rubber, coffee, maize, rice, cassava and legumes.

The rainy season is between April and November and the dry season is between December and March. The average yearly rainfall is 1,936 millimetres but there is great fluctuation between the months. Almost 93 percent of the annual rainfall occurs in the rainy season, and August gets the most precipitation.

The north and northeast mountains get the most rainfall, between 2,500 mm to over 3,000 mm in some areas. The lowlands and valleys get between 1,600 mm to 1,800 mm. The total annual rainfall has reduced by 10 percent between 2010 and 1995.

The rainy season arrives early and in March, 60.5 mm of rain are usually recorded. The heavy showers increase gradually, peaking at 364.6 mm in August. The rain doesn't stop until October. November's average rainfall is 72.4 mm and December, when the dry season begins, gets only about 0.7 mm.





The concentration of rain in the wet season affects the management of agricultural land, especially on slopes. Erosion needs to be controlled using suitable cultivation measures such as planting in contours to make green bands and using cover crops. Erosion and soil run-off also cause sedimentation of reservoirs, as in the case of the Plei Krong hydropower dam.

The annual humidity fluctuates between 68 percent and 87 percent. The months with the highest humidity are July to September and February is least humid. High humidity creates favourable conditions for pest development, and it becomes important to watch for crop diseases.

In the dry season, the sun shines for 2,379 hours ever year, with January to May, November and December getting the most sun (201 to 279 hours). Crops such as coffee and pepper need to be irrigated over these months.

There are a number of microclimates in Kon Tum due to the variations in topography. In the area around Kon Tum city, the average temperature tends to be 2 to 3 °C higher than in areas such as Kon Plong and Tu Mo Rong. In areas with higher altitudes (over 1,000 m above sea level), a cool climate makes the area suitable for economically valuable crops such as Arabica coffee, vegetables, flowers and fruit trees.

In recent years, farmers have notice abnormal weather trends. In 2010, the average annual temperature was 1.4 °C higher than the five-year average between 2005 and 2009. Higher temperatures and more evaporation would increase water requirements for crops, which could increase farmers' input costs.

Table 1: The climatic factors in Sesan catchment area

The climate factors	Kon Tum	Gia Lai
Annual average temperature (°C)	23.5	22.1
Annual average humidity (%)	78.8	81.8
Annual average rainfall (mm)	1,936.5	2,159.5

Source: Kon Tum & Gia Lai Statistical Office, 2010²⁹, average data from 2001 – 2009





4 GIA LAI PROVINCE

4.1 GEOGRAPHY AND TOPOGRAPHY

Gia Lai is a mountainous province in the Central Highlands covering 5,800 km². It shares a border with Cambodia on the west. Mountains, including the An Khe, Ngoc Linh, Chu Du ranges, account for 40 percent (6,909 km²) of Gia Lai's area. The average elevation is between 700 to 800 m. The highest mountain is over 2,023 m. Midlands and plains cover three-fifths of the province's area. Lowlands including An Khe town and Cheo Reo and Phu Tuc districts cover 2,786 km² (Figure 4).

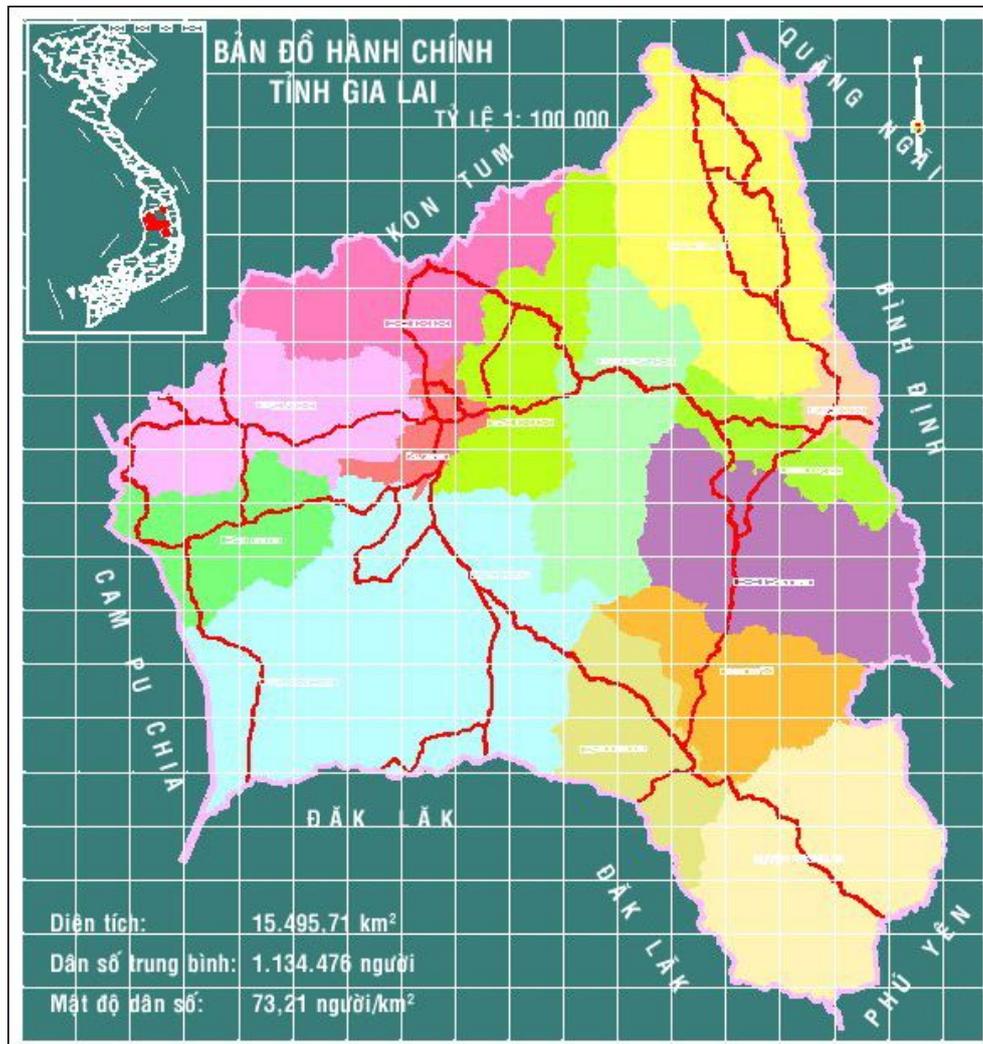


Figure 4: Administrative map of Gia Lai province⁵⁶

4.2 CLIMATE

The temperature varies between 19.7 °C and 24.2 °C (Table 1). This temperature suits a variety of tropical and sub-tropical crops, such as coffee, rubber, pepper, corn, beans, vegetables and flowers.

The annual average rainfall is 2,150 mm and much of it falls in the wet season between April and November. That's also the time of the summer monsoons.

About 85 to 96 percent of the rain for the entire year falls within a 115-day period. The concentration of rain within such a short period can cause soil erosion, especially on slopes.



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Rainfall begins in April when about 86 mm falls. The most precipitation, of 482.4 mm, occurs in August. In December, rainfall declines sharply to about 1.5 mm. From December to March, there is severe drought and a number of key crops such as coffee and pepper require irrigation.

Cultivation is done mainly in the wet season, which increases soil erosion and run-off. Slopes lose between 100 to 200 tons of soil/hectare/year. This translates to a nitrogen loss of between 150 kilograms and 200 kg, a phosphate loss of between 30 kg to 60 kg, and a potassium loss of between 130 kg and 200 kg⁵.

The dry season occurs between December and April, and it is a time when humidity is low, the northeast winds pick up speed. This increases the rate of evaporation and groundwater levels drop enough to cause severe droughts. Demand for irrigation is very high, especially for winter crops and coffee trees.

Rainfall varies dramatically with terrain, with some places getting twice or even three times as much rain as regions that are just 100 km away.

The prevailing wind directions can have clear seasonal trends. Wind regimes show the influence of the Southeast Asian monsoon. In the winter, the predominant wind direction is to the northeast. In the summer, the prevailing wind direction is to the west and southwest. The wind is hot and dry at elevations less than 500 m. The average wind speed is 3 m/second and is constant throughout the year.

Depending on the topography, Gia Lai can be said to have two broad climate sub-regions. The northern mountain highlands have a humid, tropical climate and the average temperature is 22 °C. The coldest month, January, has a low of 18.6 °C and the hottest months of March to June have temperatures of 23.8 °C.

The northern low valley has a drier climate and higher temperatures compared to the northern mountains and highlands. The An Khe and Cheo Reo – Phu Tuc lowlands occur here and have an average temperature of about 24 °C.

Fog occurs at any time in the summer, and there are about 100 foggy days every year. Thunderstorms and hail occur at the beginning of the rainy season. Thunderstorms are also common, occurring 40 days in a year, especially in the Cheo Reo – Phu Tuc area.

The microclimates in Gia Lai allow a wide range of crops and livestock to be cultivated.





5 LAND RESOURCES

5.1 SOIL

There are eight main soil groups on the Sesan catchment^{48, 25}:

- The gley group (G1) covers 1,761 ha (0.15 percent of the area) in the northern districts except Dak Gleï
- The newly changed group (CM) covers 2,417 ha (0.21 percent) and is in the Kon Tum, Dak Ha and Sa Thay districts
- The gray group (X) covers 857,108 ha (73.76 percent) and is found throughout the region
- The fluvial group (P) occupies 17,812 ha (1.53 percent) and is usually downstream of rivers and in Dak To and Dak Gleï districts and Kon Tum and Plei Ku cities
- The alite group (A) covers 6,865 ha (0.59 percent) and is found in Dak Gleï and Dak To
- The yellow-red group (F) occupies 227,159 ha (19.55 percent) and is in Pleiku city, Kon Plong, Chu Pah, Dac Doa, Duc Co and Ia Graï districts
- The slope group occupies 11,312 ha (0.97%) and is in Pleiku, Kon Tum, Chu Pah, Dac Doa, and Ia Graï
- The bare topsoil (E) occupies 23,966 ha (2.06 percent) and is found in Kon Tum, Ia Graï, and Sa Thay districts.

