Angkor Revisited: Lessons to Learn?

At its height, the Angkor empire in Cambodia ruled over a vast area and a great number of subjects; numerous temples and statutes were built on rich, fertile soil at a prolific rate. Geologist Heng Thung, who has been devoting a large part of his life to the study of the area, has attributed massive deforestation, geological and hydrological factors to the causes of the kingdom's decline. The following is an elaboration of the premises made in his previous article, 'Did earth move to fell Angkor?' (SPAFA Journal Vol. 9 No. 1, 1999).

Photo by Heng Thung

Background

The forests of Cambodia have often been in the news. Figures on the extent of forest cover and its disappearance have been the topic of heated discussions. There are many agencies involved in mapping the forests. However, there are many types of forest and thus often different figures are used.

The earliest maps were made by the Mekong River Commission starting in 1992 and then subsequently followed by other surveys, including later surveys by the Forestry Department of Cambodia, and recently as part of the land use mapping. The forests are also covered by the JICA funded Reconnaissance Survey Project.

Under the auspicious UNTAC (UN Transitory Authority of Cambodia) in 1992, a lot of attention was given to illegal logging, suggesting that the country was being deprived of the revenue it needed for the rehabilitation of the country and that logging would also destroy the precious environment.

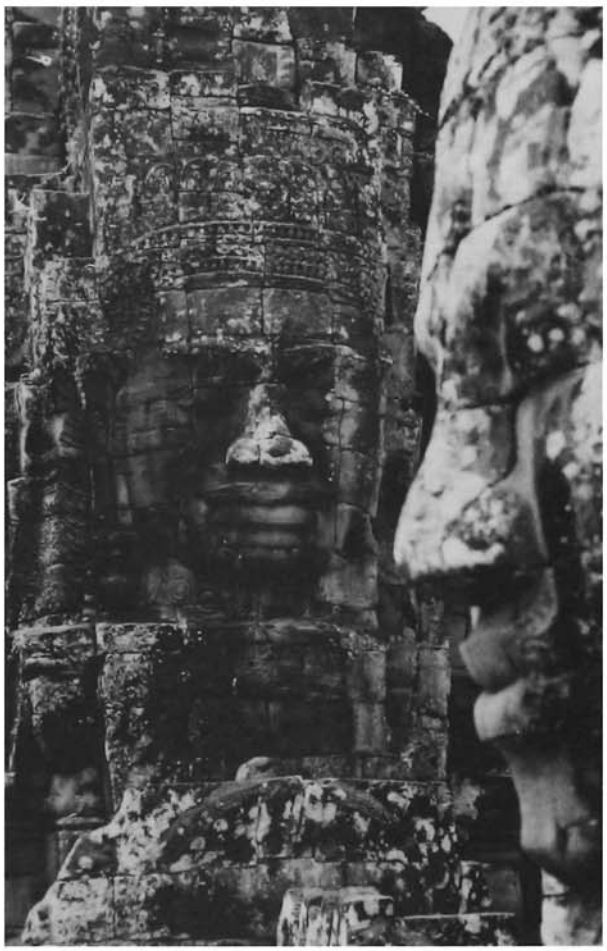


Photo by Nipon Sud-Ngam

The World Bank started their first survey in 1992 and consequently hired new consultants to develop surveillance systems for the forests. The forester sent by the World Bank was awed by the destruction of the forests, as thousands of square kilometres of land were denuded of virgin forests. She sounded the alarm on the destruction of the forests of Cambodia by illegal logging. Millions of dollars in studies were made to assess the damage to the evergreen forests.

Fires from the practice of slash and burn
(Photo by Heng Thung, taken during an overflight in the area north of the town of Kampong Thom, north of Phnom Penh and east of Siem Reap).

Photo by Nipon Sud-Ngam

Just a few years ago, Cambodia was forced to allow the Global Witness to monitor the forest. When a negative report was issued last year, the Government threatened to ex pel the organization. But the donors such as the International Monetary Fund, the World Bank and the Asian Development Bank threatened to withhold loans and aid to Cambodia. Thus the issue is a rather serious matter for the Cambodian Government.

What does this have to do with Angkor?

