Regional Dialogue on Biodiversity and Natural Resources Management in Mainland Southeast Asian Economies

Proceedings of the

Regional Dialogue on Biodiversity and Natural Resources Management in Mainland Southeast Asian Economies

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Foreword

The region comprising the countries of Myanmar (Burma), Cambodia, Lao PDR, Thailand, Vietnam and Southern China forms a geographical area with shared natural resources and environmental concerns. During the past decade, the region's economies have undergone rapid economic changes, the pace of which will continue well into the coming century. The rising economic prosperity and increasing population will have significant impact on the region's remaining natural resources. Already, this impact is apparent in areas within the region. The transborder nature of some of the resources and the concerns arising from their use calls for mutual cooperation among the countries of the region to avoid serious regional conflict, and to share knowledge and research on regional environmental problems.

As a step towards cooperation in the area of natural resources and environment management among the region's economies, the "Regional Dialogue on Biodiversity and Natural Resources Management in Mainland Southeast Asian Economies" was held in Kunming, China, from 21 to 24 February, 1995. It was organized by the Kunming Institute of Botany of the Chinese Academy of Sciences, in cooperation with the Natural Resources and Environment Program of the Thailand Development Research Institute (TDRI). The conference was an effort to bring together individuals and organizations active in the area of natural resources and environment management in the region on an informal basis. The objectives of the conference were:

- To foster personal and organizational ties that create mutual understanding and good will
- To share knowledge and expertise in the fields of biodiversity and natural resources management.
- To advance the capacity of the participating organizations.
- To encourage new areas of cooperation.

There were 56 participants from eight countries, including Cambodia, Canada, China, Lao PDR, Singapore, Thailand, USA and Vietnam. A complete list of participants is given in Annex III.

The Conference was inaugurated by the Honorable Vice-Governor of Yunnan, Mr. Zhao Shumin. Among the other distinguished guests were Mr. Wu Guanfan, Secretary-General of the Yunnan Provincial Government, and representatives of the various government agencies of Yunnan Province, as well as Dr. Zhao Borong, Director of the Chinese Academy of Sciences, Kunming Branch, and Prof. Hao Xiaojiang, Executive Vice President of the Kunming Institute of Botany.

The Conference lasted three days, with a field trip to the Stone Forest and the Dianchi Lake on the second day (see the conference schedule in Annex IV). During the final session, participants broke into three groups to discuss in more specific terms regional concerns and

possible areas of cooperation. The topics for the three groups were: 1. water resources, 2. land use, biodiversity and forest policy, and 3 environment and development and the environmental impact assessment (EIA). The account of the discussions among the three groups and their presentations to the larger plenary session best describes the outcome of the Conference (see Annex I). A consensus among the three groups was to establish an informal forum for sustainable development and environmental management in the Greater Mekong Basin. The forum representing a network of academics, NGO workers, government officials, etc. involved in natural resources and environment management in the region, will facilitate exchange of information, policies and views among the members.

The participants were also encouraged, by means of a questionnaire survey, to list down areas in which they would like to see increased cooperation. The survey results are shown in Annex II.

An effort of such magnitude cannot take place without support from others. We gratefully acknowledge the funding support for the conference provided by the Canadian International Development Agency, The Asia Foundation, Thailand and Vietnam, World Resources Institute, U.S.A., and Queen's University, Canada.

We would also like to thank Prof. Xu Zaifu, President, Kunming Institute of Botany and Dr. Ammar Siamwalla, President, Thailand Development Research Institute, for their wholehearted support to the conference.

Finally, our sincere thanks go to the staff of the Kunming Institute of Botany and the Natural Resources and Environment Program of the Thailand Development Research Institute, particularly, Eric Y Azumi, Sunil Pednekar and Phaibun Chuchailam from TDRI, and Dao Zhiling, Guan Yuqin, Cui Jingyun, Yang Yunshan, Chen Keke, Li Shuyun, Li Yun, Xia Yu, Yang Chunyaang, Wang Chonggong, Yin Ping, Zhou Yuan, Yang Jiankun, Li Haiyan and Liu Yitao from KIB, whose tireless work made this conference a great success, and to interpreters Mr. Paul Wang and Miss Yin Ping, who did an excellent job of translating Chinese into English and vice versa.

It is hoped that in future the informal network among the participants and the organizations they represent will continue to grow and provide a means of communication for sharing knowledge and experience on addressing environmental problems to better understand the need of the time to think globally, act regionally and benefit mutually.

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THE DIVERSITY OF PLANT GENETIC RESOURCES: AN ECONOMIC PERSPECTIVE

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Plant Genetic Resources Diversity as a Component of Biodiversity

The diversity of life on earth is the outcome of millennia of natural evolution, but from very early on, man has extensively tampered with that natural diversity. Agriculture, after all is nothing but the conscious elimination of a very large number of plant and animal species that would otherwise thrive on a farm, to favor a few species that the farmer wants to grow. However, in the last few centuries, man's activities have intensified to the point where large numbers of species are threatened with extinction. This concern has led to widespread discussion, culminating finally in the signing of the Biodiversity Convention during the 1992 summit on the environment in Rio de Janeiro.

The Biodiversity Convention is an ambitious document, covering not only all forms of life from microorganisms to mammals, but whole ecosystems. This approach is dictated by the fact that all life is inherently interrelated. However, for an understanding of some of the issues involved, it would be more practical for a short paper such as this to take a look at some aspects of the biodiversity. I have chosen in this paper to look at the diversity of plant genetic resources, because control over them is at the heart of a great deal of controversy among the nations of the world.

The economic perspective that we bring to bear on this issue starts from the observation that conservation and destruction of plant genetic resources is the outcome of activities of large numbers of men and women, all of whom are guided by different motives and interests. We must therefore seek to understand who it is that wants to conserve the resource diversity and who it is that wishes to destroy that same diversity and why. Armed with this understanding, we can then address ourselves to the question as to whether we can harness people's motives to maintain it for future generations.

We shall divide the following discussion into two parts, one concerning wild species and the other the domesticated species. There is some overlap in the subject matter among the two, as wild relatives of domesticated species are sometimes valued because of their potential in improving the latter's performance. By and large, the level of concern in the two cases differ also: in the case of the wild species, we are interested mostly in maintaining the diversity at the species level, while in the other case we are more concerned with maintaining the diversity of the cultivars.

Genetic Resources From the Wild Plants

Demand-side Considerations

Resources are valued because of its usefulness both directly or indirectly. In this case we say that they have "use values". There are also other reasons, moral and aesthetic, why resources may

have values. Man may value the survival of other species such as dolphins, pandas or teak trees in and of itself, not because the dolphins or pandas do anything that is useful to him, but because it is considered immoral to destroy these species. In this paper we shall ignore this second set of values, sometimes called "non-use values", not because they are unimportant. But if we do attribute non-use values to the survival of these animals or plants, then the case for arranging their survival rests on grounds other than economic.

Sedjo (1992) gives three reasons why people consider plant genetic resources useful:

- People value the germplasm (i.e. the material in which the genes are embodied) because it can be used to grow the plants which in turn yields use values directly, such as food, fibers, medicines, etc.
- The germplasm is itself a genetic material and can be used to generate new kinds of germplasm, by various kinds of genetic manipulation, such as done in classical plant-breeding, and more recently by means of genetic engineering. Obviously, this use is more frequently seen with domesticated plants and will be addressed in the next section.
- The plants embody various sorts of complex chemical compounds which they use for various purposes, such as warding off or attracting insects. Some of these chemical compounds can be used directly, for many purposes, such as insecticides, perfumes, but above all, as medicines. The plants could thus generate direct use values. However, it is often economical to analyze the chemical structure of the relevant compounds and then synthesize it from other materials in the laboratories for sale. In this case, the plants provided use value through the information of the chemical structure that is of economic value.

In its first use, plant germplasm is a conventional economic good and can be bought and sold like any other, and indeed, in most agricultural communities there is an active market for seeds and other sorts of germplasm. The second and third uses of plant genetic resources make them non-rival public goods, to use the economist's jargon. A farmer's or a plant breeder's or a drug firm's use of the genetic resources does not preclude others from using them again, provided the first party that uses them does not do so to excess. The remaining germplasm can still be used for breeding or the information embodied in the plant is still available for others to use for the same purpose. It is this characteristic that makes the creation of a system of efficient production and exchange of plant genetic resources by means of a market mechanism problematic, as will be seen below.

It is now increasingly recognized by people outside the pharmaceutical industry (who has been aware of this potential for a long time), that plants contain countless numbers of substances which may be useful. One quarter of the medicines prescribed in the North America were derived from plants in one way or another (Cox and Balick 1994). Many pharmaceutical companies have mounted expeditions to search for medicines from all over the world using various techniques, including by interviewing practitioners of traditional medicines in various parts of the world. The search procedure is becoming so systematized that it has acquired the status of a sub-discipline in Western universities, called ethnobotany or ethnopharmacology.

Generally, the knowledge is given free by these traditional practitioners. It must also be recognized that not all of these traditional practices necessarily work. And a large number of candidate plants will have to be sifted. After identifying plants that are potentially useful, a great deal of further testing will still have to be done before a marketable product is obtained. However,

the profits that may be obtained from a successful drug can be very large, certainly when compared against the returns made by the traditional practitioners who were the source of the information.

As the medical sciences are advancing all the time, the search for potentially useful plants is unending. Consequently, the disappearance of plant species would mean that a potentially useful drug will never be found. Further, as traditional medicine gives way to Western medicines in many parts of the world, the knowledge that was handed down over generations may also disappear. Both of these would increase the cost of finding new drugs greatly. There is thus a very clear demand for the diversity of plant genetic resources to be preserved.

Supply-side Considerations

But the existence of demand by itself is not sufficient to generate supply. Conserving the diversity of wild plant life is a costly business. The large number of species alone make it imperative that the conservation be done *in situ*. Besides, in many cases, knowledge about a plant's usefulness can be gained only as a result of studying it in its natural environment. For most wild tropical species, conservation of plant species would thus automatically imply conservation of the ecosystems in which these species thrive. Such conservation efforts would thus entail setting aside extensive tracts of wilderness, which, for many developing countries, have high and increasing opportunity costs. Against this, it must be pointed out that such wilderness areas have other uses than merely to conserve biodiversity, such as prevention of soil erosion. Consequently, not all the costs of the land need to be charged against the conservation efforts.

Merely conserving the biodiversity without knowing what it is that is being conserved would be quite useless. It is essential that conservation efforts be accompanied by extensive survey and placing on an adequate database of all the species within the conservation area.

Clearly, private firms or individuals are not in any way attracted to invest in any effort to conserve plant genetic resource diversity, even though some of the resources obtained may yield profits, sometimes large ones. Without adequate institutions, the public goods nature of plant genetic resource diversity precludes such investments. We now turn to the question whether such institutions can be devised.

Can We Create a Market to Make Beneficiaries of Plant Resource Diversity Pay for the Costs?

Creating a market in plant resource diversity entails the creation of clear property rights in the resources concerned. Since, for wild plant genetic resources, the true generator of use values is not necessarily the material itself, but of the information contained in it, the property rights cannot reside in the material, but in the information. Since extracting information from the material is itself costly, and need not be done by the property owner, this raises issues of some complexity. Perhaps the best approach to an understanding these issues is to look at the famous contract made between Merck, an American pharmaceutical firm and the National Biodiversity Institute (INBio), a nonprofit institute in Costa Rica, signed in 1991 (see Reid et al 1993 for further details).

In that contract, INBio was hired by Merck to gather and classify specimens of various species of plants and insects for a sum of one million US dollars. These plant specimens are not to be shared with any other pharmaceutical firm, but Costa Rican law requires that INBio shares the specimens with Wildlife Department of the Costa Rican government. If materials extracted from any of the specimens are incorporated into drugs sold by Merck, then the latter will pay a royalty (the exact amount or proportion is not specified in the contract) to INBio. Additionally, Merck is committed to provide assistance in equipping INBio's laboratory and to train INBio workers in assaying methods.

This particular transaction must be considered against a background of the Costa Rican laws. These require any collector of plant, animal or microorganism specimens, whether he or she is a foreigner or a Costa Rican national to obtain permission from the government's Wildlife Department, together with a detailed work plan. If the collector is a foreigner, then the collector must be qualified to do so. When the collection is complete, the Wildlife Department requires the collector to deposit duplicates at the Wildlife Department and the research report arising out of the collection at the Department or the National Library.

This legal framework is necessary but insufficient to protect Costa Rican interests. The establishment of INBio is an essential next step. INBio has developed a program of work that will establish its own capability in plant taxonomy and bioassay methods. The agreement with Merck is but a step in that direction. Ultimately it aims to develop a database of all plant and insect species found in Costa Rica.

From the economist's point of view, the legal framework establishes the fact that genetic resources within Costa Rica are government property, and permission has to be obtained from the government to explore it. INBio merely acts as a transaction agent in the market for the actual resources as a concessionaire from the government, but as a concessionaire who has the potential to develop Costa Rican capability in the area.

Such framework is fully consonant with the Biodiversity Convention, although it is worth pointing out that the agreement was signed prior to the signing of the Convention. Costa Rica, as a sovereign state, has a right to restrict its own citizens' and foreigners' activities in the country as long as they do not conflict with any international agreements. Prior to the Convention, there was nothing, except perhaps the FAO Undertaking on Plant Genetic Resources (which does not have the force of law) to restrict Costa Rican freedom of action in this area. The Convention merely emphasizes this freedom of action.

The lessons that may be drawn from this experiment (it is too early to call it an experience) are:

- Private companies that benefit from a country's genetic resources can be made to pay for the cost of maintaining them;
- To induce them to do so, a country's domestic laws and regulations must clearly establish rights and responsibilities;
- The amount that can be expected from such exercises, at least in the earlier stages, cannot be expected to be large, certainly not large enough to pay for the full cost of maintaining the biodiversity in a country;
- To maximize the benefits accruing to the country, it must be willing to expend efforts at building up its own scientific capability.

Genetic Resources From the Domesticated Plants

Suppliers of Domesticated Plant Genetic Resources

From the beginning of agriculture, the chief maintainers of genetic diversity among the domesticated plants have been the farmers themselves. Farmers have over millennia the seeds of those plants that are best adapted to the specific environment that they face. In some cases, a farmer would select many cultivars for strategic reasons. For example, he may wish to minimize the risks of attacks from pests and diseases -- it is well known that a genetically non-uniform field of plants would resist such attacks better than a uniform one. He may also plant many varieties in order to reduce peak labor demands. Thai rice farmers used to plant as much as three different

cultivars that mature at different times in order to spread out the harvesting season over a longer period. Indeed, in many farming systems, not only are there many cultivars, there are many species grown as well.

As farming of each crop has spread over the globe, farmers in different parts have selected different cultivars to grow in their localities. As one moves away from the center of origin of that species, the number of cultivars would tend to decline. It is this simple observation that underlay Vavilov's great work on the domestication of plants.

It must be recognized therefore that, unless there is a conscious effort on the part of the farmers themselves to grow many cultivars simultaneously, farming generally entails a reduction in the diversity of cultivars that are grown in any locality. Indeed, for the vegetatively propagated crops, the number of cultivars grown is normally quite small. Thus, Evenson and Kisslev (1975:34-5) indicated that from the sixth to the eighteenth century, prior to the advent of modern genetic improvement methods, only one variety of cane was grown throughout the world.

In recent years, however, this natural tendency has been further encouraged by the germplasm improvements that take place in the various crop research centers around the globe. These improvements have led to yield increases that are so decisive that farmers have stopped growing many of the traditional cultivars in favor of the modern cultivars.

This shift gives rise to two possible problems: genetic uniformity and genetic erosion. It is feared that the increase in genetic uniformity will expose the farmers to more severe attacks from pests and diseases, such as in the case of the outbreak of the Southern leaf blight disease in the United States in 1970. This attack was attributed to the use of the same male sterile line as the female parent of all the hybrids distributed in the U.S. A similar attack was reported on rice in Indonesia in the mid 1970s. However the analysis in Anderson and Hazell (1989) indicates that the overall gain from the improvements in yield are so large as to outweigh the increased risks.

More germane to the subject matter of this paper is the problem of genetic erosion. With farmers abandoning traditional cultivars in favor of modern cultivars, there must be some means of conserving the genetic resources embodied in the former. The more favored practice, because it is vastly more cost-effective, is to store these resources *ex situ* in gene banks or, in the case of tree crops, in botanical gardens or arboreta. For the major domesticated plants, including all the major cereals, there is now in storage an almost complete collection of seeds of most of the cultivars that are extant in the world (Plucknett et al. 1987). However, for many locally grown and consumed plants such as fruit and vegetables the problem is far from satisfactory. For developing countries, the establishment of gene banks for these species should be a priority.

More recently, voices have been heard to involve the farmers themselves in conserving genetic resources. Altieri and Merrick (1987) have suggested that a strategy of conserving on-farm genetic resource diversity be built in to development projects directed at small and poor farmers. While this approach may be justified in terms of improving the welfare of farmers in a given locality for now, as their community develops the farmers' strategy in dealing with maintenance of genetic resource diversity may also evolve away from the strategy that they are adopting now. There is very little to assure the rest of the world that the existing genetic resources will be maintained.

Once again, it has to be noted that it is costly to maintain crop genetic resource diversity. *In situ* conservation, if it implies that farmers have to accept a lower standard of living than what they would get from growing improved cultivars, is certainly a costly means of achieving that objective. It has to be admitted that *in situ* conservation also has certain benefits to the rest of the

world which are not conferred by *ex situ* methods. That is to say it permits the evolution of plants in natural conditions, and it allows scientists to study the strengths and vulnerability of each cultivar in its natural environments.

It is interesting to note that gene banks are mostly part of publicly funded institutions. If it is thought that farmers are conferring public benefits by their conservation activities, then there is some justification in subsidizing this activity, although designing such a subsidy program would be quite problematic.

In discussing the supply side, we cannot end without mentioning a fact that is often overlooked, namely that the activities of modern plant breeders also contribute to the diversity of cultivars available to farmers. By recombining the genes in novel ways, plant breeders have introduced new cultivars into the world. Modern biotechnology promises to bring even more radical transformations in the cultivars available. Again, such expansion is costly and has to be paid for. We shall return to this issue in the last part of this section.

Demanders of Diversity in Domesticated Plant Genetic Resources

Plant breeders are usually cast as the villains for their role in making farmers abandon their traditional cultivars, thus leading to the problem of genetic erosion. It is an ironic fact of modern agriculture that the people who most keenly feel the loss of the diversity of genetic resources of the domestic plants are the plant-breeders, because this loss makes their task much more difficult. It is not coincidental therefore that most institutions that house the gene banks are institutions where plant breeders have a major role.

Plant breeders demand genetic resource diversity because their work produces economic value. This value arises from the higher yields that their work makes possible. For them to be able to pay for conserving the diversity of genetic resources, they must be paid for the work that they do. However, the work that they do is embodied in the improved seeds or germplasm that is the end-product of their work. Since this material is freely reproducible, it is not possible for them to recapture the work they put into it. The case of hybrid seeds where farmers have to come back to buy the seeds is the exception that proves the rule

Thus, in most advanced countries during the last hundred years, the overwhelming part of plant breeding work has been conducted in or funded by public institutions. As modern biotechnological methods expand the scope of their and other scientists' work, the financing of future research will change. Private firms are increasingly involved in plant genetic improvements. As they are pouring resources into this activity, they are demanding that the government give them intellectual property protection over the results of their investments.

If private firms modify plants using the genetic resources that are now currently freely available from public institutions, can they be made to pay for the conservation of those resources? More strikingly, if those genetic resources arise from another country, can that country, or farmers of that country, claim some payment for the use of their material?

There are two approaches to answering these questions: one is to tackle them as questions of fairness and the other is to tackle them as questions of incentives. I do not have the competence to pronounce on the fairness of the existing or newly contemplated arrangements. In this paper, I shall only deal with the question of incentives: whether existing arrangement induce various parties to conserve *and use* plant genetic resources in ways that will enhance the welfare of the farmers around the world. To address this question, we have to tackle the question of intellectual property rights over plant genetic resources.

Intellectual Property Rights Over Plant Genetic Resources

Currently two forms of intellectual property rights protection exist in developed countries for plant genetic resources: plant variety protection and patents. The first is designed to protect the rights of plant breeders who use classical methods of crossing and selection. To be protected, the plant breeder must be able to show that the cultivar that he or she has developed is:

- distinct from other cultivars which have been hitherto available;
- uniform; and
- stable

Patents are more suited to biotechnologically developed products. To be able to secure a patent, the applicant must show that his product or process possesses the following properties:

- utility—the product or process must be actually be useful to someone
- novel—the product or process must not be something that is previously available;
- there must be a non-obvious step from other discoveries.

It is the last step that makes a patent the more significant instrument. It makes patents more difficult to obtain, but by the same token, once obtained, it provides the holder with greater protection against competition. One more feature of patents needs to be mentioned. The process and product must be described in the patent application which will be open for public inspection.

A third form of protection, not strictly an intellectual property protection, may be mentioned in this context, namely trade secrets, a subject which in many countries is covered by law. Producers of hybrid seeds rely mostly on this form of protection in preference to either of the other two forms.

Do these forms of intellectual property protection provide sufficient incentives for private firms or individuals to engage in genetic improvement work? Empirical findings in this area are meager, particularly on patents which are, as far as plants are concerned, fairly recent phenomena (Lesser 1991). By and large, the findings indicate that intellectual property protection does not lead to a great deal more improved cultivars, but also that once protection is given, they do not increase the price of seeds to the farmers significantly. One study in the U.S. indicates that holders of plant variety protection are able to get back from the farmers 25 to 50 per cent of the yield gains (Lesser 1991:36).

These are incentives for firms to engage in genetic improvements. There is no incentive for them to conserve existing genetic resources. Under present circumstances, with public institutions undertaking this task and making the material freely available to users, there is little incentive for them to do so. But since these firms are able to recover the costs of their research because of intellectual property protection, gene banks and others who attempt to conserve genetic resources should be able to recoup their costs. By the same token, developing countries from which the genetic resources are taken should share in these benefits. Here, a point needs to be inserted, most of the genetic resources from developing countries are already deposited in public institutions. What should be attempted is to enhance the collection, particularly of those species for which there is no adequate collection. Charging plant breeders or private firms for use of these new materials could provide the incentive to expand the coverage of gene banks.

Conclusions

- The first priority of all developing countries should be to conserve plant genetic resources, both wild and domesticated.

- Use of public funds for this purpose seems inescapable, although there are ways in which *part* of the costs may be recovered.
- The impact of intellectual property protection for small developing countries would be quite small.
- The Biodiversity Convention merely emphasized the rights to control the acquisition of the plant genetic resources within the developing countries; something which they already had in any case.
- To regulate foreigners' use of a country's genetic resources, there must be an adequate legal and institutional framework.

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IMPLEMENTING THE CONVENTION ON BIOLOGICAL DIVERSITY: LEGAL AND POLICY STRATEGIES FOR LINKING WITH LOCAL COMMUNITIES

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Introduction: Recognizing the Missing Link

There is no question that the Convention on Biological Diversity represents a major achievement in international law. It addresses many biodiversity issues comprehensively, strengthens the position of developing countries in negotiating benefits and access rights, and advances the important principle of national sovereignty.

This paper explores some frontier regions of current environmental law—the difficult terrain of implementing the Biodiversity Convention. The path to effective implementation of any law or policy is always beset with obstacles and difficulties. The Biodiversity Convention, in spite of its important achievements, is no different. Its prospects for implementation are undermined considerably, in the author's judgment, by a substantial flaw. In spite of some progressive language, the Convention fails to adequately take into account local peoples' rights and responsibilities in environmental planning and natural resource management.

The discussion that follows is predicated on the assumption that it is the cumulative actions of local people who ultimately determine the fate of the earth's biological resources, and thus the terms of human existence. Support for community-based management systems is based on the belief that those who have lived in a given area, especially for a long time, have the best working knowledge of the local ecology and of the long-term social and environmental impacts of their activities. Supporting this conviction is a growing body of scientific research that shows that many forest-dependent resource users work from knowledge bases uniquely suited for sustainable managing of forest and biological resources.

All economies, north and south, east and west would be well advised to consider involving their local communities in the planning and implementation of resource management—not only for this particular treaty—but for the broader objectives of increasing national economic prosperity and social well-being.

Three specific legal and policy-oriented strategies for involving local communities in natural resources management and thereby promoting the overall goal of the Convention—sustaining the Earth's biodiversity. First I will look at the efforts of Norway and the Philippines to integrate biodiversity planning into their national development processes. Then, I will look at Nepal's recent reforms in community forestry law. Third, I will examine innovative contracts between international pharmaceutical companies and resource management organizations in Latin America, agreements that have been made to share the compensatory benefits derived from the exploitation of genetic resources. Each example offers an approach for linking with local communities to promote both economic development and biodiversity conservation objectives.

The three initiatives that will be considered here were not necessarily undertaken with the direct purpose of implementing the Biodiversity Convention. Instead, they represent generic, recent legal and policy approaches to managing resources undertaken in different national contexts.

Though they were tailored to the conditions of the specific country involved, these three examples all point toward potential gains for mainland Southeast Asian economies. They also illustrate some of the dilemmas associated with particular legal approaches and provide insight for this region's policy makers and program implementors.

This paper does not suggest that the Biodiversity Convention should be re-negotiated or the language changed. Rather, it argues for building on the spirit and letter of this particular treaty and its call for action by strengthening community-based resource management systems

The Biodiversity Convention: International Law in the Making

Though drafted in Nairobi a month earlier, the Biodiversity Convention was actually signed by approximately 150 countries at the historic Earth Summit in Brazil in June of 1992. Leading up to that historic occasion were four years of contentious and often bitter negotiations (Burhenne-Guilmin and Casey-Lefkowitz, 1992, p. 49). But the results were impressive: for the first time in international law, the major elements of biological diversity: species, genetic and ecosystems diversity, in all their complexity, were comprehensively addressed.

One of the most volatile issues was national sovereignty -- a fundamental principle of all political systems whose legitimacy and importance should not be questioned or undermined. The Biodiversity Treaty adopted the principle that the conservation of biological diversity is a "common concern" of humanity. The different proposition -- that biodiversity is the "common heritage" of mankind -- failed to achieve a majority consensus during the intergovernmental negotiating process. The wording 'common heritage' is an accepted international term meaning that states do not have sovereignty. To many of the nations involved, this term implied the notion that biodiversity is part of the global commons, and thus, a shared responsibility that is subject to some degree of governance by the community of nations.

This semantic and legal distinction is indicative of the preeminence attached to national sovereignty and jurisdiction defined by the boundaries of modern nation-states. And so, according to the Article 3 of the Convention, individual countries have the sovereign and exclusive right to exploit biological resources within their own national borders.

Though the principle of national sovereignty is clear, it is also burdened with theoretical and practical problems. Article 3 also provides, for example, that a state's sovereign right to exploit its own resources is qualified by its "responsibility to ensure that activities within its jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction".

The natural world—and indeed the political and economic ones as well—does not function according to the boundary lines drawn on international maps. Many biological resources, such as oceans, river systems and natural forests, are transboundary in nature. Viable solutions to the contemporary world's growing environmental problems require international and, more immediately, regional approaches and cooperation. Climate and atmospheric changes and the daunting challenges of effectively managing international river systems and our planet's oceans, for example, illustrate this fact. This regionally-focused workshop represents a positive step in the direction of improved intra-regional communication, cooperation, and policy-making. The global objectives of the Biodiversity Convention will be well served by regional initiatives like this.

But there is another direction that national planners must also consider as well. In addition to looking outward from the nation state to the regional and international arena, they must also look inwards to the sub-regional, provincial, and community levels.

The Convention did address this set local issues in Article 8 with a call to promote indigenous communities and their conservation practices. The particular language in this section of the Convention, although general and loose, is relatively progressive compared to previous international treaties. Governments are likely to argue, however, that the issues of treatment of their citizens should not be addressed in an international agreement, only the issues of relationships among states.

Be that as it may, this paper argues that governments would be well served by strengthening local peoples' access rights to and management responsibilities of biological resources within an appropriate national policy. If part of an effective national legal framework, a policy of promoting community-based resource management systems can improve the quality of life for an entire nation, that is after all a collection of communities. It can also provide local and national economic benefits and advance international cooperation and prosperity. And in doing these things, it will also be achieving the overall goals of the Biodiversity Convention.

The set of access issues were indeed one of the most difficult negotiating areas of the entire Convention. The ultimate resolution to the question of access to genetic resources, relevant technologies, or the benefits derived from biodiversity rested on the established principle of national sovereignty over natural resources.

As we shall see with each of the next three examples, access issues are central to most legal and policy strategies for implementing resource management arrangements between groups of people.

Some current thinking about conserving or exploiting biodiversity often sidesteps the issue of equitable sharing of benefits within countries. Without creating effective and enduring linkages to the community level, the Treaty can not be adequately implemented. The following cases represent policy approaches and legal actions that can be pursued to promote more equitable and effective natural resources management between and within countries.

Strategies for Implementing the Convention: Promising Directions

Integrating Biodiversity Conservation into Mainstream Development Planning - the Cases of Norway and the Philippines

The national representatives who signed the Biodiversity Convention committed themselves to many far-reaching obligations. These relate to the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Perhaps the most important of the related obligations is the requirement in Article 6 that signatory countries develop and integrate biodiversity strategies as part of their national planning processes. Balancing biodiversity conservation objectives with the often overriding importance attached to short-term economic imperatives is profoundly difficult, especially in countries that face substantial developmental challenges.

A soon to be published report by the World Resources Institute entitled "Guidelines for Biodiversity Planning and Profiles from Early Country Experience" identifies the three critical features of successful national biodiversity strategies. They are cyclical and iterative in terms of development and monitoring, multi-sectoral in approach, and adaptive to local political and cultural conditions. Taken together, these three are components of a larger and quite flexible process that can help countries build upon existing institutions, programs, and investments.

The following illustrative cases are associated with the Biodiversity Convention to varying degrees. More importantly, they offer compelling approaches for bridging national imperatives

with local-level priorities. At the same time, they are already showing promise in terms of implementing the overall objectives of the Treaty.

Norway has made significant progress in implementing this national-level requirement of the Convention. Its National Biodiversity Strategy is predicated on a participatory framework of delegation. The government's mainstream ministries (transportation, communications, education, defense, fisheries and agriculture) were individually and collectively charged with formulating the government's economic and sectoral programs relating to biodiversity. The Ministry of Environment is working with seven local communities to develop experimental biodiversity action plans as models or frameworks for the strategy's treatment of local responsibilities (Miller and Lanou, forthcoming, p. 93-96.). At the same time, biodiversity management policies are being internalized and made consistent with Norway's legal and regulatory framework.

The Philippines has undertaken an equally ambitious and inclusive approach to developing and implementing a National Biodiversity Strategy. The Department of Environment and Natural Resources (DENR) is working in concert with the recently established Philippine Council for Sustainable Development in coordinating the Strategy. There has been active involvement from key central and line ministries, the Cabinet, and a broad range of sectoral agencies and private interests. The relatively vigorous non-governmental community has been joined by the country's many academic biodiversity specialists in providing inputs of perspective and data in formulating the strategy (Miller and Lanou, forthcoming, p. 84-87). Plans are underway to implement a series of provincial-level planning exercises within the context of an ongoing governmental decentralization initiative.

The real test of the effectiveness of Norway's and the Philippines' biodiversity planning will be in the identifiable and measurable actions that are taken as a result. Local participation in the planning and drafting of the strategies is critical in that the effective implementation of the strategies hinges on cumulative local-level actions.

One of the most significant and concrete actions for any country to take in its national environmental planning is to implement public participation mechanisms that are central to environmental impact assessment (EIA) procedures. For example, when a road is being built or expanded in regions rich with biodiversity -- a scenario of great relevance to this region of the world -- EIA is an essential development tool. Formal public hearings, village-level consultations, participatory appraisals for site selections and other approaches can effectively include local communities in development planning and implementation.

As the road network between Kunming, Mandalay, Vientiane, Hanoi and Chiang Mai is expanded, it is in each of your countries' interest to support local peoples' involvement in EIA. This will promote participatory national biodiversity planning, strengthen the quality of expanded transportation infrastructure systems, and contribute to sustainable regional economic expansion.

Strengthening Community-Based Resource Management: the Tenure Factor in Nepal

In most developing countries, the national government regards the overwhelming majority of forest-zone occupants as illegal squatters, regardless of their length of occupancy. The tenurial instability which this status results in erodes customary conservation values and undermines incentives to conserve the local resource base and make the long-term improvements essential to the sustainable development of the national resource base.[1] A promising recent development in natural resource

[1] For a detailed discussion of the dynamics of this development in six Asian countries, see Lynch *et al.* (forthcoming)

law in several countries has begun to address the widespread problem of tenurial insecurity, thus offering much promise for advancing the objectives of the Biodiversity Convention (Maggio, 1994).

In Nepal, communities of families and village clusters in the mountain valleys have gained considerable tenurial security over local forest resources as a result of recent national legislation that has codified progressive tenurial reforms in community forestry. Where small pockets of community forests are beginning to rejuvenate, the objectives of the Biodiversity Convention are being achieved. These rehabilitated forests provide valuable hydrological and other ecological services to the valleys, generate a great deal of building materials and other economic activity, and harbor much biological diversity.

The community forestry law of Nepal establishes a relatively functional and equitable national legal framework for local peoples' genuine participation in natural resource management.[2] The focus of this legislation is the "handing over" of state-owned forest resources to legitimate community users' groups in accordance with the terms of annual and easily renewable leasehold arrangements that delineate their forest management rights and duties, and establish due process for arbitrating conflicts.

Satellite imagery of the Indian state of West Bengal testifies to similar on-the-ground results. Approximately 10,000 villages there are implementing joint forest management practices in concert with the state authorities. Thousands of hectares of rehabilitated forest lands are thriving where just a few decades ago degraded wastelands existed (Poffenberger, 1992). Thailand and the Philippines have recently initiated similar, positive programs.

While positive results have been achieved where appropriate tenurial reforms are being attempted, problems in implementation still abound in the form of bureaucratic opposition, rural poverty and social inequities, and political corruption. But the message to policy-makers is getting through. Yunnan's policy of increasing the number of long-term land management certificates to collectives and individual farmers is a case in point. Laos and Vietnam as well as Cambodia are beginning to experiment with national policies to devolve significant degrees of authority and decision-making in resource management to local communities. In time and with experience, much more in this direction can be achieved -- not only in mainland Southeast Asia -- but in the rest of the world.

These developments in tenurial reforms offer governments and policy makers with a promising direction to consider in their environmental planning and policy-making. They also show a specific kind of approach to implementing some of the most fundamental objectives of conservation generally and the Biodiversity Convention.

Contracting Benefits: Compensation in Biodiversity Prospecting in the Americas

One of the most problematic areas of national and international law relating to local management of resources revolves around the issue of indigenous peoples in traditional communities. This is certainly the case with the Biodiversity Convention.