Gley soil is a hydric soil with patchy layers and is suitable for rice cultivation or aquaculture.

Alluvial soil has acidic topsoil (pH_{KCl} : 4.36). The acidity decreases with depth. The soil is rich in organic matter, and the top soil is rich in nitrogen. There are average amounts of phosphorous in the top soil and medium levels in the under soils. There are few exchangeable cations and the clay ratio is about 20 percent. Such soil is desirable for agricultural production and should be saved for growing crops like corn, vegetables and legumes. Areas with irrigation can be used for cultivating paddy.

Gray soil has acidic topsoil (pH_{KCl} : 4.98) and a less acidic under soil. Organic matter content in the topsoil is poor to medium (2.05 to 3.40 percent) and nitrogen content is poor. Phosphorous and potassium availability are also poor. There are few exchangeable cations. Such soil is not very fertile, but can be used to plant perennial crops, fruit trees, crops and food crops.

The yellow-red soil group consists of red-brown soil on basalt (rhodic ferralsols) and humic ferralsols on gneiss soil. These are distributed in Kon Plong, Sa Thay districts and Kon Tum province and in the districts of the Sesan River catchment along the boundary of Gia Lai. The rhodic ferralsols on basalt have a high porosity throughout the profile. They are acidic (pH_{KCl} : 4.0 – 4.5) and their organic matter and total nitrogen content is fair to high. The total phosphorous content is high. Potassium availability is poor and cation exchange capacity is average. This soil's drawback is that it is usually found in high terrains that lack water. It can be used to plant upland, perennial or annual crops such as rubber, coffee, pepper, food crops and beans.

Alluvial slope soil often has fairly rich organic and total nitrogen content. The total phosphorus and potassium content is average to low. Cation exchange capacity is average to high. The soil is fairly acidic. Areas with this soil in the Kon Ray and Sa Thay districts are used for growing rice and vegetables. But production is precarious due to the frequency of flash floods and flooding in the rainy season.

5.2 STATUS OF LAND USE IN THE CATCHMENT

About 39 percent of the catchment in Gia Lai and 20 percent of Kon Tum is used for agriculture. Forests account for 68 percent of Kon Tum and 48 percent of Gia Lai (Table 2, Figure 5).

Forests in Gia Lai have been heavily exploited for forest products, farming and infrastructure development. Meanwhile, Kon Tum contains more unused land though it is the smaller of the two provinces. These lands can be used for economic development.

Within Kon Tum, the catchment makes up 59 percent of agricultural area and 12 percent of the overall area of the province.





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In Gia Lai province, only four districts and the city of Pleiku make up the Sesan catchment. They account for 43.8 percent of the agricultural area and 17 percent of the total area of the province.

Overall, agricultural land in the two provinces accounts for 47.5 percent of agricultural area in and 14.9 percent of the total area of Viet Nam.

Table 2: Status of land use in Kon Tum and Gia Lai provinces (2010)

Target	Kon Tum		Gia Lai	
	Total (ha)	%	Total (ha)	%
I. Agricultural land	856,646	88.4	1,347,863.7	86.8
1. Agricultural land used for production	192,104	19.8	601,442.1	38.7
2. Forested land	663,838	68.5	745,245.8	48.0
II. Non-agricultural land	42,755	4.4	110,365.7	7.1
III. Unused land	69,560	7.2	95,463.9	6.1
Total	968,961	100.0	1,553,693.3	100.0

Source: Gia Lai & Kon Tum Statistical Office, 2011^{17, 30}.





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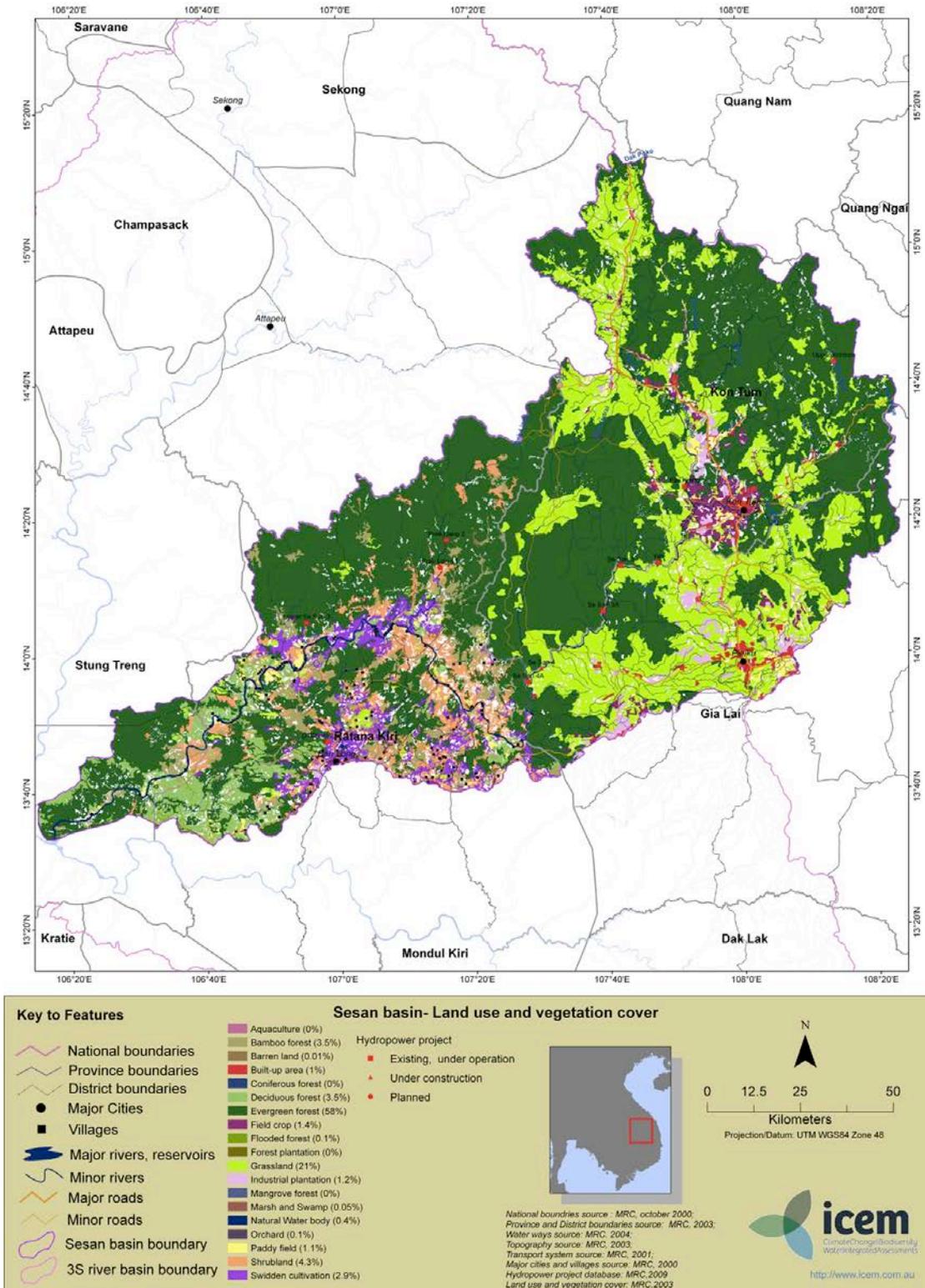


Figure 5: Land-use map of the Sesan catchment



5.3 TOTAL AREA OF AGRICULTURAL CROPS

The arable area of the Kon Tum is 122,881 ha and food crops are planted in 69.4 ha (56.5 percent). Cassava is most popular and covers 37,275 ha (30.3 percent of total agricultural land). Perennial industrial crops cover 48.5 ha (39.5 percent), with rubber accounting for 30 percent of those.

The arable land of Gia Lai (the four districts and Pleiku city) covers 140,489 ha. Perennial industrial crops cover 72 percent of the area, with coffee and rubber being the most common. Pepper is also planted. These crops are well suited to the basalt soil in the region. Farmers earn VND 50 to 100 million per ha of coffee, VND 40 to 80 million of rubber and VND 80 to 180 million per ha of pepper. Food crops account for just 28 percent of the land, with rice being the biggest crop, followed by cassava. Cashew is also a minor crop that is easy to grow and is commonly cultivated by ethnic minorities. For an overview of crops in the Sesan basin, refer to Table 3.

5.4 LAND-USE TRENDS IN THE CATCHMENT

Food crops

The popularity of maize has fallen since 2007 due to reduced yields. Much of the area has been switched to rubber cultivation, which is promoted by government policies.

Cassava

Cassava cultivation increased by 5,900 ha/year between 2005 and 2009. Since 2009, some of the crop has been displaced by rubber.

In areas planted with cassava in the Dak Bla River basin of the Kon Tum province, soil fertility has worsened. The soil has acidified, organic matter content has decreased and there are fewer nutrients in the soil, according to a study by WASI. After three years, the pH of the soil fell by 0.62 units and the total alkaline earth cations decreased by half, making the soil even more acidic. The soil's ability to absorb nutrients from fertilizers was also negatively affected. The total nitrogen, phosphorous and potassium available in the soil fell by 50 to 60 percent.

