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ORIGINAL ARTICLE

Assessment of Land Use and Land Cover Changes in the Tasik Chini Catchment Area, Pahang, Malaysia Using the Gis

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Abstract: The study was undertaken in order to explore the temporal and spatial land use changes during the periods 1984, 1990, 2000 and 2002 at the Tasik Chini Catchment using the Geographical Information Systems (GIS). The GIS has the capability of associating information with particular features on a map and creating new relationships that can determine the suitability of various sites for development, evaluating the environmental impact and identifying the best location for the new facilities. The boundary of the study area from the topographic map and four land use maps was digitized. On the basis of the 1984 land use map, there were only three types of land use, however this dramatically changed into seven categories in 2002. The three initial types of land use were forests, oil palm plantations and water bodies. The forest area decreased by 861.70 ha in 2002 and forests constituted 75.72% of the study area. The forest areas were converted into six categories of land use. These six categories increased by 740.68 ha in 2002 and covered 15.60% of the total area. The water bodies increased by 240.32 ha and covered 8.68% of the study area. The water bodies in the study area increased after the construction of the barrage downstream of the Chini River in 1995. Activities during the past 18 years have significantly affected the ecological, biological and hydrological functions of the lake system. The unsystematic and rapid urbanization that occurred in the study region not only caused the loss of important forest and wetlands, but also contributed to water and soil pollution problems.

Key words: Catchment, GIS, Land use and land cover change, Tasik Chini, Malaysia.

Introduction

Land use studies are of fundamental significance, as land resources play a strategic role in the determination of man's economic, social and cultural progress. In fact the land use of a region is always characterized by the spatial variation and is profoundly influenced by physio-socio-economic factors [17,3]. Land-use and land-cover changes play a vital role in environmental and ecological biodiversity and furthermore contribute to global change[20,24]. Changes in land-use and land-cover have direct impact on the biological diversity [36] and contribute to local and regional climatic change including global warming [5,15]. They may cause land degradation

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by altering the ecosystem and livelihood support systems, thereby disrupting the sociocultural practices and institutions associated with managing those biophysical systems [44]. Such changes also affect the vulnerability of people and places to climatic, economic, or sociopolitical perturbations [18].

In Malaysia, the Land Acquisition Act of 1960 allows all state governments to acquire land for economic purposes. Thus under such a law, extensive land areas in the states which include forests are being changed for commercial land use. Land use changes particularly through land development activities occur mostly through conversion of primary forests. A total of 5.22 million hectares of land in Malaysia were opened for development by 1990, compared to 3.4 million hectares in 1966. However, since 1991 there has been a growing competition for the acquisition of prime land among various sectors namely agriculture, urban development and settlement, industries, recreation and forestry.

Mining activities have declined significantly from the national scenario, while urban and industrial developmental activities are fast taking up quality agricultural land fringing human settlements. Most of the areas under major crops with the exception of oil palm have gradually declined. There has been extensive environmental damage and long-term impact of such conversion and abuse [22].

Malaysia is a tropical country that has been experiencing extensive land use change associated with government developmental policies. In the 1960s and 1970s, Malaysian economic development was mainly focused on the agricultural sector. During this time, most of the forested areas were converted into agricultural land, mainly for oil palm and rubber plantations [2]. In the 1980s, there was a major economic transformation focusing on the manufacturing sector. By 1987, this sector became the fastest growing area and its growth rate exceeded the agricultural sector and accounted for 22.6% of the country's gross domestic product [8]. The progress of this sector has been catalysing other developmental activities, such as urbanization, highway construction, commercial growth and development of other infrastructure. As a result there has been an increased demand for land, which involved the removal of permanent forest reserves and state forests. All of these changes have been identified as major causes of environmental degradation [1].

Recent development in the Tasik Chini Catchment has led to rapid changes in land use. The diversification and intensification of socio-economic development in the Tasik Chini Catchment over the last twenty years has increased the vulnerability of the population to environmental degradation. Land cover changes from natural to other land uses tend to disturb the natural ecosystem equilibrium. Environmental degradation in the catchment has altered dramatically the social and ecological relationship between society and environment. Since activities attempting to make profit from the land have been going on for many years, the Tasik Chini Catchment is of particular interest. From the years 1984-2002, the Tasik Chini Catchment area was used for rubber and oil palm plantations, settlements and intensive agricultural activities such as the production of diversified crops and the growing of citrus-fruits, vegetables and paddy.

This unsustainable land use patterns within and around the catchment have resulted in the erosion and sedimentation of the basin over the years, thereby depleting the lake of its original fauna and flora biodiversity. This paper discusses land use and land cover changes in the Tasik Chini catchment from 1984 to 2002. Identification of the type, total study area, land use and land cover changes were carried out using the GIS interface.

Study Area:

Tasik Chini is located in the southeastern region of the state of Pahang, Malaysia. It is located approximately 100 km from Kuantan, the capital of Pahang. The lake system lies between 3°22′30″ to 3°28′00″N and 102° 52′40″ to 102°58′10″E and comprises 12 open water bodies called "laut" by the local people and linked to the Pahang River by the Chini River. The total study area is 5820.52 ha. A few communities of the indigenous Jakun tribe live around the lake.