At the zenith of its power, Angkor needed land to grow food to feed its army of soldiers and slaves who were building and maintaining the temples. Thus, to understand the impact of the Angkor Empire on the land during its heyday requires the understanding of the agricultural expansion to meet the demand for food.

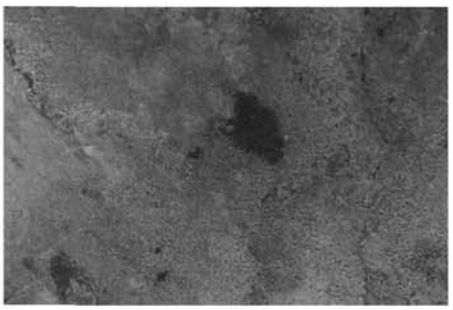
It is important to note that most of the forest destruction of Cambodia took place a thousand years ago during the peak of the Empire's supremacy, and not in the last two decades after the war. However, the forest is still under threat, but less from loggers than from hungry farmers. This fact is important in understanding the dangers that Cambodia's forests are under today.

Angkor

Originally, the area of Angkor was chosen because of specific spiritual requirements and the land that supported its population. Its location is remarkably similar to that of the Prambanan temple complex in Central Java as viewed from the Penataran. When one looks down from the Phnom Kulen (mountain range), one can almost see a replica of temples down in the rich valley of the grand lake. However, here the similarity stops, because the rich agricultural land in the Angkor region is limited to the lake shore and rich alluvium. The central Javanese plateaus

were situated in rich volcanic soils, and the water, continuously flowing down the mountain slopes, yields good crops year afte year.

The narrow lake beds along Ton Le Sap lake provided land for the growing kingdom, with the unique annual flooding leaving silt and providing the people with two crops of rice: one after the rainy season, and the other irrigated on the still wet land of the retreating shoreline of the lake after its flood stage. Three crops were harvested after the advent of the floating rice. While this rather narrow alluvium sufficed during the initial stages of Angkor's growth, it became more difficult to provide the growing population as the empire expanded. The increased urban population and construction of the many temples and other buildings required a large farming population to grow the necessary food products.



Aerial photo of the area which was destroyed during the time of the Khmer empire; it is now covered by open diptherocarpus forest.

Aerial photo of a similar area where temples ruins are found. (Both photos by Heng Thung)

The sandy alluvial plains above the more fertile lake could not cope with this demand of the ever growing empire. The fertile northwestern Battambang plains were still under water. Thus, the recourse from this demand was to move into the lush forest-covered valleys north of Angkor beyond the Kulen Mountains. They cut down and burned the trees to grow crops. They were mistaken as were the colonial agriculturists, who found that the verdant forest did not hold what they thought was the promise of rich soils. The people of Angkor, who came from the rich Mekong Delta, had always practised sedentary permanent farming methods on the flood plains and deltas. They found that these upland soils after two years of cropping did not yield much rice anymore. They abandoned these cleared fields and progressed further into the forest, into what is now the abandoned hinterland of northern Cambodia.

Satellite images of the landscape of northern Cambodia show extensive areas of denuded land covered by thin soils, grasses and shrubs and open or dry deciduous forest. Much of the land, if not eroded, was covered by rather infertile sands, lateritic soils and laterite as evident in its use as the foundation blocks of the temples. The reason why there are no large quarries of laterite is that it was widespread and easily available throughout the area.

Not only is the land denuded of forest, but tremendous erosion has taken place, which has removed the top soil over vast areas of northern Cambodia. This soil ended up filling the northwestern area of the Grand Lake. There is no way that the millions of hectares of land now laid waste could have been the result of recent human activities.

The changes are more likely the effect of environmental disturbances and the human actions that hastened the transformation of the land. Temples now lie hidden in this extensive residual forest or lie abandoned in the midst of scrubland and open deciduous forest, which indicates that at one time these areas were fully developed and supported the

Aerial photo of temple ruins in areas where recovery of better forest conditions can be found.