This meant fertilizer input needs and costs would increase for the farmer, as would the risk of contaminating surface waters with fertilizer run-off. Cassava also reduced the total nitrogen, phosphorous and potassium available in the soil by almost 50 to 60 percent.

In 2012, the researchers surveyed the regions surrounding the Sesan 3A dam and again found that after three years of cassava cultivation, the soil fertility had fallen and productivity was very low. In the first year, the yields had averaged five to six tons of fresh tubers/ha. The second year's yield was three to four tons/ha and the third year's was only two to three tons/ha. With such a low yield, farmers planned to find better land for farming and possibly convert forest land, leading to deforestation.

Rubber

About 4,435 ha/year of rubber were planted between 2005 and 2010, of which 3,000 ha/year were planted in Gia Lai. The growth was due to government policies that want 100,000 ha planted to the crop⁹. Less fertile areas and regions previously planted with cassava and maize have been converted to rubber, according to Ministry of Agriculture and Rural Development criteria (Circular No..76/2007/TT-BNN)³⁹.

Since rubber is a forest crop, converting poor areas to rubber plantations will ensure the land still has forest cover, according to WASI research. However, the plantations will eliminate biodiversity contained in the poorer forests.





Table 3: Overview of crops in the Sesan basin (2010)

Forms of land use	Kon Tum		Gia Lai		Total	
	ha	%	ha	%	ha	%
I. Food crops	63,224	55.8	39,201	27.90	108,596	41.23
1. Rice	17,593	15.5	20,253	14.42	44,017	16.71
2. Maize	8,197	7.2	2,819	2.01	11,016	4.18
3. Yam	159	0.2		0.00	159	0.06
4. Cassava	37,275	32.9	16,129	11.48	53,404	20.28
II. Yearly industrial crops	2,470	2.2	441	0.31	2,724	1.03
1. Sugar-cane	2,254	2.0	82	0.06	2,149	0.82
2. Groundnut	145	0.13	306	0.22	451	0.17
3. Tobacco	42	0.04	0	0.00	42	0.02
4. Sesame	-	-	25	0.02	25	0.01
5. Others	29	0.03	28	0.02	57	0.02
III. Perennial crops	46,579	41.2	100,013	71.19	148,560	56.41
1. Tea	13	0.01	380	0.27	393	0.15
2. Coffee	10,066	8.9	46,024	32.76	57,133	21.69
3. Rubber	36,129	31.9	44,253	31.50	81,307	30.87
4. Pepper	74	0.06	1,036	0.74	1,110	0.42
5. Coconut	49	0.04	0	0.00	49	0.02
6. Cashew	248	0.4	8,320	5.92	8,568	3.25
IV. Fruit crops	973	0.8	834	0.59	1,807	1.33
1. Orange, Mandarin, Shaddock	106	0.15	-	-	-	-
2. Mango	208	0.35	-	-	-	-
3. Longan	181	0.3	-	-	-	-
Total Area	113,246	100	140,489		263,370	100

Source: Gia Lai & Kon Tum Statistical Office, 2011^{17, 30}, DARD of Gia Lai and Kon Tum, 2011^{18, 31}

5.5 LAND-USE TRENDS IN KON TUM

- Food crops: The area planted with food crops increased by 46 percent since 2005, with most of the increase due to cassava. Cassava expansion happened at a rate of 1,900 ha/year and forest land was converted to crop land, often without planning. Forests need to be better managed to limit deforestation²¹.
- Yearly industrial crops: Decreased by 44 percent since 2005 as people switched to growing cassava and industrial crops such as rubber, coffee and pepper.
- Long-term industrial crops: Increased by 68 percent since 2005, with rubber being most popular due the government policies. By 2010, Kon Tum had 36,129 ha of rubber and the area was expanding by 3,260 ha/year. The government wants 24,000 ha more planted by 2015 since rubber is economically beneficial to highland farmers. The crop does not require much watering in these drought-prone regions. However, the expansion of the crop meant that forests are being deforested to accommodate the crop. Some 105 ha of trees were felled in a single year.
- Fruits: Increased by 47.5 percent since 2005, with some mango and longan cultivation.





5.6 LAND-USE TRENDS IN GIA LAI

- Food crops: The area increased by 40 percent since 2005 due as cassava expanded to 17,826 ha in 2008. But farmers began moving away from cassava in 2010 as the land became eroded.
- Yearly industrial crops: The area decreased by 45 percent due to land conversion to other crops, including rubber, coffee and pepper.
- Long-term industrial crops: The area increased by 46 percent, mainly due to rubber cultivation. The cashew area also increased, while the area planted with coffee remained stable. The area planted with rubber increased by 44,263 ha between 2005 and 2010. Some 3,476 ha/yr were planted in the four districts. In 2009 alone, the rubber area increased by 8,181 ha.
- Fruit crops: decreased by 11 percent since 2000 due to economic inefficiency.

6 RIVER SYSTEMS

The rivers and streams in the Central Highlands form three major river systems: the Ba River, the Mekong River (Sesan - Serepok) and the Dong Nai River. These three catchments make up 96 percent of the area of the Central Highlands⁴⁴.

The Sesan River is a major tributary of the Mekong and many of its characteristics have been discussed previously.

The Dak Bla River is a level 1 tributary that is 152 km long and covers 3,050 km² in area. It originates in the Noc Co Ring Mountains at an elevation of 2,025 m. It flows from the northeast toward the southwest and joins a tributary of the Sesan, the Krong Poko River, 16 km downstream of the Yali waterfall, in Sa Binh. The mesh density of the Dak Bla River is 2.03 km/km² and the slope factor is 4 percent.

The Krong PoKo River has a basin area of 3,530 km² and a length of 121 km.





7 WATER RESOURCES

7.1 RAINWATER

The climate in the catchment is heavily influenced by the Annamite Mountains. The area gets 2,000 mm/year of rainfall, but almost 85 percent to 90 percent of it falls in the six-month-long rainy season^{26,44}. The wet season occurs from May to October and the dry season occurs from November to December.

Flooding can occur during the periods of heaviest rainfall beginning October 5 to 8, caused by the influence of the Truong Son Mountains. This increases the water availability in rivers and lakes.

Beginning May 9 or 10, the southwest monsoon and other weather systems have in the past caused heavy rains of strong intensity and flooding.⁴¹

The rainfall total in the catchment over many years was about 25.04 billion m³, according to data of average rainfall from the Water Resource Atlas of the National Water Resources Council (Figure 6). Thus, rainwater is plentiful in the region.

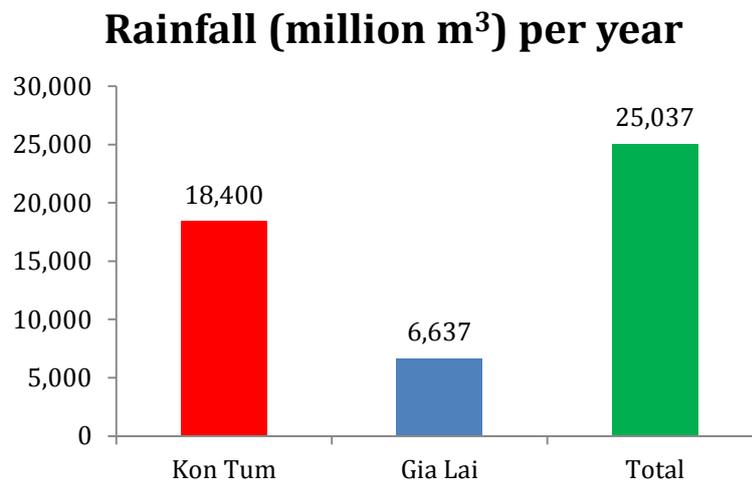


Figure 6: Total rainfall in the Sesan basin by province

Source: Pham Tan Ha, 2006⁴⁴

7.2 SURFACE WATER FROM RIVERS AND STREAMS

The average annual flow of various rivers and streams in the Western Highlands is 45 billion m³/ha, of which the Sesan makes up 29 percent. Only 7 to 10 percent of this surface water is used.

The surface water resources are unevenly distributed over the year, with heavy floods occurring if the wet season is too long and severe water shortages occurring in the dry season. Irrigation and hydropower can help regulate floods and improve water availability.

River flows depend on precipitation, vegetation cover and the terrain, and can vary in space and time. The Sesan basin has an average flow module of 32 to 35 litres/second/km².

The Sesan basin has an annual flow of 408 m³/s, which corresponds to a flow module of 35.6 l/s/km². The total annual flow is 12.9 billion m³. The Sesan's mainstem in Sa Binh, formed by the confluence of Krong Poko and Dak Bla, is 14 km long, and its average flow for past many years has been 240 m³/s, which corresponds to a flow module of 35.6 l/s/km².

The fluctuations in flow can be complex, as seen from monitoring data. In years with big tides, the flow volume can be 1.5 to 2 times greater than in years with low tides.



The distribution of flow over the year mirrors the rainfall distribution and can be divided into two seasons: the flood season and the dry season, which corresponds to the wet season and dry season.

Since the basin is regulated by hydropower projects, the floods arrive 1 or 2 months after the rains. The flood season begins in July or August and goes till September. The dry season occurs mainly in March and April. Almost 70 to 80 percent of the total annual flows are seen in the flood season, with the dry season getting only 20 to 30 percent of the annual flow.^{44, 28}

Surface water from natural and artificial lakes – irrigation

The Sesan basin has the highest density of reservoirs across the country (both natural lakes and man-made). In Kon Tum, there are 96 lakes, including 48 water reservoirs with a capacity of greater than 80 x 10⁶ m³ of water, and 48 reservoirs with a capacity of greater than 106 m³. CHECK THESE NUMBERS! In Gia Lai, there are 98 natural and man-made reservoirs. T’nung Lake, a natural lake with a total capacity of about 28.5 million m³, is the largest lake in the Central Highlands and can irrigate 2,000 ha (Table 4).