A simple, but often overlooked, principle of Western law is that there is no such thing as a legal relationship between a person and a thing (Hohfeld, 1917, p. 710 onwards). Any hectare of land or stand of forest, for example, is defined according to legal relationships between people. This becomes paramount as the genetic materials, whether in plants or microorganisms, are

[2] For a complete discussion of the theory and mechanics of Nepal's new community forestry legislation, see Talbott and Khadka (1994)

increasingly being sought by different and often competing groups of people. It is widely known that the traditional and tribal medicine men and women of indigenous or local communities often have extensive and valuable knowledge of local plants and other biological resources. These people and the traditional communities in which they live, however, are often marginalized and not considered in most national and international forums dealing with issues of access to and management of biological or other 'national' resources.

One of the most frequently cited cases of a promising contractual relationship between the so-called "North" and "South" based on distributing benefits associated with biological diversity is that of INBio and Merck. INBio, the Costa Rican Institute for Biological Diversity, was set up with both public and private interests. Merck, a U.S.-based international pharmaceutical company, signed a contract in which Merck agreed to pay US$. 1.35 million to INBio for the right to prospect for and harvest a limited number of biological specimens (Burhenne-Guilmin and Casey-Lefkowitz, 1992, p 53, footnote 25).

This innovative agreement advanced the notion that rather than searching biodiversity for strictly private benefit, it would do it for public gains. Its method for returning profits was through the government, which gets half of the economic benefits derived from the joint pharmaceutical explorations. There are no specimen collections from any lands claimed by or owned by indigenous groups, rather all collecting is in Costa Rica's national park system.

Shaman Pharmaceuticals, Inc., a much smaller U.S. company, has developed yet another, similar, creative approach to collecting natural products and distributing the associated benefits in other countries. It has begun to develop a pattern of establishing corporate relationships directly with indigenous societies and organizations. A long-term program of Shaman's in Latin America, for example, has been set up to work closely with the Pan Amazonian Indigenous Peoples Federation (COICA), a multi-country federation that represents nearly 70,000 indigenous peoples. Despite their lowly economic status and reduced political clout (a result of their rural and mostly forest-dwelling situations), COICA represents a rich, accumulated wealth of knowledge about ecosystem management. This includes a myriad of pharmacological applications of thousands of local plant species (Weiss, 1989). Shaman Inc. and the Federation have forged a long-term agreement in which a supply of local materials is guaranteed with a corresponding package direct and staged compensation and other economic benefits for the local communities.

INBio/Merck, Shaman and other similar innovative arrangements have had their own sets of problems in their biodiversity collecting efforts (WRI *et al.*, 1993). There is no perfect approach or flawless legal arrangement. Yet, they have shown that linking host country and local communities' access to future benefits can be a workable basis for legal contracting across international boundaries. As with the other examples described above, there are many ways to genuinely and effectively engage local communities in the management of biological and other natural resources (WRI *et al.*, 1992).

Conclusion

In the final analysis, it is the cumulative actions -- both constructive and destructive -- of the world 's billions of local resource users that will determine the fate of our planet's biological diversity. International agreements, national policies and laws, and governments' enforcement efforts can only go so far in meeting the challenge behind implementing the ambitious objectives of Biodiversity Convention.

This paper has argued that local people, and especially the daily actions that they take relating to local natural resources, are crucial to the real implementation of the Biodiversity

Convention. Seen this way, the conservation of biological diversity is not a North-South issue, but a shared challenge among all nations. The Philippines and Norway are experimenting with public participation approaches in their biodiversity action planning processes. Nepal and other Asian countries are developing new paradigms of local forest management that mirror similar arrangements in European countries. Large and small pharmaceutical companies are forging creative biodiversity sharing contracts with partner organizations in Latin America.

The work of the World Resources Institute has verified that knowledge of the concept of biodiversity is considerably higher in some African, Latin American and Asian countries than in the U.S. and other so-called developed countries. The countries of the mainland Southeast Asian region, for example, have in many cases developed a sophisticated appreciation and understanding of their rich biological resources. The Kunming Institute of Botany, Chiang Mai University, and University of Hanoi's Center for Natural Resources Management and Environmental Studies (CRES), for example, have established impressive records for advancing knowledge of local biodiversity and its potential contribution to society.

It is important for all world citizens to recognize the universality of the challenge to implement the Biodiversity Convention. The Convention on Biological Diversity is reassuring in that it demonstrates that good international law can be formed through the consensus of nations. Yet the utility and power of law and policy, whether national legislation or international treaty, is only as great as its potential for implementation and enforcement. As the street jargon in my country states: "it's easy to talk the talk, but can you walk the walk?" This phrase expresses the essential dilemma of the challenge at hand -- drafting and signing treaties and laws is not enough to implement policy. The three specific illustrative examples that have been presented here offer some lessons learned and concrete approaches for implementing the Convention and promoting sustainable development.

While talk is cheap, our subject matter for this conference is not. It is of vital importance to the rapidly developing regional economies as well as the world at large. The earth's garden stock of medicines is rapidly diminishing while the specter of new, as well as old, deadly epidemics rises. The steady loss of our planet's precious top soil, the increasing threats associated with human-induced changes in atmospheric conditions, and a host of other potential ecological crises underscore the importance of planning and sustainably managing human activity on our planet. Strategies for using law and policy that have the often unintended but none-the-less verifiable effect of implementing the Biodiversity Convention are a good place to begin to look for some answers to this pressing and common challenge.

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PRIORITIZING FOR INVESTMENTS IN BIODIVERSITY

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Introduction

The single greatest cause of species extinction is considered to be human activity (World Conservation Monitoring Centre, 1992). Estimates of the effects of this activity on current extinction rates suggest that we may experience a global loss of diversity of between 1% and 11% per decade over the next century (Reid, 1992). Not unrelated to changes in species diversity are concerns regarding the loss of genetic diversity within populations as a result of local extinctions, habitat fragmentation and selective breeding practices in some resource species. Such massive changes in global diversity have occured only a few times in geological history (Erwin et al. 1987) and have the potential for a profound effect on the ecological order of life on Earth and, as a consequence, on the social, economic and political organization of human society.

The challenge we face is to respond to this threat in a concerted fashion as efficiently and effectively as possible. This is not an easy task and we face a number of obstacles. The first is the lack of agreement on the nature and magnitude of the pending changes to global biodiversity. Secondly, are the debates pertaining to the species concept and the measurement of diversity itself. Thirdly, are the challenges for developing an effective strategy in the absence of complete global and regional data. Fourthly, we face the problem of implementating any global strategy where regional jurisdictions each face a unique set of local priorities. Finally, the resources available for investment in biodiversity preservation are limited.

The purpose of this paper is not to provide answers to these issues but to assess briefly some of the scientific challenges we face, as we attempt to establish priorities in biodiversity conservation, and to propose a general strategy for prioritizing for investment in biodiversity conservation.

Habitat

Habitat alteration and destruction are the key factors affecting the diversity of natural communities. The alteration of habitat can take place directly through changes in land use such as urbanization, agriculturalization and resource extraction. It can also occur indirectly as a result of pollutant discharge, the introduction of exotic species or as a result of changes in global climate resulting from increasing atmospheric CO_2

Habitat is in a constant state of succession. Within any given area with the potential to support a particular habitat type, it is possible to identify several successional stages. The area covered by a particular habitat type is a function of the maximum potential area suitable for that habitat and the rates of habitat loss and renewal. Figure 1 illustrates a simple representation of how the processes of habitat loss and renewal interact to yield a quasi-equilibrium area for a particular habitat. This model represents the rate of habitat renewal R (area t^{-1}) as a function of the area of habitat (H), the maximum area which is potentially available for establishment of that habitat type (H_{max}) and the specific renewal rate r (t^{-1}) and is given in eqn. 1

eqn. 1 $$R = r H (H_{max} - H) / H_{max}$$

This simple formulation (eqn. 1) is consistent with some basic observations. First, if a habitat type has been completely destroyed, the absence of colonizing species will make renewal impossible. Secondly, if the total area available for a particular habitat type is already fully developed, further increases cannot occur. Finally, the maximum rate of habitat renewal or regeneration will occur at some intermediate level of habitat where there is both area available for recolonization and adequate existing habitat to provide a source of immigrating populations for recolonization.

The rate of habitat loss is affected by many factors and a simple representation is that of a negative exponential (see Sinclair et al. 1995) where H_0 is the initial habitat area, H_t the area at time t, d is the specific loss rate (t^{-1}) and t is the time interval (eqn. 2).

eqn. 2 $$H_t = H_0 e^{-dt}$$

Although an over simplification (Sinclair et al. 1995), this formulation shows that as habitat declines, the absolute rate of loss tends to decrease since the natural causes of loss are directly area dependent. For losses instigated by human activity, the rate decrease is due to heightened efforts in conservation. Solving for the instantaneous rate of loss over all areas of habitat, yields a relationship between the rate of habitat loss (D area t^{-1}) and the habitat area (Fig. 1, eqn.3).

eqn. 3 $$D = H (1-e^{-dt}) / t$$

It is the interaction between the process of habitat renewal and habitat loss which, in a stable system, yields a given quasi-equilibrium area for a particular habitat type. The equilibrium habitat area, H_{eq}, is obtained at the intersection of the loss and renewal curves. This is a stable equilibrium. If H is greater than H_{eq}, the rate of loss will exceed the rate of renewal and habitat area will decline. If H is less than H_{eq}, the rate of renewal is greater than the rate of loss and habitat area will increase. In environments where human activity has increased the specific loss rate (increased d) the loss curve pivots upward resulting in lower values of H_{eq} (Fig. 1). It is the ratio of the specific loss rate to the specific renewal rate which determines the equilibrium area. Figure 2 shows how the equilibrium habitat area (H_{eq}) is a function of the ratio of the specific loss rate and the specific renewal rate (d/r).

From a management perspective, what we must establish are the lower limits to H_{eq}. Sinclair et al. (1995) termed this value the *habitat constant (H*)*. If our objective is to rationally manage biodiversity then we need to choose a value of H* which allows us to optimize its preservation. An informed decision as to the value of H* requires an understanding of the link between habitat area and biological diversity. There are two general strategies which can be used to affect H*. The first is the establishment of preserves and the second is effectively managing off-reserve areas in such a way as to optimize biodiversity by controlling loss and renewal rates (Sinclair et al. 1995).

Habitat Area and Diversity

That there is a positive relationship between habitat area and the total number of species is indisputable. As the area which is being examined increases so does the total number of species within the area. The general formulation for the species / area relationship is given in eqn. 4.

eqn. 4 $$\log S = C + Z \log A$$

where S is the number of species, A is the area and C and Z are constants. The constant Z is dependent upon habitat type and is commonly thought to vary between 0.15 and 0.4.(Connor and McCoy, 1979). This implies that a loss of 90% of the available habitat will result in a decrease in species richness of between 20 to 50% respectively Figure 3 provides a graphical representation of the change in species richness which might occur as a result of decreases in habitat area as provided by eqn 4. Given the scale of habitat erosion which has occurred already in some key areas (for an example see Fig. 4), the magnitude of the global biodiversity crisis is clear.

As with most simple models, formulations such as those outlined in Figures 1 - 3 break down when confronted with the myriad of complexities which comprise natural systems. For example, the geographic separation of similar habitat types provide for a rescue effect by which species facing local extinction can be "rescued" by immigration from a neighbouring "island" of a similar habitat type (Brown and Kodric-Brown, 1977). Conversely, as habitat fragmentation and alteration continue, the distance between such habitat "islands" increases, and the potential for a rescue effect declines. Recent empirical evidence supports this contention showing that as both habitat "patch" size declined and the distance between patches increases, species diversity is compromised (Klein, 1989; Newmark, 1991). These simple models also neglect the complexity associated with habitat heterogeneity, species identity, the complex needs of migratory species, and the size of the population in question. This has caused some authors to question the utility of these predictive models in efforts to manage biodiversity (Boeckeln and Gotelli, 1984). In fact, Zimmerman and Bierregard (1986) have suggested that there is little value in such equilibrium models for planning the establishment of conservation reserves.

Although these simple models demonstrate rather effectively the strong relationship between habitat and species diversity, their simplicity predisposes them to failure when rigorously challenged with empirical data from specific natural systems. The absence of a unifying model, rigorous enough to withstand scientific and possibly more importantly legal scrutiny, yet versatile enough to be applied to a wide range of conservation issues presents one of the major obstacles facing conservation biologists. Given the profound limitations on the theoretical basis for conservation planning, the competing demands for land use and the limited financial resources available to conservation, how then should we prioritize for investments in biodiversity conservation? More specifically, if we are to establish reserves, how should we select the areas which we wish to set aside?

Approaches to Identifying Areas of Concern

In the absence of a model which is able to withstand rigorous scrutiny, the challenge is to develop empirical methods for selecting areas for conservation and reserve priority. The key elements of any empirical system are the development of measures of biodiversity and subsequently, the ranking of various sites based on their priority for conservation..

Species Diversity

The simplest approach to identifying areas of conservation priority is to locate areas with the greatest species richness. Mittermeier (1988) and Mittermeier and Werner (1990) have shown that a few, primarily tropical, countries possess a large fraction of the world's species diversity. The use of species inventories within geopolitical regions allows for the identification of areas of particular concern for conservation. Because they are located within a single political unit, the potential for successful conservation action improves. A major deficiency in this approach is that it does not address any aspect of the uniqueness of the organisms being considered. As a result there may be a fair degree of overlap in the species represented on reserves. In short, using species richness as the sole indicator of regions of high conservation priority does not give

preference to the importance of endemic species, i.e those which occur in only one area. This approach also ignores many other important aspects of natural communities that affect biodiversity, such as the stability or fragility of certain landscapes and species groups , the rarity of some species, and scale effects. Although serving as a key starting point in conservation, this approach lacks the reliability needed for the development of global and regional strategies for biodiversity preservation.

Diversity Indices

By definition, the use of any index as a surrogate for complex phenomena requires a great deal of over-simplification. The two elements employed in most diversity indices are species richness and some indication of the relative rarity or commonness of the members of the species set. Since quite different communities can have very similar diversity index values, and different indices will often have very different values for any specific community, the usefulness of these indices has frequently been challenged , (e.g. Hurlbert, 1971). However, many studies do use one index or an other, and their uefulness is generally accepted as long as we are aware of the implicit limitations (Huston, 1995). Margules (1989) showed that the relative priority of conservation sites can change dramatically depending on which index is used.

Endemic Species Richness

To account for elements of species rarity Myers (1988, 1990) identified 18 areas which have high concentrations of endemic species. These areas have been termed "hot spots." Together, these hot spots contain 20% of the planet's plant species but only 0.5% of the earth's surface. Clearly, it is nearly an impossible task to carry out an endemic analyses for all species on the planet. However, if endemism follows similar patterns between taxa then endemic species conservation strategies focussed on a particular taxon will yield enhanced returns. In some, but not all cases, this appears to be the case (Bibby et al, 1992) suggesting evaluation of endemic species richness may be an important strategy in identifying "hots spots" for conservation priority.

Critical Faunal Analysis

Critical faunal analysis is a methodology to identify the minimum set of areas which would contain at least one viable population of every species of a given plant or animal group (Atkinson and Vane-Wright, 1984; Vane-Wright et al 1991). A key element in identifying those areas which merit conservation priority is the concept of complementarity. The most efficient use of resources is to preserve those areas which in the first instance maximize the number of species represented. The second preserve should be selected so as to maximize the number of new species not represented in preserve 1 and so on. This approach also biases in favour of those areas with high numbers of endemic species. As an approach, critical faunal analysis serves to focus attention on areas which merit concern. When used on a global level, the results can be of use to countries endeavouring to establish their own national and regional conservation priorities. A similar step-wise approach has been used by Margules and co-workers (Margules et al 1988) to select networks of reserves to maximize biodiversity.

Taxic Weighting

The measurement of diversity, or species richness, is dependent upon the taxonomic competence of the field evaluator and subject to the current debates on the basis of the species concept. Accepting these limitations and constraints, we are also forced to confront the relative value of species. Are all species equal? From a scientific perspective, is the Siberian tiger equivalent to a species of cyanobacteria. From an aesthetic or emotional perspective, the tiger would most certainly be viewed as more significant but is there a scientific approach to assessing

this relative valuation? Atkinson (1989) stated that "given two threatened taxa, one a species not closely related to other living species and the other a subspecies of an otherwise widespread and common species, it seems reasonable to give priority to the taxonomically distant form." Vane-Wright et al (1991) have shown that approaches to the relative valuation of species which are based solely on taxonomic rank are also of limited utility as they do not account for the number of species in a given taxonomic group, and hence the number of closely related species.

What is needed is a defensible measure sensitive to both taxonomic distinctiveness or rank, and the number of species associated with a particular group. Through further refinement of a cladistic approach, Vane-Wright et al. (1991) developed a system which incorporates both taxonomic rank and the number of species in a particular group. Their approach is based on the information content of the hierarchical cladistic classification. Figure 5 provides an outline of their method.

Vane-Wright et al (1991) extended this approach to indicate how it could be used to determine areas of priority for conservation. The approach involves summing the taxic weights of all species in each area of concern and focussing efforts on the conservation of the area with highest total weight. Once the area of highest priority has been identified, the area of second priority is determined by assessing the "complimentary" taxic weight of each area. This is accomplished by not including those species accounted for in the area(s) already set aside for reserves. This approach implies, as the example in Figure 6 shows, that the area of second priority may not necessarily be the region with the second highest total taxic weight. It will, however, be the region with greatest taxic complementarity to the first reserve.

By including cladistic analysis, this approach accounts for both species richness and taxic uniqueness. Although there is potential to modify this type of assessment to suit local circumstances, the magnitude of the task facing taxonomists in carrying out such analyses for all species and all regions is staggering.

A Strategy for Prioritizing

Much of the literature dealing with the problem of how to develop strategies for biodiversity conservation focuses on the topics we have addressed above, especially on how and where to select areas of prime importance. The selection of areas for the establishment of nature reserves is undoubtedly an important part of a global strategy, but it can not succeed unless supported by a broader approach. Three arguments underscore the weakness of a strategy which focuses entirely on reserves. Firstly, with realistic projections for the human population reaching ten billion within a few decades, the prospect for the establishment of large parks in fertile regions, especially in the tropics, is extremely low. Secondly, funding for biodiversity conservation of the 'aesthetic' type will be inadequate, and political support will be minimal. Finally, and most importantly, when land use management surrounding the reserves is ignored, the reserves will come under severe pressure and their integrity will be eroded (Sinclair et al, 1995).

At this point we would like to return to Figure 1-3, and use the simple models these figures represent as a guide to thinking about alternative strategies. A pure 'reserve strategy' would place a small part of the Earth in reserves. The amount reserved would depend upon the habitat type, the species area curve for that habitat and a decision as to what proportion of the biodiversity in that habitat type should be preserved. This strategy ignores the vast areas that are outside the reserves, which would suffer losses in habitat integrity and biodiversity. As pointed out above (and see also Sinclair et al , 1995.) this strategy in isolation may have a very small chance of success. The extreme alternative strategy, one without reserves, but with all effort aimed at designing land

use practices that maximize biodiversity in all man-modified habitats, would accept *a priori* a significant level of loss of biodiversity.

We believe that a mixed strategy, one which will embrace reserves where possible, but will also focus intently on the design and development of sustainable land use practices in non-reserve area, will have the highest chance of success. There are several advantages for this approach. Firstly, a strategy based on maintaining a biologically diverse landscape will be much easier to sell to political and commercial interests. The scientific evidence exists for the need for biodiversity in agro-ecosystems if we want to manage these systems with biological rather than chemical control (e.g. Harmsen, 1990). Sustainable land use in agriculture, forestry, recreation and urban environments is becoming an acceptable concept mainly because of its long term economic necessity. Sustainable landscapes are biodiverse. A second advantage to treating the maintenance of biodiversity in non-reserve areas as a priority is its effect on the preservation of habitat integrity in the reserves, which are much more likely to survive when the surrounding and intervening areas are managed for relatively high biodiversity as well.

The most difficult aspect of embracing a mixed reserve/non-reserve strategy is to have to accept *a priori* a certain irretrievable loss in biodiversity, in exchange for a long term policy that will guarantee the survival of a global patchwork of both human modified and natural landscapes. We believe that despite complexities of implementation, this strategy should be given high priority. To attempt, at this stage in our history, to preserve all or even most of our current biological diversity through the establishment of more and better protected reserves alone is not sufficient.

Conclusion

Habitat preservation is the central element in the conservation of biodiversity, and the erosion of habitat integrity in many parts of the world, including some key habitats, underscores the global threat to species conservation. A body of pure and applied bioscience is developing which focuses on problems related to the concepts and preservation of biodiversity. Currently this branch of ecology is still in its infancy, as neither a generally acceptable theoretical framework, nor an adequate data base exists to guide us into the future. In this paper we have briefly touched on the scientific problems facing us: what is biodiversity, how do we measure it, how does it relate to spatial and temporal scale effects, and how do we deal with such ecological problems as endemism and taxic weighting. We have also shown how in the current literature these concerns focus mainly on the questions of where, and how large should biodiversity reserves be. Prioritization for the establishment of reserves should include elements of species diversity and uniqueness (i.e.: taxic weighting) and the complementarity of a particular area with existing reserves.

The main emphasis of this paper, however, is on a simple general model which represents the biodiversity of any habitat is a function of an intrinsic, biological renewal process and a partly extrinsic, decay, loss or destruction process. We used this model to focus our thinking on alternative strategies for biodiversity preservation, and came to the conclusion that the best strategy accepts political and economic constraints. We advocate the establishment of networks of preserves coupled with efforts to maximizing biodiversity in all landscapes.

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FIGURE LEGEND

Figure 1

The interaction between habitat loss and renewal in determining the equilibrium habitat area. The formulation of the loss (eqn. 3) and renewal (eqn. 1) curves are given in the text. The specific renewal rate was set at 0.05 y^{-1} and the specific loss rates at 0.01, 0.02, and 0.03 y^{-1} respectively. The resulting equilibrium habitat values occur at the intersection of the loss and renewal curves and are indicated as H_{eq}.

Figure 2

The general solution for the equilibrium habitat (H_{eq}) as a function of the ratio of the specific loss rate (d) and the specific renewal rate (r).

Figure 3

The relative change in species diversity determined from the standard species/area equation (eqn. 4) for values of Z of 0.15 and 0.4 respectively.

Figure 4

Relationship between percent area of original tropical forests remaining and population density in 17 countries in southeast Asia (Collins et al. 1991). 1=Australia, 2=Bangladesh, 3= Brunei, 4=Burma, 5=Cambodia, 6=China, 7=India, 8=Indonesia, 9=Laos, 10=Peninsular Malaysia, 11=Sabah and Sarawak, 12=Papua New Guinea, 13=Philippines, 14=Singapore, 15=Sri Lanka, 16=Thailand, 17=Vietnam (from Sinclair et al. 1995).

Figure 5

Derivation of index of taxonomic distinctness, or weight as outlined by Vane-Wright et al (1991). The example is based on a fully pectinate classification for five terminal taxa, A-E. Column I indicates the number of groups to which each terminal taxon belongs within the system, these numbers being the basic measure of taxonomic information. For example, species A belongs to 4 groups (AB, ABC, ABCD, ABCDE) while species E belongs to I group (ABCDE). Column Q gives the quotient of the total information for the whole group (in this example, total information = 14) divided by the information score for each terminal. Column W gives the standardised *weight* for each terminal, the Q-values for each terminal taxon having been divided by the lowest Q-value (in this case, Q_{min}=3 5). Column P gives the percentage contribution for each terminal taxon to the total diversity, in terms of the aggregate values for Q or W. The totals row (T) gives the aggregate scores under I, Q, W and P. (Modified from Vane-Wright et al 1991).

Figure 6

Theoretical priority area analysis, based on the analysis given in Fig. 5. Three of the five terminal taxa occur in each of three areas, R1 - R3, according to the three-column matrix at the right. Column W gives the taxic weights (cf. Fig. 5). Row T gives the total (aggregate) scores for all five taxa, and for each of the three regions: row P1 gives the percentage diversity scores for each of the three regions at the first step, indicating that R3 is the top-priority region; row P2 gives the percentage diversity scores for the remaining two regions with respect to the taxa *complementary* to those occurring in R3, and indicates that R1 is the second priority. (Modified from Vane-Wright et al 1991).

Figure 1

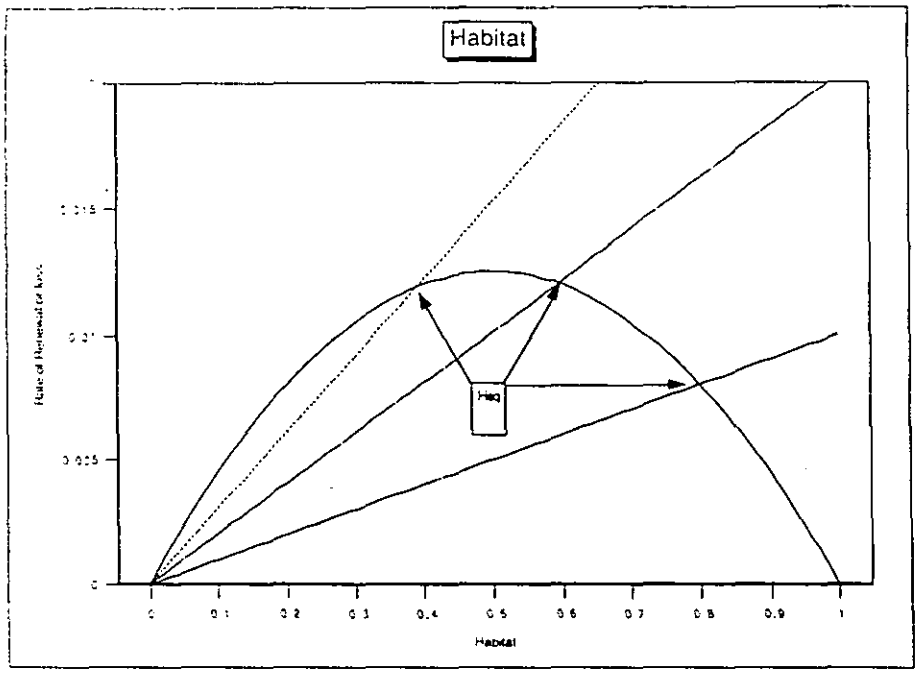


Figure 2

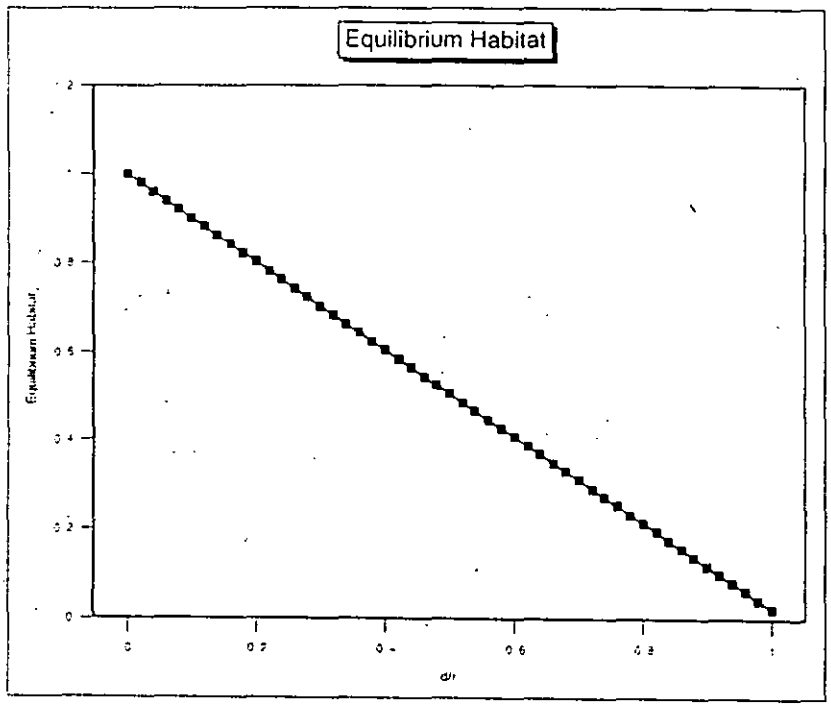
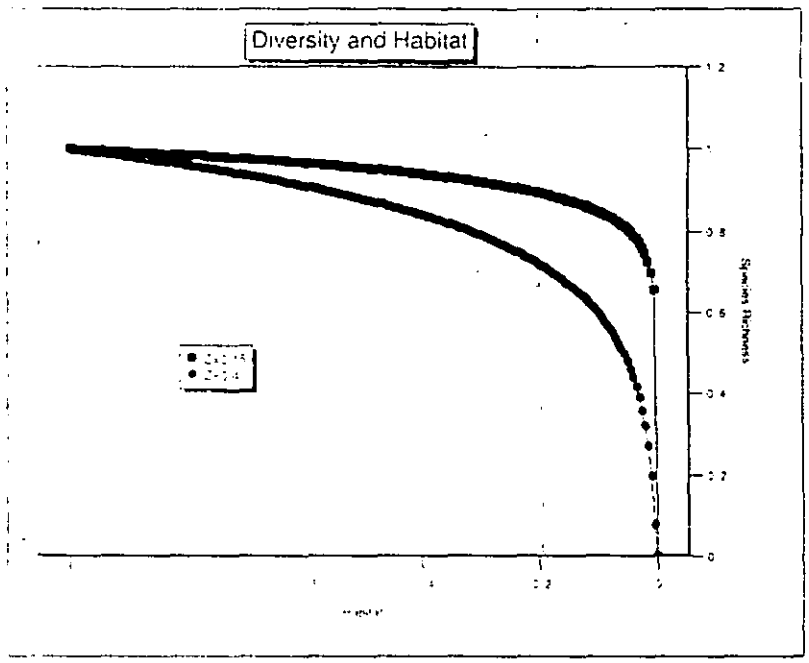


Figure 3



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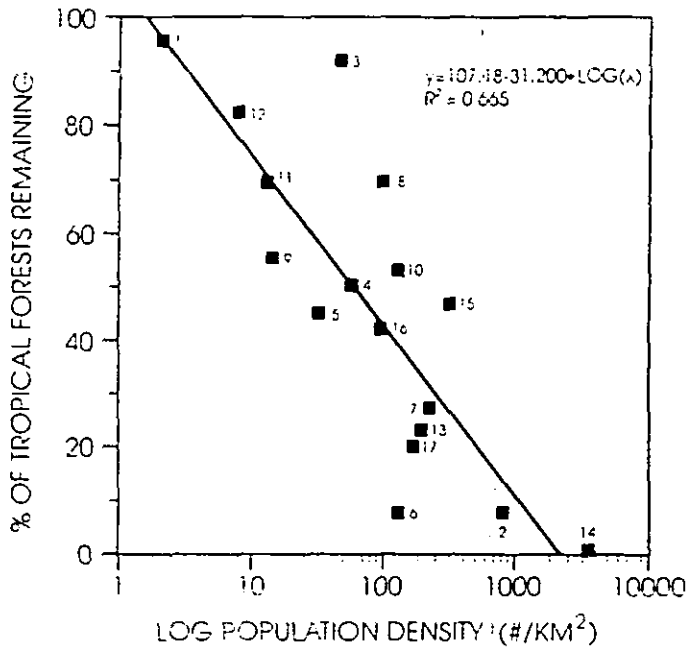
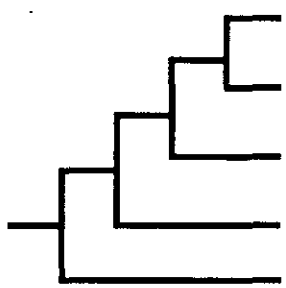
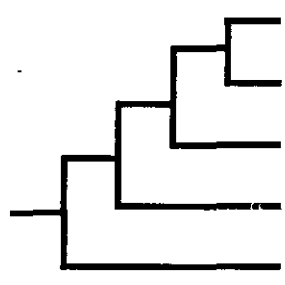


Figure 5



	I	Q	W	P
A	4	3.5	1	10.7
B	4	3.5	1	10.7
C	3	4.67	1.33	14.3
D	2	7	2	21.4
E	1	14	4	42.9
T	14	32.7	9.33	100

Figure 6



	W	R1	R2	R3
A	1	●		
B	1	●	●	
C	1.3	●	●	●
D	2		●	●
E	4			●
T	9.3	3.3	4.3	7.3
P1		35	46	78
P2		22	11	

THE IMPACTS OF LAND USE POLICY ON FOREST RESOURCE AND BIODIVERSITY IN YUNNAN, CHINA

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Introduction

Land use policies are rules regulating human activities (e.g., production and living) conducted on earth. The policies lead to the success or failure of sustainable land use.

In China, land use policy has been reformed several times since 1949, with main changes occurring in 1950, 1958 and 1982. The core of China's policy originated from the land reforms in 1950. Previously unfair land occupation between landlords and peasants was reformed to a system of equal distribution among farmers. The production organization is still based on the peasant household. Between 1958 and 1978, land resources had been under the control of large collectives and a farmer production team became the basic unit in charge of agricultural production. In 1978, the "contracted responsibility system with remuneration related to output" was put into practice all over the country. Farmers contracted and cultivated collective lands on a household basis. From 1982 to 1983, "Lingyeshanding"[1] was carried out throughout the country and the policy of "Liangshanyidi" was implemented in Yunnan. The lands and forests were prospected and given boundaries, and at the same time, land use rights certificates were issued. This third land reformation in China is still valid today. From 1992 land titles became transferable. Since 1994, purchase, sale and renting of land have been allowed. As a result, the number of private farms and household production have risen. Following this change in land policy, a series of related regulations have been enforced to assure and complement the enactment of the land possession policy.

The main problems of land use and management relate to the possession of land, distribution of profits and the consistency of the policy. The policy of land use and management is the most important influence on land use, but not the only one. Other influences are technology, population, economic development, etc., as well as related policies. The quantitative and qualitative change of China's forest resources in the last 40 years is the result of the co-influence of these factors. As will be discussed later in this paper, the connection between these changes in land tenure and land use policy and the destruction of forest and biodiversity is very strong.

The greatest threat to biodiversity loss in Yunnan is the degradation of forest, resulting in habitat loss for numerous species. Of various habitats, forests are the richest in biodiversity; therefore, the growth and decline of forest has been taken as the main example in this study in relation to biodiversity and land use policy.

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1 The "Lingyeshanding" regulations consist of three articles governing forest tenure and production. They specifically (1) stabilize tenure of hills and forests, (2) delimit the areas of individually held hills and forests, and (3) set out how responsibility for forest production is regulated. "Liangshanyidi" refers to the regulations classifying forests and other uplands into three categories and fixing their boundaries.