Aerial photo of temple ruins scattered in the area north of Angkor. (Both photos by Heng Thung)

expansion of civilization, a growth which spread along the roads, extending to the northwest, to Phimai and Phanom Rung, and eastwards towards Wat Phu (The area is now thinly populated). During the peak of development, the areas might have been populated by active farming communities, which like those of today, developed along the roads. At the same time they would have built settlements and temples, in the same way as those that have sprouted today. These remnants of civilization lie abandoned throughout this devastated land. Some temples are very extensive like the Preah Khan of Kampong Svay, which has an enclosure of about 4 by 4.5 kilometres. All through the area northeast of Angkor, there are numerous ancient roads and vestiges of temples and old settlements.

At the same time, the geological uplift (Thung 1994) had precipitated the erosion of the soils exposing bare or shallow rock over much of the areas now covered by the above mentioned vegetative cover. For that reason, sustainable slash and burn agriculture can only be practised by rotating small plots so that they can be re-seeded by the surrounding trees.

The drainage pattern of the area between the Khorat escarpment and the Kulen mountain range shows a complex system of a structurally controlled drainage constricting through the gap in the mountains, and then becoming a distributary system depositing the soils into alluvial fans, forming the edge of the northern shore of the Ton Le Sap lake.

In the northwestern exit north of the Kulen Mountains the deposits created delta and lake deposits, which now comprise the rich alluvium of the northern Battambang plains. At that time, this area was still inundated by the lake. Prehistoric sites have been discovered in this area, where raised areas were occupied by pre-historic man, who lived along the edge of the lake shore (Potier, 2000). As mentioned earlier (Thung 1994),

the old drainage systems of entrenched meandering streams north of the Ton Le Sap basin shows the result of recent geologic uplift. Much more study of these phenomena should be undertaken to understand the geologic activities in recent geologic history and perhaps the presence of this area.

A measurement was made of the Phreah Khan temple north of Kampong Thom, mentioned above. The temple ruin complex is located on a ledge at the 70-metre contour, while the broad valley bottom surrounding it is at the 50-metre. The construction of the temple has diverted the streams to both sides of the temple walls, and thus protected the sites from erosion. These measurements confirm that erosion has taken place during and after the construction of the temple. It was the same geologic uplift discussed in the previous paper about the geohydrology of Angkor that caused the erosion. The forest clearance just exacerbated the process in these valleys.

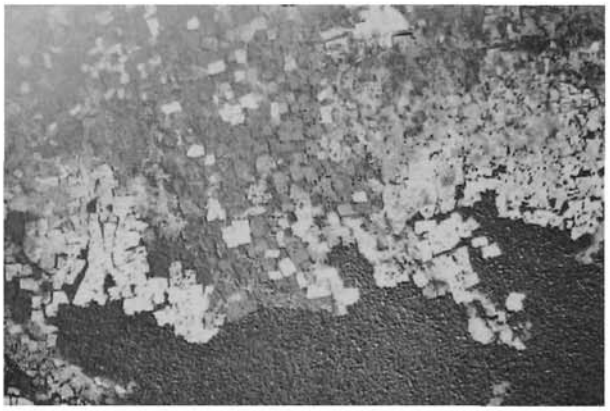
Looking at aerial photos, a dozen or more abandoned temple sites are visible, while some have been visited on the ground, such as the Koh Ker group of temples north of Ban Malea, towards the Vat Phrae Viharn temple site on the Khorat escarpment. Koh Ker was built as the capital city by Jayavarman IV in 921 (Briggs 1951). It is likely that there were many more sites, which have been eroded and washed away. Careful study may reveal more abandoned sites.

Areas east along the Mekong River show similarly extensive denuded areas. The space imagery shows strong erosion features displaying a sedimentary rock formation. However, there are no known temple complexes in the area. Could these erosion features be the result of the settlement of these areas by the ancient Chenla people, situated between the Wat Phu area in southern Laos, and north of the original Chenla and Funan heartland of the Mekong Delta? Or could these areas have been affected by the occupation by the Chams from the east? In addition, some prehistoric sites have been discovered on the laterite peneplain along the Vietnamese border area nearby, indicating early human activities.

Areas of logging concession, where destruction is minimised, due to good logging pratice.

Bad logging, taking out even small trees. White soil patches can be seen through the canopy because of excessive logging.
(Both photos by Heng Thung)

While the generalization of the phenomena may point to the definite result of deforestation some thousand years or more ago, these same phenomena along the eastern side of the Mekong are speculative. Only human activities can create such environmental disasters as we view them now. It would be very interesting to have archaeological studies include the environmental impact of human occupancy of this earth.