Table 4: The main lakes of the basin and their irrigation capacity

Lake name	Province	Capacity (x10 ⁶ m ³)	Lake area (ha)	Irrigation area (ha)
The T’nung Lake	Gia Lai	28.5	400	2,000
Hoang An	Gia Lai	6.0	90	590
Đak Uy	Kon Tum	26.1	260	1,700
Đak Lok	Kon Tum	5.4	88	880
YaLy	Kon Tum	1,170.0	6,450	-
SeSan 3	Gia Lai	92.0	-	-
SeSan 3 A	Gia Lai	80.6	-	-

Source: Institute of Water Resources Planning, 2006²⁶, Department of Agriculture and Rural Development, Gia Lai, Kon Tum 2010^{10, 11}

The many artificial lakes built in the 1990’s have been a major water resource for agriculture and power generation. The total capacity of reservoirs over the entire basin is over 1,250 x 10⁶ m³^{28, 44}. These lakes regulate flows in the rainy season and provide water for agriculture in the dry season.

The water resources in the basin are imbalanced. Dry season supplies can be sparse as lakes experience rapid evaporation when temperatures are high and humidity is low. Over 80 percent of the surface water supplies are used up in the dry season, mostly for agriculture^{3, 10, 11}. This has led to the drying up of springs and the groundwater level has dropped from 3 m to 5 m over the past five years, according to the Geological Association of the Western Highlands.

Watering crops such as coffee and pepper in the dry season can be challenge even though there are more than 100 reservoirs in the basin. The artificial lakes can irrigate only 35 to 40 percent of the area of the Gia Lai province, and 45 percent of reservoir supplies are used to irrigate coffee plantations two or three times a year. This is not always sufficient for the crop. In times of prolonged drought, the crop may need to be irrigated four times.

It should be noted that hydropower projects might not be used for irrigation if the land around them is not suitable for agriculture. Studies have shown that the high slopes around existing projects are usually uncultivated (WASI 2010). Cassava and rice are grown in small upland areas, but have low productivity due to infertile soils. The land around Sesan 3 and Sesan 3A, as well as the Yali, has small plantations of corn, rice, coffee and beans but these are irrigated using streams and wells rather than the dams.

7.3 FLOODS

Floods occur frequently, with large events recorded in 1992 to 1994, 1996, 1998, 2000 and 2009. The flood season is between September and October on the Sesan and Dak Bla Rivers. The Krong PoKo





River floods earlier, which means that the adjacent area of Kon Tum is already flooded by the time the Dak Bla overflows.¹²

Flash floods can occur when short, intense rainfall occurs in a small area or when a hydropower project fails. Floods on sloping terrain with little vegetation cover can cause serious damage to soil, resulting in landslides, sediment cascades and damaged property.

The Sesan River flood on November 3, 1996 saw 197.4 mm of rain in one day at Dak Glei and 159 mm of rain at Dak Tove. The flood crest at Dak Bla reached 3.620 m³/s with Mmax = 1.22 m³/s/km².⁴¹

To avoid damage from such flash floods, authorities need to better manage and protect forests to limit erosion and landslides. They need to limit development of roads and buildings around dams.

7.4 EROSION AND SEDIMENTATION

About 90 percent of the arable land in the Western Highlands⁴⁸ is sloping and can be affected by rainfall. At slopes of 8 to 15°, the soil loss is 22.1 to 43.8 tons/ha/year of soil planned to rubber, 19.5 to 41.68 tons/ha/year for coffee areas and 100 to 120 tons/ha/year for cassava areas³⁵.

Loss of soil can lead to sedimentation of reservoirs, so there needs to be afforestation to restrict erosion (Figure 7). Mechanical measures, such as bands against erosion, and biological measures, such as growing plants by contour, can limit runoff on slopes and extend the life of reservoirs.



Figure 7: (Left) Soil erosion causing sedimentation in the Sesan basin at the Sesan 3A hydropower plant. (Right) Soil erosion around Plei Krong hydropower plant caused sedimentation in the reservoir.

Source: WASI, 2011

7.5 GROUND WATER

Supplies are plentiful in the Western Highlands and Sesan basin, but demand is increasing due to population and economic growth^{3, 12, 44, 53}.

There are enough reserves in the basalts of the Western Highlands to meet livelihood and economic needs, according to Hieu Bui, 2005³. There is six times as much under the basalt in Gia Lai than in Kon Tum, primarily because there is more basalt in Gia Lai.

The reserves of groundwater in Kon Plong, Dak Glei, Dak To and Sa Thay are between 240 x 106 m³/year to 400 x 106 m³/year, according to the University of Mining and Geology (National-level theme KC.08.05).¹² In the lower Sesan basin of Chu Pah and Ia Grai, there are between 80 x 106 m³/year to 99 x 106 m³/year of water reserves. The potential reserves in Plei Ku city are the lowest, at 15 x 106 m³/year.

The reserves of the upper Sesan are seven times those in the lower Sesan (Figure 8), but these are not used for irrigation because the area of cultivation is small.

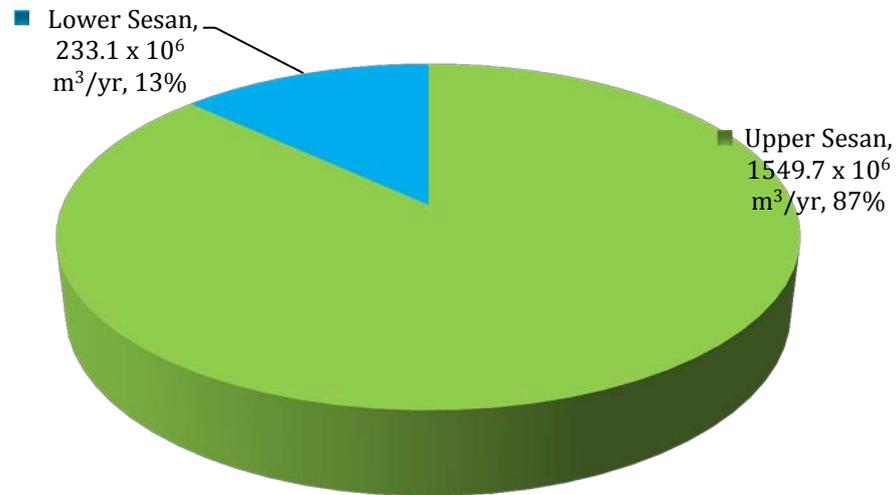


Figure 8: Groundwater potential in the upper and lower Sesan basin

Source: University of Mining and Geology, 2005¹²

Groundwater can be used for eating, drinking and daily activities in most places. It contains few minerals, mainly bicarbonates, sodium chloride and magnesium. Calcium levels are very low and sulphate ions are present only near the town of Kon Tum. Iron may need to be removed by filtration before use. The total mineral content is between 100 and 500 milligrams/litre in the Gia Lai province, and below 100 mg/l in the Kon Tum province.

Exploiting groundwater in the Highlands can be challenging since it is present at great depths that fluctuate sharply by season. City wells are drilled below 100 feet and require the use of expensive electric submersible pumps.

Lakes and reservoirs are usually found in low-lying terrains, which make it difficult to exploit the water using gravity flow systems⁵³. So, groundwater is the dominant source in the lowlands if operators do not want to build reservoirs or canals.

Water resources are being depleted in the catchment due to deforestation and reduction of land cover. Surface and groundwater supplies are being overexploited to irrigate coffee and fertilizers and pesticides are polluting supplies.

To ensure supplies during drought, it is important to save and store water.

Rainwater conservation

- Non-structural measures include forest protection strategies, selective planting of crops that use less water, restricting the use of fertilizers that harden soil and prevent infiltration of rainwater, educating the community about water conservation, and developing regulations for infrastructure development that allows sufficient rainwater to get into the ground.
- Structural measures can also help. These include the construction of underground and aboveground reservoirs to store more rain water, using technology to move rainwater directly into the underground water supply, and upgrading and developing irrigation works.



Surface water conservation

- Non-structural measures can conserve surface water. These include developing management plans for water resources, forests, agricultural land and industrial parks, promoting afforestation and forest protection, and growing crops suitable to local conditions
- Structural measures include building reservoirs for power generation, flood control and supplying water, protecting channels and ecosystems along the banks of rivers and streams, adjusting the operating regimes of irrigation reservoirs and hydropower plants to avoid significantly altering water levels downstream.

7.6 WATER RESOURCE MANAGEMENT ON A TRANSNATIONAL SCALE

The Sesan River is shared by Viet Nam, Laos and Cambodia. All management plans for the river need to accommodate the interests of all nations as laid out in the Mekong Agreement of 1995.

7.7 RESEARCH

Basic research into groundwater resources of the Sesan basin is needed. Projects should include the large-scale hydrologic and geologic mapping of economic and residential zones. Existing maps need to be annotated to promote sustainable water use, and new assessments are needed for regions that urgently need fresh groundwater resources.