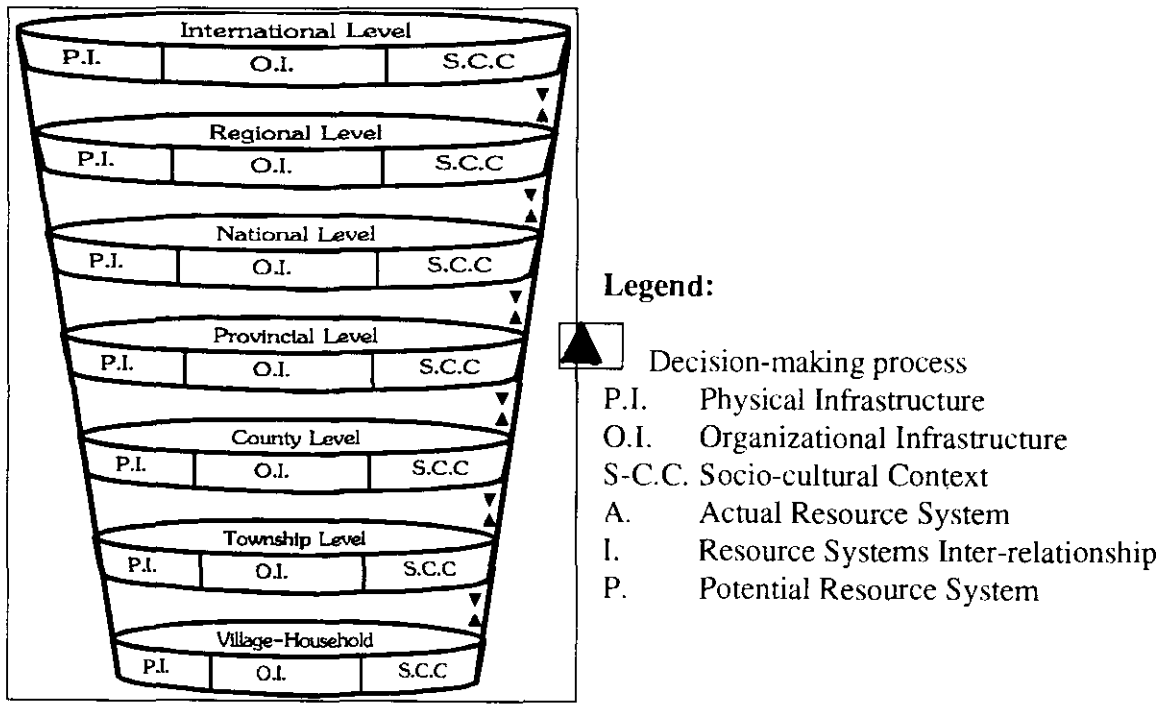
Deforestation has received much attention; yet in the world degenerated forest areas are far greater than deforested ones. In the tropics, deforestation is mainly caused by clearance for farmland rather than by logging for timber. The selective lumbering of tropical forests results in the degeneration of forest production and waste of land. Social consequences are starvation, pestilence, civil changes and large migrations. However, the costs to rehabilitate degenerated environments is high and the time needed is extensive.

Land Use Policy Relationships

1. Land Use Policy Structure

Land and management policies can be classified into four parts: (1) local rules and regulations; (2) state rules and regulations; (3) community institutions; and (4) external institutions. The policy in China is carried out on different administrative levels, viz., nation, province, prefecture, county and township. A village is the smallest unit to carry out all the policies (see Figure 1). There are three additional policies influencing land use: the agriculture, forestry, animal husbandry zoning and planning, and comprehensive agricultural zoning policy formulated by all levels of government; the five-year plan; and different programs and production policies carried out by various authorities and bureaus. All the policies mentioned interact with each other.

Figure 1. Multi-level Interactions in Land Use Policy



Source: Modified from Ruddle & Rondinelli, 1983

The laws and regulations of China can be divided into the common laws and the special laws formulated by various departments. Resource management laws include: the Land Law, the Pasture Land Law, the Forest Law, the Water Law, and the Wildlife Protection Law. When these laws are laid down, different enforcement and detailed regulations are also issued. At the same time, each province takes appropriate measures to formulate laws and regulations according to national and local conditions. Generally, it is only the prefecture that implements the orders laid

down by higher authorities, while county and township are the real executors. The latter, for example, delimit land boundaries or award land use certificates and act as mediators when disputes occur. Contradictions between counties and townships have occurred since 1983.

2. *Historical Changes in Land Management Policy*

China's land management policy has gone through three main stages within this century. The first period during 1950-1960 was marked by the taking over of all land by the State. In 1950 the "Outline of Land Law", and the "Land Reformation Law of P R. China" were instituted nationwide. Hills, forest irrigation systems, farming lands, and production and living materials belonged to the Farmer Union, and were shared uniformly and equitably by people in a village according to the population of the village, regardless of age and gender. People were also given land holding certificates. A family is the unit for land management, but large forests, major irrigation facilities, mining areas, large pastures, bases and lakes still belonged to the State according to the policy.

The second period (1958-1978) began with the appearance of People's Communes. Land, trees and other property were taken over by the collectives. Members of the collectives worked, reaped and shared forest resources together. During this period, regulations on the ownership of private plots and on raising livestock changed several times due to policy changes. "Shiguding"[2] came into effect in 1960 stipulating that land, livestock, and agricultural tools used by the production team are fixed. During the period of "Shiguding", the government delimited boundaries of hills, forests, and farming lands and made the boundaries between the State, collective, and village lands more defined. At that time, State pasture lands and nature reserves were established. Production teams were the basic unit for production activities and the policy did not change until 1978.

The third period began in 1978 and continues. The Output-related System of Contracted Responsibilities was first put into practice in rural areas in 1978. Land holdings belonged to a group or the nation and farmers had a contract to use the land. According to this policy, the collective land not designated for the individuals became fixed among individuals, but could not be transferred among the households. On the other hand, "Lingyeshanding" was carried out during the period from 1982 to 1983. During this process, boundaries earlier delimited by "Shiguding" in 1960 were reinvestigated. The policy touched off a big debate on landholding rights because it was a new policy issued after more than two decades and all investigators were changed. Meanwhile, peasants' fear that the policy of government would change led to serious deforestation in hilly, remote areas. In the course of implementing this policy, the local government also made corresponding local policies. For instance, Yunnan province's policy of "Liangshanyidi" delimits the responsible hills, individual hills and swidden fields. The ambiguity in the policy makes it easy to change one type of land into another.

Since 1984, China has issued many laws, rules and regulations, among which are the five principal resource management laws. Meanwhile, some by-laws have also been issued. The implementation plan has also been worked out in each province. In 1992, China signed the Biodiversity Convention and the Climate Change Convention. The country also prepared its Agenda 21, and the Biodiversity Conservation Action Plan. In December 1994, the Management Measures for the Natural Reserve were revised. All kinds of Chinese laws were made in accordance to all of these general laws.

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[2] The "Shiguding" regulation refers to the labor, land, livestock and agricultural tools controlled by a production team. The law was enforced in 1960 through the Chinese Central Government Document.

The new laws influenced biodiversity greatly. During the implementation of policies, contradictions and disputes occurred between different interests favouring new or earlier policy, between the national and local governments, between government agencies and indigenous communities as well as on conditions specified in the policies.

3. Discords Between Policies, Laws and Community Institutions

3.1. Between Policies

Policies that conflict with each other are mainly those issued by the Departments of forestry, agriculture and animal husbandry. For example, many cultivated lands in agricultural areas are recognized as forest lands by the forestry department, and therefore should be protected. The "Regulation for Water and Soil Conservation", stipulates that people stop tilling and begin afforestation on slopes greater than 25 degrees. However, in Nujiang Prefecture for example, despite high mountains and steep slopes, 80% of the land is under agriculture. Historical policy changes have also led to changes of forest land tenure.

The interactions between national and local policies is also of great importance. When the country carried out the policy of "Lingyeshanding" and "Liangshanyidi", farmers began cutting large areas of the forests. In Jingu county (Yunnan), the forest wasn't allocated and placed under single farms, so that 60% land still remains forested. Collective forests always have forest guards, and are directly controlled by the collective. The individual contracted forests were cut because farmers were afraid that the policy will change. Moreover, individual forests are usually closer to farmers' houses than are collective forests, making access and tree felling easier.

3.2. Between the State Policies and Community Institutions

In the course of the history of land development, the people of Yunnan formed their own regulations and used advanced technology as and when available. However, national-level policy implementation in China is quite thorough and widespread, making no exception for, say, villages of minority communities. At present, Yunnan still maintains some "holy hills" and home gardens —a result of local people's land use methods and their own laws for managing lands. During the period from 1960 to 1970, these two types of land use systems were restricted by the Cultural Revolution, but still preserved very high biodiversity

Land Use Policy and Forest/Biodiversity Changes in Yunnan

Yunnan is the province with the richest biodiversity in China. It has 15,000 species of flowering plants, which accounts for 50 percent of the country's total. These plants include 346 State-protected species, and many of these belong to old and endemic genera. Because of the population growth, irrational exploitation of plant resources, deforestation, and degradation of grassland due to overgrazing, the habitats of many wild species are deteriorating gradually. About 500 species are endangered and many other are already extinct. Protection of this plant germplasm, which is the base for human sustainable living and development, is a matter of great urgency.

Since 1958, 34 nature reserves have been established in Yunnan, four of which are State nature reserves (i.e., Xishuangbanna, 241,776 ha; Gaoligongshan, 123,900 ha; Baimaxueshan, 187,977 ha; and Ailaoshan, 50,360 ha). The nature reserves can be categorized as forest and wildlife reserves, plateau lakes, and sites of economic or cultural significance. The total area of nature reserves in Yunnan is 1,400,989 ha, or 3.6 percent of the provincial area. Establishing nature reserves alone however cannot foster long term biodiversity conservation since there are many factors damaging biodiversity in China.

From the 1950s to 1970s, birth control was encouraged by the government without a birth control policy, which led China to become the world's most populous country. The population of China reached 1.2 billion on February 15, 1995. To meet the rising demand for food and cash income, farming lands and monoculture of cash crops are expanding. Huge areas of natural forest with high biodiversity have been transformed into croplands, leading to heavy biodiversity losses. The factors impacting biodiversity are quite complicated. In spite of the conservation policies, population growth, economic development and indigenous technologies are also affecting the forest resource and biodiversity. In addition to land use policies, other related policies such as birth control and economic policies are also indirectly affecting biodiversity conservation. China could be the typical region for studying the dynamics of these complex factors affecting biodiversity changes.

1. Land Use Policy and Deforestation in Yunnan

Forest ecosystems, especially tropical forests with various habitats are high in biodiversity. Deforestation reduces animal food supplies and may be responsible for their extinction. Even partial clearance leads to species losses. For instance, *Ammomum villosum* cultivation in the tropical primary forest led to 36.7 percent tree species loss, and 52.8 percent stem loss; in addition, most of the shrub and herb species disappeared. This kind of cultivation is very common in tropical Yunnan. Many endemic species, especially the current endangered species, are highly prone to become extinct because of deforestation.

With population increase from 17,306,019 in 1953 to 36,972,610 in 1990, the forest resources in Yunnan have faced many policy changes. The forest cover, age, and species structure varied greatly, especially in 1950, 1960, and 1982. According to three forest resource surveys in Yunnan, forest cover has decreased from 10,862,000 ha in 1949 to 9,680,000 ha in 1964, and then from 9,817,500 ha in 1980 to 9,320,000 ha in 1988 and 9,400,000 ha in 1992.

From 1949 to 1980, 1,660,000 ha of forest have been cleared at an annual rate of 50,350 ha. About 1,181,000 ha were cleared from 1949 to 1964, while 56% were cleared during 1958 to 1960. In 1958, the "Great Leap" was encouraged by the government, where the land was returned to the People's Commune and Collective Communes simultaneously. The "Farmers Making Steel" and "Getting the Grains as the Goal" (see under the Xishuangbanna case below) were adopted by the government. Food crops were expanded to huge areas so that large forest areas were cut for food cultivation. From 1980 to 1988, forest land decreased by 765,600 ha at 85,100 ha annually while agricultural land increased. During this period, natural forest cover decreased, but cash trees increased. From 1980 to 1988, 268,800 ha of economic forest were added at an average of about 29,900 ha per year (Table 1).

Table 1. Economic Forest Changes from 1980 to 1992

Year	1980	1988	1992
Total Area	320, 592	590,200	676,600
Oil Tree	81,166	163,100	143,900
Rubber tree	65,509	124,800	129,568
Tea	93,439	196,700	231,667
Fruit Tree	55,189	81,600	139,200

Large areas of natural forest with high biodiversity have been replaced with monocultures of sugarcane, rubber, tea and fruit trees of a few species. This has led to weed invasion into the plantations. For example, *Imperata* grass can occupy 70.4 percent of the community population in

rubber plantations; 32.4 percent in tea plantations; 50.8 percent in mulberry plantations; 40.5 percent in orange orchards (Table 2).

Table 2. *Imperata* in Monoculture Cash Crop Plantations

Trees Crops	Rubber Temperate	Fruit Tree	Woody Tropical Fruit Trees	Banana, Pineapple	Mulberry (Central Yunnan)	Mulberry (Southern Yunnan)	Tea
Appearance Rate (%)	90.9	98.4	50.2	68.0	70.4	70.4	40.0
Harmfulness Index	40.0	30.0	30.2	28.4	18.0	20.8	28.0
Population (%)	70.4	70.4	60.4	40.5	34.1	50.8	32.4

At the same time, however, areas under special forests like nature reserves, conservation forests etc. have increased from 1,874,499 ha in 1980 to 580,600 ha in 1988 and 633,400 ha in 1992, as new nature reserves were established during these periods.

Most deforestation occurred in 1984 following the adoption of "Lingyeshanding" and "Liangshanyidi" policy during 1982-1983. Most of the collective lands were allocated to households under the responsibility system. However, the farmers were afraid that the land policy would change again so they cut the collective forest both for timber and agricultural land but preserved the individual forest. The land policy also led to confusion of land and forest tenure for the second time in 1960 and the third time in 1982-1983. The boundary between the State and the village forests changed, as they were identified by different officials. The local people further cut the forest, taking advantage of the ambiguity over boundaries and confusion over tenure. Many shocking examples can be found in the province. In the Zhuoxi village of the Akha community in Mojiang County, for example, nearly 60 *mu* (four ha)[3] of natural State forest was cut in a single day for swidden cultivation.

Since 1988, the selling of land has been allowed (only the right of use). A lot of "waste land" (most of these are covered by shrubs and secondary forest) have been sold in 1993-1994. These lands are usually slashed for annual crop cultivation or joint-venture rural industries.

2. Deforestation and Biodiversity Losses

Destruction of forest and biodiversity has three aspects: first is the habitat and species loss; second is direct destruction of biodiversity, including population reduction and species extinction; third is indirect destruction caused by replacement of native plant communities by hardy, invading weed communities.

One of the most serious problems caused by deforestation is the rapid increase of invading plants, especially weeds. At present, this situation is getting worse in Yunnan and throughout China. There are three kinds of vicious weeds in Southeast Asia:

- *Eupatorium cordorata*, which usually grows in waste lands, by the roadsides, in courtyards and in sparse forests below 1,000 m;
- *Eupatorium coelesticum*, which grows in upland fallow fields, waste land, eucalyptus monocultures and camphor woods, moving towards north at the speed of 10 km per year and becomes a poisonous weed endangering livestock in mid-elevation areas; and

[3] A *mu* is equivalent to one-fifteenth of a hectare.

- *Imperata cylindrica*, which causes difficulties in tilling and becomes the main competitor for other crops struggling for nutrition and water, spreading at most elevations, especially in fruit tree gardens.

For decades, all countries have been trying to control these weeds, but neither biological, chemical, nor industrial approaches can achieve the goal. In the weed areas, it is very difficult to recover biodiversity and protophytes. Besides, the introduced economic plants is a factor causing the loss of biodiversity and difficulty of recovering forest vegetation; for example, *A. villosum*, *A. tsao-ko* and teas planted under natural forest in tropical and sub-tropical area. The spread of coffee, sugarcane and rubber has also caused surprising damage to biodiversity and vegetation.

In 1978, Yunnan successfully introduced eucalyptus from Australia. Monoculture afforestation of eucalyptus is very popular in Yunnan. Today, the total area of eucalyptus forest in Yunnan province has increased to 19,200 ha, and the rubber forest increased from 65,509 ha in 1980 to 124,800 ha in 1990. Although eucalyptus has a greater output of organic matter than native trees of Yunnan, (e.g., Yunnan pine), its ability to sustain that output is questionable. In fact, eucalyptus does not grow faster than *Alnus nepalensis*, a species native to Yunnan. Eucalyptus has benefited paper making and the fragrance industry, but it is at the price of sacrificing the country's natural forest resources. Meanwhile, planting eucalyptus for the purpose of timber production is very harmful to the diversification of plants and animals. The problem is the same with other cash crops, but the monoculture of eucalyptus promotes the spreading of weeds, such as *E. coelestucum* and greatly prevents many social forestry programs. The problems of weeds and poor soil and other environmental problems caused by eucalyptus have become very serious now. Yet, however, the World Bank is still supporting this kind of projects.

Two Cases from Yunnan

1. Population Growth, Land Use Policy and Forest Resource in the Gaoligong Mountain

The Gaoligong Mountain is located in western Yunnan, bordering Northern Myanmar (Burma). This region has attracted world-wide interest because of its diverse forest types and rich biological, cultural and geophysical diversity. The mountain is considered as the key point of the origin and evolution of flora and fauna and was recognized as one of the four State natural reserves of Yunnan in 1985, and recognized as a critical region of the Eastern Himalayas.

The Gaoligong Mountain State Nature Reserve, with a total area of 123,900 ha, contains large percentages of Yunnan's animals (42.1%) and birds (32.4%). About 347 species of birds, 117 species of animals, 29 species of amphibians, 48 species of reptiles, 17 species of fishes, and 844 species of insects have been recorded from the mountain. 1,700 species of higher plants have also been recorded in 1980, but many of the species are unknown. Prof. Li Heng estimates that there may be 6,000 species of higher plants in the area. The main purpose of Gaoligong Mountain State Nature Reserve is to protect the various vegetation and many endemic and endangered plant and animal species in the area. Fifty-eight plant and 81 animal species have been identified as endangered and endemic in this area and are State protected such as *Magnolia rostnata*, *Coptis teeta*, *Magnolia campbellia*, *Taxus yunnanensis*, *Taiwania flousiana* etc. Two families and eight genera are endemic to the area.

The Gaoligongshan Mountain provides irrigation and drinking water, firewood, food, medicine, and wood products for 229,235 people of the surrounding rural communities. There are 258 plant species that are used for food, perfume oil, timber, edible oil, starch, fiber, dyes, tannin, and weaving materials, while 1,077 species are known medicinal herbs. There are 133 species of edible fungi. These plant resources provide a potential income for rural people but many are

currently endangered because of over-collection by local inhabitants who often sell them to pharmaceutical companies.

Guo *et al.*(1993) found that the indigenous people have rich experience in agroforestry technology and native tree use and plantation. *Catalpa fargesii*, *A.nepalensis*, and *T. flousiana* are fast growing native tree species of the area. Indigenous peoples have grown some of these trees on a large scale for many years by agroforestry or social forestry approaches. However, with the increase in population, commercialization, and policy changes, these collective forests have been almost completely degraded or destroyed during 1982-1993. It is urgent to adopt effective and action-oriented sustainable forestry management and biodiversity conservation measures to protect forest tracts in the Gaoligong Mountain. If such measures are not implemented, perhaps within ten years, large State forests, along with valuable flora and fauna will be destroyed or degraded.

1.1. Population Growth and Economic Development

The 229,235 people living around the Gaoligongshan Mountain State Nature Reserve comprise 48,169 households, 99 villages and 6 townships. They belong to more than 10 ethnic groups, such as Han, Lisu, Dai, Bai, Yi and Hui. In 1981, there were only 89,466 people in 13,271 households. The population has doubled since 1981. This population growth has led to a dramatic increase in subsistence and commercial demands (i.e., construction materials, fuelwood, food production and commercial crops cultivation). These increasing demands have resulted in the destruction and degradation of most collective forests which had acted as a buffer zone for the nature reserve in the past decade (1982-1992). Commercial crop cultivation has been dramatically developed during past decades to meet the growing population and government income needs. Processing of these crops depends mainly on fuelwood from the mountain and results in considerable forest destruction and biodiversity losses. The major commercial crops are sugarcane in the east, tobacco in the west, and tea plantations in the south.

Tobacco cultivation was started with an order from the local government in 1985 and has been developed since 1989. Jietou and Qushi townships on the western slope have developed 8,021 *mu* and 1,816 *mu* of tobacco in 1990, which expanded to 35,163 and 4,500 *mu* in 1992. The dramatic expansion of tobacco requires a lot of fuelwood for drying. Each family cultivating tobacco constructs one leaf roasting house. As estimated, 1 kg of tobacco requires 4 kg fuelwood, and additional timber for building the roasting house. Jietou and Qushi townships produced 7,715.8 tons tobacco from 1990-1992 and 30,863.2 tons fuelwood were used for tobacco drying. Approximately, 17,529 m^3 of timber were used for the construction of 5,843 tobacco roasting houses. Recently, 40 percent of fuelwood has come from the nature reserve. Sugarcane plantations were started in 1958 when the first processing factory was established in 1957 in Bawan. There are currently 5 sugarcane processing factories around Gaoligongshan, which utilize 6,000 m^3 of fuelwood annually. Most of this fuelwood comes from the Gaoligong Mountain. Most of the collective forest has been cut for fuel, and the nature reserve is also threatened.

Commercial forest cutting is another pressure on sustainable forest management. For example, Yew (*T. yunnanensis*) is an endangered woody species because the taxol from the bark and its leaves can be used for curing cancer. Many overseas companies search for the barks and leaves of yew to extract the taxol. One gram taxol (50%) can earn US$300.

1.2. Forest Policy and Tenure Conflicts

The Gaoligongshan Nature Reserve was planned in 1958 and identified as a State forest in 1962, a Provincial Nature Reserve in 1983, and a State Nature Reserve in 1985. In 1962, under the State regulation of "Shiguding", the boundary between collective and State forests was established, and

six Forestry Stations were established in Jietou, Qushi, Mankuan, Bawan, Dahaopin and Lushui. Baihualing Forestry Farm was also established for logging timber in the State forest, as well as developing monoculture of Chinese fir for reforestation. Most of the residents (most of them belong to the Lisu ethnic minority) within the forest were forced to move out down to lower elevations. The Nature Reserve Stations were established during 1982-1983 when the government enforced the "Lingyeshanding" and "Liangshangyidi" Regulations.

The border marks between State forests, natural reserves and collective forests were investigated and established again and the boundary between villages, households were set again. Because the surveyors were different from 1962, many parts of the boundary have been changed because of misunderstandings between foresters and local communities. The misunderstandings have led to forest tenure conflicts between the Nature Reserve officials and local communities. Many of these conflicts occurred in Datang and Ganding. Farmers often cut these forests for timber and fuel since they believed these forests belonged to them and were afraid that they would lose tenure of the forests in the future.

Many endemic and endangered species were destroyed because of tenure conflicts. For instance, Hanglong village of Baihualing Community (one of the FMBC/KIB-MacArthur project sites) had 10,000 *mu* of forest owned by one family before 1950 without cutting and hunting. These were taken back and divided, some parts for the collective, some portion for allocation to households. In 1955, all of these forests were regained to the collective as State forest, but only 1,700 *mu* still belong to the village. There are 1,000 *mu* of the forest that is embroiled in the conflict between the nature reserve and the village for the following reasons: after the "Shiguding" Regulation, a mark delineating the State forest from the village forest was made on the bark of a large tree. To protect from rains, the mark was later moved under shade. In 1982, the new official only recognized the current mark instead of the original mark, causing, according to the villagers a loss of 1,000 *mu* of village forest. Meanwhile, tree felling occurs very often on these forest fragments. Similar cases have been found in Baka (Xishuangbanna) among the JInuo people, and in Zhuoxi (Simao prefecture) among the Akha where our project sites are located.

The competition between community development and forest resources and biodiversity conservation has become an urgent global concern.

2. Economic Policy and Biodiversity Conservation in Xishuangbanna, Southern Yunnan

Xishuangbanna is one of the regions with high biodiversity in Yunnan, and is one of the earliest (1958) established nature reserves. Three pieces of the nature reserve (Menglun, Xiaomengyang and Damenglong) have a total area of 850,000 *mu*, but 70,000 *mu* have been destroyed during 1960-1970. Damenglun Nature Reserve has been totally destroyed because of population growth, cash crop plantation and land use policy. Xishuangbanna had a population of 179,300 in 1949 (Han Chinese only 0.26%, 52.27% basic ethnic minorities, 34.7% hill tribes). In the absence of a birth control policy and due to immigration, the population increased to 645,895 in 1982 (Han Chinese 28.7%, most of them immigrated from interior of China to work on rubber plantation, 34.59% basic ethnic minorities, 34.0% hill tribes), and 790,460 in 1992 (25.5% Han Chinese, 25.5% basic ethnic minorities, 40.20% hill tribes). To meet the food demands of a growing population, two policies were applied during the "Great Leap" from 1958 to 1960. One called "the farmer making steel" resulted to cutting of large areas of primary forest for firewood to make steel. Another is called "the farmer getting food grains from the mountain" permitted tree cutting for food cultivation.

During the 1950s, swidden field was only 200,000 *mu*, but it reached to 400,000 *mu* in 1958. The fallow period has been shortened from 15-20 to 3-5 years. Most of the destroyed

forests are primary forest. Even in 1978, Yunnan province established an office for developing farming land. In 1981, upland swidden fields reached to 800,000 *mu*. Food grain raising was based on the destruction of large forest tracts so that many rare and endemic species were lost. Forest cover was 40 percent in 1949, but it decreased to 33.85 percent in 1973, 26.69 percent in 1982 and 24 percent in 1992. Simultaneously, monoculture cash crops developed dramatically For instance, there were 6,130 ha of rubber plantation, which expanded to 57,700 ha in 1983, and 92,480 ha in 1992, accounting for 38.25 percent of the total territory of Xishuangbanna. One of the important transitions between natural forest to monoculture is cash crop cultivation within the natural forest, (e.g., *A. villosum*, tea, *A. tsao-ko*, and *Baphicacanthus cusia*). There are 87,000 *mu* of *A.villosum* and 100,000 *mu* of *A. tsao-ko* cultivations in Southern Yunnan. According to our field studies, except for the 26.2 percent tree species loss and 47.7 percent population reduction of tree species, the pioneers on the fallow *Ammomum* field are *Eupatorium cordata*, *E. coelesticum* and *Digitaria sanguinalis*.

The development of cash crops like rubber and *A. villosum* are highly dependent on the State economic policy During the 1950s rubber and *Ammomum* supplies depended on imports from overseas. The price was quite high and the international blockade limited the import of these products. During the 1960s, the Chinese government adopted these products as important to the development programs

Another common problem is land and forest tenure conflicts between indigenous communities and nature reserves. Usually, the local people also live within the nature reserve. The tenure conflicts continued for a long time as in other places in Yunnan. For instance, the Baka village of Jinuo people, close to Menglun Nature Reserve, has 2,000 *mu* of contested forest. They still have swidden fields and *A. villosum* cultivation within the nature reserve. This area is equal to their total current land area. Land use policy has not been adopted throughout the community, some of the indigenous communities have not adopted the " Liangshanyidi " and "Lingyeshanding" regulations in 1982-1983 For instance, Manmuo village of the Akha people, close to Baka village as mentioned above, did not allocate their 2,000 *mu* of collective forest to households in 1983. They still preserved a nice tropical rain forest and opened it for tourism recently.

The indigenous people also possess rich knowledge and experience of conserving forest and biodiversity gained over generations. Much of the forest has been protected using this indigenous knowledge. Two important examples are the "Holy Hills" in most ethnic minority communities and the home garden systems in Xishuangbanna. Ethnic people in Xishuangbanna have preserved about 30,000-50,000 ha of holy hills, which accounts for 1.5 percent of the total land area of Xishuangbanna. Zhu Hua *et al.* have studied the plants species in the holy hills. It is recorded that there are more than 100 species on just 1,500 m^2 of holy hills. With the human interference, tree species have decreased but the shrubs and herbaceous plants have increased. During 1960-1970, because of the Cultural Revolution, worshipping these holy hills were recognized as backward activities and restricted. Many of the holy hills were destroyed during that period.

Home gardens are gene pools and experimental plots for domesticating wild plants. Food boxes are also a cultural heritage for the rural people. The Dai developed high biodiversity home-gardening. Some home gardens contain about 128 species (Long Chunling, 1994). Generally about 50 species can be found in the Dai's home garden. The local people also possess knowledge about domesticating wild species to cultivars. In Manggang village (Xishuangbanna) of the Jinuo people, 71.5 percent of the cultivated plants in their home gardens are domesticated by themselves from the surrounding forest, since it is too far for them to gather these plants for daily use, and these have gradually become rarer due to deforestation (Guo Huijun, 1994). The indigenous people

have also developed many successful folk rules, taboos and values for forest resource conservation in Yunnan.

Indigenous communities have made great contributions to biodiversity conservation, that can provide important lessons to today's conservationists and policy makers. But during the past decades, these have been interrupted by policies and neglected by policy makers and the society in Yunnan. Only recently, these efforts have started to attract the attention of the society.

Conclusions and Implications

Mismanagement of forest and biological resources in Yunnan is rapidly increasing along with an accelerating population growth, land resource degradation, natural disasters, conflicts between farmers and management agencies, and rural poverty Destruction of natural vegetation without replacement by sustainable agriculture and forestry techniques, and land transformation caused by population growth, changing agricultural and land policies, and a market-driven economy have resulted in severe biodiversity losses, simplified agro-ecosystems, and increased soil erosion and sediment transport. Natural forests with high biodiversity have been destroyed and replanted with plantation crops (e.g., Eucalyptus, Chinese Fir, tobacco, sugarcane, tea, coffee, rubber etc). At the heart of forest mismanagement lies deep-seated differences between local government agencies and rural people about who should control these lands, and how they should be managed. Unless action is taken to resolve these conflicts, unsustainable use practices will continue to lead toward the ultimate destruction of biodiversity.

Over the past decades, there has been an increasing tendency for agencies to emphasize the technical dimension of problems and programs. Many current development projects dealing with conservation and management of forests and sloping lands focus on highly technical and costly activities. Moreover, these schemes promote hillside farming technologies and practices without first taking careful steps to establish, or re-establish community cooperation or to strengthen local organizations This does not foster long-term sustainability of such procedures.

Policy is the critical external factor affecting sustainable natural resource management and biodiversity conservation. But these issues have been neglected by the local government, farmers, and researchers. The "Lingyeshanding" and "Liangshanyidi" regulations adopted in 1982 have attempted to respond to the needs of indigenous communities, and implemented many reforestation programs, but these efforts have generally failed to slow deforestation. Little is known about how to establish collaborative management systems which bring foresters and communities together. The need to facilitate and formalize community involvement in forest management and biodiversity conservation has barely been recognized. China has made a lot of efforts to conserve the forest resource and biodiversity by establishing a lot of nature reserve as well as running many projects for biodiversity study, but most of the projects focus on flora and fauna inventory and taxa study; rarely is there a study on policy. Biodiversity conservation in China is an important part of human being's sustainable living and development of the world, just as Yunnan is an important part for environmental conservation in Mainland Southeast Asia.

Recent studies note that both pure technical and policy (e.g., compensating farmers' lost right to utilize the forest) programs in many places in Yunnan have failed to receive cooperation from farmers and local agencies. Farmers are the primary participants in resource management programs who can either protect or damage the system, yet they have been underestimated by decision makers and managers. Participation of the farmers, multi-disciplinary local agencies, and regional authorities have been ignored by decision makers. The benefits and costs of natural resource use and environmental conservation should be shared fairly among different communities. Nature reserve management needs to incorporate a participatory approach among farmers, local

officials, village or community leaders, nature reserve agencies and policy makers. Unfortunately, most of the current policies and regulations have been designed to restrict indigenous peoples, instead of promoting cooperation among all concerned parties.

Indigenous technologies and knowledge (experience and approaches) on natural resource management have not been respected by policy makers, researchers and watershed project workers. For example, many minority peoples who have rich experiences in agroforestry, home gardening, forest protection and irrigation in their villages have prospered, and live under good circumstances. Most of the current environmental conservation research and projects in China focus on nature reserve *per se* or measures on *ex situ* preservation of endemic species. However, in reality, these systems and species have not been protected. Farmers claim ownership of the forest and are not involved in local management decisions. Consequently, they are disturbed by past forestry practices that has destroyed large tracts of primary forest for commercial gain.

Only limited areas of forest can be totally conserved from all interference, and some of such areas are encroached by people seeking land to farm or log (SAG, PLEC, 1994). More than 95 percent of the land on earth is not under the control of public communities but instead nature reserves. The nature reserves in Yunnan only account for 3.6 percent of the total land area. But most of the species or their population have not been and cannot be strictly protected. Furthermore, many nature reserves are threatened by the growing population and economic development activities. About 7,000,000 people in Yunnan are poor and fighting with poverty. The trade of rare, endemic or endangered species still prevails among the countries in Mainland Southeast Asia. It is urgent to set a series of policies and action plans for the participation of the whole society, including indigenous communities. And the developing countries need the support from the developed countries for the purpose of fostering long term sustainable living and development of the human being.

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AGRODIVERSITY AND NATURAL RESOURCES CONSERVATION IN NORTHERN THAILAND

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ABSTRACT

The highlands of Northern Thailand, which are among the most marginal areas in the country, have received much attention over the past 30 years due to (i) national and international concerns over illicit opium cultivation by ethnic minorities, and (ii) national campaigns against communist insurgencies. Many changes have taken place in these areas in the last 30 years, some due to development efforts, while others have occurred spontaneously. Illicit opium production has generally been satisfactorily curtailed through a combined effect of alternative cash cropping and strict law enforcement. Other causes and consequences of highland development, however, are less clearly understood. A better understanding of current changes is essential for the future of sustainable development of the area.

A high rate of population growth is one of the major forces behind changes in the highlands. Most villages had an average growth rate of 6% per annum between 1986 and 1993 with the population now approaching one million. Shifting cultivation, which requires 5-6 hectares per head for a sustainable 8-9 year rotation, is no longer feasible in many parts of the highlands

Preliminary studies suggested that the internal pressure (population increase) combined with external pressures (restriction of forest land use by national conservation policies) and opportunities (improved transportation and expanding markets) have led to a shift from the traditional shifting cultivation to more permanent land use with various levels of cropping intensification, e.g., multiple cropping with irrigation, mixed annual cropping of cash crops with soil and water conservation measures or fruit trees and agroforestry systems. Advancement of alternatives to traditional shifting cultivation has been largely dependent on the local people who simultaneously adapt their traditional farming systems to meet market opportunities as well as developmental policy changes. Inevitably, certain farming practices are "successful" while others have failed. Some successes are private, with a high public cost in the form of environmental and watershed degradation. Others are economically successful while simultaneously contributing to forest and watershed conservation.

The agrodiversity concept can be introduced to examine the local adaptation to land use changes and land management under multiple pressures at different levels. Preliminary results from selected villages with productive and sustainable strategies are presented and discussed.

1. Background

Until recently, the population in Northern Thailand had been concentrated in the alluvial plains of the major rivers. Although these places account for three quarters of the total land area, the majority of the highlands were sparsely populated. The population in these areas has always been made up largely of people who belong to one of the ethnic minority groups. Among these major groups are Karen, Hmong, Lahu, Akha, Lisu and Yao. These people form part of a much larger population of similar ethnic background that populate the mountainous area covering the southwestern provinces of China, Laos, northern Vietnam, Myanmar and Thailand (TDRI, 1994). Collectively, this area may be called "Montane Mainland Southeast Asia". The people in this area have been living largely from agriculture, traditionally in the form of shifting agriculture. Land use in the highlands, however, has undergone major changes, especially in the last 30 years.