Clear cutting by farmers moving into the forest.

Clear cutting by farmers in good evergreen forest; not using degraded forest, realising that burning the good forest provide them with better nutrients.

Good logging in evergreen forest.
(The above 3 photos by Heng Thung)

Photo by Nipon Sud-Ngam

One thing is for sure, the extensive eroded areas covered by deciduous forest, grass and scrubland are not the creation of recent human activities, but since centuries ago over a rather long period, during which the search for agricultural support of the ancient empires took place. Recent activities are visible and definitely of a different appearance.

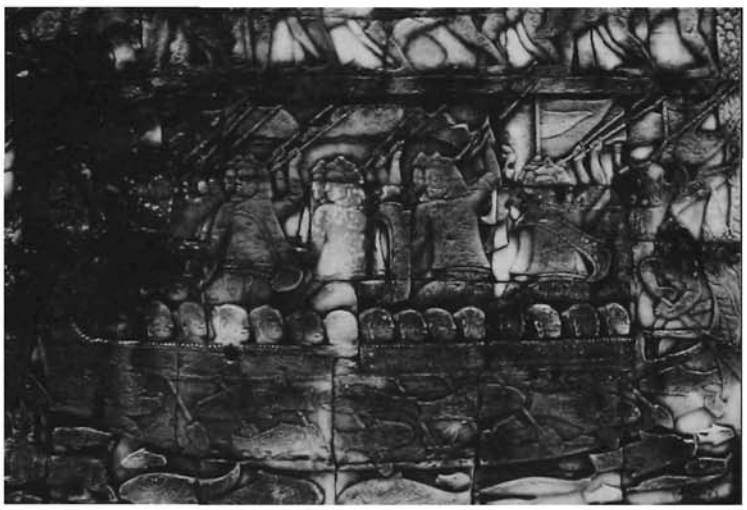
The Tropical Forest and its Environment

We view many areas of the world in terms of their present environment. Thus, very few people realize that the world a thousand year ago was much different from what it is today. It seems that we believe that many countries at one time were covered by virgin forest, and that in just a few decades the forests have been denuded to supply material to the developed world for its insatiable hunger for wood. Often we forget that the developing world needs wood for fire and charcoal and land to feed its hungry people. While the developed world derides the developing countries for destroying their forest, they do not seem to be able to quench their own hunger for acquiring products made from these beautiful tropical woods.

To understand the destruction of the forest today or a thousand years ago requires a background on the process of primitive agriculture expansion. In temperate climate, the forests are unlike those of the tropics. Often these temperate forests are monocultures which are harvested by clear cutting. Even the hardwood forests around my hometown Asheville in North Carolina were destroyed a hundred years ago, and allowed the millionaire George Vanderbilt to buy the destroyed land for a penny an acre, but it also gave birth to the first forestry school in the United States at the turn of the century.

The tropical forest consists of the mixed vegetation of large and small trees. The evergreen forest is characterized by a multilevel of trees, so that it is dark with little undergrowth. Only where the canopy has been destroyed, or the large emergent trees removed by old age or logging, will young vegetation clog up these holes. The lush vegetation growth along trails and tracks are the common view that people have seen while traveling along the forest edge. Massive vegetable growth is the result of sunlight, while the removal of the larger trees gives the smaller trees a place literally in the sun. The lush tropical climax forest often does not reflect the soils beneath it. These soils are often leached and form an infertile lateritic soil, and only the large trees with their deep roots are able to penetrate down beyond the soil horizon into the rich rotten rock layer to access the necessary minerals to maintain the green organic mat (Mohr and van Baren, 1954. Richards, 1952). The forest will not recover once this association is broken by removing the trees by slash and burn and growing crops until the soil is exhausted. Instead the land is replaced by short-rooted grasses, in particular the dense cogon grass (imperata cylindrica), which are not able to reach the rich minerals layer deep below again.

Both photos by Nipon Sud-Ngam



In contrast with the soils in the temperate climates, the organic layer or horizon in the tropics is very thin. The reason is that the high temperature in the tropics caused the organic material, such as leaf litter to disintegrate rapidly and dissolve into the soils or run-off. This was the surprise that many of the colonial agriculturists encountered. When they opened land for field crops they found that it was not suitable for sustainable agriculture. Once the nutrients in this shallow surface layers are depleted and the forest cover removed, only the grasses take over the land.