8 WATER REQUIREMENTS

8.1 REQUIREMENTS BY PRODUCTION SECTOR

- Aquaculture: requires $5.15 \times 10^6 \text{ m}^3$ in Kon Tum and $11.86 \times 10^6 \text{ m}^3$ in Gia Lai. The total requirement for both provinces is $17.01 \times 10^6 \text{ m}^3/\text{year}$.
- Breeding: Water needs for buffalo and cattle is 135 litre/day/piece and for pigs is 50 litre/day/piece. The water requirement for breeding in Gia Lai is three times as high as in Kon Tum. The total for both provinces is $226 \times 10^6 \text{ m}^3/\text{year}$.
- Farming: Gia Lai needs $1.637 \times 10^6 \text{ m}^3/\text{year}$ of water for rice and coffee, while Kon Tum needs $429.3 \times 10^6 \text{ m}^3/\text{year}$ of water. [CHECK THIS - THE NUMBERS MAY BE INVERTED].
- Industrial agriculture: Gia Lai requires four times the water that Kon Tum uses because it has more industrial agriculture production. The two provinces use $120 \times 10^6 \text{ m}^3/\text{year}$.
- Services and industry: commercial, recreational and tourism in Gia Lai requires three times the water as Kon Tum. The two provinces use $219 \times 10^6 \text{ m}^3$ annually. The total water requirement in both provinces is $4.3 \times 10^6 \text{ m}^3$.
- Domestic use: The two provinces use $49.4 \times 10^6 \text{ m}^3/\text{year}$ of water. The Sesan catchment alone makes up 61 percent of the domestic water requirement.

Overall, farming accounts for almost 48 percent of the total demand and aquaculture makes up 39 percent. Breeding and services make up about 5 percent each, followed by industry at 2 percent. Domestic water needs make up just 0.5 percent of the demand. The sectors together require 1.2 billion m^3/year , according to the Institute of Water Resources Planning.

8.2 REQUIREMENTS IN 2020

Water needs for agriculture are projected to be 2,231 million m^3 in 2020, a growth rate of 1 percent/year. That is based on a projected population growth rate of 1.6 percent/year. Water needs for industry is expected to grow by 2.3 percent/year and the water needs for services will grow by 4 percent/year. Agriculture will account for 47 percent of the demand. Additional details are in Table 5.

Table 5: Forecast: water requirements in 2020 ($\times 10^6 \text{ m}^3$)

Sector	Kon Tum	Gia Lai	Total
Farming	463	1,768	2,231



Industry	28	114	142
Breeding	53	191	244
Aquiculture	556	1,281	1,837
Domestic activities	7	15	22
Service	74	215	289
Total	1,181	3,584	4,765

Source: Gia Lai Provincial People's Committee, Gia Lai and Kon Tum Statistical Office, 2006 - 2011; Bui Hieu, 2005³; WASI, 2012; Planning on socio-economic development in Gia Lai and Kon Tum period 2010 – 2020

8.3 WATER BALANCE IN THE CATCHMENT AREA

There is positive water balance in both provinces. In 2011, the balance was + 10,448 x 106 m³. Still, groundwater levels have dropped and the topography of the Sesan basin is steep and rugged, which makes extraction difficult in certain areas.

In 2020, the water balance is expected to be + 10,036 x 106 m³ due to greater demand.

9 WATER RESOURCE DEVELOPMENT

9.1 GIA LAI

In 2010, the province had 313 irrigation projects, including 98 reservoirs, 177 dams and 38 electric pumping stations (Figure 9). They irrigated 48.3 ha, which included 30.7 ha of rice and 17.4 ha of vegetables, coffee and pepper. In winter and spring of 2009 and 2010, the system irrigated 24 ha of rice and 14 ha of vegetables and crops. Some local projects have further increased irrigation availability to 50 ha¹⁰, and there is enough water to supply some processing factories for rubber, coffee, pepper and cassava.

The province has planned 359 new irrigation projects that will supply 63,410 ha. Of these, 105 are reservoirs and 12 are large enough to hold more than 10 million m³.

9.2 KON TUM

It has 484 irrigation projects that, in theory, irrigate 10,071 ha of rice crops twice a year and 5,262 ha of coffee (Figure 9). The actual area of irrigation is less, however, with 6,700 ha of rice, and 3,087 ha of industrial plants. About 48 reservoirs can hold 83.4 x 106 m³ of water, 19 reservoirs can hold over 106 m³ and 29 reservoirs can hold less than 106 m³^{11,22}.





MEKONG CPWF | Optimising cascades of hydropower (MK3)
 Basin Profile for the Upper Sesan River in Vietnam

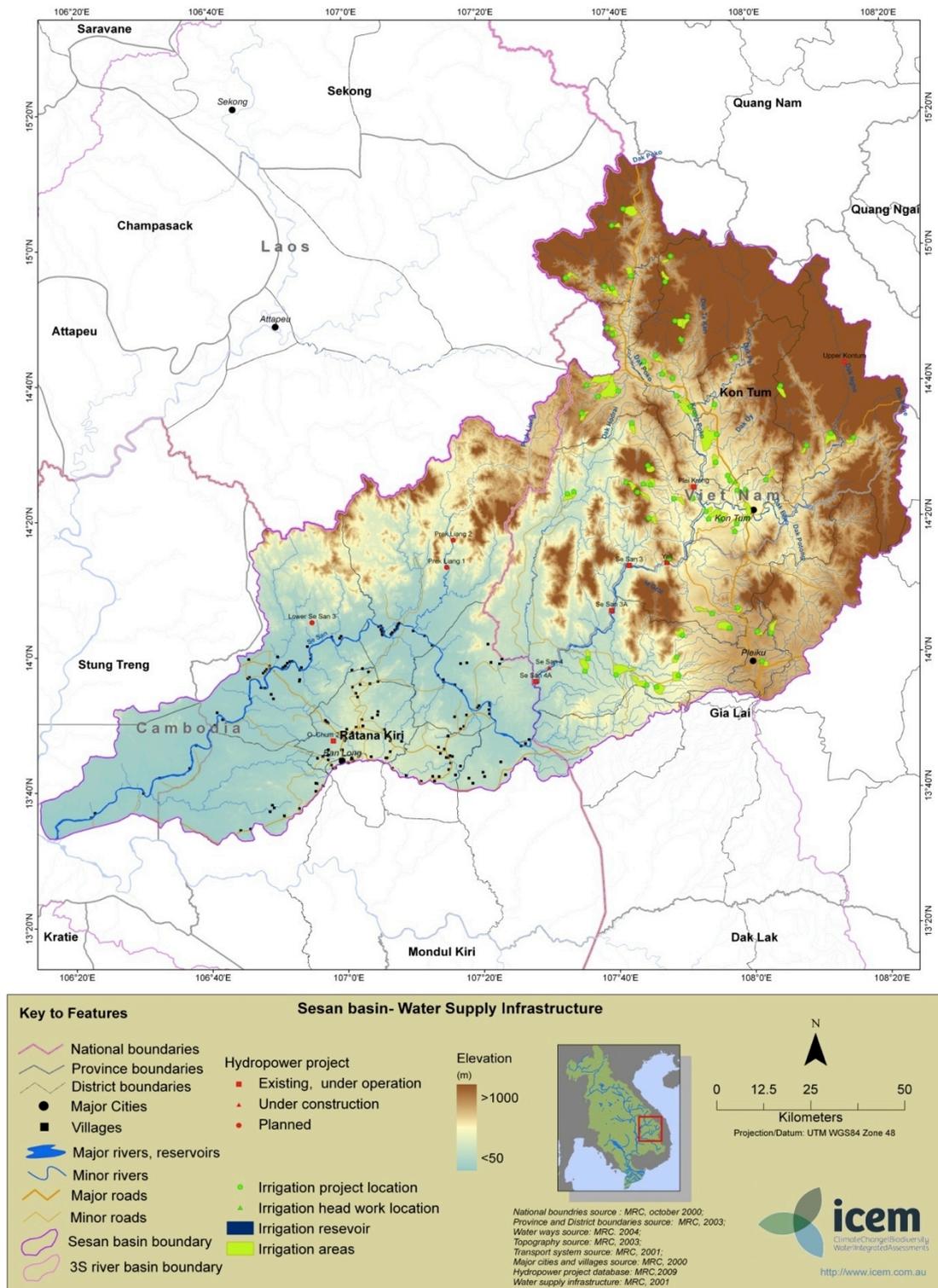


Figure 9: Water supply infrastructure in the basin



10 AQUATIC RESOURCES

There are 196 species in the river system^{14, 15, 23, 24}, of which the carp is the most valuable. About 32 species are endemic to the basin, and seven of these are threatened or vulnerable.

Some species found in the wetlands include Anabantidae, Channidae, Osphronemidae, Clariidae, Synbranchidae, Cobitidae and *Carasius auratus*. Their habitats are increasingly being destroyed for rice cultivation and aquaculture.

Economically valuable species include *Hampala dispar*, *Mystus wyckioides*, *Mystus nemurus*, *Bagarius yarelli*, *Bangana behri* and others. The fish are caught using nets or electric currents. Some fishermen choose to fish in reservoirs using traditional methods, but they have to pay a tax to the local administration and hydroelectric station for this privilege. For instance, in the reservoir of the Yali hydropower plant, dam authorities tax fishing while the Ia Grai province taxes the catch. About 1.5 to 2 tons of fish are caught in the reservoir every year. Local administrations release juvenile fish into the Krong Plei and Yali reservoirs every year to improve breeding.

Local fishermen say that fish yields have decreased in the Sesan basin. Two decades ago, the Sesan yielded 8 to 12 kg of fish per day using traditional methods and this has fallen to 1 to 3 kg. Both over-fishing and step hydropower plants that altered the river's flow are responsible for the decline.

Aquaculture is also practised, and there were 515 hectares of fish farms in Kon Tum in 2010 and 1,186 ha in Gia Lai.