Tasik Chini is the second largest natural fresh-water lake in Malaysia covering 202 ha of open water and 700 ha of Riparian, Peat, Mountain and Lowland Dipterocarp forest [46]. Tasik Chini is surrounded by variously vegetated low hills and undulating land which constitute the catchment for the region. There are three hilly areas surrounding the lake: (1) Bt. Ketaya (209 m) located southeast; (2) Bt. Tebakang (210 m) at the north and (3) Bt. Chini (641 m) located southwest. The Tasik Chini catchment is representative of the upstream site of the Pahang River in Pekan. The area has a humid tropical climate with two monsoon periods, characterized by the following bimodal pattern: southwest and northeast monsoons bring rainfall which varies from 1488 to 3071 mm annually. The mean annual rainfall is 2,500 mm and the temperature range is from 21 to 32°C. Potential

evapotranspiration (PE) is between 500 to 1000 mm.

However, the open water area has expanded since 1995, due to increased retention of water after the construction of a barrage at the Chini River. The climate of Tasik Chini is typical of the equatorial climate of Peninsular Malaysia, which is characterized by moderate annual rainfall, temperature and humidity. The lake drains northeasterly into the Pahang River via the Chini River, which meanders for 4.8 km before it reaches the Pahang River.

Materials and methods

Changes in land use patterns at Tasik Chini were assessed using four land use maps. The topographical map, with the scale of 1:50000 was used to assess the span of the catchment area of Tasik Chini. On the basis of contour the boundary of the study area was digitized. The GIS extrapolation analyses were used to quantify changes in land use of the study area. The topographical map was first rectified to provide baseline estimation of Tasik Chini. Changes of line and polygon were detected by superimposing the maps of segment and raster. This technique provided the distortion of the base map and overlay maps [28]. Digital scanning plus tablet and on-screen digitizing techniques were applied to all the maps. The procedure is summarized in three stages: Stage one: Scanning and downloading of images. The 1992 Topographic and land use maps of 1984, 1990, 2000 and 2002 were scanned using a Digital Scanner and saved in a *jpg file.

All digitized maps which were already available for analysis, were saved as vector data into CorelDraw12. In the process of integrating them into the GIS database, all the scanned images were registered and imported into the GIS-ILWIS map projection. The registration process was important for interfacing with the location and orientation of the stored maps and images. Stage two: Manipulating the database. On the digitizing tablet all the land use maps for the different years were digitized using the GIS - ILWIS (Version. 3.3). Initially the metric coordinate systems of all the maps were set up.

According to the ILWIS concept, first the segment maps then the point maps after which the polygon maps and finally the raster maps were created. In the present study, the final scale was set up at 1:13772 so that all the four maps could be analyzed using a similar scale. Stage three: Analyzing the databases. By taking into account the rectification procedure, the base map (Scanned Map) and the overlay map (Digitized Map) were assumed to have a RMSE (Root Mean Square Error) as zero, taking into consideration that all the aspects of distortion had been minimized [27]. Finally the attribute maps were created to get additional information on various elements in a map.

Results and discussion

In this study, the land use and land cover changes occurring from 1984 to 2002 in the Tasik Chini catchment area were investigated and it was found that oil palm, rubber, mining, agriculture, water and settlement areas had increased, whereas forests had decreased. In determining the natural and cultural changes of the Tasik Chini, land use maps of the area for the years 1984, 1990, 2000 and 2002 were used.

The spatial distribution of land use and land cover changes of the forest at different time periods including the temporal difference between them, are shown in Figure 1.

Land Use and Land Cover Changes: Trend, Rate and Magnitude (1984-2002):

The maps show types of land use and land cover prepared with the land use maps from the years 1984, 1990, 2000 and 2002. The main types of land use and land cover contributed to the following; diversified crops, forests, mining areas, mixed horticulture, oil palm, orchard/shifting cultivation, orchards, paddy, rubber, scrub, scrub grassland, shifting cultivation, shifting cultivation/orchards, shifting cultivation/scrub, swamp, settlement areas and water.

On the basis of land use and land cover, classification was categorized into seven major types, which were forests, oil palm, water, rubber, mining, agriculture and settlement areas. When compared after the changes in land use and land cover from 1984 to 2002, it was seen that the areas under oil palm increased from 286.76 to 577.44 ha, rubber areas from 0.00 to 117.20 ha, agricultural areas from 0.00 to 165.18 ha, mining areas from 0.00 to 38.48 ha, settlement areas from 0.00 to 9.84 ha and water bodies from 264.60 to 504.92 ha. Forested areas decreased from 5269.16 to 4407.46 ha. Changes of land use and land cover for 1984, 1990, 2000 and 2002 are displayed in Table 1..

Forest Area:

Deforestation rates in developing countries such as Malaysia during the 20th century were considered to be among the highest in the world [48,23,37,31,45]. Before 1984, agricultural practice

around the study area was low because this type of land use brought in low income for the local people. But later when oil palm, which generates more income, was introduced, it became widespread.