It is the small-time, rather than the professional, loggers and hungry farmers - eking out a living - who destroy the forest. It is also not just the logging road; any road into

Photos by Nipon Sud-Ngam

or through the jungle will have an impact on the forest as people in search of a livelihood will cut the forest, first for wood, then for charcoal, then for farming and thus the cycle of destruction. I first encountered this invasion of people along a trail in the middle of the jungle of Sumatra, where I was drilling for oil. They even had the audacity to levee a toll on my team who had built the road to pass.

In 1965, I worked in an area selected as forest site for tropical forest experiments next to the Khao Yai National park in Thailand. At the end of that year, I saw the first bulldozers cutting a road between the lowland and the Khorat plateau in Thailand. In 1969 I revisited the area and found not a forest, but a single tall Yang tree as the sole survivor of the forest site. I saw abandoned land, trails into the hinterland and settlements. It was not just a few kilometres deep. After the aerial survey, we found the forest removed as far as 26 kilometres from the new road. My thesis then was born: to measure the impact of roads on the environment.

People are in search for a living. Roads give them access to virgin areas, and the destruction of the tropical forest begins; from the Amazons, to the Central African jungles to the forest of Southeast Asia. It is the rhythm of destruction, which is often not recognized until too late. We have forgotten the barren lands of Greece now and the Mediterranean classical world that once were covered by dense forests.

Slash and Burn Agriculture

The most primitive cultivation practice is slash and burn or swidden agriculture. It requires very little capital but is labour intensive. However, this system of agriculture can be sustainable if some basic principles are maintained. The traditional swidden farmers observe rotational slash and burn agriculture. The principle of rotational slash and burn is based on the short interval of cultivation and a limited size of the fields to allow reseeding from the adjacent forest. This system can be maintained almost forever as long as the cycle of fallow can be maintained at least every twelve years for the forest to regrow and provide the nutrients the trees have drawn from the rock strata below, and stored in the biomass to be released by

firing (Nye and Greenland, 1965; Peltzer 1941, Thung 1972). The scattered rice fields occupy at most only a fraction of the forest. The rest of the land is covered in secondary forest.

Larger clearings usually do not revert to forest but usually end up covered by grass and shrubs, because the forest trees are not able to reseed areas a distant away from the forest edge. In the tropics, these areas are mainly covered by imperata cylindrica or cogon or lalang. Once this grass has invaded the area, reseeding becomes difficult and large grass areas remain in place, which can only be cultivated using heavy equipment and much inputs in fertilizers. But in general the poor farmer is forced to leave it behind as grass and scrubland.

In the Congo, Belgian soil scientists recognized the problem and developed the corridor agricultural system, which in essence is a systematic linear rotational swidden practice. They cut plots along parallel strips some 100-200 metre wide with a strip of forest in between to allow reseeding from the adjacent forest. They cultivated sections up and down along this corridor, rotating linearly like the primitive tribes in cycles of ten to twelve years. This corridor system allowed the rejuvenation of the soil's fertility along a systematic linear rotation.