11 FOREST RESOURCES

The Sesan basin contains tropical dense forest mixed with broadleaf trees at an altitude of 500 m⁵, tropical wet dense forest along rivers, sub-tropical dense forest on high mountains, dry thin forest of dipterocarp trees (Dipterocarpaceae) in the Ngoc Hoi district, Dak Glei district.^{5, 42}

11.1 FLORA

There are 300 plant species and more than 180 genera and 75 families of flowering plants⁵. Three types of tropical monsoon forests occur in the basin at altitudes of over 1,600 m, between 600m and 1600 m and below 600 m.

The most common type of plant in these forests is dense wood, such as *Pinus latteri*, *Fagus sylvatica* and others. At an altitude of 1,500 to 1,800 m, the forests contain a mixture of *Pinus kesiya*, *Chua*, *Fagus sylvatica*, *Cinnamomum obtusifolium* - A. Chev, *Cinnadenia paniculata*, and *Engelhardtia roxburghiana* Wall. Some medicinal plants grow on the Ngoc Linh Mountain.

Illegal logging and the over-exploitation of forest products is starting to affect the biodiversity in the catchment⁴⁵. As of now, the economic value of the forests remains high⁵.

11.2 FAUNA

There are 165 bird species, including 40 families and 13 orders in the catchment. There are 88 animal species, with 26 families and 10 orders, which make up 88 percent of the mammals in the Western Highlands. Elephants, bison, guar, wild buffalo, sambar and muntjac are among the species found here. Recently, tigers have appeared in Sa Thay, Dak To and Kon Plong districts.

Some rare wild birds³³ that require protection are found here, such as *Pavo muticus*, *Rheinartia ocellata* Elliot, *Lopura diardi* and *Lophura nycthemera annamensis*.

Kon Tum province has tried to protect primary forests to ensure survival of these fauna, but a national system for grading forests is urgently needed.



12 FORESTED AREAS IN THE SESAN BASIN

There are 762,896 ha of forests on the catchment, with 87 percent in Kon Tum and 13 percent in Gia Lai. About 92 percent of these are natural forests. Trees are being deforested at record rates for agriculture, especially to grow cassava. The government supports the growth of rubber, a forest crop, in barren areas and this is causing some afforestation.

12.1 FOREST AREA IN GIA LAI

There were 719,812 ha of forests in 2010. Of this, natural forests made up 94 percent (Figure 11). These included production forests (75 percent), protected forests (17 percent), and special forests (8 percent). The rest were artificial forests.

Natural forests were primarily timber, 0.7 percent bamboo and 0.3 percent mixed forests. About 75 percent of timber forests are used for production, and 17 percent are protected. Such production forests need to be well managed to ensure forest cover and sustainable development²⁰.



Figure 10: Deforestation for cultivation in Gia Lai, leading to soil degradation and decreased biodiversity. Photo taken downstream of the Sesan 3A hydropower plant

There were 5,000 ha of bamboo forests, of which 56 percent was used for production and 28 percent was protected. There were 387 ha of mixed forests, of which 86 percent was used for production.

There were 46,271 ha of artificial forests, of which 75 percent was used for production. They were planted under forest development plans such as the “Five Million Hectare Reforestation Programme”.

Overall, the forested area decreased at a rate of 1.6 percent/year between 2005 and 2010. Forest coverage was 45.5 percent in 2010, down from 49 percent in 2005. Protected forests were converted to rubber plantations in the Central Highlands, and some were converted to coffee, cashew and cassava cultivation.

Between 2009 and 2010, the forested area of Gia Lai increased by 24 percent to 88,508 ha. About 3,200 ha of the increase was due to artificial forests and 3,377 ha were due to natural forests. The government plans to convert vacant land to rubber plantations, which would increase rubber area to 122,500 ha by 2015. This would further increase forest cover.



Type of forest, in hectares

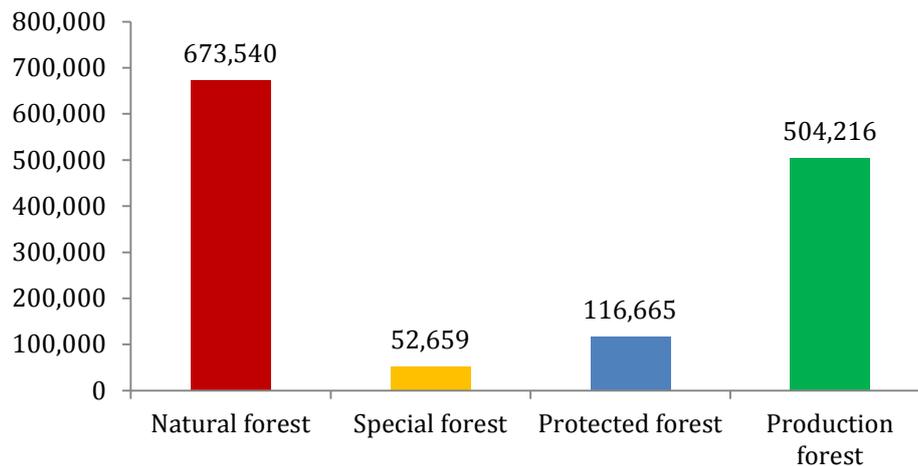


Figure 11: Forest areas in Gia Lai in 2010

Source: *The People's Committee of Gia Lai province, 2011*¹⁸

12.2 FOREST MANAGEMENT IN GIA LAI

Gia Lai has the second largest area of forests in Viet Nam^{18, 20, 17}, but the area is decreasing due to changes in land use and urbanisation. In response, the government plans to protect forests until 2020 and improve supervision. It issues certificates for use of forestry land but the speed of processing of these permits is slow. Only about 35.2 percent of the eligible land has been certified.

The management of forests in Gia Lai is done by the Kon Ka Kinh National Park, the Kon Chu Rang Natural Conservation zone, the 11 Forestry Company (now called MTV Forestry) and 20 protective forest management boards. The local governments oversee only 39 percent of the forest land.

The government has implemented some schemes to encourage people to protect forests. These include:

- 661 Project, 'Five Million Hectare Reforestation Programme': Protecting a hectare of forest in 2007 and 2010 earned VND 100,000 per year. The remuneration increased to VND 200,000 per year thereafter. The goal was to protect 74,343 ha, but only 21,985 ha have been protected so far due to shortage of funds. The contractors who took up protection were not always committed to their cause.
- Decision No. 304/2005/QĐ-TTg: 4,392 ha of forest area were allocated to 185 households, and forest protection contracts were issued to 1,561 households to protect 40,414 ha. However, the contractors were unmotivated because of the low incomes derived through this programme and the lack of interest. The programme ended in 2010.
- Forest protection contract with benefits: The Forest Company Kong Chiang and the Kong Hde, Ia Pa, Ka Nak and Chu Se forest management boards were given contracts for 5,492 ha in 2004. The contracts were distributed to 165 households. However, the programme was badly managed and terminated in 2010.
- Allocation of forest production land: In 2005, about 1,489 ha were allocated to 159 households to cultivate industrial plants. The project is ongoing. A total area of 1,489.2 ha has been allocated to 159 households to afforest and cultivate industrial plants.

All forest activities by the Forest Department in Gia Lai are based on management plans developed for each of three forest types. However, implementation of the plans is limited because of a lack of coordination, poor sanctions if participants do not follow instructions and a lack of enforcement.



The biggest challenge is the lack of funds to invest in the programmes. Forestry does not contribute to the provincial budget, and permits that could generate some income for the government are not easy to acquire. So far, only 228,996 ha worth of certificates have been issued.

12.3 FOREST AREAS IN KON TUM

Natural forests made up 597,328 ha, including 93,226 ha of special use forests in 2010. The total wood reserve was more than 60 million m³ and there were 950 million bamboo trees. Types of forests include coniferous closed, mixed broad-leaf, tropical and seasonal evergreen closed rainforest.

Only 966 ha were reforested between 2005 and 2010 and there were changes in forest type. Productive forests increased by 46,520 ha, while the protected forest area decreased by the same amount. Special use forest area increased by 1,900 ha.

Due to government policies, about 31,600 ha of mostly natural forests have been converted to rubber plantations. Some rubber has been planted on artificial forests and barren lands as well. The rate of conversion between 2007 and 2011 was 6,321 ha/year.

Much of the forested area in Kon Tum is in the Sa Thay district, followed by Dak Glei and Kon Plong, which have large protected reserves.

12.4 FOREST MANAGEMENT IN KON TUM

The province is reforesting areas close to hydropower projects such as Dak Mi 1A that are under increased risk of erosion. Officials are also becoming stricter when approving land for conversion to rubber. Only areas that match desired slope and terrain characteristics are allowed for conversion.

Kon Tum's plan for sustainable development by 2015 requires that authorities need to:

- promote afforestation, forest regeneration and restoration to increase forest cover by 68 percent.
- ensure natural forests assigned to the Forestry Sole Member Company are harvested sustainably and approved by authorities. Artificial forests should yield 600,000 m³.
- process 2.1 million m³ of wood supplied by artificial and natural forests for construction, export and production of wood pulp.
- manage an income from forestry in 2015 that should reach VND 200 billion per year, of which 60 billion will be given to the national budget.
- establish a forest protection and development fund that can pay forest owners to protect the forest.

13 NATIONAL PARKS AND BASIN CONSERVATION AREAS

13.1 BASIN NATIONAL PARKS

Include the Chu Mom Ray National Park (56,621 ha) and the Kon Ka Kinh National Park (33,565 ha of natural forest). The two parks are highly biodiverse due to their topography, altitude, climate and soil conditions³³. The flora found here are typical of northern Viet Nam (such as Fabaceae, Euphorbiaceae, Magnoliaceae, Moraceae, Anonaceae, Lauraceae and Fagaceae), Malaysia and Indonesia (needleleaf species of gymnosperm, flora) and India and Myanmar.