In Thailand, highland development policy in the 1960's until the early 1980's was driven by two major concerns:

- national and international concerns over illicit opium cultivation by ethnic minorities;
- a national border security campaign against communist insurgencies.

These have translated into programs that have resulted in:

- social integration, i.e. granting of Thai citizenship and the beginning of the process to integrate highland villages into the regular administrative structure of government through the hierarchy of village, sub-district, district and provincial offices of the Department of Local Administration, Ministry of Interior;
- improving road access and electricity supply;
- relocation of a number of villages away from insurgent influences,
- opium substitution (with alternative cash crops) and eradication (by strict law enforcement involving the army in crop destroying operations).

At the same time, another national policy to conserve national forests and watersheds was implemented independently by the Royal Forest Department (RFD). This has resulted in the establishment of national parks and wildlife sanctuaries (totaling almost 2 million hectares), and the designation of areas to be strictly protected and conserved as watersheds. The major effect of these policies on land use in the highland has been the restriction of access to forest land for the highland's agricultural population who principally practiced traditional shifting cultivation on a rotational basis.

The objectives of this paper are to describe some significant effects on land use and the role of biodiversity in the marginal areas of northern Thailand.

2. Dynamics of Land Use in the Highlands

Many changes have taken place in the highlands over the past 30 years. Some of these changes are the result of development efforts, but some have occurred spontaneously. Illicit opium production has been curtailed through a combined effect of alternative cash cropping and strict law enforcement (Figure 1).

In addition to the "external" factors responsible for changes in the highlands mentioned above, another force was operating from within. This is the pressure exerted on the land by population increases (TDRI, 1994). The population of the highlands in northern Thailand is now approaching 1 million. The annual growth rate between 1986 and 1993 was estimated to be 6 percent. In some areas such as Chiang Mai province, the rate is as high as 12 percent per annum. In this case, migration is undoubtedly a major contributing factor, adding to an already high internal (natural) growth of about 3 percent per year In the upper part of northern Thailand, illegal migration comes across the border from Myanmar and Laos and sometimes from as far as China. Internal movement of the lowland northern Thais up to the mountain areas has also been significant for many years mainly due to land shortages in the valleys (CMU/CUSRI, 1985). The average farm size of the low-landers in the region has decreased slightly from 3.77 hectares in 1985 to 3.68 ha. per family in 1992 (Table 1).

Traditionally, shifting agriculture in northern Thailand had derived a degree of sustainability from the use of long fallow periods, 8-10 years, to restore soil fertility and to keep down the population of pests and weeds. This land use practice, however, requires a lot of land. For example, a detailed study of Lua and Karen villages which practice "sustainable" rotational

shifting agriculture, indicated that a total of 5-6 hectares of land was required per head of the population (Kunstadter, 1978; Nakano, 1980). Pioneer shifting agriculture villages, largely belonging to ethnic groups of Hmong, Lahu, Yao, Lisu, and Akha, appeared to perceive the need to adapt to cope with the mounting pressure on the land even 30 years ago. Many of these began to buy and/or develop paddy land for wet rice and settle down to become sedentary since the early 1960's. Rotational shifting agriculture villages were already sedentary. In the past, population increases had been managed by a group of households splitting off to form new villages. The pressure on the land is indicated by difficulties in finding new sites for these "daughter" villages. The government's forest and watershed conservation policy has further aggravated this increasing pressure on the land.

Under this increasing pressure on the land, three types of coping strategies have been identified:

- People become economically poorer, their land and nearby forest become degraded.
- Cash cropping is adopted, sometimes with economic success, sometimes with failure, but the resource base becomes degraded; may also have negative effects on forests and watershed. (Examples: cabbages, vegetables, fruit trees).
- Adoption of sustainable land use alternatives that are economically viable, and also have positive impacts on forests and watersheds.

The remaining part of this paper will focus on this third strategy, examining the mechanisms by which land use in the highland might adapt to various external and internal pressures. Our preliminary studies have indicated that biological diversity plays a primary role in the development of sustainable land use alternatives in the highlands.

3. Role of Biodiversity in Sustainable Use of Marginal Land

There are two elements of diversity that have been identified as core to the development of sustainable land use alternatives.

3.1 Diversity of livelihood activities

Diversified livelihood activities are a common feature of land use in the mountains of the Montane Mainland of Southeast Asia (Souvanthong et. al., 1994; Sam, 1994; Huijun, 1993; KIB, 1992). Table 2 illustrates the degree of diversity in livelihood activities found in seven villages in Northern Thailand

A "typical" farming system is engaged in 6-10 activities. The performance and impact of a mountain farming system on the resource base and the environment is a combined effect of these numerous activities. Evaluating the performance of mountain farming systems and their impact may not be possible by looking at each individual activity, but should take into account the interactions among the different activities.

3.2 Agrodiversity on the highlands

The concept of agrodiversity has recently been proposed to examine how farmers adapt or fail to adapt to the growing resource scarcity (Brookfield, 1993). The term 'agrodiversity' is used to denote the many ways in which farmers use the natural diversity of the environment for production, including not only in their choice of crops but also in their management of land, water and the biota as a whole (Brookfield, 1993; Brookfield and Padoch, 1994). This concept might be used to explore the linkages between population growth, economic and social change, the management of land resources, and environmental change.

The primary hypothesis relating to natural resources management in the marginal areas of northern Thailand may be stated as.

"In each farm household and each village in the highlands, these several livelihood activities are not carried out in isolation, but could be closely related. Synergies among different activities can be identified at different hierarchical levels of the agro-ecosystems, e.g. in a field, a farm, a whole village, and sometimes even among a number of neighboring villages."

Some examples in Ban Pah Poo Chom (Hmong) and Mae Rid Pagae (Skaw Karen) are selected to illustrate such interactions so far identified.

Gathering bamboo shoots from wild stands for sale in the Hmong village of Pah Poo Chom, north of Chiang Mai, is kept below the level of "maximum sustaining yield" and hence sustainable, partly because of a competing demand for labor for the cabbage crop (Figure 2).

Cabbage production was adopted in the Karen village at Mae Rid Pagae, in Mae Hong Son Province of Thailand, as an alternative income generating activity. It has had a further impact on land productivity, as the yield of rice that followed the cabbage was doubled or tripled, presumably as the result of residual effects of cabbage fertilizers. Intensification and commercialization of highland agriculture has effectively reduced pressure on the land, simply by increasing yield per area.

In Pah Poo Chom, on the brink of collapse in 1970 as the result of a decline in land productivity (Cooper, 1984), cash cropping with irrigated cabbages and lychee combined with bamboo shoot gathering has significantly alleviated pressure on the land and enabled the village to allow the forest to regenerate on a large part of a formerly cultivated area using shifting agriculture. On the other hand, many cases of land use intensification and commercialization have also led to a loss of genetic resources of many domesticated species, e.g. sesame, chilies, legumes and traditional vegetables, leading directly to a decline in nutritional diversity and security.

The above hypothesis is expected to be tested in more quantitative detail in the near future.

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Table 1. Changes in farm size in northern Thailand, 1963-92.[1]

Province/ Region	Farm Size (ha/family)		
	1963	1985	1992
Chiang Mai	1.21	1.39	1.47
Chiang Rai	1.77	2.49	2.57
Lamphun	1.28	1.31	1.35
Lampang	1.18	1.77	1.88
Mae Hong Son	1.18	1.37	1.52
Nan	0.99	1.85	2.28
Phayao		2.33	2.45
Phrae	1.33	1.71	1.79
Tak	1.54	3.13	3.42
Upper North	1.31	1.93	2.08
Kamphaeng Phet	4.52	6.52	6.01
Nakorn Sawan	4.82	6.57	6.19
Phetchabun	2.93	6.21	6.19
Phichit	5.13	6.91	6.51
Phitsanulok	3.71	5.22	5.28
Sukhothai	3.34	4.44	4.32
Uthai Thani	4.47	5.38	5.47
Uttaradit	2.31	3.67	3.83
Lower North	3.90	5.61	5.48
North	2.61	3.77	3.68
National Average	3.46	4.22	4.15

Note: [1] Data in Table 1 were obtained from interviews with a sample of farmers, individually and in groups, in seven mountain villages in Northern Thailand, representing 10-20% of the population in each village. The farmers were asked to list all daily activities considered to contribute to their living, and to give each a rating in contribution to their annual income, in cash and kind, relative to the most common crop, usually rice. Some activities were not quantified, i.e. not determined = nd. Household activities, e.g. cooking, cleaning, washing, raising children, house repair, were not considered.

Sources: Thodey 1972, OAE 1987 and OAE 1992

Table 2: Summary of Livelihood Activities in Seven Mountain Villages (Ethnic Groups: Hmong, Karen, Lahu, Lua) in Northern Thailand[1].

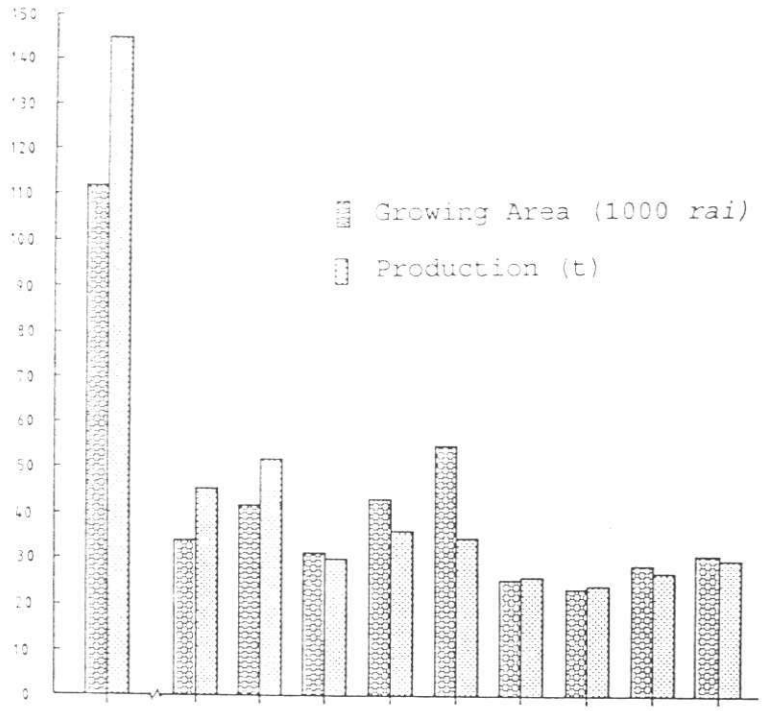
Activity	Degree of involvement		Range of contribution to income (%)
	Number of villages[2]	Percentage of households[3]	
Upland rice	7	76	10-80
Livestock	7	81	5-50
Earning wage	5	44	5-70
Wetland rice	4	64	25-70
Cabbages	3	52	5-50
Fruit trees	3	48	10-70
Soybean	1	75	15-25
Chilies	1	95	10-50
Flowers	1	5	10
Minor crops	2	45	5-30
Teak harvesting	1	nd	nd
Opium	1	nd	nd
Swidden crops	5	100	nd
Gathering:			
for subsistence	7	100	nd
for sale	3	60	5-30
Handicrafts:			
for own use	7	100	nd
for sale	3	53	5-25

Notes: [1] See footnote in Table 1.

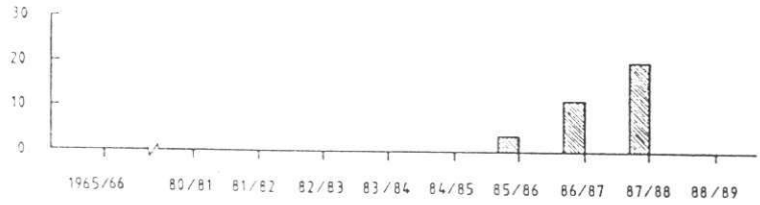
[2] number of villages in which the activity was found

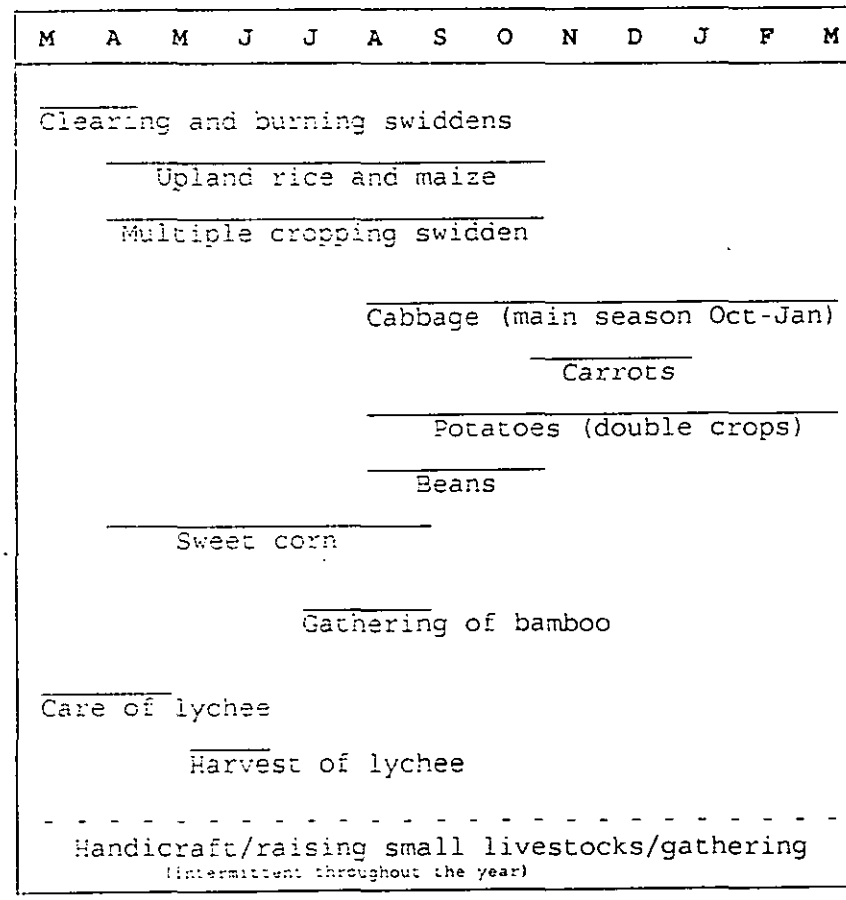
[3] % of households involved in the villages where the activity was practiced

(a) Growing Area and Production



(b) Opium Destruction (1000 *rai*)




M A M J J A S O N D J F M
Clearing and burning swiddens
Upland rice and maize
Multiple cropping swidden
Cabbage (main season Oct-Jan)
Carrots
Potatoes (double crops)
Beans
Sweet corn
Gathering of bamboo
Care of lychee
Harvest of lychee
Handicraft/raising small livestocks/gathering
(intermittent throughout the year)

FORESTRY POLICY IN VIETNAM

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PART I : General Situation

General situation

Vietnam covers an area of about 330,000 km^2 with a population of approximately 70 million people, of which 20 million live in mountainous areas. The majority of Vietnam is covered by tropical evergreen forest, with sub-tropical and temperate forest in belts of high mountains.

Table 1. Forest Types and Area

Type of Forest	Area (km^2)
Broadleaf evergreen and semi-evergreen forests	5,005.4
Broadleaf deciduous forest	914.9
Coniferous forest	164.2
Forest in limestone mountains	322.4
Mangrove and sulfate acid soil forest	984.1
Bamboo forest	984.1
Mixed tree - bamboo forest	674.5
Plantation	776.3

Source: Forest Inventory and Planning Institute (FIPI)

Forests in Vietnam contain approximately 544 million cubic meters of stumpage trees, six billion bamboo poles, and many other forest products Due to natural conditions and inter-flows of fauna and flora systems among regions, Vietnam owns a diversified forest ecosystem with a lot of endemic features.

- **Vascular Plants**: It is estimated that there are over 12,000 species of vascular plants (of which 7,000 species have been identified). There are many species with high pharmacological value (227 species), essential oil (500 species), and fat oil (181 species).
- **Trees**: There exist 1500 - 1600 species belonging to 100 families, according to Mr. Vu Van Can (FIPI), of which 354 valuable species have been put into eight merchandise wood categories in Vietnam. Specifically, there are 91 species of good timber such as: *Dalbergia bariensis, Pterocarpus macrocarpus*.
- **Fauna**. According to Prof. Dang Huy Huynh and Prof. Vo Quy, there are 273 animal species of which 14 species are special There are 773 bird species of which 34 are rare, 180 species of reptiles, and 80 frog species.

The forest ecosystem of Vietnam is also the habitat for fauna and flora species unknown elsewhere in the world, such as the large animal species - Sao La (*Pseudoryx nghetinhensis*) in Vu Quang forest, Ha Tinh province.

It is estimated that there are 350 - 400 species of flora in danger of extinction, of which some 60 have high economic value like: *Dalbergia Sp, Dalbergia tonkinensis, Manggletia fordiana*.

The red book of fauna lists 365 species which should be protected, including

Animals:	78 species
Birds.	84 species
Amphibious reptiles:	54 species
Salt water fish.	36 species
Fresh water fish.	75 species

Many animal species such as rhinos, bulls, elephants, tigers, spotted deer, peacocks, etc., are in danger of extinction.

Over the last decades, Vietnamese forests have been seriously degraded. The loss of forest has many causes, for instance: war destruction, food pressure and ineffective management. According to Maunrandt (a French scholar) in 1943 there existed 14.3 million hectares of forest accounting for 48% total area of the country, and at present (1993) there are only 8.27 million hectares of forest (25%) remaining. In the 1970s and 1980s, annual forest loss was estimated at over 200,000 hectares, with significant effects on human ecology, the national economy and the society.

No adequate surveys on the consequences of forest loss to the environment and society have been conducted nationally so far, but a lot of specialized research projects on a regional scale reached a conclusion that "weather changes in recent years, especially floods and typhoons," are closely related with forest loss. In addition, farming and hydrological conditions in many regions have declined (i.e., rapid loss of soil fertility, regular droughts or floods, etc.), resulting in the unplanned migration of people. In recent years, Vietnam has also been faced with big problems of wood and fuel demands.

Main difficulties and reasons

According to a report by Prof. Minister Nguyen Quang Ha on forest development strategy to the year 2000, the difficulties facing Vietnamese forestry are.

Natural forests have been continuously decreasing, while plantation forests have been developing at a slow speed.

According to present statistics, annual forest loss is about 100,000 hectares. (This figure may be an underestimation.) If the rate of forest loss continues as in 1980s, by the year 2000 the tropical forest ecosystem will basically not exist in Vietnam anymore.

It is said that slash and burn agriculture is one of the causes of deforestation. There are many contrary opinions on this issue, but slash and burn is the main source supplying food for some 3 million ethnic people in mountainous areas. This is a big social issue that has been carefully considered by the Vietnamese State, any compulsory solutions aimed at preventing slash and burn agriculture seem to be inappropriate.

In periods of economic development, hundreds of thousands of hectares of forest have been destroyed for cultivation of industrial crops (rubber trees, coffee, tea, etc.), for aquaculture (especially in the South west provinces in recent years), and for staple crops in "new settlements" both within and outside the migration program of the State. This unplanned and unregulated deforestation has serious consequences for the protection of natural resources of the country.

Forest fires, especially in the needle-leaf and *Melaleuca leucadrindron* forests during the dry season are another main cause of deforestation.

The measures taken for saving forest resources such as small timber utilization, log processing, utilization of substitute materials instead of wood (i.e., plastic) are still limited

Forest plantations only reach some 12,000 hectares annually, with 400 million alley trees. At this speed, the "Green Bare Hills" program of Vietnam will take 50 - 60 years to be completed.

Scientific and technical studies and processing industry are slow to develop.

This work has been focusing on the following:

- Seed research
- Silviculture techniques
- Wood and forest products processing

While research on agricultural seeds is well advanced with studies on progressive seedling production, tissue transplanting, grafting, etc., forestry research is far behind. Compared to the agricultural sector of the country, an effective forest management system has not been developed to supply high quality seedlings for afforestation.

Silviculture techniques like afforestation, enrichment, and rehabilitation of natural forests have not been well studied either, and results of successful studies have not been broadly applied in production, especially in the extension program for millions of farm households involved in the "Green Bare Hills" program of the State.

Wood and forest products processing has not been developed yet. The value of forest products exported in raw form is still low, with little value added.

In short, science research has not met the demands of production and forest resources management.

Policy and management system is still ineffective

In recent years, some of the policies and laws on forests that have been promulgated by the Vietnam State and Forestry sector have had a great contribution to the completion of the forestry policy of Vietnam. For instance, laws regarding on land use, forest resources protection and development, and environment protection have all been completed recently. However, written guidelines for the implementation of these laws are still missing.

At the same time, there have been many upheavals in the institutional and administrative management bodies, as responsibility has shifted from the central to the local level. Other related bodies and business institutions also have not been stabilized yet.

Inadequate infrastructure

In Vietnam, the economic situation in forested areas is less developed, with a lack of roads and other social services.

Science research units, business enterprises etc. have not been fully equipped and most equipment is out of date.

PART II: Fundamental Objectives of the Forestry Sector to the Year 2000 and Orientation for Long Term Development

Objectives and Development Orientation

According to the report on forestry development strategy to the year 2000 and the orientation for subsequent phase - 1993, Tropical forest action plan - 1991, as well as the report of Prof. Minister Nguyen Quang Ha - Renovation of forestry development strategy to the year 2000, groups of issues can be summarized as follows:

1.1. Protecting and managing effectively existing forest resources and land to meet the demands of forest products, ecological environment and biodiversity with a long term perspective.

It is estimated that 8.6 million ha. of natural forest and 0.7 million ha. of plantation forest should be strictly protected; 5 million ha. of timber and industrial trees should be newly planted and millions of hectares exhausted forest should be rehabilitated.

1.2. Using forest resources economically and rationally: Increasing forest productivity (both natural and plantation) to contribute to national economic development.

- Increasing the present utilization of stumpage trees from less than 50% to 70%.
- Elevating the present growth of natural forest from 2 m3/ha/year to 4 m3/ha/year and of plantation from 5-6 m3/ha/year to 10 - 15 m3/ha/year.
- Expanding the area of special use forest to over 2 million ha. (including national parks, natural sanctuaries etc.).

1.3. Encouraging the participation of farmers and other economic sectors (state, co-operatives, households, private etc.) in forest protection and development At present, the total area of natural forest are:

- Under state management 4.6 million ha.
- Under co-operative management . 0.397 million ha.
- Under household management 0.014 million ha.

Millions of hectares of barren land and exhausted forests will be allocated to households for management and utilization.

1.4. Making contribution to the improvement of living conditions and income generation for people in rural areas, especially in mountainous areas;

- Getting 1 million households involved in forestry business utilizing agroforestry methodology; job creation for 2 million laborers.
- Incorporating fixed cultivation and sedentarization of ethnic minorities with forestry program.

PART III: Main Forestry Policies

I. Overview of some of the laws and decisions related to forestry policies in Vietnam

To achieve the main objectives stated in the Part II, some laws and regulations have been promulgated by the State of Vietnam, of which the most important are:

- Law on Forest Protection and Development
- Law on Land
- Law on Natural Resources and Environment Protection
- Decision 327 - the national program of forest protection and greening bare hills.

1. Law on Forest Protection and Development

This law includes,

Article 3: Natural and plantation forests that use state funds belong to the State.

Article 4: Investment in the form of labor, material, funds, technology application from all organizations involved in afforestation, forest protection, forest products exploitation and processing will be encouraged.

Article 5: "Every citizen has obligations of forest protection and development, ecological environment protection."

Article 6: Any activity destroying forest resources is strictly prohibited.

Article 7: Based on regulations of utilization, forests are classified as follows:

- Protected forest
- Special use forest
- Production forest

Decisions on defining forest types, changing utilization purposes of this type of forest to another will be made by competent state bodies.

The Ministry of Forestry has so far defined,

Total forest area : 18.6 million ha, of which:

Protected forest : 6.0 million ha.

Special use forest : 2.0 million ha.

Production forest : 10.6 million ha.

The above law also has separate chapters and regulations for each type of forest. This is the fundamental law dominating activities within forestry sector.

2. Law on Land

This law affects every Vietnamese citizen, and supports forest protection policies in many facets. There are some articles that should be noticed, in particular:

Article 3:

- Legal rights and interests of land users will be protected by the state.

- Households and individuals allocated land by the state have rights to change, release, mortgage and inherit land use rights.
- The State should have policies to secure that farmers get land for agriculture, forestry and aquaculture production.

There is also an important policy regarding land and forest allocation on the basis of the Law on Land and the 327 program.

3. Law on Natural Resources and Environment Protection

This law reserves one chapter of 5 articles for forests in which it is clearly defined that forest resources consist of:

- Natural forests, including coastal and mangrove forests.
- Plantation forests, including industrial trees.
- Shrub vegetation of formerly existing shrubs.
- Trees concentrated in rural and urban areas, tree planting along roads, canals, lakes, pools.

Article 21: There are regulations against:

- Forest destruction for fuel wood, for exploiting forest products, animal hunting, collecting valuable forest products contrary to the laws and regulations of the State.
- Slash and burn practice in natural forests and plantation for agricultural production, residence, construction or other purposes without the permission of competent offices.
- Causing forest fires.
- Polluting the forest, affecting the existence and growth of forest fauna and flora.
- Causing flood or swamp in forests, making forest and forest land poor by irrational water conservancy methods.
- Causing bad effects on existence and growth of rare and specious fauna and flora by the destruction of environment, living and migration cycle of creatures in forests.
- Breaking regulations on nature and environment protection in National Parks and Sanctuaries.
- Affecting the landscape and environmental quality in urban and project areas by the cutting of trees.

There are also 5 articles for animal and plant life, an important part of the forest ecosystem.

4. National Program on forest protection and Green Bare Hills

The following are the main contents:

- Planning forest land use and forest land allocation for long term utilization (land will be allocated to some 4 million farmers living in mountainous areas) to encourage farmers to become interested in forest protection and soil and water conservation, whereby they can produce many agricultural and forestry products to meet their daily needs.
- Promoting extension services to assist farmers in using land for the long term.

- Developing rural credit, soft loans, and support for infrastructure development; for example, the construction of roads, bridges, water conservation systems, drainage systems, communications and electricity supply networks.
- Training and fostering program officers. This program has been implemented since 1993, and there are 1,200 projects approved by the State, with an annual program fund of 600 billion Vietnamese Dong (equivalent US$5.5 million).

II. In relation to forestry policies

The policy system plays an important role in the renovation process. Within the forestry sector some of the policies in the "Renovation of Forestry Development Strategy to the Year 2000" report by Minister Prof. Nguyen Quang Ha include:

- Land allocation and forest lease;
- Incentives for forestry investment and development,
- Price,
- Science and technology;
- Extension,
- Rural and mountainous development.

1. Land allocation and forest lease

This is a key policy, and affects many development fields within the forestry sector.

According to this policy, production forest lands are partially allocated to farmer households; depending upon the amount of land and the working capacity of each region, each household will receive some 2 - 5 hectares of sloping land with a term of 30 - 50 years. Hopefully with the financial support of the State, rural poverty will be eliminated in one to two decades and deforestation will be stopped and people participating in the green bare hill process for natural forest protection and rehabilitation will be mobilized as well.

Millions of hectares of hilly land have been allocated so far. Many household-based farms have been established in which forestry, agriculture and aquaculture are combined, improving people's living conditions and have contributed to forest ecosystem preservation.

However, to implement such an important policy, time and financial support are required. (In order to obtain a land and forest allocation file, it costs about 20,000 VND/ha.). Besides, farmers, especially in ethnic minorities need capital support and general knowledge especially on products preservation. Unfortunately, these policies have not been carried out simultaneously with land allocation and forest lease.

2. Incentives for forestry investment and development

Investment policies have been changed, to replace the previous diffuse and disjointed ones;

The State budget concentrates only on protected and special use forests (protection of water resources, coastal areas, National Parks and Sanctuaries), seedling forests, and environmental forests for urban and industrial areas. Production forests with high value species require a rotation of more than 20 years.

Apart from a.m. forest types, credit with low interest rates will be provided to business enterprises (State and private etc.). At the same time, the State encourages every economic sector to invest in plantation forestry, and gives out land and tax incentives.

This policy has the following advantages:

- Uses the State budget efficiently, focusing on fields "for the long term interest of the country"
- Promotes flexibility of business enterprises (especially state enterprises used to subsidy).
- Attracts capital from investors at home and abroad. However, in the forestry business, especially plantations, the shortest rotation takes at least 10 years, and the attractions to investors are limited.

3. Price policy

The price of forest products should include both exploitation, transportation, processing costs and the cost of the reproduction of forest resources. In addition, the State should form a policy for the price support of forest products to ensure that producers, especially farmers, are protected from bankruptcy.

Some forest products, in particular sawn timber and fuel wood have been strongly affected by the present market, where the selling price is not enough to cover costs of reproduction, even for plantation timber. On the other hand, the price of several products are too high resulting in over-exploitation and the destruction of forest resources: for instance, POMU, sandal wood, and several kinds of animals and pharmaceutical plants.

The price should be regulated by the State through tariffs, and producers should be assisted through market information, and strategic planning support (domestic and abroad).

4. Renovation of science and technology

4.1. Plantation forestry,

- Defining appropriate crop structures to be applied in each ecological zone, paying attention to indigenous species.
- Improving seeds and applying biotechnology to seedling production.
- Applying techniques of intensive farming to concentrated plantation forestry to improve forest productivity, focusing on mixed plantation and agroforestry.

4.2 Applying improved forecast methods for the prevention of forest fires and disease.

4.3 Forest exploitation should be in accordance with regulations: design and appraisal before cutting and examination after cutting. The volume of exploitation (timber and other forest products) can not exceed the forest growth.

4.4. Applying modern equipment and technology in the processing of forest products to save material and improve the value of products.

4.5. Establishing farming models on sloping land for each ecological zone, aiming at environment protection and extension for people.

5. Development of extension network

In order to facilitate farmers involved in forestry business, especially farmers from ethnic minorities, the State will promote extension activities to provide information about policies on land allocation and forest lease, basic articles in the Law on Land, and Law on Forest Protection and Development. Information on the investment and support policies of the State as well as techniques etc. should be transferred to farmers.

It is important, first of all, to form an extension network at the local level; there should be one technical worker with the organizational and mobilization capacity for an average of 50 households. This worker will receive an allowance to develop specific investment projects.

The improvement of people's knowledge is an urgent task and requires a lot of time and effort. It has to be carefully applied in each target group. Each region has different geographical and socio-economic conditions and, first of all, a group of competent staff are required.

6. Policies for rural mountainous development

Rural areas in Vietnam, especially in mountainous regions, are generally less developed. The State of Vietnam launched a broad program on this issue, consisting of the following objectives:

- Developing agricultural production to meet local demands, combining staple crops cultivation and animal husbandry for meat, dairy, fruit trees, vegetables and so on.
- Paying attention to health care for preventing malaria and goiter, and supplying clean water and health care services.
- Education and extension should be provided to improve people's knowledge. In the coming years, primary universal education for juveniles should be completed. Secondary universal education for local leadership should be completed.
- Building infrastructure, primarily, roads and an energy supply system. The above objectives are enclosed within key programs of the State, for example the credit program for hunger elimination and poverty alleviation, and the Green Bare Hills program.

Experience has shown that the achievements of forestry projects/programs in Vietnam need not only policies and appropriate regulations as stated above, but also a specific action plan with an effective executive board, as well as financial resources strong enough to attract people to become involved. All these challenges have been facing the policy makers of the forestry sector.

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COMMUNITY RESOURCE MANAGEMENT IN NAM NGUM WATERSHED, LAO PDR

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Introduction

Natural resource management is central to the economic, social and environmental well-being of the Lao People's Democratic Republic (Lao PDR). More than 80 percent of the country's population depends directly on land, water and forest resources for mainly subsistence-based livelihood. Most of the country's foreign exchange earnings are derived from forest products and hydroelectricity sales. Rapid changes in the country's economy, combined with other factors including population growth, have led to increasing pressures on the country's natural resource base.

Although the natural resource endowment of Lao PDR is relatively healthy when compared with its neighbors, environmental degradation resulting from resource competition has become evident and has received attention at many levels. While the legacy of war and population growth are generally recognized as causes of stress on the country's ecosystems, institutional aspects have received less attention.

Many aspects of resource competition and related environmental degradation are closely linked to common property resource management. Common property in Lao PDR has historically taken a number of forms. Traditional patterns of community resource management and demarcation involve common property and cooperative management of forest, water and land resources, and these continue to play an important part in local resource management practices. After 1975, the new regime socialized production, in theory making all resources common property; in reality, limits to collectivization of land and the State's limited scope for management of land and forest resources meant that local and traditional systems of tenure and management persisted.

Thus while many resources are in principle the property of State, traditional tenure and management system have continued to vest local communities with an important role in management of land, water and forest. Until recently, this was acknowledged but not formally recognized. Informal arrangements were often acceptable and adequate means of avoiding problems of open access. However, since 1987 the country has undergone significant economic change, involving a move toward an open market economy. Resources are increasingly seen as commodities, potentially as earners of export income or as attraction for foreign investment. This has significantly increased the pressure on State property. A key priority for Lao PDR is clarification of the rights and responsibilities of local communities in issues of resource tenure and management, including demarcation and protection of forests.

This paper is a preliminary report on the research project investigating resource management in the Nam Ngum Watershed in Lao PDR. The research has involved a survey of 176 villages in the watershed area, combined with a more intensive participatory study of resource management in two adjacent communities in the northeastern edge of the Nam Ngum reservoir.

The focus of the study was emerging resource conflicts within and between communities, together with resource competition between communities and external claimants on local resources, in particular, forestry activities and the hydro-power sector. Many of the conflicts involve common property resources.

Nam Ngum Watershed

Nam Ngum Watershed is of special economic and environmental importance to Lao PDR. The country's three main resource sectors are represented strongly here, namely hydro-power, forestry and subsistence agriculture. In many instances, competition is evident between and within these sectors. Environmental degradation is of particular concern to the country's policy makers, given the importance of the Watershed's ecological integrity to the country's long-term economic well-being.

The Nam Ngum Watershed covers some 8,460 square kilometers, or 3.6 percent of the national area. It includes all or part of six districts in two provinces (Xieng Khouang and Vientiane). Topography is dominated by sharp relief, with altitudes ranging from 198 meters (minimum level of the Nam Ngum Reservoir) to 2,820 meters at Phou Bia, the country's highest peak. The lower part of the Watershed shows the sharper relief, as the upper section is dominated by the Xieng Khouang Plateau including the Plain of Jars. Much of the area is inaccessible. The Nam Xan Valley has been linked by road to the capital, Vientiane, since 1992. Xaysomboon District is accessible via Routes 13 and 13B. Only Xieng Khouang has something of a road network, but it is poorly connected (via Route 7) to the rest of the country.

Many of resource pressure evident in the Nam Ngum watershed are representative of problems found more widely in upper watershed areas throughout Lao PDR. the watershed areas feeding the Nam Ngum river is also of great importance to the country to its own right of generating electricity.