However, because of tourism and mining activities, there was rapid migration from neighbouring areas to this area and the population increase led to a rapid decrease in forest areas. Verburg and Chen [43] realized that land use and land cover changes were particularly related to the increase in population and intensive agriculture. When the changes in land use and land cover from the years 1990 and 2000 were examined, the spatial sizes of agricultural and settlement areas were determined digitally. The reason for this increase was the rise in rapid and unsystematic settlement, together with the spread of shifting cultivation in order to obtain higher income from areas previously occupied by forests.

Because of economic reasons, forest areas were converted into oil palm and rubber plantations, which generated more income per unit area and had the potential of production throughout the year. Mining activities, tourism, settlements and agricultural expansion activities carried out have drastically reduced the area of forests in the study area after 1984 (Figure 2).

The results of the transition in Figure 3 indicate the areas that increased or decreased between 1984 and 2002 for each land use type. In the past decade, the forest areas decreased by 861.70 ha or 14.81% of the study area. Between 1984 and 2002, the decrease was about 290.68 ha or 4.99%, 117.20 ha or 2.02% and 38.48 ha 0.66% for grassland and forests transformed into oil palm, rubber and mining areas respectively. In addition, there were 240.32 ha or 4.13% of swamp and wetlands converted into water bodies.

According to the land use and land cover maps 165.18 ha or 2.84% of forest areas were converted into agricultural land. There were no settlement areas in 1984 but 9.84 ha or 0.17% of settlement areas were present in the study area in 2002. This meant that 9.84 ha or 0.17% of forest areas were converted into settlement areas.

The most notable change of land use and land cover in the Tasik Chini Catchment was the decline in forest areas and the increase of areas under oil palm, rubber, water bodies, mining, agriculture and settlement activities (Figure 3).

Wong [47] determined that most of the natural forests in Malaysia from the 1950s to the1970s were converted into agricultural land, mainly for rubber and oil palm plantations. Abdullah and Nakagoshi [1] stated that human land use change was the main cause of deforestation in the state of Selangor, Peninsular Malaysia. In tropical regions, many studies have shown that human intervention in land utilization has changed forest cover over time[16,25,42].

Oil Palm Area:

Oil palm is considered a major land use type in Malaysia. Due to the high demand of its product both at the local and international market, oil palm plantation areas increased by about 503% from only 641,791 ha in 1975 to 3.9 million ha in 2004 [29]. Palm oil production plays an important role in economic development; this human land use activity has been recognized to cause degradation of forested areas [33]. The results of the study showed that the largest increase in land use was recorded for oil palm plantation activities. Oil palm expansion of up to 9.92% occurred from 1984 to 2002. In 1984, oil palm land use occupied only 286.76 ha.

However, the area was almost double in 2002 with a total coverage of 577.44 ha. When the changes in land use and land cover from 2000 and 2002 were examined, it was found that oil palm areas had drastically increased. Among the industrial crops, oil palm covered the largest area of 577.44 ha or 9.92% of the total land area in 2002. However, its expansion has been recognized to intrude into the forested areas.

Historically, large areas of forest were converted into oil palm, which predominantly occurred when the Malaysian development policy favoured agriculture in the 1950s to the 1970s [19]. During that period several land schemes were introduced for the development of oil palm, which involved vast clearance of forested areas [11]. In addition, Abdullah and Nakagoshi [1]calculated the index to measure the association between oil palm and two other natural land use types namely forest and wetland forest and marshland in Selangor, Malaysia. The results showed that within 30 years (1966 to 1995) oil palm obviously expanded into both forest and, wetland forest and marshland areas.

Water Bodies:

Analyses carried out from 1984 to 2002 have indicated a two-fold increase in the area of water bodies. The expansion of the area under water from 1984 to 2002 was 8.86%. In 1984, the water area occupied 264.60 ha or 4.54%.

However, the area was almost doubled in 2002 with a total coverage of 504.92 ha or 8.68% of the study area. The building of the barrage across the Chini River in 1995 blocked off the lake from the Pahang River. The lake then became a blocked sump and the area of the

water increased. Since the construction of the barrage, the natural ecosystem of the lake started to deteriorate and showed signs of stress. The water remained stagnant and this brought about all sorts of problems. Collier *et al.* [6] and Petts [35] showed that dams/barrages could disrupt the structure and function of river ecosystems by modifying the flow regimes, disrupting sediment transport, altering water quality, and severing their biological continuity.

The barrage trapped sediment and silt that would normally have drained away through the Chini River into the Pahang River. Thus in the long run, the lake became shallower even as the water level was pushed higher, causing permanent flooding of the lake fringes and surrounding swamp forests. Devi *et al.* [7] described siltation and nutrient enrichment as the major cause of problems in the Gilgel Gibe dam in Ethiopia whereby reduced water storage capacity, indirectly shortened the lifetime and increased maintenance costs.

Rubber Plantation Area:

Results showed that there were no rubber plantations in the study area up to 1984 and beginning 1990, about 121.76 ha or 2.09% rubber areas were identified in the study area. This meant that 121.76 ha or 2.09% of forest areas were already converted into rubber plantations since 1990. The rubber plantation areas increased from 121.76 to 127.40 ha or by 5.64 ha in 2000. In 1990, the percentage change to rubber was about 2.09% but it increased to 2.19% in 2000. When the changes of land use and land cover from 2000 and 2002 were examined, it was found that the rubber areas had decreased.