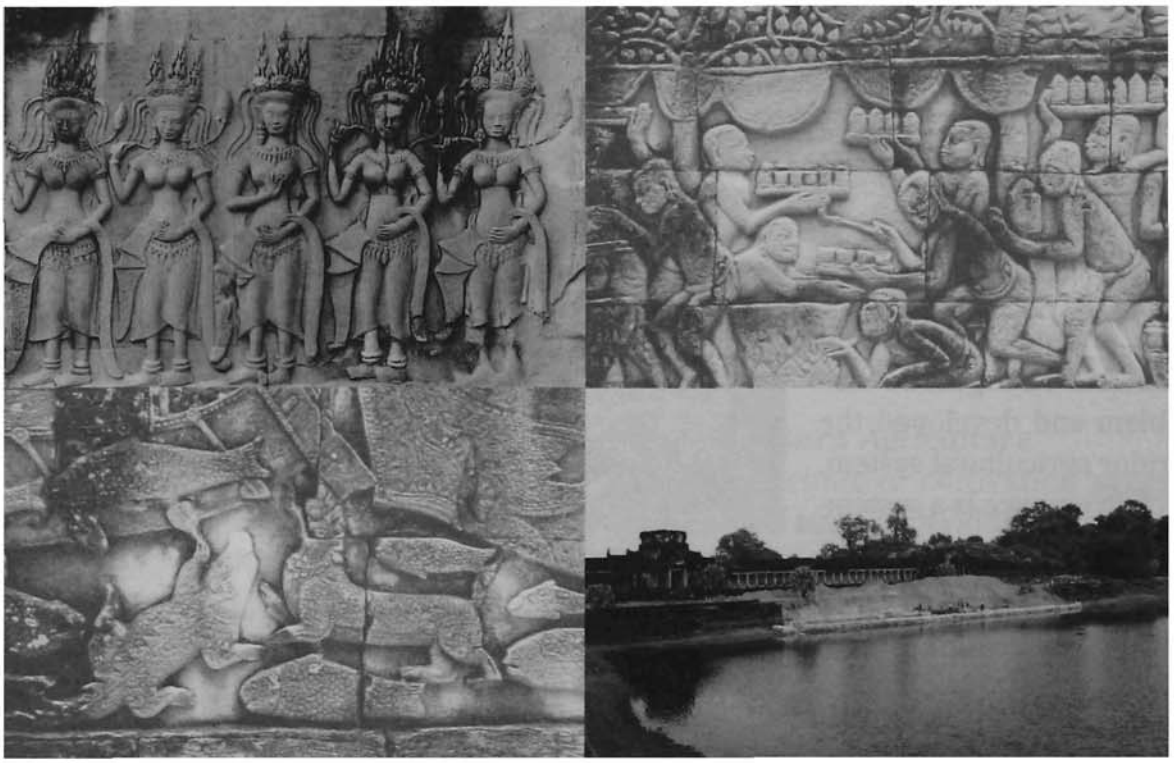
Basically, swidden agriculture requires a lot more land to be cultivated. In essence, to properly rotate, one needs at least twelve times the areas to cycle the fields in order to maintain the proper soil fertility. However, in many areas in the world, rapid population growth has encroached on these traditional swidden agricultural lands. For instance, in Thailand and in Burma, the hill tribes were able to maintain these practices until three decades ago. The inherent population growth, and increased encroachment from the lowlands, has made it necessary to reduce the rotational cycles, which means a lower soil fertility, thus also an increase of land clearing to compensate for the production loss and, in turn, destruction of the forest.

Photos by Nipon Sud-Ngam

The ashes from the fires and the opened up tropical evergreen forest (prime forest). (Photo by Heng Thung)

Present Environment and Activities

Thus, over the past fifty years, population growth has exceeded the land bearing capacity. It has slowly permeated the many tropical lands, where agricultural development lagged behind the population growth. It is especially noticeable in tropical Africa where the climate and the soils have very low capacity for permanent agriculture, causing almost annual cycles of starvation. In Asia and the Americas, this phenomenon is just reaching crisis proportions and is now exacerbated by the rapidly growing population and access to the wilderness through the opening of land by building new transportation networks and logging.



Photos by Nipon Sud-Ngam

This is the threat to the present forest. While we berate the logging industry, we fail to realize that the greatest destruction of the forest is precipitated by the landless farmers following the logging activities, moving along new roads or the forest periphery to encroach. In this case the logging acts as a catalyst by facilitating access to the forest and removing the large trees, which these farmers would have difficulty to handle. Thus the smaller trees are left for these farmers to harvest for firewood and charcoal, then finally allowing the clearing of the land for cultivation.

However, as stated earlier the decrease in soil fertility forces the farmer to encroach further and leave behind them swaths of grassland. These can only be brought back into cultivation by using heavy equipment and large inputs, such as cassava (as in northeast Thailand), or conversion into tree crops (such as rubber in southern Thailand and

palm oil in south Thailand and Borneo or Kalimantan).

It is not necessarily the logging roads that have an impact on the forest. In the early sixties, oil companies built roads into the coastal plain of eastern Sumatra to reach their drilling sites.