Within the watershed are about 200 communities of lowland (Lao Loum), upland (Lao Theung) and high land (Lao Soung) ethnic status. They include both wet rice farmers and shifting cultivators, most of whom practice subsistence-oriented livelihoods. All these cultivators rely heavily on local land, forest and water resources. Near the Nam Ngum reservoir and the large rivers (particularly Nam Ngum and Nam Xane), several communities are dependent of fishing for a significant part of their livelihoods.

Forestry is another important activity in the Nam Ngum Watershed, in part reflecting the growth of commercial forestry as a foreign exchange earner for Lao PDR. The largest scale logging activities are in and around the Nam Ngum Reservoir, but there are more local logging activities above the reservoir in several of the Districts within the Watershed. Logging activities are carried out by foreign investors (mainly Thai and Malaysian companies involved in joint ventures), provincial and district level companies, and private businesses.

Nam Ngum Watershed thus represents a wide range of resource uses and users. As indicated above, the watershed is significant in its own right, but in addition it reflects problems of resource management found more widely in Lao PDR. Many of these problems result from increased competition over a limited resource base. Competition exists at a number of levels: between communities, between lowland and upland cultivators, between local and external claimants of resources and between different resources sectors.

To understand current problems of environment and resource management in Nam Ngum Watershed, it is important to look at the history of the area. Lasting physical and social effects of the war are still evident. War damage was especially heavy on the Plain of Jars in Xiang Khouand

Province, but other areas also suffered destruction of forests and villages. Aerial bombardment destroyed agricultural lands, and forestry continues to be affected by chemicals used in the warfare; the northeastern part of the watershed in particular was effected by "bombies", i.e. bomblets from cluster bombs that still lie unexploded in the soil. No inventory of damage has been made to date, but remaining live munitions continue to cause injury or death to local people working their fields. Large areas are rendered uncultivable two decades after the cessation of bombing.

Environmental destruction also occurred as a result of the support given by the United States to the Hmong General Vang Pao and his counter-revolutionary Hmong army. In the 1960s and early 1970s, an attempt was made to create a buffer zone centered on Xaysomboon district, involving some 40,000 tribes people. This involved the clearing of more than 100,000 hectares of forest, for cultivation and to remove cover for the Naew Lao Hak Sat (Pathet Lao) revolutionary forces.

As a result of disruption caused by the war, many people moved outside the watershed area, either to lowland areas close to Vientiane or to revolutionary strongholds close to the border with Vietnam. This itself led to forest clearance for cultivation, but following the war it also encouraged renewed environmental destruction within the watershed. This was because the returnees' rice fields had been destroyed, as had their buffaloes and other farm implements. This meant that for many years after 1975, former sedentary farmers relied on shifting cultivation, often in those areas of forest not badly affected by the war.

The continuing impact of war-time disruption of communities and ecosystems is reflected in the recent return of villagers who had fled the war. Many are now reclaiming agricultural lands abandoned during the 1960s and early 1970s. This is promoted by the economic reforms, notably the breaking up of the cooperatives and return to the family household economy as the basic unit of production. In parts of the upper watershed areas, this is leading to increased competition for the limited land and other resources on which local people continue to depend.

Lower parts of the watershed are experiencing resource pressures and competitions as a result of settlement since 1978. In particular, Mouang Hom district was targeted as a potentially productive and accessible area for resettlement of Hmong families displaced by the war, many of whom had fought on the revolutionary side. Recently, pressures in Mouang Hom have increased greatly as a result of settlement of large numbers of people than can be accommodated by the limited area suited to wet rice cultivation, and by the commercial exploitation of timber—notably eagle wood (genus *Aquilaria*) and non-timber forest products. Mouang Hom includes communities in the Nam Xane valley and also several villages settled near to the Nam Ngum reservoir.

Policy Background to Resource Management in Lao PDR

Many of historical and current problems of communities and ecosystems in the Nam Ngum watershed and elsewhere in Lao PDR are a product of rapid change, and of factors beyond the control of individual communities. In order to stabilize both livelihoods and environment, there is an urgent need for attention to institutional aspects of resource management to help communities cope with change and the range of pressures on their resource base.

Institutional support for tenure and management of forest resources are particularly important. There have been important changes in government policy relating to community rights and responsibilities over forest resources. In the past, problems have sometimes been a result of unsuitable policies, but often they have also arisen as the result of problems with interpreting and implementing policy at the local level. Nevertheless, recent developments in community forest

policy point the way to enhance local control over resource and community rights and responsibilities in local resource management. An important question is the extent to which such policy is compatible with traditional patterns of community forest management.

There have been important changes in government policy since 1975. The socialist economic management principles adopted following the political changes of 1975 meant that all natural resources were treated as national common property, with management and utilization the responsibility of the State. In principle, production was organized through State farms or collectives, with no provision for a private or individual role in occupation and management of resources. This was combined with a policy to promote food self-sufficiency in each locality, leading to a distorted incentive and taxation system, compounded by weak government planning and monitoring. Forest destruction and unsustainable utilization of natural resources were a direct result of application of these policies.

Since 1989, the government has revised its natural resource management policy as a result of growing concern over destruction of natural resources and the country's environment. Under the revised policy framework, natural resources such as forest, land, water and wildlife are still considered national common property for which the State maintains overall management responsibility, but participation of individuals and communities is encouraged. Particular attention is given to the village community and its role in resource management.

Current policy initiatives include the following:

- A Prime Ministerial Land decree No. 99, dated 17 March 1993.
- Strengthening of village forestry services within the Department of Forestry and issuing of the village forestry management regulation by the Ministry of Agriculture and Forestry.
- A pilot program on consensus land use planning in selected villages.
- A new decree on Forest and Forest Land Management No. 169, dated 3 November 1993.

These revised policies on natural resource management, particularly their support for village level management, are promising in many respects, although difficulties remain in a number of areas. The new policies are being implemented in a context of rapid economic change, which means that there are uncertainties regarding both individual and community tenure over resources. Continuing weaknesses in district level administration means that policy set at a national level is not easily applied or supported more locally. Understanding of national policy changes at a local level is still very vague. Moreover, policy is often made and implemented on the basis of relatively sparse knowledge of physical and social parameters of resource use, suggesting that information systems need to be improved. Need for detailed local knowledge also requires structures to enhance community involvement in resource planning at a wider level where it impacts on community resource management.

Resource Use: Land, Forest and Water

While there is a general association between land use and ethnicity, the relationship is less fixed and more ambiguous than sometimes assumed. It would commonly be expected that ethnic groups classed as Lao Loum would be mainly wet-rice (*na*) farmers, Lao Sung would be mainly shifting cultivators (*hai*) and Lao Theung carry out the two together. However, about one third of the villages surveyed depart from this pattern. Table 3 indicates the relationship between main occupation and ethnicity, and it can be seen that more upland villages depend mainly on wet rice

farming alone as the main occupation than on shifting cultivation alone. Conversely, several "lowland" villages depend mainly on *hai*. "Midland" villages, as might be expected, depend on a combination of *na* and *hai*.

Shifting cultivation in the Watershed includes both rotational practices and clearing of old-growth forest. Rotational shifting cultivation involves fallow cycles of between two and seven years. Cycles in the lower part of the Watershed, including in most reservoir-edge communities, are particularly short. In most cases, shifting cultivators plant upland rice, but maize and cassava are also gown in swiddens, as is a range of subsidiary crops.

Wet rice cultivation is practiced wherever possible, but there are three major constraints. The first is topographic suitability, since much of the Watershed is steeply sloping land. The second constraint is water for irrigation. The third, and related constraint is labor, since creating new rice fields, particularly steeper terraces and associated channel-weir irrigation systems (*meuang-faai*) requires intensive effort in the absence of mechanical assistance.

Non-timber forest products provide an important resource to many communities in the Watershed, particularly those in the lower section. Many rely on bamboo; of those who rely on sawn wood, villagers in Xieng Khouang mainly depend on pine, while those lower in the watershed rely on hardwood species. Fuelwood is the main source of energy in all communities surveyed. Some 79 percent of villages supplement their diets with forest foods, while 81 percent use traditional medicines collected from the forest. Those unable to supplement dietary and health needs from nearby forest are mainly located on the grasslands of the Xieng Khouang plateau. In the lower parts of the Watershed local people derive cash income from forest products; this is due to a combination of availability and accessibility to markets. In some cases, commodification of non-timber forest products has led to non-sustainable rates of exploitation, particularly in Hom District.

Shallow wells supply domestic water needs for the majority of communities. Of those for which data is available, 73 percent have weirs as sources of irrigation water to supplement rainfall. Most irrigation systems in the Watershed are constructed manually of local materials, typically involving the building of a weir across a small stream to divert water into a channel that feeds ditches to individual fields. Management of irrigation systems is on a joint basis. Most communities have at least one weir, and majority have two or more.

Is sum, therefore, Nam Ngum Watershed represents a wide range of resource uses and users at the village and other levels. Land, forest and water are used in various ways for subsistence and commercial purposes. The largest and most prominent single resource user in the Watershed is the Nam Ngum Dam itself.

Nam Ngum Dam

Nam Ngum Dam generates most of Laos' electricity, including all the power used in the capital, Vientiane. Even more important is the 70 to 80 per cent of the electricity that is exported to Thailand, accounting for about a quarter of Laos' foreign exchange earnings.

The Nam Ngum Dam was completed in 1971. It was financed with assistance from ten countries under the auspices of the United Nations and constructed by a Japanese firm. The dam has a hydro-electric generating capacity of 150 megawatts. The reservoir covers an area of at least

370 square kilometers[1] and has a capacity of about 7 billion cubic meters. Officially, some 3500 people lived in communities inundated by the dam, but this is most likely an under-estimate, given the difficulty of carrying out surveys during the wartime conditions prior to the dam's completion. The conflict also prevented removal of much of the inundated vegetation, so that several hundred thousand trees and stumps dot large areas of the reservoir.

Nam Ngum Dam is a resource user in a number of respects. Most directly, water used to generate hydro-power makes a significant contribution to the national economy. The reservoir occupies what used to be a fertile land and forest resource, and communities affected by the flooding continue to suffer direct or indirect consequences a quarter of a century later; this is illustrated further in the case of Namon.

The case of Nam Ngum is important in its own right, but also as a baseline for planning watershed management for future hydro-electric schemes. Lao PDR is likely to expand its hydro-power potential considerably in coming years, but there is still inadequate planning and limited understanding of the complex social and physical linkages within watersheds that result from, and in turn affect, hydro-electric schemes.

Resource Tenure and Management

Patterns of tenure have a significant bearing on resource management in Nam Ngum Watershed. Resource tenure refers to rights and responsibilities over resources devolved to particular resource users. Such users may be individuals, households, groups of households, communities, cooperatives, or state agencies. As tenure arrangements have changed, so have key parameters of resource management. Many of the pressing issues regarding tenure, and hence management, of resources revolve around the issue of common property. Many ambiguities in common property management are best understood in terms of changes that have affected Lao PDR in general, and Nam Ngum Watershed in particular, over the past few decades.

5.1. Management Structures

Resource management in the Nam Ngum Watershed depends in part on administrative structures and in part on arrangements specific to particular resource uses. The Watershed covers parts of two Provinces, or *Khwaent* (Vientiane and Xieng Khouang) and all or part of seven Districts, or *Meuang* (Phukood, Paek, Xaysomboon, Hom, Vangvieng, Kaeo Udom and Tulakhom). Each District is divided up into several Sub-districts, or *Khet* (formerly known as *Tasseng*). Provincial authorities are responsible for transmitting central government policy measures to Districts. In the area of resource management, provincial authorities are only concerned directly with larger scale operations, for example, larger sawmills or resettlement programs. The District-level administration is more directly involved with resource management; for example, if village authorities wish to use an area of forest for a particular purpose, District authorities' consent is required. District officials are sometimes called on to adjudicate in disputes between communities over land and forest boundaries and infringements by outsiders. Districts thus play a key role in local resource management decisions. There is, however, still only limited expertise at the District level in this field and most Districts are severely understaffed. District authorities therefore lack resources for detailed and regular consultation, particularly in more remote villages. Sometimes, this means that District staff have to rely on written directives. Alternatively, villagers' problems

[1] Discrepancies exist between the official figure of 370 km^2, the Mekong Committee figure of 450 km^2 and the figure 555 km^2 calculated by the current study. These discrepancies go well beyond those that might be accounted for by differences in assumed water levels.

can sometimes only be aired through petitions to the authorities. Sub-districts tend to serve as representatives of the District authorities in their immediate areas.

At the village level, there are two main formal organization structures. The Village Committee, or *Khana Baan* is the primary body responsible for day-to-day administrative affairs. It also takes on responsibility for administration and adjudication of traditional resource management rights and responsibilities. The Committee thus plays a key role in both local, vernacular resource management affairs and more formal initiatives passed down through the District. The *Naew Home*, a kind of council of elders, provides advice to the Village Committee and is also often involved in adjudication conflict in areas including resource management disputed. A village head in each community, elected every two years, heads the Village Committee.

Administrative structures in Lao PDR are in a state of flux, reflecting the wider economic and associated political reforms of the country. There are moves both in the direction of centralization and decentralization, with important implications in the field of resource management. Centralization is occurring in particular with regard to reducing the autonomy of provinces to raise revenue from forest concessions. Key management functions are also being centralized within the Department of Forestry. On the other hand, forest management and community forestry initiatives point toward an enhanced formal role for village communities to manage local resources, which would nevertheless formally remain State property.

The pace of change in formal structures needs to be set against long-standing mechanisms for resource management at the village level. The extent to which traditional structures can serve as the basis for strengthening local resource management is an important aspect of the current study.

In the existing forest management arrangements, it can be said that community level forest management is almost ubiquitous. A range of rules and prohibitions, usually differentiated between locals and outsiders, defines the rights and responsibilities in use of local forest resources for various purposes. In many cases, local management rules are combined with government regulations. A village forester is sometimes elected. In most cases, forest is managed at the community level, but in some villages individual households are devolved the responsibility for looking after small areas. Enforcement involves a range of fines and other penalties that also sometimes involve formal authorities. Enforcement procedures are best established in the longer settled communities in the upper part of the watershed.

Water management for domestic use is normally at the household level, with most relying on well water and nearby streams. Irrigation is organized communally, sometimes among a few households, sometimes at the community level, depending on the size of system. The largest scale of water management is the Nam Ngum Dam itself. In this case, releases from the dam control the reservoir level, and at present this is carried out in the absence of consultation with surrounding communities. In 1993, a rise in the water level led to flooding of lower lying rice fields at the reservoir edge.

Other than Provincial, District and village level structures, resource management responsibilities rest also with particular agencies. In particular, Electricite de Laos, which is responsible for operating Nam Ngum Dam, is a major resource user and has a vested interest in avoiding patterns of resource use that lead to environmental degradation above the dam. To date, a good deal of attention has been paid to the areas immediately surrounding the reservoir, but less to the upper parts of the Watershed.

Physical Change in Nam Ngum Watershed

There are few baseline data for assessment of physical change in the Nam Ngum Watershed area. Declining water flows into the reservoir are a subject of concern above. The Watershed survey gives indications of changes at the village level that help in part to explain Watershed level changes.

Land use change for agricultural purposes can be indicated by means of two variables. The first is the opening up of new areas for wet rice cultivation. The second is the rotation period for shifting cultivation. Areas with shorter rotation cycles are those where pressures tend to be greater and vegetation clearance more pervasive.

Change in forest cover is reported in all villages, and great majority of villages report a decrease in forest cover in recent years. There are clear differences in the background to forest clearance in different parts of the Watershed. In the Xieng Khouang section, war and its aftermath are important, while in the lower section a combination of population increase (in part through immigration) and shifting cultivation are the main attributed causes. In Hom District in particular, logging is reported to be an important cause of forest loss

Streamflow change at the Watershed level is evident by the reduced inflows to the Nam Ngum Reservoir. Change in volumes and seasonality of streamflow is closely related to land use and forest cover changes. It is one of the important physical linkages between upstream conditions and management of the Nam Ngum Dam.

Resource Use: Competition and Conflicts

A basic objective of the Nam Ngum Watershed Resource Management Study has been to examine emerging resource competition and conflict resulting from changing resource use patterns. The underlying research question, as originally conceived, was how existing and changing patterns of resource use at one level, in one sector, in one community or among one particular ethnic group may impact on resource strategies and constraints for other levels, sectors, communities or groups. This has meant investigating competition between communities, between lowland and upland cultivators, between local and external claimants on resources, and between different resource sectors.

Many aspects of resource competition and related environmental degradation are closely linked to common property tenure arrangements. Common property in Lao PDR has historically taken a number of forms. Traditional patterns of community resource management and demarcation involve common property arrangements and locally organized cooperative management of forest, water and land resources. The role of the state has shifted with the substantial changes that have occurred in Lao PDR during the past several decades, from the colonial state, through the US supported Royal Lao Government, the period of fragmented and shifting authority of the war years, the period of socialist management after 1975, and the reforms since the mid-1980s. Nevertheless, a continuous tension and ambiguity has been the question of state versus local rights and responsibilities over land, forest and water resources.

Watershed Level Issues

Competition and conflict over land is closely related to land uses. The pattern of land use in different parts of the Watershed varies according to the proportion in each community of those practicing the major agricultural occupations: shifting cultivation only, wet rice farming only and a combination of the two. Shifting cultivation predominates more heavily in central and lower parts of the Watershed, while wet rice farming dominates on the Xieng Khouang plateau.

Land and forest allocation at the community level relies on clearly defined boundaries. While village committees in most of the communities surveyed were quite clear and consistent with their neighbors in identifying the natural features that serve as dividing lines, there are several areas of conflict. Most of these cases are in Pack District in the upper part of the Watershed. Moreover, in many of the villages surveyed, rules were said to be difficult to enforce due to a reluctance to upset relations between communities, and it was often suggested that government regulations and assistance with enforcement might help to overcome such problems.

While certain conflicts exist between neighboring communities, more substantial problems exist as a result of recent migrants' demands on local resources. Migration has been a problem for many communities. The related problems of land shortage and population pressure were most commonly mentioned, although pressures on other aspects of livelihood such as fishing and livestock were listed as the major issues elsewhere. It should be noted that the responses indicated in this map are only the main problems mentioned, whereas the diverse and integrated nature of livelihoods suggests a more complex pattern.

Certainly there are tensions between Hmong and lowland Lao communities, and many of these derive in part from shifting cultivation practices that place pressure on forest and water resources of importance to lowland cultivators. However, there are many instances of Hmong communities where wet rice farming has been adopted, particularly in the lower part of the Watershed, and here similar tensions with upland farmers are apparent even when there is not ethnic conflict involved. Sometimes ethnic differences can serve to highlight or exacerbate resource competition, but more often the root of the problem lies in incompatible production systems rather than ethnic differences in and of themselves. Moreover, incompatibility of upland and lowland cultivation has been often exacerbated by resettlement, which means that ultimate causes of conflict may be exogenous. Attention to tensions between Hmong and Phuan farmers thus needs to treat ethnicity as symptomatic rather than a fundamental cause of conflict.

Another important issue at the Watershed level is competition between national and local interests. In the case of the Nam Ngum Watershed, this is highlighted by the demands of the Dam. The Nam Song and Nam Leuk schemes are serving to highlight such competition in the case of reservoir-edge communities. At present, there are few institutional channels for weighing up and coordinating the range of interests. In future, this is likely to be important issue in impact assessment and compensation arrangements for large scale resource projects.

District Level Issues

Certain factors are relevant at a Watershed level. However, physical, social and economic conditions vary considerably from one part of the Watershed to another, so that there is a danger in taking a too generalized approach to resource management. Key issues can be isolated at the District level for each of the five main Districts in the Watershed.

Hom District

The Nam Xan valley witnessed a high rate of immigration by displaced Hmong after the war. In some cases, newcomers cleared forest for cultivation,; in others, they occupied lands abandoned by lowland Lao. Recently, some of the original inhabitants have started to return to claim land. Hom District has limited valley land, most of the area being marked by sharp relief. Shifting cultivation at the heads of streams has become a problem for those dependent on natural streamflow for wet rice irrigation. Another issue in some localities in Hom District is the cutting of forest to supply small sawmills. The relative accessibility of the District provides a ready market for non-timber forest products, which have declined markedly as a result.

At the reservoir edge a particular set of problems arises from the situation of fisher-folk who have come from other provinces. As the fishery resource has declined, many have taken up shifting cultivation under a situation of uncertain tenure. Tenure uncertainties discourage sustainable land development. Similar problems have arisen with resettlement of Hmong from upland areas to the reservoir edge in the expectation that they can adapt to fishing as a main source of income; almost invariably, Hmong in communities such as Don Seua have ended up clearing forest on steeper slopes above existing villages as a means of subsistence.

Vangvieng District

Vangvieng is similar in some ways to Hom District. Fisher-folk attracted to reservoir edge communities have ended up clearing forested slopes for upland rice cultivation. Soils in the part of the district within the Watershed are thin and of low fertility.

Xaysomboon District

The wartime history of Xaysomboon District helps to explain the main resource management problems faced today, notably the clearance of forest with settlement of large numbers of Hmong. Their is little forest remaining in some areas. Several of the communities are very isolated, and there are continuing problems of access.

Phukood District

In Phukood District, intensified settlement along streams and construction of rice terraces to heads of valleys has contributed to water shortages for downstream communities. In some cases, streams have ceased to flow below the terraces. Another difficulty is resettlement of state employees into some areas of neighboring Paek District, which has led to intensified cutting of wood in Phukood for house construction and firewood. Minor conflicts have also arisen due to timber demands of small sawmills. Particular problems arise where Hmong have been resettled close to Phuan communities, sometimes destroying remaining forest as there are usually insufficient wet rice areas for Hmong newcomers.

Paek District

There is very little forest remaining in Paek; that which exists is mainly pine re-growth. Paek villagers face more difficult living conditions than those in Phukood. Most of the land is open grazing land. Problems include livestock disease, and soil is low in fertility due to lack of manure resulting from wartime loss of livestock. Live munitions in the soil continue to be a hazard. Farmers in some communities cannot use hoes in places. Paddy yields are low, less than one ton per hectare without fertilizers. Hmong resettlement immediately upstream of Phuan settlements has led to water shortages. Competition over water is most acute in cases where weirs have been built upstream of established villages. A particular problem of Paek District is that of overlapping village boundaries. In recent years, some of the Phuan who abandoned land during the bombing have started to return to reclaim abandoned lands, in some cases coming from Vientiane.

Local issues: Namon and Houai Nhang

Just as Nam Ngum watershed is representative of wider problems of resource management and common property definition and demarcation in Lao PDR, so the problems within the watershed can be examined close-up by reference to one locality. The area in and around the villages Namon and Huai Nhang in Hom District represents in microcosm many wider aspects of resource competition and resulting stress in the human ecology of many communities and the ecosystem of which they are a part.

Namon is a lowland Lao village of 57 households on the northeastern edge of the Nam Ngum Reservoir. Until the late 1960s, the villagers of Nasagha farmed productive wet rice land and made a subsidiary livelihood from the abundant surrounding forests. In the late 1960s, there was ground fighting in the area, between Neaw Lao revolutionary forces and the US supported Royal Lao Army. The village was bombed by American planes and crops were sprayed with herbicides. The villagers had no option but to flee into the mountain above the village, where they remained for several years. By the time they were able to return, the reservoir had been completed (the dam was sealed in 1971) and Nasagha was under several meters of water.

Most of villagers settled at the present site of Namon, and reconstructed their livelihoods on the limited area of land between the reservoir edge and the slopes of Phou Houad foothills which could be leveled and irrigated. Stone weirs were built in the streams above the fields, and channels dug by hand to bring sufficient water to the fields for annual cropping. In addition, rotational swiddens were established near the forest boundary and seasonal grazing of livestock in draw-down area of the dam has also helped to supplement livelihoods, as has fishing and vegetable gardening.

In the early 1980s, as a result of resettlement program several Hmong families settled close by at Houai Nhang, adjacent to Namon. These Hmong settlers also cleared wet rice fields. They had come from Phou Houad, having earlier migrated from Xiang Khouang after losing their homes and fields to US bombs in the late 1960s and early 1970s. From the point of view of the Hmong, access to basic medical services was an important reason for settling in the area. Many families have since settled, and there are now 60 households in Houai Nhang.

The settlement of Hmong farmers who arrived later has been associated with a number of problems. While there is still substantial natural forest close to Namon and Houai Nhang, it has thinned noticeably, and latecomers have had little choice but clear upper slopes for swiddens. Namon Villagers report a significant decline in seasonal streamflow, with several of the streams that used to flow year-round now dry for several months of the year and, more significantly, with insufficient water during parts of the annual rice cropping season. This has been the source of some tension between the two villages.

The problems emerging at Namon/Houai Nhang raise a number of issues concerning resource management and common property. One of the issues is determining the level at which property is held in common. While there are reasons for establishing and demarcating common property resources and management areas (particularly forest) for each village to manage separately, there may be some resources better managed jointly between the two villages or, alternatively, by smaller groups within each village. Such details are important for local application of national policy initiatives in areas such as community forestry. In order to determine potentials and problems of common property resource management in this situation, it is important to consider practices and perceptions of the lowland Lao and Hmong community respectively. These are an outcome of historical settlement experience, traditional cultural practices and local ecological parameters.

A major problem faced in Namon and Houai Nhang is lack of clear recognition and support by District or Provincial authorities for community rights over resources, even though the two communities have in fact been managing forest, land and water resources since the area was first settled. Without external guarantees, it is difficult for leaders of local communities to exert authority. In the past, forest protection was according to customary community rights, not dependent on clearly drawn boundaries or written codes of conduct. Forest and land were common property, used and managed by all in the community. Rules emerged gradually over time, as problems made themselves felt, with the general consent of villagers. However, with the sudden

arrival of outsiders with different production systems, not bound by the established rules and mores of existing communities, and in particular in a situation of increasing resource scarcity, the pace of competition has accelerated. This has led to over-exploitation, not only by newcomers, but also by Namon and Houai Nhang villagers who are concerned to reap the benefits before resources are depleted entirely: a classic "tragedy of the commons" in the absence of effective common property definition and enforcement.

Even though the District authorities have been informed of problems arising from recent settlement, no response is forthcoming to date This has led to a general sense of grievance, expressed in the complaint of a Namon farmer that, "Our village is forbidden by the District from clearing forest, but outsiders can come and clear land without punishment. if it carries on like this we'll go and clear new forest ourselves, rather than depend on the less fertile old swiddens as we do now."

Despite these difficulties, village leaders in both Namon and Houai Nhang are seeking new ways to solve the problems, involving joint management of local forest by the two communities. This involves drawing of clear boundaries within which villagers from elsewhere are forbidden to clear. Support of the District is being sought to formalize boundaries and to legitimize and help enforce regulations, since it is sometimes difficult to apply locally set rules without upsetting relations between neighboring villages.

The village elders of both Namon and Houai Nhang are in agreement over the need for joint rather than separate management of local forest resources. This would allow for more comprehensive enforcement and make it easier for the District to lend support and recognize community management rights. In addition, drawing a boundary between the two villages would raise problems of how to divide up the area on an equitable basis and thus possibly increase rather than diminish conflict. A difficulty that will need to be overcome is the difference in understanding of such issues between the village leaders, on the one hand, and the majority of villagers on the other. Despite the relatively close knit structure of both Namon and Houai Nhang communities, considerable effort is required to involve all villagers in the new forms of management that might arise. One of the contributing reasons for gaps in understanding between the village leaders in both villages is that the village heads, whose election was supported by District authorities, have previously spent considerable periods away from the village. In the case of Namon, the village head was formerly a soldier; in the case of Houai Nhang, the village head is a relatively recent arrival. Irrespective of their background, there are also limits to the authority of village leadership, and the village heads themselves have to devote time to making a living.

In addition to competition between the two communities, there are other aspects of competition over common property resources that affect Namon and Houai Nhang, and which have the effect of intensifying pressure on limited resources and hence competition within and between the two communities. Historically, the Nam Ngum reservoir itself has competed with the land resource that was the basis for the livelihood for Naasangha, now Namon, farmers. The reservoir has, of course, also provided a new resource in the form of fisheries, but this has proved to be a mixed blessing as it has attracted more people to the area and has been unsustainable. A new development, the diversion of water into the Nam Ngum Reservoir from the Nam Song River, would further constrain livelihoods. In particular, higher water levels in the reservoir for longer periods would limit seasonal livestock grazing, reduce opportunities for vegetable gardening in draw-down areas, and flood some of the lower lying wet rice fields. Another source of competition is a small timber mill in Namon. Owned by a Vientiane-based businessman, this mill has relied on timber from the surrounding area. In principle, all the timber for the mill came from trees already felled, but in practice it would not be easy to maintain a supply without continued encroachment on

natural forests by swiddeners. The mill did not operate between mid-1991 and early 1993, and although cutting has resumed, it is soon to move elsewhere

Conclusion: Practical and Policy Findings

The current study has not been designed to come up with a comprehensive blueprint for land use, forest management or irrigation development. Rather its purpose has been to indicate first, the nature of emerging resource conflicts and associated management issues within the Watershed area at different levels, and second, to point toward resource management potentials in terms of processes rather than blueprints. A basic premise is that Watershed level planning requires local involvement and account to be taken of local conditions A number of summary findings with practical and policy significance can be highlighted:

1 Contrary to common assumption, based on Lao PDR's relatively low population density, there is substantial pressure on natural resources and food production systems in the Watershed area, despite the fact that the population density here is only half the national average. Implication: significant changes in land, forest and water use and management are required in order to achieve a sustainable pattern of production.

2. The nature of resource degradation and resource conflicts varies significantly from one part of the Watershed to another, based on a range of social, historical and ecological parameters. Implication: an overly generalized approach to watershed management should be avoided in favor of one based on local knowledge and participation of communities and local authorities in each area.

3. Community management of forest, land and water resources is long-standing and widespread throughout the Watershed, and well founded on indigenous knowledge. Implication: local/traditional practices and arrangements based on indigenous knowledge should be seen as the starting point for resource management initiatives and planning.

4. Resource competition and conflicts can be identified at a number of levels: within communities; between communities; between local people and external claimants (notably forestry and hydro-power); between ethnic groups with different agro-ecological practices, or differently stated, between upland and lowland production systems. Implication: there is a need to develop conflict preemption and resolution procedures at a number of levels, including more participatory impact assessment procedures for externally conceived projects.

5. Ambiguity of both individual and community resource tenure is a basic source of competition, conflict and resource degradation. Implication: demarcation and definition of resource tenure at the village level need to be backed up at the District and other levels.

6. At the District level, division of duties is often unclear. District level staff lack technical and organization experience. District staff also tend not to be involved in activities at the village level, relying more often on written directives. Meanwhile, villagers often rely on petitioning on a case-by-case basis to seek District assistance in various matters, including resource conflict. Implication: District level staff need support, including technical and organization training and experience in community liaison, in combination with more clearly defined duties in the field of forest, land and water management.

7. From a local perspective, there are ambiguities in government policy regarding rights and duties of village, district, provincial and national authorities. Implication: the rights and duties regarding resource management, planning and enforcement need to be clarified.

8. Resettlement policy and practice have often created more problems than they have solved, particularly in intensifying competition and conflict over resources. Meanwhile, new areas suited to wet rice are very limited in most parts of the Watershed, and in many cases development of wet rice land leads to water shortages for downstream cultivators and other users. Implication: there is a need for *in situ* development to suit local physical, social and economic conditions, and this does not necessarily mean concentrating resources in clearing wet rice land.

9. There is a tendency for provincial and other government authorities to concentrate watershed protection efforts on the immediate area surrounding the Nam Ngum Reservoir; yet, many of the sources of the problems facing subsistence cultivators and the Nam Ngum Dam alike are to be found in upper parts of the Watershed. Implication: more attention should be paid to the physical conditions and socio-economic background to resource degradation in upper parts of the Watershed, and appropriate local resource management and livelihood improvement initiatives should be supported.

There are several areas in which practical action is needed. Among those of highest priority are community forestry, enhancement of traditional irrigation schemes, small scale livelihood development in communities facing the greatest pressures and clarification of resource tenure rights and responsibilities. These are all areas where small scale inputs have the potential to produce more secure and sustainable resource use patterns.

The potential for improved resource management thus lies in a number of areas. Of particular significance is the issue of common property, with indications that community level initiatives in areas such as forest management will become a significant part of resource management policy. There is a firm commitment on the part of the government to promote local participation in natural resources management, built on the understanding that communities have traditionally managed and utilized forests quite effectively. Government policy is thus based in part on strengthening traditional ownership and rights of village common property: this is in contrast to many other countries in Southeast Asia, where traditional rights are often overlooked or denied.

In rural areas of Laos, the awareness of problems caused by forest destruction is high, yet many villages still maintain sizable areas of remaining forest. The country has a low population density compared with surrounding countries, although demographic pressures are increasing and low population numbers can sometimes encourage complacency.

There are still many constraints and obstacles to be overcome. Government regulations and incentive systems are still unclear. Moreover, national policy is often diluted or distorted by the time it is applied locally. The legal system is quite inadequate to back up local participation and assertion of rights over resources by village communities. Government extension services are poorly developed, partly due to lack of resources and trained personnel. There is a lack of documentation of successes and problems with local resource management initiatives. Certain features of the population of Lao PDR, including the very great ethnic diversity, make implementation of national policy a complex task. Finally, there is always going to be a difficulty in maintaining a balance between national and local interests, and between commercial pressures and environmental values. A key to dealing with these problems will be a combination of improved information systems and institutional development in support of clearer local resource management rights and responsibilities.

PRESENT STATUS OF NATURAL ECOSYSTEMS IN THE MEKONG DELTA OF VIETNAM

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1. Terrestrial Ecosystems

1.1. Mangrove Ecosystems

Distribution of mangrove vegetation

The mangrove ecosystem in the Mekong Delta covers the coastal fringe of tidal swamps, stretching from the Soairap river (Tiengiang Province) to the Camau tip (Minh Hai Province) and to Hatien (Kiengiang Province) (Figure).

Mangrove vegetation consists mainly of halophytic species. In the past the mangrove forests in the Delta were among the most luxuriant ones in the world. More than 40 species belonging to the families Rhizophoraceae, Verbenaceae, Palmae, Acanthaceae, Asteraceae, etc., have been identified.

Depending on locally prevailing geotopography and hydrological conditions, the distribution of mangrove plants differs from place to place.

In the tidal zone along the coast from the Soairap river (Tiengiang Province) to Mythanh river marine deposits mixed with alluvium sedimentation from the Mekong branches and the Bassac are found. As a result of high tidal amplitudes and rapid sedimentation, mud shales are being deposited not only at the river mouths but also further from the coast. On these deposits, still flooded by daily tides, mangrove plants can develop.

In this zone, sea action has also led to the formation of sandy ridges with higher elevation. These ridges separate the sea coast from the inland, and mangrove forests can grow in the narrow belt towards the sea. In these saline ridges, (6-18 ppt in the rainy season and 8-22 ppt in the dry season at the river mouths) no mangroves are found. At lower elevations, in areas daily inundated by salt water, the dominant trees are *Avicennia alba*, *Sonneratia griffithii*, and *Acanthus ebrateatus*. In moderately elevated sites periodically inundated in September and October, the dominant species are *Rhizophora apiculata*, which requires permanent salinity and inundation, and *Seasuvium portulacastrum* and *Paspalum vaginatum*. *Nipa friticans* is widely distributed in the latter two areas mainly in brackish water backswamps. The dominant trees in higher elevations include *Pluchea indica*, *Phoenix paludosa* and *Azima sarmentosa*.