In 2002, rubber plantations covered only 2.01% of the total study area. While the oil palm areas expanded, the area under rubber decreased slightly in 2002, the planted area being only 117.20 ha compared to the previously reported area (127.40 ha) in 2000. Most of the rubber areas were replaced with oil palm plantations in the Tasik Chini Catchment area after 2000. Abdullah and Nakagoshi [2] stated that rubber was a declining land use type in Malaysia. A lot of the rubber estates were converted to either urban areas or oil palm estates and these changes were due to the decline in world rubber prices after the introduction of synthetic rubber.

Mining Area:

There were no mining activities in the study area in 1984 but 50.40 ha or 0.87% mining area was identified in 1990. This meant that 50.40 ha or 0.87% forest areas were converted into mining areas in 1990. The mining areas decreased from 50.40 ha (0.87%) to 40.7 ha (0.70%) in 2000.

When the changes in land use and land cover from the years 1990 and 2002 were examined, it was found that mining was once a dominant activity in the Tasik Chini region, but it also decreased in 2002. Mining activity had started in the early 1990s, when two mining companies; Penyor Iron Mines and Good Earth Mining extracted iron and manganese ores from Bt. Ketaya, but due to the decrease in market demand (new deposits) mining activities were terminated. Later another company, Pacific Oriental started excavation for barite and sulfide minerals. Their activities also ended when they were unsuccessful in their search for new deposits [46,30]. However, due to the abandoned mining projects, all mines in the Tasik Chini Catchment area were closed in 2002.

Agricultural Area:

Agricultural activities rose from 91.24 to 165.18 ha or 1.57 to 2.84% from 1990 to 2002. The opening up of many new areas to be used as farm land was the basic reason for the decrease in forest and swamp areas. On the other hand, during the same period, part of the study area had lost some forest cover due to human activities, mainly logging and shifting cultivation.

Miyakuni [26] mentioned that shifting cultivation was one of the main factors that caused forest degradation in many humid tropical countries like Malaysia. The change detection analysis revealed that the total change of forest area into the agricultural land in 2002 was higher than that in 1990. On examining the results there is indication that there has been extensive change in the land cover due to land use activities, such as clearing of forests for supporting economic and commercial activities, wood fuel harvesting, increased area of agricultural land and hunting.

Over the last decade, the significant land conversion from forests to agriculture has rendered Tasik Chini vulnerable to water pollution. FAO [9] stated that land used for permanent agricultural crops had increased by approximately 35% between 1980 and 2001.

Nonetheless, this occurred particularly in developing tropical countries [13], where it has been recognized as one of the major proximate causes of deforestation [13,4,12,34]. On the global scale 96% of deforestation is associated with agricultural expansion [10].

Settlement Area:

Results showed that there were no settlement areas in the study area from 1984 to 1995, but 6.44 ha or 0.11% settlement areas were present in 2000. This meant that 6.44 ha or 0.11% of forest areas were converted into settlement areas in 2000. It was found that settlement areas had consistently increased after 1995. When the changes in land use and land cover from 2000 and 2002 were examined, the spatial sizes of settlement areas were determined digitally. The expansion of the settlement areas of up to 9.84 ha or 0.17% of the study area occurred from 2000 to 2002. The reason for this increase was the rise in rapid and unsystematic settlement, together with the spread of agriculture and tourism activities in order to obtain higher income from areas where forests had previously occupied. Results of land use changes between 2000 and 2002 showed that settlement areas increased, while forest areas decreased. Settlement areas included a resort, National Services Centre Camp, tourism centre and road network.

Urban settlements in developing countries are, at present, growing five times as fast as those in developed countries [41]. The transformation of natural forest, open or agricultural land into settlements and urban areas is one of the major environmental impact in most urbanized countries and regions [14,32,3].

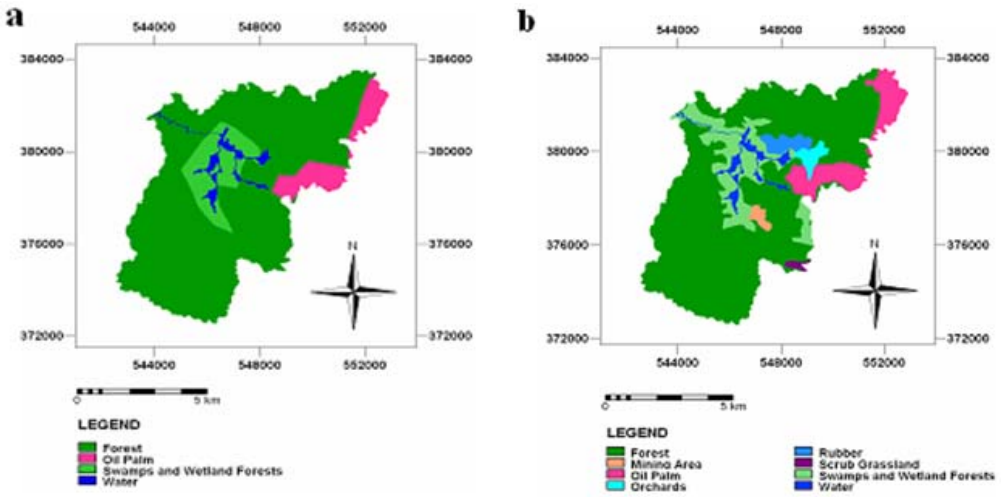
Factors Affecting Land Use and Land Cover Changes in the Tasik Chini Catchment:

Land cover modification and conversion are driven by the interaction in space and time between biophysical and human dimensions [39,38, 40]. The results indicate that the forest cover in the Tasik Chini Catchment area declined from 5269.16 ha in 1984 to 4407.46 ha in 2002, or 14.8 percent forest loss. These changes were attributed to both anthropogenic and natural factors, including population growth, changes in the economy, occurrence of landslides, cropping trends, indigenous agricultural practices, innovation of new technologies and implementation of government policies, etc. Each of these factors contributes with varying degree to the observed land cover and land use change dynamics of the area. Due to the extensive use of land in the area for agricultural purposes, excess emission of nitrogen and phosphorus from the area would bring about the presence of excess nutrients in Tasik Chini. Nutrient enrichment due to waste water runoff from oil palm plantations, containing fertilizers, pesticides, and herbicides has caused the eutrification phenomenon in the lake.

Furthermore there were also pollutants from the existing National Service Centre Camp (PLKN) and the Tasik Chini resort.

Table 1: Total area and changes in types of land use and land cover from 1984 to 2002

Land Use and Land Cover Type (ha)	Year				Area (%)			
	1984	1990	2000	2002	1984	1990	2000	2002
Forest	5269.16	4929.36	4604.36	4407.46	90.53	84.69	79.11	75.72
Oil Palm	286.76	370.80	371.48	577.44	4.93	6.37	6.38	9.92
Water	264.60	256.96	504.96	504.92	4.54	4.41	8.68	8.68
Rubber	0.00	121.76	127.40	117.20	0.00	2.09	2.19	2.01
Mining	0.00	50.40	40.76	38.48	0.00	0.87	0.70	0.66
Agriculture	0.00	91.24	165.12	165.18	0.00	1.57	2.84	2.84
Settlement	0.00	0.00	6.44	9.84	0.00	0.00	0.11	0.17
Total	5820.52	5820.52	5820.52	5820.52	100	100	100	100



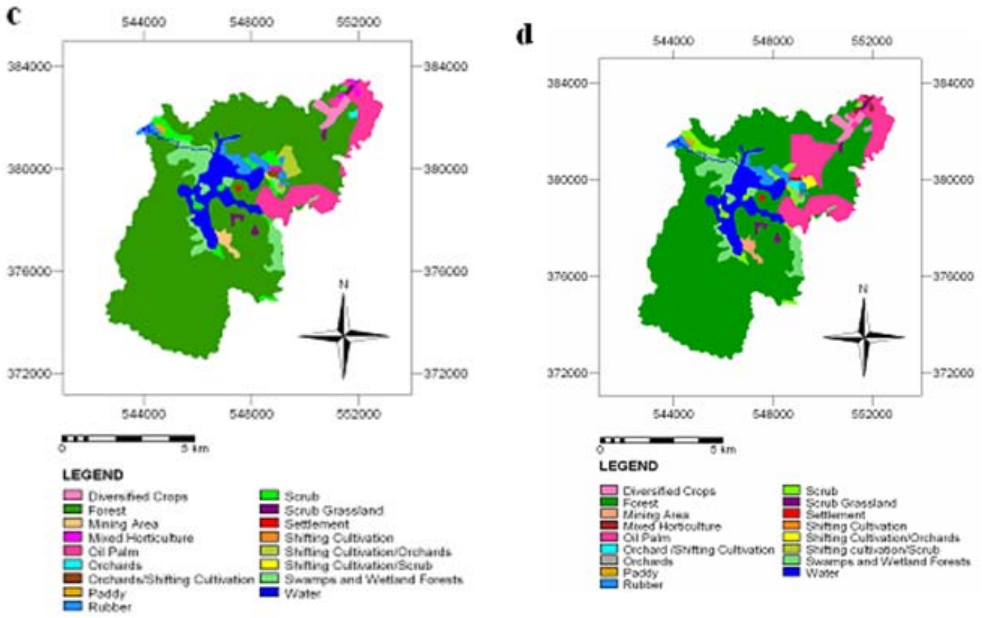


Fig. 1: Land use and types of land cover of the study area in 1984 (a), 1990 (b), 2000 (c) and 2002 (d)