There are 687 flora species, with 459 genus and 140 families.

The Kon Ka Kinh national park is home to 34 rare, endemic species such as *Afzelia xylocarpa*, *Dalbergia annamensis*, *Dialium cochinchinense*, *Alchornea annamica*, *Calamus poilanei* and *Dendrobium bellatulum*. Of these, 24 are endangered.

The two national parks contain evergreen forests, subtropical wet rainforests and low mountain forests, mixed subtropical needleleaf and broadleaf forests. *Fokienia hodginsii* is dominant.

There are 428 animal species, with 223 vertebrates (34 orders, 74 families), 205 invertebrates, and 10 families of Lepidoptera. There are 16 endemic species of fauna including mammals such as *Hylobates*





gabriellae, *Pygathrix cinerea*, *Panthera Tigris*, *Muntiacus truongsoneensis*, *Megamuntiacus vuquangensis*. Endemic birds include *Garrulax milleti*, *Jabouilleia danjoui*, *Garrulax konkakinensis* 49, 33, which are all in Kon Ka Kinh. The parks are also important for the conservation of amphibians, including four species in danger of extinction.

Overall, there are 38 endangered species of fauna, including 10 mammals, 14 birds and 14 amphibians and reptiles in the parks. The management boards of the two parks are working to strengthen, manage and protect forests and biodiversity.

13.2 BASIN CONSERVATION AREAS

Ngoc Linh Nature Reserve

It covers 38,109 ha of forest that supports 874 vascular plant species and 309 fauna. There are nine endemic plant species, and the forest types include the broadleaf and coniferous forests. Five animals found here are threatened, including the tiger.

Since the Ho Chi Minh road was built, poachers have increasingly exploited the forest and people have cleared land to plant coffee. Forest management is difficult due to limited resources, and local residents need livelihoods that do not unsustainably exploit forest resources. Some have suggested that residents grow and market Vietnamese ginseng, 1 kg of which fetches VND 50 million, but the knowledge to grow this plant is not available.

Dak Uy Nature Reserve

It contains a special use forest that is used for conservation of rare plant and animal species. Trac wood, which fetches a high price per kg, is being logged unsustainably.

Kon Cha Rang Nature Reserve

It covers 16,000 ha and contains many streams and rivers that flow into the Kon River. Thus, the reserve protects the Kon River, which supplies many irrigation and hydroelectric projects downstream. The reserve contains mainly lower montane evergreen forest at elevations below 900 m. There are 546 vascular plant species, including some of medicinal value. There are 62 mammal species, 169 birds and 161 butterfly species. Eight mammals are threatened globally, and 17 are threatened in Viet Nam. Two bird species are globally threatened.

The reserve is now uninhabited, but there are 5,564 people living in the reserve buffer area. Some forest fires and land clearing for coffee cultivation are threatening the area's biodiversity, but since the area is sparsely populated, the overall human impact is low.

Of the three nature reserves, the Kon Cha Rang Nature Reserve is the least threatened due to its complex terrain and sparse population. The Dak Uy is the most threatened due to exploitation by Trac wood loggers.





14 MINERAL RESOURCES

There are 214 mines in Kon Tum including ones for limestone, bauxite, dolomite, felpat, clay, sand and gravel^{56, 57}. About 12 percent of national deposits of bauxite occur here. There are four gold mines, and precious stones such as green silicon, light green and opal are also found here. Peat is found in Bien Ho, Bua village and Ve village (Gia Lai) and used for the production of organic fertilizers.

15 INFRASTRUCTURE

- **Housing:** There are more permanent houses in Kon Tum than in Gia Lai, which contains more semi-permanent structures.
- **Traffic:** The road infrastructure is limited in the basin. Roads are narrow and conditions are poor. Four communities are currently not connected by roads that can support car traffic. Flights are only available between Da Nang – Pleiku – Ho Chi Minh and Pleiku - Hanoi city.
- **Industrial parks:** Kon Tum has four parks covering 459 ha, while Gia Lai has five parks covering 507 ha. Three additional parks are planned⁵⁷.
- **Telecommunications and electricity transmission system:** Telecommunication networks have improved since 2005, with 16 phones per 100 people in 2010. The number of internet subscribers have also increased, with 3 subscribers per 100 people in 2010. The electricity transmission grids in Viet Nam are 500 kV, 220 kV and 110 kV.
- **Water supply infrastructure:** There are 3,847 hygienic water supply projects in Gia Lai. In 2010, 80 percent of the rural population had access to clean water throughout the year. There are 221 water supply projects in Kon Tum, and more than 70 percent of rural population had access to clean water in 2010.

16 THE HYDROPOWER SYSTEM

There are seven hydropower projects with a capacity of 1831 megawatts on the Sesan River system that generate over 8.5 billion kW/hr of electricity annually. Five additional projects are planned in Gia Lai province and two are planned in Kon Tum. Six are already in operation, and one in Kon Tum is under construction.

The existing plants include:

- Yali, which has four power turbines, each with an output of 180 MW
- Sesan 3 plant located in Gia Lai that has two units that generate 260 MW of power
- Sesan 3A plant located in Gia Lai is 10 km downstream of Sesan 3 and has two units that each generate 54 MW
- Pleikrong is located in the Sa Thay district in Kon Tum and has two units, each producing 50 MW
- Sesan 4 has three units, each generating 120 MW and is used for power generation and flood regulation
- Sesan 4A plant has a single unit with an output of 63 MW
- Upper Kon Tum hydropower plant is under construction and has two units, each with an output of 110 MW

The Yali Hydropower Company controls the Yali, Sesan 3 and Pleikrong reservoirs.

Hundreds of smaller projects have been approved in Gia Lai and Kon Tum, and some are now under construction. These projects may hinder the operation of other reservoirs power production and irrigation by altering river flows⁴⁰. They also may cause deforestation because two to three hectares of forest need to be felled for every hectare of land used by dams.



Power plants can be designed to curb flooding, according to Doan Tien Cuong, deputy director of the Yali Hydropower Plant. However, in recent years, the flood peak has changed and floods are happening more frequently, which makes the task of regulation even more difficult.

The changes in flood patterns are part of larger climatic changes caused by deforestation. Higher temperatures, reduced rainfall, irregular distribution of rainfall and more frequent flash floods have been seen in recent years. There were unusually strong winds and storms in 2009, which caused serious damage to rubber plantations in Gia Lai.

Table 6: Existing hydropower plants in the Sesan catchment

Plant	Year of operation	Scale	Installation output	Province
		TM (x) MW	MW	
Yali	2000	4 x 180	720	Gia Lai
Sesan 3	2006	2 x 130	260	Gia Lai
Sesan 3A	2006	2 x 54	108	Gia Lai
Sesan 4	2009	3 x 120	360	Gia Lai
Sesan 4A	2010	1 x 63	63	Gia Lai
Plei Krong	2009	2 x 50	100	Kon Tum
Upper Kon Tum	2011	2 x 110	220	Kon Tum
Total			1,831	

Source: DONRE and DOIT, Gia Lai and Kon Tum, 2010

In general, hydropower project planning has not included a comprehensive socio-economic benefit analysis. Instead, planners have focused on power generation and economic outputs. Existing dams do not accommodate other uses such as irrigation, fisheries and tourism, and due to adverse effects, the government has decided to suspend 35 small and medium hydropower projects on the Sesan and Sere Pok River basins.

The water quality of reservoirs on the Sesan River is evaluated annually. There are monitoring stations upstream and downstream of the reservoirs, especially for the Yali, Pleikrong and Sesan 3 plants.

Electricity is also generated from small and medium sized diesel-fired hydroelectric plants. The output in Gia Lai is 42,784 kW and in Kon Tum, is 1,272 kW.

Gia Lai is planning small and medium sized hydroelectric plants, with 113 plants in a step that will generate 549,781 MW. The Sesan River will have 22 of the plants, the Sere Pok River will have 26 plants and the Ba River will have 65 plants. Each will have a capacity of less than 5 MW.





17 SOCIO-ECONOMICS

17.1 POPULATION

Gia Lai's density is 213 people per km² and Kon Tum has 46 people per km². The lower Sesan region's population density is five times that of Kon Tum, with 227 people per km². Pleiku city has the most people. Between 2006 and 2010, the population of the catchment grew by 86,802 people.

The urban population of both Gia Lai and Kon Tom is increasing since there is a general economic shift from agriculture to industry.

There are 37 ethnic groups on the catchment, including the Kinh, the Gia Rai, Xe Dang, Ba Na, Gie Trieng, Brau and others. They live in high mountains and dense forests with underdeveloped infrastructure and few government benefits. They account for more than 70 percent of the population.

Smaller ethnic groups rely on farming and forestry for their livelihoods. Their traditional methods of cultivation, which include the burning of forests to create arable land, can affect soil fertility and reduce crop yields. Food shortages are frequent in the months between harvests and local governments have policies to help them out.

17.2 LABOR FORCE

The average working age in Gia Lai and Kon Tum is lower than in the Central Highlands. Most workers on the catchment are employed in the agriculture, forestry and fishery sectors, which accounted for 80 percent of the total employment in Gia Lai in 2010 and 70 percent in Kon Tum.

The labor force in Kon Tum and Gia Lai is shifting toward services, processing industries and trade, away from agriculture, in keeping with government policy. The participation of women in the labor force is strong in many sectors including agriculture, services and trade.