In the South Camau peninsula (Minh Hai Province) where deposition in the Delta continues to extend to the South and West coasts by 50-100m annually, and where sea waves are weak and land elevation is low, dense mangrove forests develop, both along the sea coast and further inland. The dominant trees, from the sea-land inwards, are *Avicennia (A. officinalis, A. alba) Bruguiera gymnorhiza, Rhizophora apiculata, Lumnitzera racemose, Ceriops spp.* etc.

Nipa fruticans formations are found in brackish water environments near river mouths and backswamps.

Along the Gulf of Thailand from Rachgia to Hatien, because of limited salinity intrusion and less fluviatile deposition, the mangrove vegetation grows only in a narrow strip, with *Avicennia, Rhizophora* spp and *Nipa* as dominant species.

Mangrove vegetation succession

Under the impacts of human activities the mangrove vegetation is degraded both in quality and density. Stages of vegetation succession in mangrove communities in the eastern coast indicate that the succession process is irreversible: some salt-tolerant grasses and sedges, such as *Diplachne fusca, Eleocharis dulcis, Paspalum vaginatum*, which have low economic values and provide much less coastal protection, could replace *Avicennia, Rhizophora spp.* In this manner a mangrove forest is destroyed and prevented from re-establishment.

Fauna in mangrove forest area

Mangrove forests provide important habitats for various aquatic fauna as well as for insects, amphibians, reptiles, birds and mammals. In the Nam Can mangrove forest (Minh Hai Province) according to the 1989 Wetland Inventory of Vietnam(Le Dien Duc, 1989) 53 fish species belonging to 13 orders and 29 families, 58 bird species of mostly water birds, and several mammals such as macaques, otters and wild boar species have been identified. The mangrove forests are very important breeding sites for pelicans, cormorants, darters, egrets, herons, and storks. Breeding colonies are found in *Rhizophora* and *Phoenix* stands. Birds include the painted stork (*Ibis leucocephalus*), black-headed ibis (*Threskiornis melanocephalus*), and glossy ibis (*Plegadis falcinellus*).

Area of mangrove forests

The area of mangrove forest has dramatically decreased during the last few decades. Average annual rates of loss are given in Table 1. The loss and degradation of mangrove forest is partly the result US herbicide spraying operations during the Vietnam War, which completely destroyed 124,000 ha of mangrove forests, including 52,000 ha in the Camau Peninsula (Westing, 1984). Subsequent destruction of mangrove forests was caused by over-exploitation, expansion of settlement areas, and especially the clearance of forests for development of extensive shrimp culture in the last decade. Most of the present mangrove area consists of recently planted *Rhizophora, Avicennia* and *Nipa* species.

Table 1: Mangrove forest area in Vietnam

Year	Area (1000 ha)	Location	Average rate of loss (1000 ha/yr)
1950	400	Whole Vietnam	
	250	Mekong Delta	
1983	252	Whole Vietnam	4.48 (1950-1983)
	126	Mekong Delta	3.76 (1950-1983)
1988	93.5	Mekong Delta	6.50 (1983-1988)

Source: Compiled from several publications

There are no official figures on the continuing loss of mangrove areas from 1989-1994. However, considering the increase in extensive shrimp cultivation in or near mangrove forests, the

present trend of forest destruction is most likely continuing. The ecological and economic importance of mangrove forests, and the consequences of mangrove deforestation in the Mekong Delta have been indicated in several reports.

1.2 Inland Swamp Ecosystem

Distribution of inland swamp vegetation

The inland swamp ecosystem can still be found in its original form in the Mekong Delta. A large inland swamp area occurs in the Uminh area (Minh Hai Province), and in the Plain of Reeds (Dongthap, Tiengiang, Longan Provinces) and the Longxuyen Quadrangle (Kiengiang, Angiang Provinces). All are now under increasing human pressure for reclamation and development.

The main characteristics of inland swamp are temporary or permanent inundation by fresh water, at a depth of 0.5-3.0 m, depending on location and season. The soils in this area are mainly ASS (actual or potential ASS in the Plain of Reeds and Longxuyen Quadrangle) or ASS overland by a layer of peat in the Umint area. Deep and prolonged flooding, or acidification of surface water resulting from oxidation of ASS can affect a number of species, but in general these swamps are rich in fauna and flora species.

Species diversity in an inland swamp is higher than in coastal saline swamps. The dominant tree in this area is *Melaleuca leucadendra*. In these melaleuca forests 134 plant species have been identified. In Vodoi – a typical, reserved melaleuca forest – 78 plant species have been identified. On sites of higher elevation (in the Uminh forest), *Alstonia spathulata, Ilex thorelii, Syzygium cumini, Syzygium lineatum* and *Melaleuca* are dominant. In deep depressions, e.g. in the Plain of Reeds and Longxuyen Quadrangle, melaleuca forms dense stands. However severe acidity (water pH 3.5) will partly kill even the acid-tolerant melaleuca. This can be observed in some parts of the Plain of Reeds and in the Hatien plain.

Vegetation succession

Human intervention, such as irrational forest cutting or burning of melaleuca forests leads to rapid degradation. Obviously, the rich melaleuca forest on peat soils can be completely replaced by low-value sedge and reed species such as *Eleocharis dulcis* and *Phragmites karka*.

Fauna in the inland swamp ecosystem

The inland swamp areas in the Mekong Delta are rich habitats for various wildlife species, i.e. water birds, reptiles, amphibians, mammals and fish. According to the 1989 Wetland Inventory of Vietnam, in the Uminh melaleuca forest, 20 wild mammal species occur, including sambar deer (*Cevus unicolor*), wild boar (*Sus scrofa*), fish-eating cat (*Felix veverrina*), and Asian golden cat (*Felix temmincki*). Also 33 reptile species and 11 species of amphibians have been reported.

The inland wetland areas are particularly rich in bird species. In the Uminh forest and in Tramchim bird sanctuary (Dongthap Province) 82 and 92 bird species have been identified, respectively. Rare birds include the Eastern Sarus crane (*Grus antigone sharpii*), painted stork (*Ibis leucocephalus*), Bengal florican (*Eupodotis bengalensis*) in the Tramchim sanctuary; Asian stork (*Ephippiorhynchus asiaticus*) in the Uminh forest and black-headed ibis (*Threskiornis melanocephalus*), greater adjutant (*Leptoptilos dubious*), lesser adjutant (*Leptoptilos javanicus*) in both melaleuca forest areas.

Because of human pressure, habitat destruction and alteration, most wildlife in the inland swamp area as well as in the mangrove area is seriously threatened. An exception is the successful conservation program of Sarus cranes. Reportedly, the number of Eastern Sarus cranes in

Tramchim increased from 20-30 in 1985 to 114 in 1986, 400 in 1987 and 1052 in 1988, but numbers declined to 701 in 1989, and increased again to 816 in 1990. In the sixties, *Thaumatibis gigantea, Pseudoibis davisoni* and some other rare birds species had been recorded, but it is felt that these have now disappeared.

Area of melaleuca forest

Originally, the melaleuca forest covered approximately half of the ASS area. In 1972, the melaleuca forest area had decreased to 174,000 ha. During the period 1972-1983, the average rate of melaleuca forest loss was 5,000 ha annually. The area of melaleuca forest in 1985 was 110,133 ha and it had slightly increased to 121,270 ha in 1988, occupying 53% of the total forested land in the Mekong Delta at that time (Ministry of Forestry, Vietnam, 1990). Most of these forests consisted of young trees. Most melaleuca forests are found in Minh Hai (40,850 ha), Longan (27,300 ha), Kiengiang (20,729 ha) and Dongthap (11,755 ha). Although there are no exact data available for the period 1989-1994, it is felt that the forest area has been reduced due to forest fires and forest clearance for cultivation especially in Longan and Minh Hai Provinces.

2. Aquatic Ecosystems

The Mekong Delta has a wide variety of aquatic habitats, including rivers, tributaries and their flood plains, inland swamps, paddy fields, irrigation and drainage canals, waterways and ponds, estuaries and coastal zones.

Based on the predominant characteristics of natural waters, three aquatic ecological zones have been identified: (i) fresh water aquatic ecological zones, (ii) salt and brackish water ecological zones, and (iii) acidic water ecological zones.

2.1. Fresh Water Ecological Zones

This type of zone occupies about 1.2 million ha or 30.7% of the Mekong Delta, and includes the surface waters in large parts of Angiang, Kiengiang, Cantho, Dongthap, Vinhlong, Tiengiang and Longan and in some parts of Minh Hai, Bentre, Travinh and Soctrang Provinces.

The main characteristics of water quality in the fresh water aquatic zone are neutral pH (6-8 in paddy fields and ponds, 7-8 in main rivers; with the exception of the West Vaico River) and dissolved oxygen content (DO in the main river is relatively high (DO = 5-7 mg/l); in most paddy fields and canals DO = 4-6 mg/l. The water contains moderate concentrations of ammonium, nitrate and phosphate, usually under 0.2 mg/l, 1.0 mg/l and 0.2 mg/l, respectively in main rivers. Sediment load and dissolved salt contents are generally low, the diversity of aquatic organisms is high: 254 phytoplankton species, 49 zooplankton species and 47 zoobenthic species occurring at high densities. Water pollution is mainly caused by household waste. Pesticide pollution is evident in certain chemically treated fields. In the main rivers, pesticide and industrial pollution are still of minor importance (Le Trinh, 1992).

Such ecological conditions create favorable habitats for a great variety of fish species. In this zone, 260 fish species (57 of which have economic importance), have been recorded. The most common families include migratory species from the coastal area, i.e., Cyprinidae (84 species, 32.3% of the total number of species). Other families include Gobiidae (14 species), Schilbeidae (13 species), Ariidae (11 species), Cobitidae, Siluridae, Cynoglossidae and Bagriidae, each family being represented with 10 species; Anabantidae (7 species) Clupeidae and Engraulidae (each with 6 species); and Ophicephalidae (4 species) (NEDECO/MDMP, 1991). Another study indicates that from 1985-1987, 255 fish species were identified in the fresh water zone of the Southern Vietnam (Mai Yen and Nguyen Trong, 1988).

In rivers and canals "white" fish species such as Cyprinidae (*Puntius* spp, *Cuprinus* spp, *Leptobarbus* spp, *Cirrhinus* spp), Schilbeidae (*Bangasius* spp) are widely distributed. In standing waters (paddy fields, ponds) "black" fish species, such as Anabantidae (*Anabas* spp), Claridae (*Clarias* spp) and Ophiocephalidae (*Ophiocephalus* spp) are most abundant.

Of great economic importance are some of the 8 freshwater prawn species found in this zone, including the giant prawn, *Macrobrachium rosenbergii*.

2.2. Acid Water Ecological Zones

This type of zone occupies an area of 714,300 ha or 18,3% of the Mekong Delta (mainly in the depression area), including 496,700 ha in the Plain of Reeds and 217,000 ha in the Longxuyen Quadrangle. Rapid development of canal systems and use of irrigation water from the Mekong Delta for reclamation of ASS areas will gradually reduce the acid water zone.

The acid water zone is located in the ASS areas in the depression zones subjected to yearly flooding by Mekong water. During flood season (July-November), several freshwater fish species migrate from upstream areas to this zone for spawning. These sheltered river flood-plains are essential for the reproduction of these species. In the dry months when flood waters recede young fish return to canals and rivers. Only a few fish species, mostly black fish, stay in swamps and ponds.

The main characteristics of water quality in the acid water ecological zone, during the beginning of the rainy season, are high acidity (pH 3.0-5.0), high aluminum contents (1-100 mg/l), high iron contents (1-30 mg/l) and low content of aquatic organisms. Very few aquatic animals and organisms can survive in such waters. During the flooding season, and in the early dry season water quality improves.

Under such environmental conditions, only acid-tolerant species of families such as Ophiocephalidae, Anabantidae and Claridae can survive. Annual yields of these black fish are, in general, 50-60 kg/ha in the acid water area.

2.3. Salt and Brackish Water Ecological Zones

This type of zone occupies a large area in the Mekong estuary (the South-Eastern part of Longan, Tiengiang, Bentre, Travinh and Soctrang Provinces), the Camau peninsula (Minh Hai, Soctrang Provinces) and along the coast of the Gulf of Thailand (Kiengiang, Minh Hai Province). The main characteristics of water quality in this zone are: salinity, varying from 8 -22 ppt at the Mekong mouths, to 23-31 ppt in the coastal area of the Camau peninsula, depending on upstream discharges and location; low pollution levels; high concentration of oxygen (DO) (6.5 mg/l) and high content of aquatic organisms. At the Mekong estuary, in 1980, a total of 278 phytoplankton species at densities ranging from 114,300 to 3,103,300 individuals/m3 have been identified (Le Duc, 1989). The main phyla are Bacillariphyta, Pyrrophyta and Cyanophyta. At that time, 36 zooplankton species belonging to phyla Rotatoria, Cladocera, Copepoda, Chaetognatha, Tunicata, Pterpoda, Decapoad and Stomapoda, as well as 24 zoobenthic families of which 13 crustacean and 8 mollusk families, were also recorded. The plankton density increases gradually, from upstream towards river mouths.

Several oligohaline, euryhaline, stenohaline fish species occur in the Delta's estuarine and coastal habitats. According to the 1989 Wetland Inventory of Vietnam, 15 orders comprised of 43 families and 102 species have been identified in the Mekong estuary. The main orders are Perciformes, Clupeiformes, Pleuronectiformes, Tetrodintiformes and Anguilliformes, which occupy

52.4, 14.6, 7.8, 3.9 and 3.9% of the total number of species. According to Mekong Committee statistics, over 300 fish species have been recorded in this zone (Pantulu, 1986).

Most fish species are diadromous (species migrating between marine and estuarine or fresh water), some species seasonally ascend the river, spawning in the fresh water zone. Fresh water fish species observed in the Mekong estuary include *Protus anguilcaudatus, Leiocatsis siamensis, Siluriliesthys phaiosona, Kryptopterus kryptopterus, Clarias macrocephalus, Clarius batrachus* and *Trichigaster trichopterus.*

Distribution and abundance of marine fish species differ considerably for the South China Sea (Mekong estuary) and the coastal area of the Gulf of Thailand. The main captured fish families in the South China Sea are Sauridae, Caranguidae, Lutianidae, Engraulidae etc., whereas in the Gulf Thailand the most commonly found families are Leiognathidae, Caranguidae, Clupeidae, Angraulidae and Scombridae.

In the coastal area, especially in the mangrove forest area, shrimp density and diversity are high. Over 20 shrimp species have been identified. The most common species are Penacidae species, of which *Penaeus merguiensiss, P. indicus* and *P. monodon* have the highest economic values. In the Mekong estuary the penaeid shrimp density is over 3,000 individuals/ha, according to a survey in 1992 (Le Trinh, 1992).

Besides finfish and shrimp, many species of crab, mollusk, etc., are abundant in the coastal area, particularly on Bentre, Tiengiang and Travinh. The following are among the fish species in the Mekong Delta that can be considered as threatened species: *Hilas kangurata Bleaker* (Clupeidae), *Probarbus jullilieni Sauvage, Catlocarpio siamensis Boulenger* (Cyprinidae), *Pangasiannodon gigas Chevey* (Schilbeidae), and *Ophocephalus gaclua Hamilton* (Ophiocephalidae).

Fishery resources of the Mekong Delta are of great economic and nutritional importance to the people of the Delta as in the Whole of Vietnam. The total fishery production of the Delta in 1989, was 407,830 tons or 43% of the total fishery production of Vietnam.

3. Conservation Status of Biological Resources

The mangrove and melaleuca forests constitute important wetlands in the Mekong Delta. In 1985, the Government approved the establishment of Protected Area system of Vietnam including 6 national parks and 81 nature reserves. In 1991, the Ministry of Forestry decided to set aside 6 reserved areas, including bird sanctuaries, in the Mekong Delta. The agencies responsible for management of the reserved areas are the Ministry of Forestry and the Provincial People's committees.

The reserved areas in the Mekong Delta are the Tramchim Crane Reserve, Nam Can Mangrove Forest, Vodoi Melaleuca Forest, Damdoi Bird Sanctuary, Baclieu Bird Sanctuary and Cainuoc Bird Sanctuary. Characteristics and conservation values of these sites are summarized in the Appendix.

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Appendix. Reserved areas in the Mekong Delta

No.	Name	Area (ha)	Natural condition	Typical Flora	Typical Fauna
1	Tram Chim (Plain of Reeds Dongthap Province	5200	-Flood depression -Actual ASS -Avg annual rainfall 1250 mm. -Elevation 0.5-1.0 m	Melaleuca leucadendra, Eleocharis dulcis, Echinochloa crusgalli Cyperus spp. Phragmites karka etc.	Wild ducks (Anas querquedula. A. acuta, A. penelope). Cormorants (Phalacrocorax. carbo egrets Egretta intermedia herons (Ardea purpurea: A. cinerea). Rare birds. Eastern Sarus Crane (Grus antigone sharppii Bengal Florican (Eupodotis bengalensis Painted stork (Myeteria leuocephalus) Lesser adjutant (leptoptilos javanicus Greater adjutant (leptoptilos dubius Black-headed ibis (Threskiornis melacephalus)
2	Vo Doi Lower U Minh forest (Minh Hai Province)	3945	-Flood depression -Peaty ASS -Avg annual rainfall 2250 mm -Elevation 0.4-0.5 m	Melaleuca, Stenoclaena alustris, Syzygium spp., Alstonia spatulata, Ilex thorelii, Asplenium spp. Elacocarps griffthii Cyperus spp.	Fruit bats (Cynopterus, Megacerops); Deer (Cervus unicolor) Wild boar (Sus scrofa), Macaques (Macaca mulata). Otters (Lutra etc Various species of aquatic birds reptiles fishes
3	Bac Lieu Bird breeding colonies (Minh Hai Province)	40	-Mangrove flats -Saline soils -Avg annual rainfall 1750 mm	Lumnitzera racemosa, Phoecix paludosa, Excoecaria agallocha, Avicennia alba, Sesbania grandiffora	Birds: Cormorants (Ph. carbo. Ph. fuscicollis herons (A. purpurea. A. cinerea Pelicans storks etc.
4	Damdoi Bird breeding colonies (Minh Hai Province)	119	-Mangrove flat -Saline soils -Avg annual rainfall 2000 mm	Natural Mangrove forest, dominants: Avicennia (50% Bruguiera (33%) Rhizophora (50%) Others: Lumnitzera racemiosa, Exocecaria agallocha, Phoenix paludosa, Acanthus illicifolius Nypa fruticans, Aerostichum aureum	Birds: cormorants (Ph. carbo. Ph. fuscicollis, Ph. niher), herons (A. purpurea, A. cinerea. A. sumatrana), storks egrets (Egretta alba, E. intermedia, E.garzetta), pelicans, night heron (Nycticorax), painted stork (Myeteria leucocephalus) ibis (Threskiornis melanocephalus etc Fruit bats rats
5	Nam Can Mangrove forest (Minh Hai Province)	76.308	-Mangrove flat -Saline soils -Avg annual rainfall > 2000 mm -Elevation < 0.5 m	Dominants Avicennia spp; Rhizophora (R. apiculata R. mucronata); Lumnitzera recemosa. Nypa, Bruguiera spp, Ceriops, Kandelia. Acanthus, etc.	-Birds: cormorants, herons. storks, moorhens -Mammals: Macaques. Lutra. Sus scrofa, Viverra zibetha. Felis chaus, Panthera tigris, Neofelis nebulosa -Reptiles and various species of fishes
6	Cai Nuoc bird sanctuary (Minh Hai Province)	14	-Mangrove flat -Saline soils -Avg annual rainfall > 2000 m -Elevation 0.5 m	Phoenic paludosa, Nypa fruticans, Bruguiera parvifloria, Excoecaria agallocha, Acrostichum arurum, Sarcolobus globosus	Various species of aquatic birds. Anhinga melanogaster. Anastomus oscitans. Threskiornis melanocephallus Plegadis falcinellus.

Source: Compiled from several publications

HYDROLOGIC REGIMES OF THE GREATER MEKONG BASIN: BIOPHYSICAL ENVIRONMENTS AND WATER RESOURCES MANAGEMENT UNITS

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Abstract

The Mekong river drops 5000 meters, and crosses 25 degrees of latitude between it's headwaters on the Tibetan Plateau and the mouth of the river, in the South China Sea. In the 4000 kilometers between it's headwaters and mouth, the Mekong river passes through a wide range of biomes - biophysical environments - ranging from the alpine tundra of the Tibetan Plateau, through the montane belt of Yunnan Province, China, Myanmar and Lao PDR, the seasonally-arid savanna of Thailand and Kampuchea, to the wetlands of the Viet Nam Delta. These environments are determined primarily by differences of topography and latitude, which together, control variations in water and energy exchange. Annual precipitation amounts range from less than 250 mm near the headwaters to over 4000 mm in southern Lao PDR. Within the lower basin, specific runoff - depth of runoff per unit area - ranges from a high of nearly 2500 mm in the montane of central Lao PDR, to a low of approximately 250 mm from the savanna of central Thailand.

Management strategies for the Mekong river basin should reflect this complex of environments, and the human uses to which each is now being put. Each of the major biophysical environments could be approached as a distinct management unit. In order to accomplish this, it will first be necessary to undertake a detailed environmental survey of the biophysical and water resources characteristics of each.

Introduction

To be effective, management strategies for the water resources of the Mekong river basin must recognize the range of water, human use and biogeographical environments characterizing the basin. These biomes range from the cold, dry alpine environments of the Tibetan Plateau, through the montane environments of the upper basin and bordering mountain ranges of the lower basin, the seasonally-arid savanna of the central basin, to the wetlands of the delta where the river enters the South China Sea in Vietnam. Each of these biogeographical environments will represent a corresponding diversity in water budget relationships, as **input,** in the form of rain or snow, **storage**, as ground water and lakes, and **output**, as evaporation and stream flow.

While the available data are not sufficient to define each element of the water budget within the basin with any precision, it is possible to calculate the **specific runoff** — the depth of runoff per unit area — for a wide range of tributary basins, based on the availability of surface area and hydrometric measurements. Specific runoff is a useful indicator of biogeographical variation among catchment basins, since it is independent of surface area, and may be considered as a dimensionless index of the variation in annual amounts of water and energy exchange within each of the basins.

It is the purpose of this paper to discuss broadly the range of water environments of the Greater Mekong Basin in terms of variations in specific runoff , and to consider the implications of this diversity on aspects of the development and management of the water resources of the basin. In particular, general environmental diagnostic studies, or development of management options for the

basin, could most profitably be based upon a subdivision of major water sub-regions, as indicated by variations in the water regimes of these sub-regions. The ready availability of large data bases describing the water budgets of sub basins of much of the Mekong river basin provides a useful starting point for broader analyses.

In this paper, the relationship between the biomes of the Mekong basin, and variations in specific runoff, is considered in the most general terms, and the results are presented primarily in tabular and graphical form.

The Mekong River Basin

The Mekong river is one of the largest of the earth's rivers (Table 1). It is arguably far more complex than most of the other rivers on this list, both politically and biophysically. The Mekong river originates at an altitude of approximately 5000 meters, at approximately 34° N. Lat., 95° E. Long. on the eastern Tibetan Plateau in a region with mountains rising to altitudes of approximately 6500 meters. It flows generally southward for approximately 4000 km to a mouth in the South China Sea, at approximately 10° N. Lat. During this course, it flows through the Chinese province of Yunnan, defines the border between Lao PDR, and Myanmar (Burma), and between much of Thailand and Lao PDR. It flows through Kampuchea (Cambodia), and finally enters the South China Sea in Viet Nam (Fig. 1).

Each year, about 475 million cubic meters of water empty into the South China Sea, off the Mekong Delta. At Chiang Saem, in northern Thailand, the maximum discharge (13,300 m^3/s) is approximately 17 times the minimum discharge (800 m^3/s). At Pakse, where the drainage area accounts for 69% of the total area, the maximum discharge (57,800 m^3/s) is more than 50 times the minimum discharge (1600 m^3/s) (Fig. 4).

The flow of the Mekong and its tributaries are closely related to the rainfall pattern. The water level starts to rise at the onset of the wet season (April-May), reaching a peak in August, September or October. It than falls rapidly until December, and afterward recedes slowly during the annual dry period, or dry season, to reach its lowest level in March/April, just before the monsoon (Mekong Secretariat, 1992).

The mean annual rainfall ranges from less than 250 mm at the headwaters, approximately 1000 mm over much of northeastern Thailand and Kampuchea, to more than 4000 mm in the Truong Son mountains between Lao PDR and Viet Nam. 80-90% of rainfall occurs during the monsoon season. At that time, the atmospheric dew-point is only a few degrees below the air temperature, and a moderate uplift of the air caused by topography or convection can induce precipitation. The effect of topography is seen in rainfall distribution of the basin and adjacent areas, being highest on the windward side of mountain ranges lying across the path of the south-west monsoon, such as the Cardamom Range along the coast of Cambodia, and the Truong Son Range across Lao PDR, eastern Cambodia and adjacent areas in Viet Nam (Fig. 2). Rainfall is lowest on the leeward side of these mountains, in the Great Lake (Tonle Sap) basin and northeastern Thailand. Here, rainfall is intense, brief and mainly during thunderstorms, affecting limited areas (Mekong Secretariat, 1992, p. 25).

The Hydrological Data Bases

Streamflow: In the lower Mekong basin, south of Chiang Saen, Thailand, hydrometric data are published annually by the Mekong Secretariat for 112 stations. Of these stations, only gauge height measurements are given for 63 (56%) of the stations, while discharge measurements are given for 49 (44%) stations. For those stations for which discharge measurements are published, 27 (55%)

are in Thailand, 19 (39%) are in Lao PDR, and 3 (6%) are in Vietnam. Taken together, the 49 stations for which hydrometric measurements are available represent approximately 60% of the total surface area of the Greater Mekong Basin, the remaining 40% being in the upper basin , in China (25%), and minor ungauged tributaries in the lower basin (15%). This data network describing stream flow on individual tributaries to the Mekong river is supplemented by 11 gauging stations on the Mekong river itself, between Chiang Saen, Thailand, and Stung Thep, Cambodia.

Rainfall: Data from 207 precipitation stations are published by the Mekong Secretariat. Of these, 7 (3%) stations are in Cambodia, 62 (30%) in Lao PDR, 136 (66%) in Thailand, and 2 (1%) in Vietnam.

Other: Water quality and sediment concentration are also measured, together with evaporation and wind speed at selected climatological stations.

Discussion

Major tributary basins of the lower Mekong river for which runoff data are either measured directly, or estimated by the Mekong Secretariat, range in size from approximately 235 km ^{2}, to 120,000 km^2 (Table 2). Specific runoff - depth of runoff per unit area - for these sub-basins of the Mekong river basin ranges from a low of 260 mm in the Mun-Chi river system of Thailand, to 2330 mm for the Nam Thuen river of Lao PDR (Fig. 3, Table 2).

Based on the limited analysis possible for this paper, at the scale of the river basin - the macro-scale - specific runoff corresponds well with major biomes. Minimum specific values are associated with the savanna of northeastern Thailand and central Cambodia, while maximum values have been measured in association with the montane biome of Lao PDR. For both Thailand and Lao PDR, far more data are available than could be utilized, and a more detailed analysis of these data could show local variations at an intermediate scale - the meso-scale - in this broad regional pattern of biophysical zonation.

An advantage of defining biophysical regions within the basin in terms of specific runoff is that it permits the delineation of management units, within which specific management objectives may be specified with some precision. To a large degree, such a delineation only formalizes an *ad hoc* management approach that has evolved as a result of common usage, or formal planning by the countries of the basin. In this respect, however, by recognizing formally the biophysical zonation of the basin, the management objectives can be given priorities that reflect the primary needs of those living in each zone. Thus, in northeastern Thailand and a majority of Cambodia, in the arid to semiarid savanna, irrigation management becomes a priority. In the mountains of Yunnan province of China, and much of eastern Lao PDR, on the other hand, a primary objective could be the generation of hydroelectric energy, and flood control. The fact that the primary biophysical zonation of the basin coincides closely with the major political subdivisions of the basin (Table 3) could lessen the political difficulties of the planning process, since each country within the basin can assume responsibility for one major management plan, perhaps in collaboration with it's nearest neighbor(s).

The extreme altititudinal and latitudinal range of the Mekong basin produce a correspondingly wide range in the biogeographical environments through which the river runs. Originating in the cold, dry alpine tundra of the Tibetan plateau, the river passes through sub-alpine and montane forests before entering the subtropical savanna of northeastern Thailand and the wetlands of the Vietnamese delta. Each of these biomes exists as a result of a complex interaction involving primarily variations in the exchange of water and energy among major portions of the river basin. While most, or all, of these biomes have been extensively modified by

centuries of human uses, the fundamental character of each remains unchanged. This character, defined primarily by water and energy availability, largely determines the management potential of each of the major subdivisions of the Mekong river basin. Each of the biomes imposes constraints on, and offers opportunities for, resource development. To be effective, planning and management of this development in any of the biomes of the basin must reflect both the constraints and opportunities of the biophysical system of each, and the differences among them. This planning and management of resource development must be based on a more thorough understanding of the biological and physical characteristics of the biomes of the Mekong basin than now exists.

Such an undertaking will be complex and require the contribution of many disciplines over an extended time period. An initial approach, suggested in this paper, involves an analysis of the water budgets of the various biomes, using existing data bases, to begin to define the range of variation that exists within, and among, the biomes. The immediate advantage of this suggested approach lies in the availability of standardized data bases - measurements of rainfall and stream flow - for sub basins covering at least 60% of the lower basin. These data, and the analytical methods that computers have made possible, such as distributed process models, using Geographic Information System (GIS) technologies, offer a rapid, inexpensive means of assessing the range of biophysical environments and management options that exist within the basin.

Table 1. Area-Runoff Relationships for Major Rivers of the Earth

Ranked by Discharge Volume

Rank	River	Length (miles)	Area (sq.miles)	Discharge (acre-feet)	Qsp[1] (feet)
1	Amazon	3900	2231000	6100000	2.73
2	Zaire	2720	1550000	1400000	0.90
3	**Ch'ang**	**3370**	**750000**	**770000**	**1.03**
4	**Brahmaputra**	**1500**	**361000**	**700000**	**1.94**
5	**Ganges**	**1550**	**409000**	**660000**	**1.61**
6	Yanisey	2410	1000000	614000	0.61
7	Mississippi	3760	1244000	611000	0.49
8	Orinoco	1600	340000	600000	1.76
9	Lena	2660	936000	547,000	0.58
10	Parana	2580	600000	526000	0.88
11	St. Lawrence	1900	498000	500000	1.00
12	**Irrawaddy**	**1000**	**166000**	**479000**	**2.89**
13	Ob	3460	959000	441000	0.46
14	**Mekong**	**2600**	**390,000**	**310,000**	**1.90**

Note: [1] Qsp = Specific Runoff

Source: Man's Domain: A Thematic Atlas of the World, 3rd edition. Norman J.W. Thrower, Ed. McGraw-Hill Book Co., New York, 1975.

Table 2. Selected Tributaries of the Greater Mekong Basin: Area-Runoff Relationships

	Area (%)	Flow (%)	Area, (10^3 km^2)	Q_{av} (m^3/sec)	Volume (10^6 m^3)	Q_{sp} (mm)
CHIANG SAEN	25	20	165	2410	97.9	590
Mae Kok	1.4	1.5	11	180	5.7	520
Mae Ing	1.1	0.8	8	105	3.3	410
Nam Tha	1.1	1	8	135	4.3	540
Nam Ou	3.4	3.0	26	434	13.8	530
Nam Suong	0.8	0.7	6	120	3.8	630
Nam Khan	1	0.9	8	135	4.3	540
Nam Hueng	0.6	0.3	5	45	1.4	280
Nam Loei	0.5	0.3	4	45	1.4	350
VIENTIANE	38	30	299	4553	144.0	480
Nam Ngum	2.3	5.4	17	120	25	1470
Nam Nhiep	0.6	1.5	5	224	5.0	1250
Nam Theun	1.8	5.2	6	778	14.0	2330
NAK. PHANOM	42	47	373	7400	201.0	540
Se Bang Fai	1.2	2.5	9.5	374	12.0	1260
Se Bang Hieng	2.5	4	20	598	19.0	950
Se Done	0.9	1.6	7	239	7.6	1080
MUKDAHAN	49	51	391	8019	241.0	620
KHONG CHIAM	53	64	419	9250	302.0	720
Mun-Chi	15	6.4	119	957	30.4	260
Se San	10.1	20.5	75	2498	95.0	1270
Tonle Sap	10.7	6.4	85	957	30.4	360
PAKSE	68	67	545	10,110	319	590
STUNG TRENG	80	98	635	13,380	465	580

Note: All percentages are based on estimates of flow volumes and surface areas published by the Mekong Secretariat. Total flow volume is estimated to be 475,000 million cubic meters, while the total surface area of the basin is estimated to be 795,000 km2.

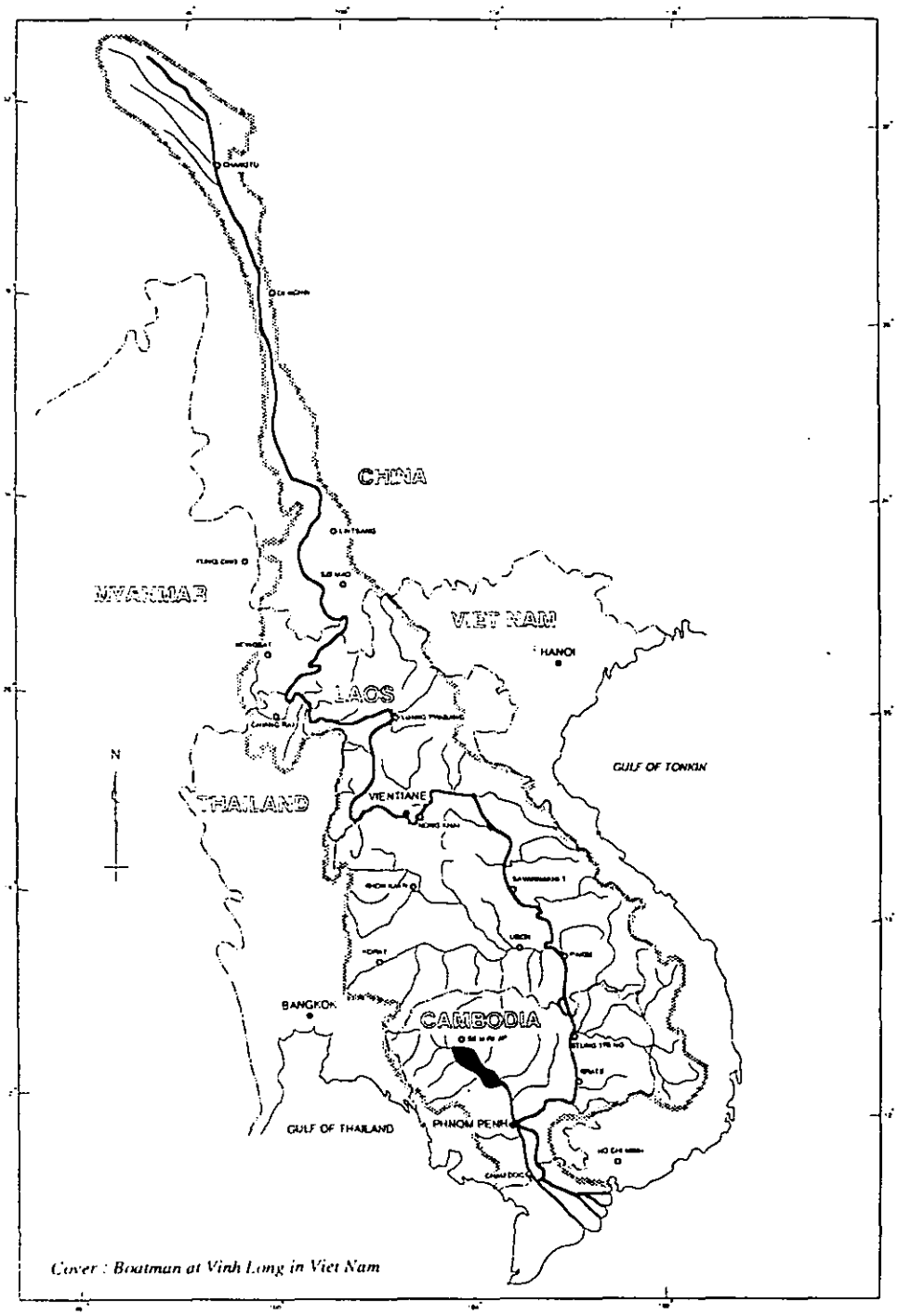
Source: Mekong Secretariat Hydrologic Yearbook, 1991.