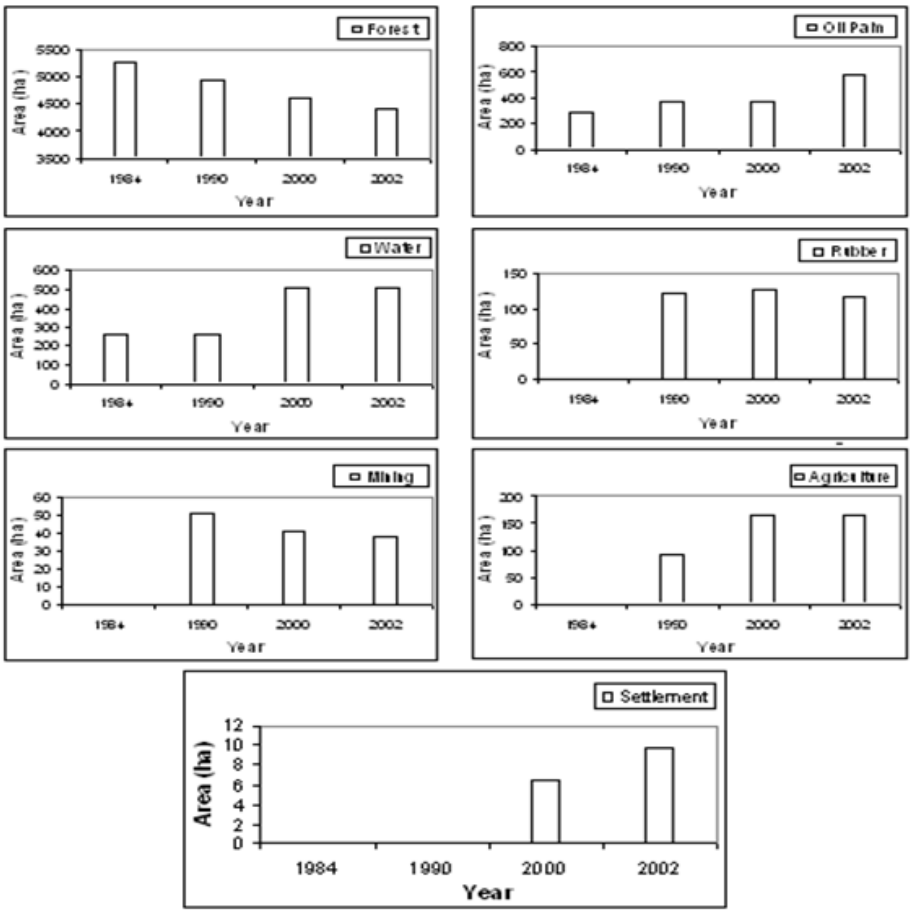


Fig. 2: Changes in forest, oil palm, water bodies, rubber, mining, settlements and agricultural areas in the Tasik Chini Catchment from 1984 to 2002

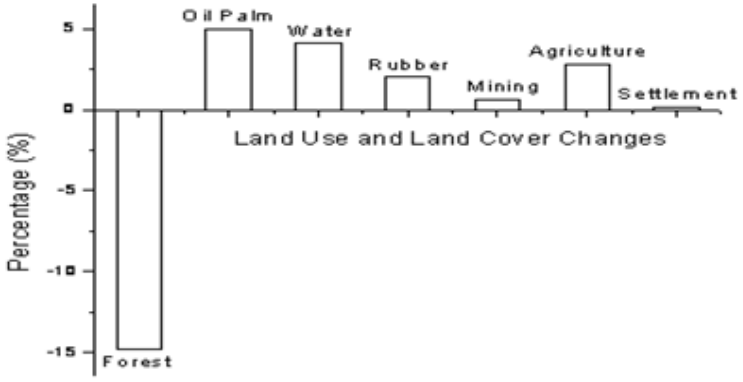


Fig. 3: Trends in land use and land cover change in the Tasik Chini Catchment from 1984 to 2002.

Although relatively low (0.01 and 0.04%), the latter two still play a vital role in joining in and being responsible for causing the water pollution in Task Chini. It follows that proper mitigation is needed in order to maintain the water quality of the lake system. Li *et al.* [21] realized that two factors namely natural factors and socio-economic factors affect land use and land cover changes worldwide.

Conclusion

Land use and land cover changes from 1984 to 2002 in the Tasik Chini Catchment area were dominated by agriculture, settlement activities as well as by rubber and oil palm plantations. Forest areas decreased over the last 18 years, while oil palm, water bodies, settlement areas and agricultural areas increased. The study of land use and land cover changes during the period 1984 to 2002 has contributed greatly to the prediction of expected future development and has played a guiding role regarding the precautions to be taken in future planning so that the environment in which we live is sustainable.

From this study it is apparent that the determination of changes in land use and land covers that would take place over time, using GIS techniques is very effective. By using the GIS it is possible to examine geographical changes in agricultural, settlement and forested areas as well as in natural habitats within the study area. Measurement of the changes on the basis of specific areas can also be carried out.

According to the study results, rapid and unsystematic settlement has, to a great extent, caused destruction of forest and wetland areas, natural recreation areas and wild-life habitats which according to international agreements should be protected, as all of the above mentioned areas are indispensable elements of urban life.

Land-use and land-cover change can serve as an indicator of the political-economic causes of environmental change and vulnerability. Apart from natural factors, economic systems and population growth were the main driving force that jointly determined how local dwellers changed the landscape pattern. Fortunately, from the late 1990s, the environmental problems of logging activities, rapid development and unsustainable agriculture in the study area were recognized widely, and thus national and international ecological projects to protect the wetlands have been developed and adopted. Reasonable industrial structure and proper techniques are needed for maintaining sustainable agriculture. Meanwhile, harness of the degraded land and input of organic fertilizers should also be emphasized. If proper alternative arrangements such as sustainable management of the water resources, protection of logging and creation of awareness among the local people are not immediately implemented, the Tasik Chini environment might degrade at an alarming rate.