17.3 UNEMPLOYMENT RATE

The unemployment rate in the provinces is 3.3 percent in urban areas, and just 1.3 percent in rural areas. This reflects the higher employment potential of agricultural activities, though these jobs pay less.

17.4 POVERTY RATE

The poverty rate in the provinces rose in 2010 after the government revised the indicators of poverty. The rate is 60 percent higher in rural areas compared to urban areas.

17.5 EDUCATION AND HEALTH CARE SERVICES

Kon Tum is more literate than Gia Lai and the Central Highlands, with 21 percent of students completing high school, as compared to 20 percent in Central Highlands and 17 percent in Gia Lai. Between 2005 and 2010, the number of students attending literacy classes increased. Almost equal numbers of men and women get educated.





18 ECONOMY

18.1 INCOME

The average income per month is VND 1,181,000 (USD 55) in Gia Lai and Kon Tum. This is lower than the Central Highlands' income of VND 1,389,000 (USD 65).

People in urban areas earned almost twice the amount earned by rural residents, and the gap is getting wider with time. Agriculture and forestry account for 40 percent of the total income earned in the provinces, followed by 27 percent derived from commercial services. Those percentages are shifting, however, suggesting that people are moving away from agriculture.

18.2 ECONOMIC ACTIVITY BY SECTOR

- Agricultural income was VND 16,385 billion in 2010 to Gia Lai, with an annual income growth rate of 70 percent since 2001. Agricultural production was worth VND 3,671 billion in 2010, seven times higher than the rate in 2001. Perennial crops accounted for much of the growth in 2010, followed by food crops. Annual crops and fruit trees were also planted.
- Forest production brought VND 620.5 billion to Gia Lai and VND 242.2 billion to Kon Tum in 2010.
- Fisheries brought VND 84.4 billion for Gia Lai in 2010, a 686 percent increase from 2006. In Kon Tum, the production value was VND 39.7 billion in 2010, up from VND 15.3 billion in 2006. A majority of the increase came from investments in breeding in both provinces.
- Industries in Gia Lai and Kon Tum earned VND 5,429 billion. The value for the catchment area excluding the provinces was VND 3,836 billion.
- Hydroelectric plants fetched VND 2,973 billion in 2010 in Gia Lai. This was a 640 percent increase from 2006 because of new power plants including the Sesan 3, Sesan 3A and Sesan 4. Electricity generation fetched VND 274 billion in 2010 in Kon Tum, a 150 percent increase from 2006.
- Stone and mineral mining fetched VND 370 million in 2010 in Gia Lai, a 50 percent increase since 2005. It fetched VND 101 million in Kon Tum, a 75 percent increase since 2005. Much of the material went toward road construction projects by the government.
- Tourism brought VND 153.7 billion to Gia Lai and VND 32.3 billion to Kon Tum in 2010.

18.3 GDP BY ECONOMIC SECTOR

The GDP per capita of Gia Lai was VND 19.5 million (USD 916) in 2011, a 20 percent increase from the previous year, according to the Gia Lai People's Committee 2011 report. About 40 percent of this GDP came from agriculture, forestry and fishery.

The GDP per capita of Kon Tum was VND 13.42 million (USD 629), with much of the contribution coming from the agriculture sector.





19 LAND AND WATER MANAGEMENT AGENCIES

A number of management and service agencies are involved in the water sector. The responsibilities of key agencies are shown in Table 7. The agencies that oversee land and water management do not coordinate with each other and there is significant overlap of responsibilities, say staff of agricultural and environmental agencies in Gia Lai and Kon Tum.

For instance, the construction of small and medium hydropower projects has been haphazard, and regular inspections are not done. This resulted in a dam break on June 12, 2013, when the Ia Krel 2 Hydropower Plant reservoir collapsed and caused a flash flood. Some 200 ha of crops and a bridge were destroyed, causing VND 20 billion in damage.

Table 7: Responsibilities of agencies relating to water and land management

Agency	Functions
National	
Mekong Committee	<p>Implements policies, strategies, plans and legislation on water resources, environment, meteorology and hydrology of the Mekong River system.⁴</p> <p>Supports education, research⁴³ and public awareness, and advises on appropriate technology for water conservation.</p> <p>Receives social and environmental impact assessment reports before issuing approval for development projects.</p> <p>Collects and distributes information on water resources, environment, meteorology and hydrology.</p> <p>Carries out international obligations relating to water resources and the environment.</p>
Ministry of Natural Resources and Environment (MONRE)	<p>Manages land titles and land assessment for taxation purposes⁵³.</p> <p>Advises local authorities on resolution of land conflicts.</p> <p>Provides land and land tenure information for policy and legislation development.</p> <p>Manages water resource titles and water assessment for exploitation purposes and taxation.</p> <p>Manages minerals and assess for taxation.</p> <p>Manage water, soil pollution and determines penalties.</p> <p>Participates in Initial Environmental Assessment and Environmental Impact Assessment (EIA) processes of large scale hydropower development projects and other projects.</p>
Ministry of Agriculture and Rural Development (MARD)	<p>Plans land use, water and forestry for the nation</p> <p>Plans water resources for agriculture, and determines usage fee</p> <p>Implements government policies, strategies and programs related to the development and management of irrigation, drainage and rural flood control.</p> <p>Formulates and implements forestry and water resource development programs and projects approved by the government.</p> <p>Trains and educates technical staff in forestry and water resource management.</p>



	<p>Implements government plans, details provisions of the laws governing the managing of forestry and water resources. Assesses the implementation of programs to identify their impacts, positive and negative.</p> <p>Determines policies, plans, laws and regulations of the government for livestock, veterinary, and fisheries development. Encourages a switch from traditional agriculture and fishing to commercial production and marketing.</p>
Ministry of Industry and Trade (MOIT)	<p>Determines policies, plans, laws and regulations for developing and controlling the production and distribution of electricity. Reviews and evaluates power project proposals, contracts and agreements.</p> <p>Manages production of electricity, including hydropower plants with more than 30 MW capacity. Owns and operates main public sector generation, transmission and distribution assets. Undertakes project development and joint ventures.</p> <p>Determines policies, plans, laws and regulations for developing and controlling the production and concession of mines and mineral resources. Reviews and evaluates mining project proposals, contracts and agreements.</p>
Central Hydrometeorological Office	<p>Establishes a network of forestry and water resource statistical data and information centres. This includes hydrometeorological data at the national level, which assists in the formulation of effective and efficient directives, policy framework, programs, and projects.</p> <p>Collects and evaluate such statistical data and information in order to report changing situations in each sector to the leading bodies on a regular basis, and notify on a timely basis concerned agencies and affected people to control the damage of storms, floods and other extreme weather events.</p>
Center for National Extension (CNE)	<p>Implements agriculture and forestry development and expansion.</p> <p>Cooperates with relevant organisations to study, develop regulations, methodology and strategy of agriculture and forestry development projects.</p> <p>Trains farmers in new agriculture and forestry technology and sustainable use of water at provincial, district, and village level.</p> <p>Raises awareness about agriculture and forestry projects.</p> <p>Cooperates with international organisations and agencies.</p>
Ministry of Investment and Planning (MPI)	<p>Determines policies, plans, laws and regulations for investment projects (within and outside the country) including land use, hydropower (>30 MW capacity) and water use.</p> <p>Reviews and evaluates the effectiveness of such projects.</p>
Agricultural and Forestry Universities	<p>Trains provincial human resources staff on agriculture, water, land, forest management.</p>
Provincial	
Department of Natural Resources and Environment (DONRE)	<p>Implements government policies on natural resources in local areas, including water, land, sand forests.</p> <p>Manages provincial land titles and land assessment for taxation purposes.</p>



	<p>Advises local authorities on resolution of land conflicts.</p> <p>Manage water resource titles and water assessment for exploitation and taxation.</p> <p>Manages mineral mining and assess for taxation.</p> <p>Monitors for water and soil pollution and determines penalties.</p> <p>Assesses environmental impacts of investment projects.</p>
Department of Agriculture and Rural Development	<p>Maintains inventory of land use, water and forestry for local areas.</p> <p>Plans water resources for agriculture and collects fees for water use in agriculture.</p> <p>Plans exploitation and protection of forestry and fishery resources.</p> <p>Implements government policies, strategies and programs related to the development and management of irrigation, drainage and rural flood control in local areas.</p> <p>Formulates and implements forestry and water resource development programs and projects as approved by the government.</p> <p>Trains technical staff in forestry and water resource management.</p>
Department of Industry and Trade (DOIT)	<p>Implements policies, plans, laws and regulations for developing and controlling the production and distribution of electricity. Reviews and evaluates power project proposals, contracts and agreements.</p> <p>Manages production of electricity, specifically hydropower facilities with less than 30 MW capacity.</p> <p>Owns and operate main public sector generation, transmission and distribution assets. Undertakes project development and joint ventures.</p> <p>Controls the production and concession of mines and mineral resources. Reviews and evaluate mining project proposals, contracts and agreements.</p>
Department of Investment and Planning (DPI)	<p>Determines policies, plans, laws and regulations for investment projects including land use, hydropower (<30 MW capacity) and water use.</p> <p>Reviews and evaluates effectiveness of projects.</p>
Provincial Extension Centre	<p>Implements annual expansion plans for agriculture and forestry.</p> <p>Cooperates with relevant organisations to carry out development projects.</p> <p>Trains farmers in new agriculture and forestry technologies and sustainable use of water.</p> <p>Sets up demonstrations of crop types, fisheries, animals, and irrigation.</p>
Water supply Company	<p>Manages and supplies water for domestic and industry use, mainly in urban zones.</p>
Centre for Clean Water, Sanitation and Environment	<p>Manages and supplies clean water for home use in rural zones.</p>



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