These roads were usually planned at least six months ahead. It is interesting to note that within that short period settlements sprung up spontaneously along these access roads in the middle of the jungle. This was in contrast to the elaborate transmigration effort to transplant the people from the traditional culture of Java into a hostile environment.

Conclusion

There is a lot of noise about illegal logging. However, that has to be carefully defined and it requires understanding, being a perpetual problem, which cannot be resolved with words and accusation.

This does not mean that logging is not damaging. In many instances the logging roads and, for that matter, any road will precipitate the practice of clear cutting, if the population pressure is large enough. They provide easy access into the forest, and also facilitate clear cutting, because the removal of large trees facilitates the invasion of the land left devoid of large trees and thus easier to be attacked by farmers with less sophisticated tools. They make charcoal first and then clear the land for cultivation. In addition, their use of fire exacerbates the destruction, killing the seedlings before they grow to maturity.

Large areas of northern Cambodia are fired every year, and in March this year, the smoke covered the land, leaving extensive areas blackened. Many Cambodian farmers have found that the dense evergreen forest provides the best nutrients after firing. In many places these people have not even waited for the loggers to remove the large trees, and cut the smaller trees while leaving the large trees behind, as they do not have the capabilities to cut them down, and burn them.

Ironically, scattered through this destruction of the forest there are cells of people practicing proper slash and burn agriculture. The perfect system of rotational swidden agriculture is still practised on top of the Kulen Mountains, where once the Angkor dynasty built its first capital city, just an hour-ride away from the Angkor monumental complex. Here, perfectly circular fields of crops lie sprinkled in a pattern of similar uniform-size round dots of secondary forest, resembling - from above - the skin of a lizard. They pose a very interesting question for the next researcher climbing those mountains.

Today, the rate of deforestation in Cambodia is much less than, for instance, in Thailand where in the northeast, the forests were removed in several decades (Sakhit, map 1984) because of population pressure and the need to have land for commercial agriculture (cassava for export).

Epilogue

As early as in 1939, the famous soil scientist working in Thailand, Robert L. Pendleton, mentioned that he believed that this cycle of

shifting cultivation may have contributed materially to the downfall of the Khmers in Cambodia. He stated that although the Khmers used the plow on very limited areas of wet riceland, they had to depend largely on the planting stick and shifting cultivation for their food supply.

As demand rose from the rapidly increasing population concentrated in the city of Angkor, the fallow period granted to the uplands had to be progressively shortened. At the same time, fires became very frequent and destroyed seedlings in the adjacent secondary forest and impeded the recovery of the forest, thus diminishing the food supply available to the people of Angkor (Pelzer, K. J. 1945, R. L. Pendleton, 1939)

Lawrence P. Briggs, in his concluding chapter about the abandonment of Angkor, stated: "All the great monuments of antiquity were built by forced labour and the most necessary consequence of a prolonged period of architectural greatness was an exhausted spiritless people" (Briggs, 1951).

Photos by Nipon Sud-Ngam

Today, satellite technology records the present and ancient conditions of the earth, and its monuments. What earlier scientists observed and concluded was based on their experience and instinct, but even so they already suspected that such events that had taken place would leave scars on the earth surface for this generation to confirm.

With the present tools available, the opportunities exist for scientists to determine with greater accuracy the events of the past and present but with that knowledge, they will also have the responsibilities to provide solutions to today's urgent needs that threaten the environment and also find solutions for the livelihood of those people who depend on the forests.

The time has come to stop the hysteria of saving the environment without coming up with a comprehensive solution for both the people and the environment. We have to stop driving and flying around on junkets in the name of science and research, and drawing conclusions based on frail facts and from quick views, and uttering mighty words to impress the next donor.

We should classify the damage of the forest into five different groups: 1. Proper logging, 2. Small-time logging with damaging effect, 3. Scavenging of firewood and charcoal, 4. Slash and burn agriculture, 5. Rotational swidden.

Then in the end, we should measure the population bearing capacity and identify those areas which demand priority assistance. With that information, we could isolate the threat to the forest by 1) having an extension service to properly manage the land; 2) limiting the access to environmental conservation areas; and 3) finding alternate livelihood for the farming population.

Perhaps we can save the forest of Cambodia by making a positive attempt to save its remaining forests, so that the history of a thousand years will not be repeated in a few decades.

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