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References

1. Abdullah, S.A. and N. Nakagoshi, 2006. Changes in landscape spatial pattern in the highly developing state of Selangor, Peninsular Malaysia. Landscape and Urban Planning, 77: 263-275.
2. Abdullah, S.A. and N. Nakagoshi, 2007. Forest fragmentation and its correlation to human land use change in the state of Selangor, Peninsular Malaysia. Forest Ecology and Management, 241: 39-48.

3. Bolca, M., B. Turkyilmaz, Y. Kurucu, U. Altinbas, M.T. Esetlili and B. Gulgun, 2007. Determination of impact of urbanization on agricultural land and wetland land use in Balçovas' Delta by remote sensing and GIS technique. Environmental Monitoring and Assessment, 131: 409-419.
4. Cardille, J.A. and J.A. Foley, 2003. Agricultural land-use change in Brazilian Amazonia between 1980 and 1995: evidence from satellite and census data. Remote Sensing of Environment, 87: 551-562.
5. Chase, T.N., R.A. Pielke, T.G.F. Kittel, R. Nemani and S.W. Running, 1999. Simulated impacts of historical land cover changes on global climate in northern winter. Climate Dynamics, 16: 93-105.
6. Collier, M., R.H. Webb and J.C. Schmidt, 1996. Dams and river: Primer on the downstream effects of dams. Geological Survey Circular, 1126, US.
7. Devi, R., E. Tesfahune, W. Legesse, B. Deboch and A. Beyene, 2008. Assessment of siltation and nutrient enrichment of Gilgel Gibe dam, Southwest Ethiopia. Bioresource Technology, 99: 975-979.
8. Economic Planning Unit Malaysia, 2004. Eight Malaysia Plan. Economic Planning Unit, Prime Minister's Department, Malaysia.
9. FAO, 2003. Summary of Food and Agricultural Statistics 2003. Food and Agricultural Organization of the United Nations, Rome.
10. Geist, H.J. and E.F. Lambin, 2002. Proximate causes and underlying driving forces of tropical deforestation. Bioscience, 52: 143-150.
11. Goh, K.C., 1982. Environmental impact of economic development in Peninsular Malaysia: a review. Applied Geography, 2: 3-16.
12. Grau, H.R., N.I. Gasparri and T.M. Aide, 2005. Agricultural expansion and deforestation in seasonally dry forests of north-west Argentina. Environmental Conservation, 32: 1-9.
13. Hall, C.A.S., 2000. The changing tropics. In: Quantifying Sustainable Development: The Future of Tropical Economies. Hall, C.A.S. (Ed.), pp: 3-18.
14. Holdgate, M.W., 1993. The sustainable use of tourism: a key conservation issue. Ambio, 22: 481-482.
15. Houghton, R.A., J.L. Hackler and K.T. Lawrence, 1999. The U.S. carbon budget: Contribution from land-use change. Science, 285: 574-578.
16. Kammerbauer, J. and C. Ardon, 1999. Land use dynamics and landscape change pattern in a typical watershed in the hillside region of central Honduras. Agriculture, Ecosystems and Environment, 75: 93-100.
17. Kapadnis, N.R., 2003. Application of GIS for Land Use Planning- A Case Study of Nashik City (India). Land Use Analyses Technical Sessions, Conference Proceedings of Map Asia, India.
18. Kasperson, J.X., R.E. Kasperson and B.L. Turner, 1995. Regions at risk: Comparisons of threatened environments. United Nations University Press, Tokyo.
19. Kumar, R., 1986. The forest resources of Malaysia: Their economics and development. Oxford University Press Pte., Singapore.
20. Lambin, E.F., B.L. Turner, H.J. Geist, S. Agbola, A.J. Angelsen, J.W. Bruce, O. Coomes, R. Dirzo, G. Fisher, C. Folke, P.S. George, K. Homewood, J. Imbernon, R. Leemans, X. Li, E.F. Moran, M. Mortimore, P.S. Ramakrishan, J.F. Richards, H. Skanes, W. Steffen, G.D. Stone, U. Svedin, T. Veldkamp, C. Vogel and J. Xu, 2001. The causes of land-use and land-cover change: Moving beyond the myths. Global Environmental Change, 11: 261-269.
21. Li, X., Z. Wang, K. Song, B. Zhang, D. Liu and Z. Guo, 2007. Assessment for salinized wasteland expansion and land use change using GIS and remote sensing in the west part of northeast China. Environmental Monitoring and Assessment, 131: 421-437.
22. LUCC SEA, 2003. Malaysia land use and land cover change case study. IGBP-UNDP SARCS.
23. Meyer, W.B. and B.L. Turner, 1992. Human population growth and global land use/cover change. Annual Review of Ecology and Systematics, 23: 39-61.
24. Meyer, W.B. and B.L. Turner, 1991. Changes in land use and land cover: A global perspective. Cambridge University Press, Cambridge.
25. Millington, A.C., X.M. Velez-Liendo and A.V. Bradley, 2003. Scale dependence in multitemporal mapping of forest fragmentation in Bolivia: implication for explaining temporal trends in landscape ecology and applications to biodiversity conservation. Journal of Photogrammetry and Remote Sensing, 57: 289-299.
26. Miyakuni, K., 1999. Changes of land tenure and the introduction of tree cash crops by shifting cultivators: the case of the Paluan Muruts in Sabah, Malaysia. Journal of Forest Research, 4: 67-74.
27. Mohd Ekhwan, T., 2003. Channel geometry change response to flow regulation on the Langat River. Proceedings Seminar on Society, Space and Environment in a Globalised World, 29-30 April 2003. Penang.