Table 3. Approximate Flow Distribution of the Mekong River and Associated Biophysical Environments

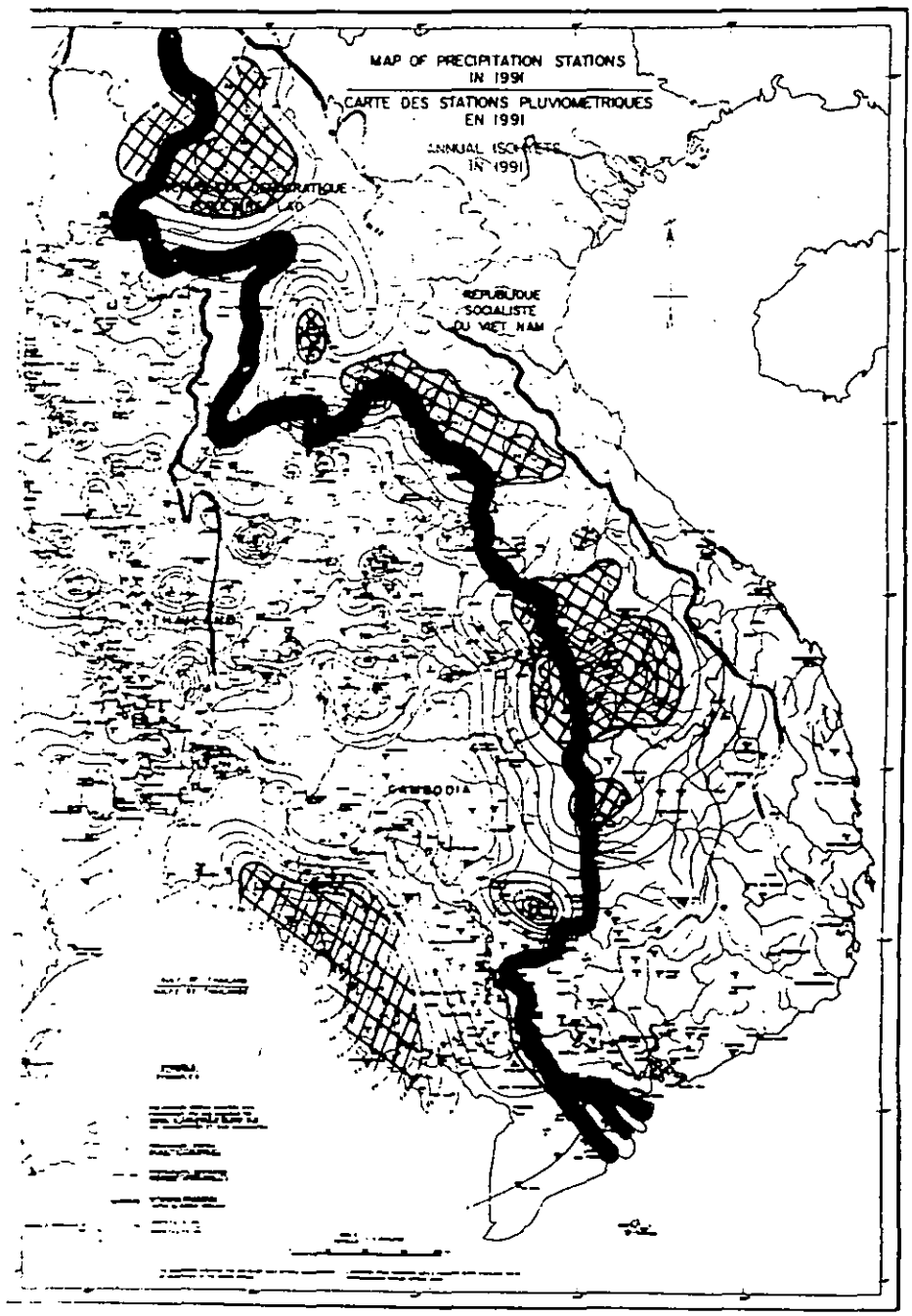
Country	Catchment Area		Average Flow		Major Biophysical Unit(s)
	(Km^2)	%	(m^3/sec)	%	
China	165,000	21	2,410	16	Alpine, Montane
Myanmar	24,000	3	300	2	Montane
Laos	202,000	25	5,670	41	Montane, Savannah
Thailand	184,000	23	1,260	12	Savannah
Cambodia	155,000	20	2,860	18	Savannah
Viet Nam	65,000	8	1,660	11	Wetlands
Total	**795,000**	**100**	**14,160**	**100**	

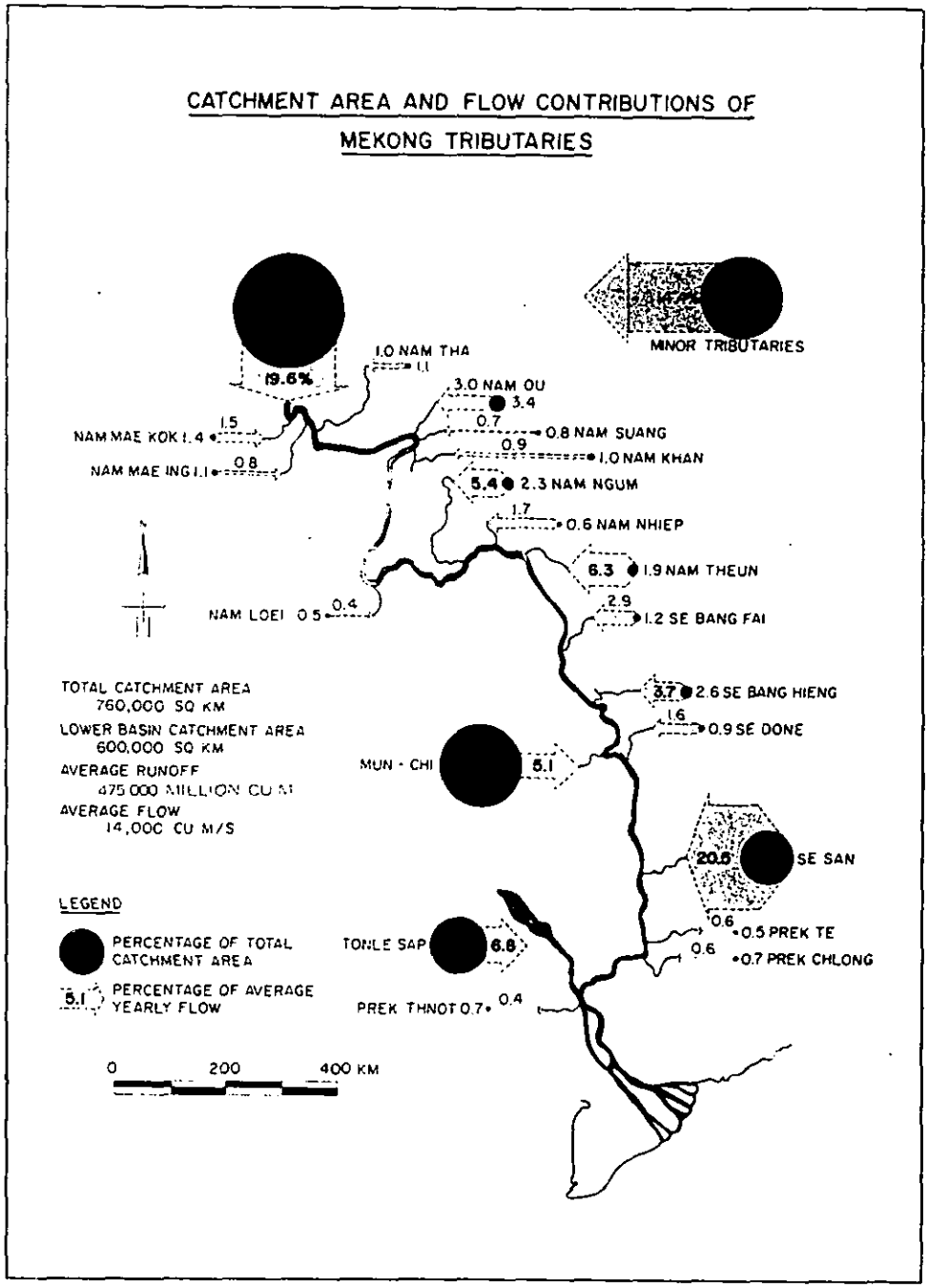
Source: Modified from *Mekong Committee Annual Report*, 1991

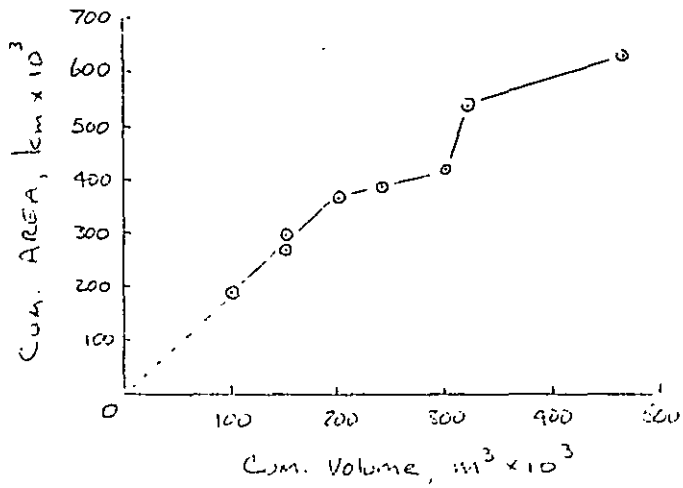
MAP OF THE MEKONG BASIN

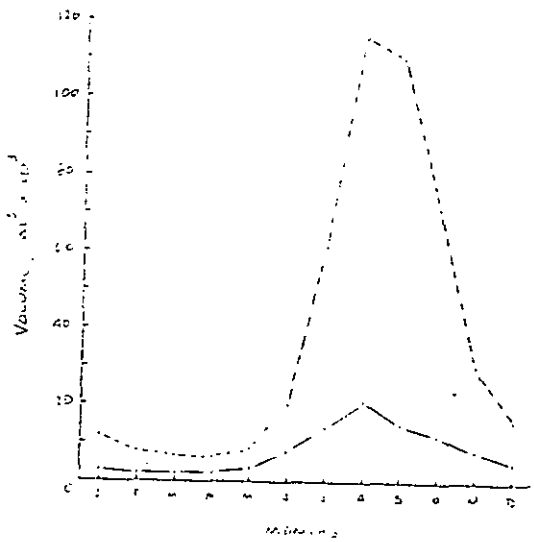


Cover : Boatman at Vinh Long in Viet Nam


MAP OF PRECIPITATION STATIONS
IN 1991
CARTE DES STATIONS PLUVIOMETRIQUES
EN 1991
ANNUAL ISOHYETS
IN 1991
REPUBLIQUE
SOCIALISTE
DU VIET NAM
CAMBODIA


CATCHMENT AREA AND FLOW CONTRIBUTIONS OF
MEKONG TRIBUTARIES
19.6%
MINOR TRIBUTARIES
1.0 NAM THA
3.0 NAM OU
3.4
1.5
NAM MAE KOK 1.4
0.7
0.8 NAM SUANG
0.9
1.0 NAM KHAN
0.8
NAM MAE ING 1.1
5.4
2.3 NAM NGUM
1.7
0.6 NAM NHIEP
6.3
1.9 NAM THEUN
NAM LOEI 0.5
0.4
2.9
1.2 SE BANG FAI
3.7
2.6 SE BANG HIENG
1.6
0.9 SE DONE
TOTAL CATCHMENT AREA
760,000 SQ KM
LOWER BASIN CATCHMENT AREA
600,000 SQ KM
AVERAGE RUNOFF
475 000 MILLION CU M
AVERAGE FLOW
14,000 CU M/S
MUN - CHI
6.1
20.5
SE SAN
0.6
0.5 PREK TE
0.6
0.7 PREK CHLONG
LEGEND
TONLE SAP
6.8
PERCENTAGE OF TOTAL CATCHMENT AREA
6.1
PERCENTAGE OF AVERAGE YEARLY FLOW
PREK THNOT 0.7
0.4
0
200
400 KM


Cum. AREA, km x 10^3
700
600
500
400
300
200
100
0
100
200
300
400
500
Cum. Volume, m^3 x 10^3



DISAPPEARING LAKES — WHAT IS TO BE DONE?
A CASE OF THE TONLE SAP, CAMBODIA

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Introduction

Rumor has it that Cambodia's Tonle Sap Lake is disappearing. This is an astonishing concept - that the largest standing body of water in South East Asia, the shining centerpiece jewel of Cambodia's constitution can somehow vanish. It is also an alarming concept - that the Tonle Sap, central to Cambodian mythology, culture, and livelihood, one of the most productive fisheries in the world, refuge to some of the rarest fauna in the region, ceases to be. Given the experiences in other countries, where notable lakes are indeed disappearing, the scenario is not implausible. Is this the case for the Tonle Sap?

This paper first attempts to define, or at least questions, the term "disappearing", examines the available evidence that refutes the assertion, examines some of the current issues in and around the Tonle Sap, and addresses the question "what is to be done" within the context of various uncertainties.

Tonle Sap - Background[2]

During the dry season the Tonle Sap, also known as the Great Lake, covers an area approximately 2,500 km^2, stretching 160 km in length to 35 km wide at its widest point. At the height of the rainy season the lake covers 13,000 km^2 some 300 km in length and over 100 km wide at some points. The depth varies from an average of less than two meters at minimum to between eight to ten meters at its maximum. The outstanding hydrological feature of this system occurs during the flooding of the Mekong River when the Tonle Sap changes direction and the Mekong waters flow back into the Great Lake.

The stored water flows out of the lake as the flooding in the Mekong River subsides. Accordingly the Tonle Sap plays a key role in the water supply and regulation of the water-flow between the lake and the delta area in Viet Nam.

The lake is surrounded by a broad belt of fresh water inundated forest, generally 20-30 km wide, but extending to 65 km at the north-west corner of the lake. The belt of inundated forest is in turn surrounded by river bank levees which can be quite extensive, characterized by rich alluvial soils cultivated with orchards and crops. Behind the levees are the lowlands which flood regularly and are cultivated under a variety of rice agricultural systems depending on the depth of the flooding. Beyond the agricultural land and off the flat flood plain are the upland forests.

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[1] Supported by the International Development Research Centre (IDRC) of Canada.

[2] Two publications produced by the Mekong Committee that have collated and synthesized much of the available data on the Tonle Sap are worthy of mention. Fisheries in the Lower Mekong Basin (Mekong Committee, 1992) evidently focuses on production fisheries, while Development Plan for Tonle Sap and Chakdomuk (Mekong Committee, 1993) examines the opportunities and constraints to development plans for the lake.

The natural flooded forest probably covered an area of about one million hectares at its maximum. Man's influence first began in earnest in the 1930's when the French colonial administration began to exploit the flooded forest for the production of firewood and charcoal. While the flooded forest supplied 90-95 percent of the country's firewood and charcoal at that time, the forest management practices were not necessarily overly exploitative (Van Honsebrouck, pers. comm.).

Deforestation around the Tonle Sap has always been about excessive cutting for fuelwood and the clearing of forests for expanding agricultural lands. It has taken place in three distinct periods; first, from the 1940's as a result of mounting population pressures; second, indiscriminate deforestation during the Pol Pot era; and third, the more recent demands from an expanding economy. By the late 1960's the original one million hectares had been reduced to 614,000 ha., then further reduced to 564,000 during the 1980's. FAO (1991) estimates the coverage at 460,000 ha. in 1990, and the Mekong Committee (1991) differentiates between 361,700 hectares of flooded forest and 157,200 hectares of degraded forest and associated vegetation types.

The fish catch from the Tonle Sap represents between 60 to 80 percent of the animal protein intake of the population of Cambodia. The lake is often cited as one of the more productive freshwater fisheries in the world, with a yearly fish production estimated by the Fisheries Department at some 50,000 tons or 71 kg/ha/yr for an average water surface of 7,000 km^2. On a per hectare basis the Tonle Sap has been calculated to be nearly ten times more productive than the North Atlantic Sea fishery (Dennis, 1984). There are no up-to-date statistics regarding populations engaged in different activities but the agricultural sector, including fisheries, but not forestry, is estimated at 61 percent of the GDP. Agriculture, forestry and fisheries account for 80 percent of the employment (EIU, 1991).

It is possible to reliably estimate the number of commercial fishermen based on the number of permits issued but less so the number involved in family fishery, for which, no permit is required. For Siem Riep, the industrial, artisanal and family fishermen have been estimated to be 420, 880, and 2,600 respectively; composite figures for the whole area are not available (Mekong Committee, 1993). There is a significant but unquantified migration of Viet Namese and Cham (Cambodia's Muslim minority) that occurs from October to May with a peak in March and April, and is responsible in part for the transfer of fishery and aquaculture expertise. Five of the country's 22 provinces border the Tonle Sap and comprise 22 percent of the population of the country. Major cities include Siem Riep, Pursat, Battambang, Kompong Thom and Khompong Chhnang.

Is the Tonle Sap Disappearing?

The answer is an equivocal "no". The reality is that the information base simply does not exist to determine the implications of trends (or, in some cases, to identify a trend one way or another), or to support one hypothesis over another. Cambodia is at the very beginning stages of rebuilding its research capacity after a long period of international isolation. Consequently, there is scant data available with which one can make responsible statements. There is, on the other hand, no lack of anecdotal evidence that has created great concern that the lake is indeed disappearing. Nevertheless, the argument can and should be made that evidence that is not statistically valid should still factor into public policy and decision making. The question remains how to do so responsibly.

The first question is "disappearing in what sense?". There are central issues that relate to the possible fate of the Tonle Sap[3]. The first is the impact of changes in the physical characteristics of the lake, i.e. declining minimum depth of the lake and role of sedimentation, or the impact of direct exploitation or over-exploitation of its resources, particularly in fisheries. The second is a measurement of the changes in the integrity of the ecosystem. In order to gauge this, habitat and biodiversity can serve as indicators, evidently a reflection of the physical and exploitation impacts and, in the case of the Tonle Sap, not well documented.

Decreasing Depth and Sedimentation

Several reports in the 1960's indicated that the physical conditions in the Tonle Sap were changing rapidly. As the Mekong Committee (1993) notes, the sedimentation conditions of the Tonle Sap, especially at the confluence with the Mekong and at the entrance of the lake (Snoc Trou) are reported to be an obstacle to flow movement in the Tonle Sap river. In response to the allegations that sedimentation has seriously reduced its depth, the Mekong Committee undertook a study to "identify and examine morphology change, the present use of natural resources and the development possibilities ". The results of the study are less than definitive: "In conclusion, it should be noted that available data relating to sedimentary phenomena are insufficient and that complementary investigations are necessary to determine the actual situation". The value of the study, despite the lack of resolution to a critical question, is to throw a cautionary note into an ongoing debate. The review and re-interpretation of historical data has questioned the view that the Tonle Sap is sliding rapidly and irreversibly into a severely degraded state as a result of siltation and over-fishing.

Historical data on hydrological variation in the lake clearly shows a precipitous decline in the minimum level of the lake, from three meters to two meters from 1925 to 1956, and from two meters to one meter in 1957. The investigators consider the recordings of the variation to be aberrant and have proposed an alternative hypothesis, adjusting the historical data so that the level of the lake would appear to be constant since 1925.

> "Knowing that the water level in the lake at the end of the dry season is around 1.3 m asl [above sea level], we conclude that the situation of the gauge was probably in accordance with sea level topography during the last period. We assume that this was not the case before and make the following hypothesis:
>
> (i) the shifting of the gauge was exactly 1 m during the 1957-61 period and 2 m during the former 1925-56 period.
>
> (ii) the shifting was the same for all gauge staffs, from lowest to highest levels.
>
> Thus we have corrected the data, subtracting 2 m from the readings during the 1925-56 period and 1 m during the 1956-57 period".
>
> (Mekong Committee, 1993, page C.6)

In supporting the contention that there has been no significant decline in the minimum depth of the Tonle Sap lake, the report addresses the role of sedimentation. The report cites Charbonnel (1964) who writes: "The material brought by the Mekong in high water periods is negligible in the Great Lake. All alluvial matters transported by the Mekong as it flows up towards the Great Lake settle in the region between Kompong Chhnang and Snoc Trou". The Mekong Committee agrees with this assessment and maintains that the deposition of silt in the main body of the lake remains minimal.

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[3] A third question, more academic and not terribly pragmatic, is that of the disappearance of the lake over geological time. The Tonle Sap is a young lake, some 5000 years old formed in the late Quaternary. As the history of the earth is one of appearing and disappearing land forms and water bodies, the Tonle Sap will eventually cease to exist. But this reality is less than useful as a guide for the development of more immediate management objectives and strategies.

On the other side of the argument, Csavas (1990) contends that "deposition in the bed of the Great Lake is currently occurring at a rate of 4 cm/year and, as the lake has an average depth of 40 cm in the dry season, it could cease to exist as a lake in the dry season in ten years time". Without refuting the claim that the lake is filling at the rate of 4 cm/year, the Mekong Secretariat (1993) responds that "some caution is necessary, however, in this regard. Considering that the average surface area of the lake is about 5,000 km^2 then the available storage volume is about 2 x 10^9 m^3. For a deposited sediment density of 1.4 t/m^3, this would require some 1,500 years at the rate proposed by Charbonnel (1.9 x 10^6 t/year). At the more pessimistic rate of 4.7 x 10^6 t/year the period would be 600 years, which is very different from the 10 years suggested by M. Imre Csavas".

However, the report later notes that the contributions to lake sedimentation due to the rivers in the catchment of the lake and due to flood flows in the Tonle Sap are not known either in absolute or in relative terms. These represent, therefore, two markedly different ways of analyzing the situation based on two different sets of numbers that cannot be compared and, in any case, both speculative in nature.

Finally, the report questions the assertion that the deforestation of the flooded forest is in measure responsible for the sedimentation of the lake. The logic applied is that deforested zones around the lake are gently sloped and that the erosive action of rainfall would not be significant. By the same reasoning, the report acknowledges that deforestation on the upper slopes of the catchment area of the lake is of greater concern.

Fisheries

Data from over fifty years ago indicates that the total annual fishery yield in the Tonle Sap was around 50,000 tons per year (Chevey and Le Poulain, 1940). This is supported by thirty year old data presented by Fily and d'Aubenton (1966) who estimate the total catches for Tonle Sap at 54,000 t/year and the University of Michigan (1975; citation not available) which estimated between 50,000 and 80,000 t/year.

More recent statistics are available from the Department of Fisheries going back to 1981. For the period 1981-1991 the total catches range from 50,000 to 74,000 t/year. The data does not indicate a trend one way or another over the recorded period although variation in fish catch is attributed to variation in hydrological flow. The catch for 1994 was the highest in the last 12 years and is speculatively attributed to the timing of the floods, meteorological patterns and lunar influence (Van Zalinge, pers. comm.). The Mekong Committee (1993) advises caution in interpreting the Department of Fisheries' figures as (i) family fisheries are not taken into account and are probably significant; (ii) it is unknown if small scale fishing is considered; and (iii) undeclared catches, e.g. poaching, are likely to be significant.

The Mekong Committee (1993) concludes that "In any case there is no evidence of any diminution of stocks, even though the figures do not distinguish between different forms of exploitation of fresh water fish, nor between adults of small species and juveniles of others. Nevertheless, the broad findings of this study do not substantiate any biological over-exploitation.".

At the same time it is acknowledged that, even if the overall size of the fish catch is not diminishing, the average size of the fish is becoming progressively smaller. The greatest pressure is on the larger commercial species, some of which are not only smaller but increasingly hard to find (W. Rainboth, pers. comm.).

Ecological Integrity of the Tonle Sap as an Indicator

Measuring the integrity of an ecosystem is infinitely more complex than measuring hydrological variation (the data for which is unreliable and patchy), sedimentary rates (still undetermined), or fisheries catches (questionable empirical data). It would be folly, therefore to draw any conclusions on the overall health of the Tonle Sap on the basis of almost no information. The following is not intended as a review or assessment of the literature but attempts to gauge whether the alarming prospects of irreversible degradation of the lake or even its disappearance is supported by what evidence is available. As a starting point, it is assumed that the quality of the lake habitat and the surrounding area and impacts on it are critical to its ecology.

Habitat

There is a general assumption that the flooded forest is central to the overall ecology of the Tonle Sap system and to its prodigious biological productivity. The current pressures on the flooded forest for the production of fuelwood and charcoal and the conversion to agricultural land has created concern and speculation as to the likely implications. Yet the specific ecological interactions and the precise relationships that support this productivity are relatively unknown. Pantalu (1986) notes that the Mekong fisheries is supported by detritus, i.e. the silt is nutrient deficient and that production is likely sustained by terrestrial and aquatic plants.

According to revised IUCN classification, most of the flooded plain surrounding the Tonle Sap lake can be classified as "seasonal freshwater swamp savannah", a more descriptive and accurate term than "flooded forest". What this classification implies, according to the Asian Wetland Bureau (1994), is that the plain is not covered by trees with a closed canopy as is often assumed but is more open and shrubby. In fact, closed canopy forest covers very little area of flood plain.

The danger according to the Asian Wetland Bureau is the assumption that open, shrubby areas vegetated by species such as *Polygonum barbatum* and *Sesbania javanica*, or those dominated by trees such as *Barringtonia acutanglia* and *Xanthophyllum glaucum*, represent a secondary or degraded forest. Only herbaceous or shrubby vegetation can survive in areas where flooding is prolonged and deep; where flooding is less deep *Barringtonia* appears where its crown remains emergent. There is concern that the perception that much of the flood plain is already degraded will lessen its apparent conservation value, i.e. if the land is deemed degraded, it will become more acceptable to convert it to agriculture. The Asian Wetland Bureau (1994) states "There is no real evidence to state categorically that most of the inundated plain is secondary or degraded habitat....While it is possible that some areas of the plain have been slowly modified over hundreds of years due to regular burning, it is also completely possible that large areas may be under natural vegetation".

This proposition needs to be reconciled with the remote sensing data that indicates that there was once approximately one million hectares around the lake which has been reduced to 361,700 hectares of flooded forest and 157,200 hectares of degraded forest and associated vegetation types according to the FAO (1991). As well, the physical evidence as to the continuing clearing of the flooded forest is overwhelming. A Mekong Committee project reports that during field work in January, 1995, bulldozers were working continuously in some areas around the Tonle Sap to clear the forest for agriculture (W. Rainboth, pers. comm.), a situation that was thought to contribute substantially to the siltation problem (Mekong Committee, 1991) and appears to have intensified over the past two years.

Biodiversity

Fish

Of some 1,200 species of fish in the Mekong system, over 850 species have been recorded in the lower Mekong river, including some 215 species in the Tonle Sap lake belonging to 127 different genus and 47 families (Kottelat, 1985). These numbers are approximate as the taxonomy is still in a very confused state. According to Kottelat, there is an overwhelming abundance of Cyprinidae, with 42 genus and 81 species, and Siluriforms which include 23 genus, 41 species and 8 families. Bardach (1959) considers there to be 18 species of high commercial value but notes another 36 of some economic significance.

According to the Mekong Committee (1993) the distribution of species does not prove any particular endemism and the "great majority" of species are found elsewhere in the Mekong. The importance, however, of what endemism exists has not been evaluated and should not necessarily be measured only in terms of its value to production fisheries.

There are three recognized groups of fish based on their ecological characteristics (Mekong Committee, 1992):

a) white fish: a group associated mainly with the larger streams and the main river, but undertake spawning migrations between these and the flooded areas in the wet season. Mainly cyprinids;

b) black fish: species which are able to survive under more adverse and varied environmental conditions (low oxygen, some acidity, some salinity) and which can stay in swamps and plains year round. Families Claridae, Ophicephalidae, Bagridae, and Anabantidae;

c) opportunists: smaller, fast growing and prolific species during flood periods. Mainly cyprinids.

There is not sufficient evidence to state categorically that species have disappeared from the lake. However, fisheries scientists who have worked on the lake for the past twenty years note that there is a strong downward pressure on the larger species and that several, including the large carp *Catlacarpio siamensis*, have not been recorded for a number of years. On this some scientists will venture that, given the highly efficient harvesting methods on the lake, some species "are likely to be disappearing" and that there is a problem with maintaining the reproductive stock for a number of species (W. Rainboth, pers. comm.).

Birds and Otters

Cambodia is one of the few Asian countries which has not participated in the Asian Waterfowl Census —a major international waterbird monitoring program. Less comprehensive surveys have been undertaken which indicate that many species suffered a significant decline since the 1960's. A number of species which were present in the 1960's were not located in a 1992 survey of the Cambodian wetlands (Scott, 1992). The destruction of habitat and hunting pressures are held largely responsible for the decline in numbers.

Scott lists 18 rare and declining species of waterbirds foe which the wetlands of Cambodia may now constitute a refuge of considerable international importance. The species include the Greater Adjutant Stork, the Lesser Adjutant Stork, the Milky Stork, the Giant Ibis, the Eastern Sarus Crane, and the Spot-billed Pelican.

The area around the Tonle Sap was recently populated by elephants, deer, wild buffalo, wild pigs, small cats, leopards. No systematic surveys have been undertaken recently but there have been no

confirmed sightings of these animals in this area (D Ashwell, pers. comm.). Three species of dolphin as well as crocodiles are found in the lake.

Discussion

This brief review of the current status of the Tonle Sap - whether based on changes in minimum depth, sedimentation, commercial fisheries, reduction in flooded forest, or impact on biodiversity - does not suggest that the overall situation is of crisis proportion. Nor does it suggest that the lake and its surrounding area are in a state of well managed equilibrium.

The word "suggest" is judiciously used here, as opposed to "substantiate", "verify" or "confirm". There has been very little primary field work done in Cambodia since the 1960's. Since the mid-1980's on, expert missions have prepared numerous reports on the fisheries and forestry sectors and on the ecology/environment of the Tonle Sap. Invariably they have based there conclusions on few field observations. They have reported speculative assertions a sufficient number of times that conjecture becomes conventional wisdom.

In the absence of hard information, however, conventional wisdom shifts rapidly. Until recently it was fashionable to predict the demise of the Tonle Sap on the basis of inference and speculation. Two recent reports - Mekong Committee 1992 and 1993 - have critiqued the previously held assumptions. The alternative hypotheses that these reports propose are challenging the old conventional wisdom (the gloom and doom scenario), and to some measure will succeed because they did an admirable job in compiling the current data base.

On the one hand there is some relief in what evidence is available to suggest that we can afford to adopt a less drastic view regarding the fate of the lake. On the other, the authors of these reports are quite correct in noting that their findings and conclusions are hypothesis that need to be validated with additional studies. In other words these are perspectives that are still based on inference and speculation. The revision of historical data without solid evidence to warrant such a drastic modification of baseline information is questionable and can only cast doubt on the evenhandedness of the data evaluation that leads to yet more speculative assertions.

What worries those who are concerned with an ecosystem approach to lake management, as opposed to having an eye on only production variables, are the increasingly frequent occurrences in other parts of the world where ecological or production systems, that we think we understand, suddenly collapse. In the face of what appears to be a wealth of solid information, a surfeit of comforting statistics, and an implemented regime of well devised management practices - all of which have suggested that only a little fine-tuning is required to achieve optimal production - these systems (fisheries systems being the most common) abruptly crash. Analysis in the aftermath of the occurrences suggest that when a few key species disappear (usually the abundant herbivores that make up the base of the food chain), the rest of the system quickly follows.

It is as if the wisdom, accumulated knowledge and instinct that seems to be inherent in people, particularly the users of the resources, counts for little in the face of statistics and larger, ill-conceived public policy. In Canada this was certainly the case of the Great Lakes fisheries or the more recent collapse of the cod industry off the east coast. In the latter case, the fishermen had been warning for years about the dangers of over-fishing but somehow, between the government scientists and the federal politicians (who are now pointing fingers at each other), the decision was made to continue with the prevailing management practices. There were some indications of declining trend but when the collapse occurred it did so dramatically. From the tons that had been regularly caught, trawlers were coming back to port without so much as a single fish.

Similarly, anecdotal evidence, while necessarily suspect, at least needs to be factored into the analysis in the absence of hard data. The Mekong Committee in 1992 noted that although there had not been successive sedimentation surveys of the lake bed "...there is considerable personal testimony on the part of several knowledgeable inhabitants to the fact that the lake has been progressively silting up ". How does one reconcile quantified total fisheries catches against the assertions by Chevey and Poulain (1940) that the fishing pressures on the lake were "relentless" and that overfishing was directly responsible for the decreasing fish size, or the observation of Blanche and Goosens (1954) that species of large fish were being harvested at smaller sizes which they termed a classic example of over-fishing.

It is worth repeating that the destruction of the Canadian cod industry happened with mountains of information and an abundance of qualified expertise at hand. Cambodia has no such advantage in assessing the status or trends for the Tonle Sap. Yet Cambodian policy makers are being told in the absence of evidence, with little equivocation, that "there is not as yet any evidence of over-exploitation of fish in Cambodia" (Mekong Committee, 1993). The definition provided of 'over-fishing " is 'excessive catches which do not allow the recovery from one annual fishing cycle to another - other things being equal - of the optimal production level that the ecosystem is capable of providing". Optimal is viewed in the report as either overall production (quantity of protein), the economic value of production (some species have a higher value and/or larger size than other), or as a target for minimum income for fishermen. This is a classic fisheries production perspective that does not take into account larger implications of diversity and other indicators of ecosystem soundness.

"What is to be done?"