28. Mohd Ekhwan, T., Y. Zulkifli, M. Mazlin and J. Hafizan, 2006. Application of GIS for detecting changes of Sungai Langat channel. Malaysian Journal of Civil Engineering, 18(1): 59-70.
29. MPOB, 2004. Malaysian Oil Palm Statistics. 23rd ed. Malaysian Palm Oil Board, Bangi, Malaysia.
30. Muhd. Barzani, G., I. Mushrifah, O. Mohd. Shuhaimi, I. Shaharudin and A.R. Sahibin, 2004. Environmental degradation of the Tasik Chini, Pahang, Malaysia. In: Proceedings of the International Workshop on Integrated Lake Management, 19-21 August 2004. Songkhla, Thailand, pp. 45-52.
31. Negi, A.K., B.P. Bhatt, N.P. Todaria and A. Saklani, 1997. The effect of colonialism on forest and the local people in the Garhwal Himalaya, India. Mountain Research Development, 17: 159-168.
32. OECD, 1997. Toward sustainable development: Environmental indicators. OECD Publication, Paris.
33. Okuda, T., K. Yoshida, S. Numata, S. Nishimura, M. Suzuki, M. Hashim, N. Miyasaku, T. Sugimoto, N. Tagashira and M. Chiba, 2004. An ecosystem-management approach for CDM afforestation and reforestation activities: the need for an integration ecosystem assessment based on the valuation of ecosystem services for forested land. In: Proceedings of the International Symposium/Workshop on the Kyoto Mechanism and the Conservation of Tropical Forest Ecosystems. Okuda, T. and Y. Matsumoto (Eds.). Waseda University, Tokyo, Japan, pp: 67-78.
34. Pacheco, P., 2006. Agricultural expansion and deforestation in lowland Bolivia: the import substitution versus the structural adjustment model. Land Use Policy, 23: 205-225.
35. Petts, G.E., 1984. Impounded river: perspectives for ecological management. John Wiley and Sons, New York.
36. Sala, O.E., F.S. Chapin, J.J. Armesto, E. Berlow, E.J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Osterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker and D.H. Wall, 2000. Biodiversity: Global biodiversity scenarios for the year 2100. Science, 287: 1770-1774.
37. Sehgal, J. and I.P. Abrol, 1992. Land degradation status: India. Desertification Bulletin, 21: 24-31.
38. Skole, D.L., W.H. Chomentowski, W.A. Salas and A.D. Nobre, 1994. Physical and human dimensions of deforestation in Amazonia. Bioscience, 44: 314-322.
39. Turner, B.L., R.H. Ross and D. Skole, 1993. Relating land-use and global land cover change (IGBP Report No. 24, HDP Report No. 5). IGBP of the ICSU and HDP of the ISSC, Stockholm and Geneva.
40. Turner, B.L., D. Skole, S. Sanderson, G. Fischer, L.O. Fresco and R. Leemans, 1995. Land-use and land-cover change, science/research plan (IGBP Report No. 35, HDP Report No. 7). IGBP of the ICSU and HDP of the ISSC, Stockholm and Geneva.
41. United Nations, 1996. Urbanizing World: Global Report on Human Settlements. United Nations Center for Human Settlement (HABITAT). Oxford University Press, Oxford.
42. Van Laake, P.E. and G.A. Sanchez-Azofeifa, 2004. Focus on deforestation: zooming in on hot spots in highly fragmented ecosystems in Costa Rica. Agriculture, Ecosystems and Environment, 102: 3-15.
43. Verburg, P.H. and Y.Q. Chen, 2000. Multiscale characterization of land-use patterns in China. Ecosystems, 3: 369-385.
44. Vitousek, P.M., H.A. Mooney, J. Lubchenco and J.M. Melillo, 1997. Human domination of earth's ecosystems. Science, 277: 494-499.
45. Wakeel, A., K.S. Rao, R.K. Maikhuri and K.G. Saxena, 2005. Forest management and land use/cover changes in a typical micro watershed in the mid elevation zone of Central Himalaya, India. Journal of Forest Ecology and Management, 213: 229-242.
46. Wetlands International Asia Pacific, 1998. The ecological assessment of Tasik Chini Pahang, Peninsular Malaysia: an evaluation of its conservation value and environmental improvement requirements. WIAP, Kuala Lumpur.
47. Wong, K.H., 1974. Land use in Malaysia. Ministry of Agriculture, Kuala Lumpur.
48. Wood, T.S. and S. Baldwin, 1985. Fuel wood and charcoal use in a developing country. Annual Review of Energy, 10: 407-429.