As a starting point, let us assume defensible and supportable the recent positive assessment regarding the relative health of the Tonle Sap. Does this suggest that there is nothing to be done, i.e. if it's not broken, don't fix it'?. There *are* in fact trends, some of which are better documented than others, which are recognized as to have foundation. These trends are *likely* to have adverse social, economic and environmental consequences in the future, even if the impacts are not being felt immediately. These include the *facts* that:

- there are intense pressures on the remaining flooded forest for fuelwood, charcoal and agricultural conversion. The total area of flooded forest *is* decreasing;
- habitat for species of rare and endangered species of birds and animals is consequently decreasing;
- upland deforestation is increasing, resulting in increased erosion and sedimentation to the lake;
- pressures on the fish stock are resulting in smaller fish, if not in reductions in overall catch size;
- unsustainable harvesting methods of fish and other animals are currently practiced including dynamiting, poisoning, and the use of small mesh nets and unselective traps, and indiscriminate hunting.

These examples are only a small fraction of the influences and impacts that affect the viability of the Tonle Sap and, in short, there is only a very rudimentary understanding of the complexity of the ecosystem and how it works. It would be presumptuous and arrogant to think that we (people, institutions, governments) can "manage' the lake, particularly with single-sector (fisheries, forestry, agriculture) production objectives in mind, with no danger that the unexpected might happen.

The case of the Tonle Sap is one where revised historical data and production statistics are saying one thing but where judgment regarding the relationship between observable impacts and predictable consequences say another. There is an evident conflict in the two approaches in that they

would necessarily result in different policy perspectives and adoption of different resource management regimes. The issues are how responsible public policy is formulated in the face of contradictory advise and how supporting sectoral development plans are devised in the absence of information.

Legislation, Mandate and Authority/Inter-Jurisdictional Issues

As a first step, public policy at a national level cannot be developed when mandates and authorities are ill-defined and contentious. The institutional context for the development and management of the Tonle Sap needs to be sorted out, including the role and responsibilities for various government ministries involved in the Tonle Sap.

The following is a partial list of agencies and authorities that potentially have a role in the management of the Tonle Sap area:

- Fisheries Department, Ministry of Agriculture (MoA): jurisdiction over the open waters and the inundated areas around the lake;
- Forestry Department (MoA): jurisdiction over forests elsewhere in the catchment area;
- Ministry of Environment: responsible for the planning and development of protected areas. The inundated forest of the Tonle Sap has been designated as a multi-use management area by Royal Decree. In addition the Ministry has the nominal responsibility for pollution control and environmental impact assessments of development projects;
- Wildlife Protection Office (MoA): responsible for wildlife management, hunting, and control;
- The Ministries of Transport, Communication and Post: responsible for navigation and river transport;
- Ministry of Tourism: authority for the development of the considerable tourism potential of the lake.

There is not good precedence for integrated natural resource management or environmental management in Cambodia. These are relatively new disciplines, refined over the past 25 years which coincides with the period of Cambodia's isolation. it is to be expected that many of the resource management policies and management techniques that are in place in other countries are not in place in Cambodia. Natural resource or environmental management is not a sectoral activity, it is multi-sectoral. Comprehensive policies requires resolution to conflicting resource uses, and dispute resolution requires dialogue. The institutional mechanisms for resolving these issues in Cambodia and for formulating broad-based, multi-sectoral policy and legislation need to be developed. Simply said, if there is to be a resolution between two conflicting approaches to resource management, it can only happen through dialogue with good technical information and viable policy options at hand - something that is not taking place at present.

Development of Policy and Regulatory Framework

In an ideal situation the development of policies, legislation and regulations is a relatively ordered affair. It entails a process, a sequence of events where one stage is built on the foundations of the previous. A problem is identified, information is gathered and analyzed, options are considered, and a program response is developed to address the problem. This response either reflects an existing policy or is used to feed back into the policy development process. The promulgation of legislation or the development of regulations is an extension of the established policy.

The absence of information, the lack of defined authority, and the political exigency of being required to react to a problem, all conspire to produce a reverse of the ideal process. Presently in

Cambodia, legislation and regulations are the first response to a problem, in the absence of a broader policy that defines the government's position and intentions. The policy is not defined because the information is not at hand. In this case, legislation becomes the vehicle to define or expand the agency's authority, not necessarily to comprehensively address the problem at hand.

If not only for the lack of enforcement capacity, governments should not be under the illusion that legislation will solve the problem. This will be more readily accomplished by (i) development of a workable institutional framework for lake management with government agencies, as well as private sector, non-governmental organizations, and communities; (ii) collection and analysis of basic information; (iii) development of policies and programs, and (iv) if and when necessary, the formulation of appropriate legislation that takes into account the roles and responsibilities of the implicated agencies.

As noted, this represents only the first step in the process of imposing a management regime over a relatively chaotic, if not anarchic, natural resource free-for-all. Other recommendations that can be added are fairly standard - institutional capacity building, enforcement, community participation in resource management, etc., and can be found in dozens of reports, books, presentations on integrated resource or environmental management However, the technical skills and financial resources to incorporate these recommendations are, to some degree, easier to secure than the prerequisite political will.

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The Environmental Conditions of the Dianchi Lake, China

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1. Characteristics of the Dianchi Lake

Lake Dianchi is a well-known fresh-water lake on a plateau. It is located to the south of the city of Kunming in Yunnan province, in the middle of the Yun Gui Plateau (which forms the Southwestern part of China) at 1,885.5 meters above mean sea level, between longitude 102^0 36' and 102^0 47' E and between latitude 24^0 40' and 25^0 2' N. The Dianchi Lake is situated in the watersheds of three large river systems, viz., the Yangtze, the Pearl and the Red River. The lake is 40 km long from south to north, and 12.5 km from east to west. Its average depth is 4.4 meters with a maximum of 10.9 meters, and a surface area of 306 km^2, giving a total capacity of 1.29 billion m^3. There is a natural dam-like dike which divides the lake into two parts: the larger part called Wai Hai at the southern end and the smaller Cao Hai at the northern end. Some 20 rivers and streams flowing through farm lands, towns and phosphorus mining sites drain into the lake, carrying nutrients such as nitrogen and phosphorus. There is an outlet in south-western part of the lake, which flows via the Tanglangchuan River, eventually joining the Jinshajiang River. This outlet is controlled by a dam. The flow toward the outlet is influenced by jet flows, wind-driven waves and large-scale pumping, in addition to the natural discharge direction. However, circulation still exists in some parts.

The catchment area of the Dianchi lake is 2,920 km^2. The Dianchi catchment lies in a northern sub-tropical humid monsoon climate, with the mean annual temperature of 14.7°C, and average precipitation ranging 797-2,120 mm/year. The lake is surrounded by mountains, hills and accretion plains. The soils in the drainage area are varied and their structures complicated due to land forms and bioclimatic influences. A total of 12 soil types, 19 sub-types, 36 soil categories and 59 soil species have been identified. The main soils are krasonzem, rice soil and purple soil, which respectively hold 73.8 percent, 14.6 percent and 7 percent of the total coverage.

The main landforms in the Dianchi catchment are mountains (covering 1,380.89 km^2, or 47.3% of the total area), terraces (410.55 km^2, or 14.1%), valley basins and plains.

The zonal vegetation around the lake includes sub-tropical broad-leaf ever-green forest, Yunnan Pine forest, shrub-grass land, aquatic plants and paddy fields. The condition of the habitat is retrograding from humid or semi-humid backward to dry and impoverished. The primary vegetation is replaced by secondary vegetation such as sparse trees, shrub-grassland and Yunnan Pine. The forest cover is now only 23 percent.

The Dianchi catchment has known reserves of 14 kinds of minerals. There are 41 mining sites, mainly phosphorus. The area is one of the three largest phosphorus mining sites in China, with total reserves estimated at 1.48 billion tons.

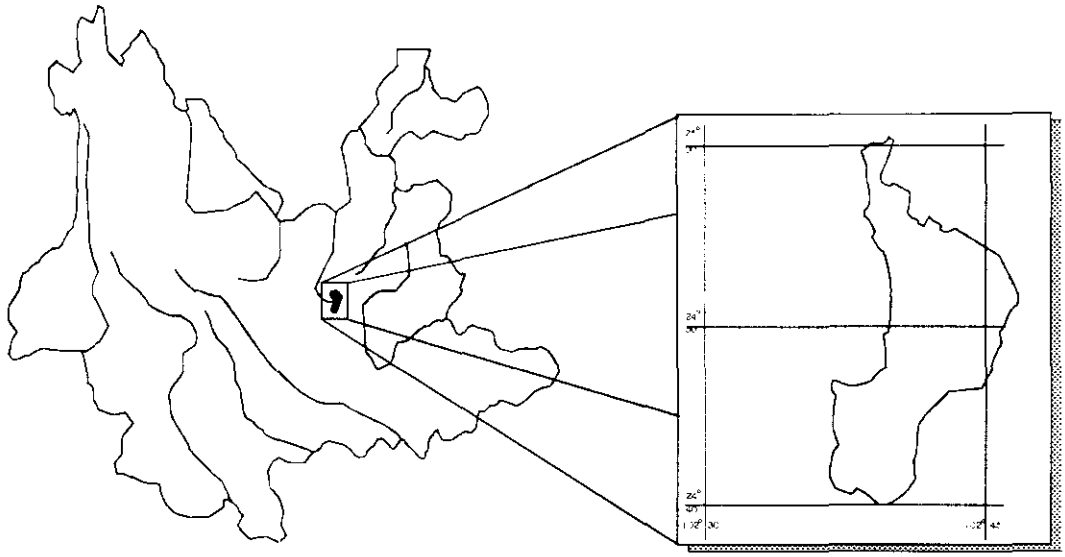


Figure 1. The Dianchi Lake and Its Location in Yunnan Province, China

Lake Dianchi is the source of water for drinking, industrial and agricultural use. It plays various vital roles including storage, flood protection, tourism, navigation, aquaculture, climate adjustment and hydropower generation.

Social and Economic Conditions

The total population in the catchment is 1.8 million. With a density of 689 people/km^2, the catchment is the most densely populated area in Yunnan province. The birth rate is 13.33 percent, the death rate 38 percent and the natural growth rate 7.95 percent.

Kunming city is the political, economic and cultural center and transportation hub of Yunnan province. The city's economy is of great importance to the entire province. Kunming's total industrial and agricultural output is 32.05 percent of that of the province, with the industrial output alone being 44.35 percent of that of the province. Large and medium-sized enterprises contribute 81.4 percent of the city's output

Kunming's economy is, in turn, dominated by the Dianchi catchment. Although it covers a mere 18.7 percent of Kunming's total area, the catchment accounts for 80 percent of the city's economy: 79.8 percent of the industrial and agricultural output and 82.8 percent of the industrial output alone.

Most of Kunming's industries are distributed in the catchment area. There are more than 5,000 enterprises in various sectors including machinery, metallurgy, textile, food-processing, cigarettes, chemical industry and building materials. Agriculture in the catchment is typically suburban, based on plantation and husbandry, producing grains, vegetables, fruits and meat.

Water Resources of the Dianchi Catchment

In the Dianchi catchment, average annual precipitation is 2,753.38 million m^3, evaporation is 2,208 million m^3, runoff volume is 545.38 million m^3. Industry and agriculture consume 142.03 million m^3. The three prominent characteristics of the water resources in the Dianchi catchment are:

- *Relative scarcity:* The average annual runoff of 545.38 million m^3 spread over the total catchment area of 2920 km^2 gives a runoff depth of 186.8 mm, which is small

compared with other places in the world, or even China or Yunnan province itself. Per capita water demand in the catchment is only 1/33rd of that of the world, 1/9th of that of China and 1/23rd of Yunnan province. Calculated by arable land, the water resource per *mu*[1] is 1/3rd of that of the world, 2/3rd of China's and 1/6th of that of Yunnan province.

- *Sharp seasonal change:* A sharp seasonal change in annual precipitation results in unevenness in runoff, causing fluctuations in the quantities of water available. During the rainy season, the water resources are 81 percent of the whole year; the remaining 19 percent occurring during the dry season. The months of July, August and September together account for 60 percent of the total water resources, while August alone accounts for 25 percent. April is the month of lowest precipitation, about 1.2 percent of the whole year. The allocation is extremely uneven. The coefficient of variability is 0.44-0.45.
- *Long-term changes in water availability:* In addition to the annual fluctuation, water resources in the Dianchi catchment also exhibit long-term periodic variations, with high and low water flows.

Through years of development, construction and urbanization, industrial and domestic use of water from the Dianchi Lake is increasing, along with the demand from irrigated agriculture. Irrigation based on both pumping as well as storage coexists in the Dianchi catchment. We have established 110 various engineering sites for water storage, mainly distributed in mountainous and semi-mountainous area, and also built 607 discharge and irrigation stations, along the lakeside. A total of 460.6 thousand *mu* are irrigated. However, due to the great increase in domestic and industrial water consumption, the Songhuaba Reservoir in the upper reaches of the Dianchi Lake, which used to be the source chiefly for irrigation, is also supplying for industrial and domestic use. Irrigation agriculture using water pumped from the Dianchi Lake is expanding northward. The lake also serves as a source of water for industries located along its side.

With supply and discharge of water dependent mainly on the Dianchi Lake, a semi-closed circular recycling system has come into being in the catchment. A return flow of water carrying waste from farmlands, industrial effluents and domestic wastwater directly or indirectly enters the Dianchi Lake and is used again.

Agriculture in the catchment accounts for 87.7 percent (184.7 million m^3) of water consumption, industrial and urban household consumption is 12.2 percent (25.66 million m^3), while consumption by human-being and livestock in the rural areas is only 0.1 percent (0.18 million m^3). Water resources in the catchment provide 130.08 million m^3, in addition to the down-draught of 161.15 million m^3. During the period of water shortage, this is supplemented by water from the Songhuaba Reservoir and the previous year's storage in the Dianchi lake. Supply and demand are balanced by annual adjustments.

2. Major Environmental Issues

2.1 Soil Erosion

A remote-sensing investigation revealed that soil erosion in the Dianchi catchment is about 1.06 million tons per year, with an average erosion coefficient of 123.29 tons/km^2, and a mean annual erosion depth of 0.68 mm. About 37 percent of this erosion (about 390,000 tons) enters the Dianchi Lake.

[1] A *mu* is the Chinese unit of area. A *mu* is equivalent to about one-fifteenth of a hectare.

The two main erosion types are surface erosion and furrow erosion. The intensity of erosion increases from the low ground level to the high level. Some 37 percent (about 965 km^2) of the catchment area suffers slight to strong erosion (Table 1). Increasingly intense erosion is evident in the watershed areas in the upper reaches, the upper reaches in the southern, western and eastern parts of the lake.

Table 1. Area and Percentage of Soil Erosion in the Dianchi Catchment

Catch-ment	Degree of Erosion Intensity and Area Affected									
	Very Slight		Slight		Moderate		Severe		Very Severe	
Area*	area	%	area	%	area	%	area	%	area	%
2620	16.38	62.52	807.64	30.83	151.20	5.77	2.12	0.08	4.00	0.15

Note: * Excluding the lake's surface area

Soil erosion in the Dianchi catchment is caused by natural erosional processes but it is accentuated by human activities. The natural erosion is caused by factors such as precipitation, topography, rock types and structure. Accelerated erosion is caused by human activities, such as:

Extensive cultivation and land reclamation due to population pressure: Because of the rapid growth of population in the catchment, land resources per capita are very low. People over-reclaim the land to relieve the land pressure, only to worsen soil erosion. The rate of land reclamation in the catchment is 27.65 percent, far above the provincial average of 7 percent.

Mining and Construction Activities: As mentioned earlier, the Dianchi Lake area is one of the important phosphorus mining sites in China. Every year, thousands of tons of surface soil and vegetation is removed as a result of open mining. During the rainy season the bare soil is exposed to heavy precipitation and carried downslope along with discarded stones and mining tailings.

During the past 45 years, about 56.1 million m^3 of sediment has accumulated in the Dianchi Lake. The deposition rate has been increasing, with the average being 1.34 mm/year. The lake bed has risen by 47 cm, and the surface area has shrunk from 320 km^2 to 306 km^2, with a resultant decrease in water storage capacity from 1.5 billion m^3 to 1.29 billion m^3. The silting and aging of the lake has been very serious.

2.2 Lake Pollution

The main causes of pollution in the Dianchi Lake is organic waste entering the lake and eutrophication.

Three pollution sources can be identified, viz., industrial effluent and domestic wastewater discharge; non-point source pollution from waste matter carried in natural runoff, precipitation on the lake surface, and dustfall and human activities; and pollution caused by decomposition of lake sediments.

Pollution from point sources is particularly significant in the north, east and south, and its loads of total nitrogen (TN), total phosphorus (TP), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) are, respectively, 69, 55, 90 and 88 percent of the total pollution loads in the Dianchi Lake. Among the non-point sources, the most significant source is waste in surface runoff, followed by precipitation on the lake surface, and dustfall and human activities. The TN, TP, BOD and COD loads from non-point sources are 31, 45, 10 and 12 percent, respectively (Table 2).

Internal pollution due to decomposition of sediments is significantly higher in the Cao Hai area. Cao Hai represents only 2.7 percent of the lake area, but receives 45 percent of the wastewater that enters the lake; 40 percent of the pollutants in the organic nutrient-rich wastewater settle down in Cao Hai. The Wai Hai area, though much larger, has higher concentrations of phosphorus because of phosphorus mining and processing activities along the lakeside. The sediment bed in Cao Hai is 10 cm thick, with an estimated 9,700 tons of nitrogen and 4,650 tons of phosphorus in it. In Wai Hai the nitrogen and phosphorus amounts in the sediment are estimated to be more than 100,000 tons. Under certain conditions, these sediments release substances that pollute the lake, particularly in Cao Hai.

Table 2. Pollution Load Contribution by Different Point and Non-point Sources

		Point Sources			Non-Point Sources			Total
		Domestic wastewater	Industrial effluent	Total	Runoff	Rainfall	Total	
Water	Amount	7928	7260	15188	28055	-	28055	43243
Volume	%	18	17	35	65	-	65	100
TN	Amount	2443	791.1	3234.1	1057.2	411.6	1468.8	4702.9
	%	51.59	16.82	68.77	22.48	8.75	31.23	100
TP	Amount	175.43	75.73	251.16	168.87	35.79	204.66	455.82
	%	38.49	16.61	55.10	37.05	7.85	44.90	100
BOD_5	Amount	6253	2000	8253	909	-	909	9162
	%	68.3	21.8	90.1	9.9	-	9.9	100
COD	Amount	12509	5929	18438	2000	439	2439	20877
	%	59.9	28.4	88.3	9.6	2.1	11.7	100

Since the amount of pollutants entering the Dianchi Lake is far higher than the lake's natural regeneration capacity, the water quality is low. Water in Cao Hai is highly eutrophic. Eutrophication is also significant in Wai Hai. With the rise in population and the consequent increase in the quantities of organic nutrients discharged into the lake, eutrophication of the Dianchi Lake is becoming increasingly severe and has greatly impaired many of the Dianchi Lake's biologically and economically important functions:

- *Tourism:* Deteriorating water quality is adversely affecting tourism. During the 1960s and earlier, water in Cao Hai was clear and potable. Increased wastewater discharges in the last two to three decades, however, have led to increased loads of nitrogen and phosphorus leading to algal and other vegetation growth. The diaphaneity is only 40 cm (at Wai hai it is only about 1 cm). The decomposition of organic material leads to emission of methane (CH_4), hydrogen sulfide (H_2S) and ammonia (NH_3) giving the water a peculiar odour.
- *Changes in fish species structure:* The changes in water quality, oxygen levels and the occurrence of floating algae have destroyed the delicate balance among the lake's trophic levels. Populations of fish species living on floating algae have increased significantly, while some economically important fish species are gradually being pushed toward extinction.
- *Water supply:* Deteriorating water quality makes water supply difficult and increases treatment costs. The Dianchi lake is one of the main sources of drinking water for Kunming city. Some 22 million tons of the water supplied to the city comes from the lake. Currently, concentrations of ammonia nitrogen and nitrite nitrogen in the lake

water are above the maximum permissible levels. Treating the water therefore becomes difficult and costly.

- *Accelerated aging and decaying of the lake:* Eutrophication and the subsequent settling of dead vegetation on the lake floor as well as sediment loads entering the lake raise the lake bed. The lake is becoming shallower and is turning into a marsh as the processes of aging and decaying continue to accelerate.

2.3 Water Resource Deficiency

The current annual water demand in the Dianchi catchment is estimated to be 655 million m^3, while the water resources available are only 545.38 million m^3, leaving a shortage of about 100 million m^3. Balancing the supply and demand therefore relies heavily on the recycling of water re-entering the lake. The Dianchi Lake plays an important role as a circulation pond recycling water. Some 230,000 *mu* of farmland lies along the lakeside. The water company that supplies to Kunming city, draws 292.6 million m^3 from Wai Hai, with a recycling rate of 32 percent. Industrial enterprises along the lake draw another 3,000 million m^3 themselves.

With urban, industrial and agricultural development recycling of water re-entering the lake is increasing. According to the Water Supply Plan of Kunming City, by the year 2000 the city's daily water need is estimated to reach 810,000 tons/day, up from the current use of 330,000 t/d. This suggests an increase of about 500,000 t/d. Presently—and perhaps also in the future—there is only the Songhuaba Reservoir which can be used as a source of drinking water for the city. After its renovation the total amount is expected to reach 310,000 t/d. Adding the 50,000 t/d of ground water currently used, the total water supply will be 360,000 t/d—still a far cry from the anticipated demand of 810,000 t/d. The remaining 450,000 t/d would thus have to come from the Dianchi Lake. This means that in Kunming city, urban water consumption will mainly depend on the recycling of the water re-entering the lake.

Serious pollution and accelerated eutrophication intensify the discrepancy in water supply and demand. They also impair the many vital functions the lake serves, including adjustment and storage, flood protection, tourism, navigation, aquatic culture, climate adjustment and hydropower generation. For the social and economic development of the catchment area to continue, it is important to develop and utilise the water resources of the Dianchi Lake to meet the water demands of the urban area, industries and agriculture. Much of the water entering the Dianchi Lake is used and includes domestic wastewater, industrial effluent and agricultural discharge. Currently, some 300,000 tons of industrial effluent and 120,000 tons of domestic wastewater enter the lake daily. Each year, more than 58,400 tons of organic pollutants, 456 tons of phosphorus and 47,030 tons of nitrogen are added. Yet, there is only one water treatment plant with a capacity to treat daily 55,000 tons of wastewater. Some 84 percent of industrial effluent enters untreated. It is more difficult to control the pollution from farmlands.

To solve the water shortages it is important to consider the recycling of the returning water. Pollution control is the key and a pre-requisite to the full utilization of the water resources of the Dianchi Lake.

3. Protection and recovery of the Dianchi Lake

Geological, geomorphic, hydrological, chemical and biological processes occurring in nature are interrelated. Together these processes form a part of the complete ecological system such as a lake. Over the geological time since the lake's formation, this ecosystem develops and reaches a dynamic equilibrium. If people disregard the integrity of the ecosystem while utilizing the lake resources and destroy one of the many interconnections, a chain reaction will occur causing the whole ecosystem

to lose its balance and collapse. The environmental issues of the Dianchi Lake are caused by unreasonable and excessive utilization of its resources. A comprehensive treatment of the lake must, therefore, take into account the ecological laws which govern the lake ecosystem. The measures must be directed toward recovery and improvement of the disturbed ecosystem.

Controlling the discharge of phosphorus- and nitrogen-rich nutrients into the lake is essential for checking further eutrophication of the lake. Measures to remove existing nitrogen and phosphorus should also be considered.

As the statistics in Table 3 shows, in the Dianchi lake pollution from point sources is much larger than from non-point sources, and industries contribute a significant part of the point source pollution. By the year 2000, the share of point source pollution, particularly industrial, is expected to increase even further. More efforts must be directed, therefore, toward controlling point source pollution, particularly industrial effluent. Control of non-point sources and treatment of sediment are also necessary steps.

Table 3. Pollution Load Trends in the Dianchi Lake

(unit: percent)

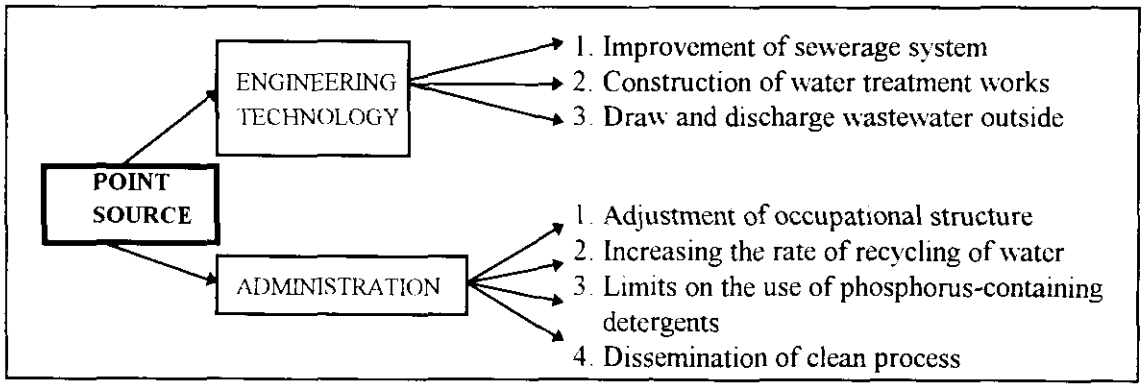
	Point Source			Non-point Source			Industrial Pollution Source		
	1988	1995	2000	1988	1995	2000	1988	1995	2000
TP	55.1	64	71	44.9	36	29	16.1	22	23
TN	66.8	74	83	33.2	26	17	16.8	25	26
BOD_5	90.1	91	94	9.9	9	6	21.8	44	37
COD	88.3	90	93	11.7	10	7	28.4	58	53

Comprehensive Treatment of Point Source Pollution

The analysis of sources of Dianchi Lake pollution shows that bio-available phosphorus comes mainly from domestic wastewater. Therefore, the first important step toward comprehensive treatment is to improve the urban sewerage system for efficient collection of wastewater. In line with the city's optimization plan water treatment plants need to be established. Since the Dianchi Lake's regeneration capacity is limited, the option of collecting wastewater and discharging it outside the catchment to reduce the pollution load in the lake must also be considered (Figure 2).

Along with the above technological measures, some administrative measures are also needed. These include adjusting the occupational structure in the catchment and increasing the frequency of recycling the water, limiting the use of detergents containing phosphorus, and overall transparency in the dissemination of information.

Figure 2. Treating Point Source Pollution in the Dianchi Lake Catchment

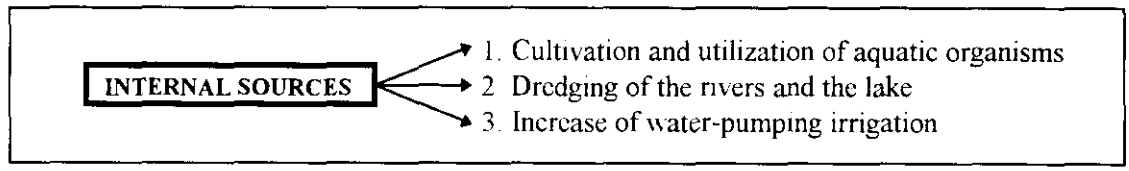


Internal pollution treatment

Internal pollution exists in the lake water as well as in sediments on the lake floor. The release of nitrogen and phosphorus from sediments can be greatly reduced by regularly dredging the in-flowing rivers and Cao Hai. Dredging the waterbodies would also help control non-point source pollution occurring during the storm period, since storm-flows wash away soils and stir sediments in river beds and the lake. Non-point source pollution is the greatest during the storm period. Sediments in the river beds are washed into Cao Hai, and those in Cao Hai are washed into Wai Hai deteriorating its water quality. It is, therefore, very important to desilt the rivers and Cao Hai regularly to control non-point pollution.

Another effective way to control internal pollution is to cultivate aquatic organisms that live upon nutrients present in water (Figure 3). This would help reduce the nutrient contents in the lake water. Increasing water-pumping for irrigation agriculture would also help control pollution load in the water. When used for irrigation, the nutrient-rich water would increase soil fertility, thereby increasing agricultural productivity. Since the nutrient concentration is higher in Cao Hai than in Wai Hai, considerations should be given to increasing the irrigation area near Cao Hai and reducing it near Wai Hai

Figure 3. Treating Internal Pollution of the Dianchi Lake



Non-point Source Pollution Treatment

Since soil erosion is the major non-point pollution source, the treatment should focus mainly on controlling this source. Sediment entering the Dianchi Lake both silt the lake and affect water quality.

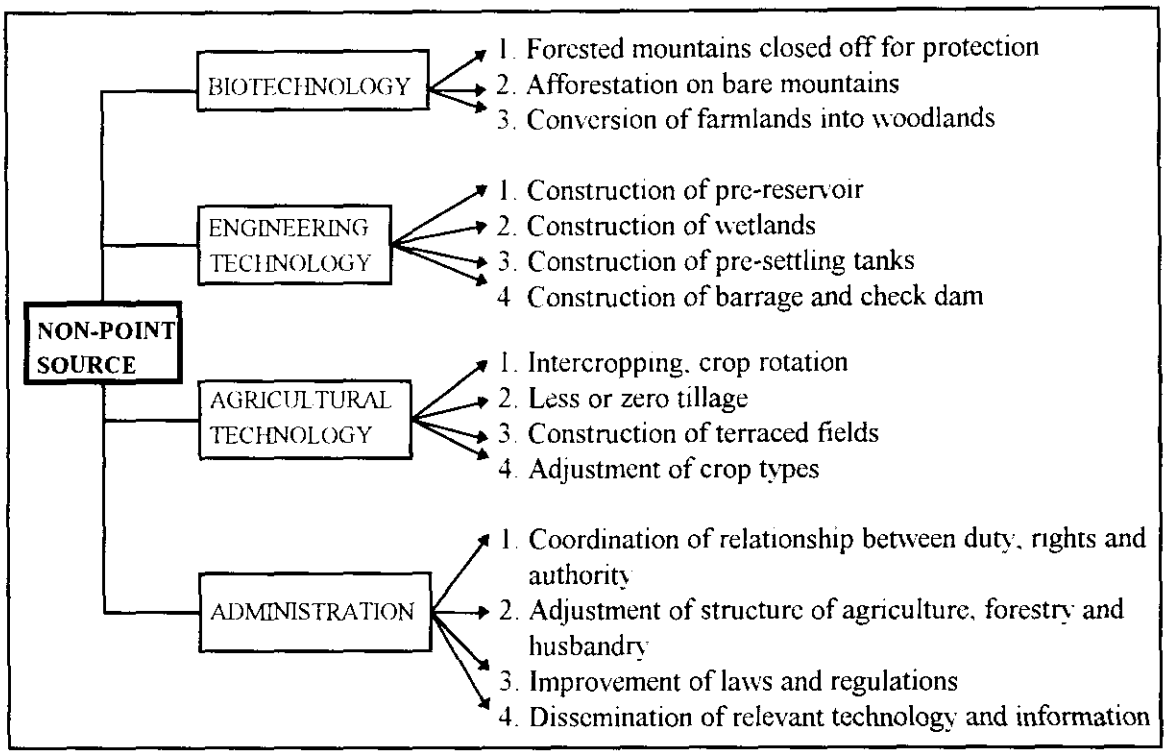
There are many ways to control soil erosion, including agricultural technology, biotechnology, engineering technology and strengthening the administrative structure (Figure 4). Construction of siltation tanks and weirs can reduce siltation of the lake.

A prereservoir-wetland system can effectively control nitrogen- and phosphorus-rich nutrient pollution from non-point sources. Surface runoff can be collected in a prereservoir where solid material containing nitrogen and phosphorus compounds as well as some dissolved nutrients can be removed. The plants in the wetland can absorb much of the remaining dissolved nutrients. Such prereservoir-wetland systems can be built on low, submerged land.

The purpose of soil erosion control is to prevent rain from washing away surface soil and to increase surface soil coverage. These objectives can be achieved by afforesting bare mountains, protecting forested areas, converting cultivated land into woodland, and employing agricultural methods that prevent soil erosion and nutrient loss, e.g., intercropping, crop rotation, less or zero tillage, etc. Nutrient output in agricultural discharges can be reduced by limiting the use of fertilizers and by changing to crops that make a more efficient utilization of fertilizers.

The above measures would greatly help in solving the environmental issues affecting the Dianchi Lake, and restoring its health and that of the environment of the catchment. This way, the Dianchi, a precious plateau lake, can survive.

Figure 4. Treating Non-point Source Pollution in the Dianchi Catchment



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Annex I

Small Group Discussions

Group 1. Water Resources Management

Issues

- *Water shortages amidst abundance*: There is evidence of wasteful practices during times of shortage.
- *Water quality*. Deterioration of water quality has led to biodiversity destruction as well as reduced supplies of water for consumption or high costs of water treatment.
- *Mismanagement*: Policy inconsistencies, lack of enforcement of the legal framework or even lack of policies altogether are a big part of the problem. Policies undertaken without taking due consideration of the effects on people and communities or other downstream riparian countries are also creating conflict in the region.

Information and Action Needs

- There is a need to define water problems more comprehensively, without limiting the discussion to supply problems, which has traditionally been the case. Information on socio-economic and environmental impacts of a policy decision need to be gathered, assessed and disseminated to affected parties. Pilot scale water budget studies and the value of water to each group of stakeholders could be undertaken to better understand the above issues.
- We should compile information on current, ongoing and future development projects in the Mekong Basin, including both public and private investments.
- There is a need to make the process of law-making more transparent and responsive to the needs of the affected communities.

Proposals

- To increase national and regional awareness on possible options to solving water problems, including economic instruments,
- To increase national and regional awareness of the environmental impacts of water consumption;
- To maintain an informal network of academic NGOs and government officials in their professional expertise rather than as representatives of the government. The network would enhance natural resources and environmental conservation through exchange of experiences and information dissemination.

Group 2. Biodiversity, Land Use and Forest Policy

Issues

- Community participation in forest management: Most governments do not have the capacity to monitor activities in forests throughout their countries. It is therefore incumbent upon the communities that reside in or near the forests to develop ways to protect and sustainably use the forests.
- The link between poverty and forest destruction: Forests often supply much needed income and nutrition to poorer families. When basic needs are not being met, little attention is paid to longer run concerns of biodiversity or sustainability. Agricultural

or agro-ecosystem development is necessary to alleviate problems of chronic poverty. Other sources of income will relieve pressure on the forests.

- The establishment of protected areas: Putting forests out of bounds to human use can harm the communities that live near a protected area. Also, the reasons for establishing a protected area should be clearly defined (i.e., as a wildlife sanctuary, as a watershed area, etc.).
- Technical issues of reforestation activities: Much forest cutting is a result of the search for fuelwood, and international projects have sought to address this problem by planting fast-growing species such as eucalyptus. However, the benefits of eucalyptus are proving more and more tenuous, and the replacement of eucalyptus with fast-growing native species is gaining popularity. Some problems that remain include a lack of research on native species and few nurseries for these species.
- Infrastructure development and forest protection: The planned construction of roads and dams throughout the region will have large effects on the forests, both through direct cutting and through providing greater access to other potential users.
- Cross-border trade in forest products: Both legal and illegal trade in timber and non-timber forest products put further pressure on the remaining forests. There is also a penchant for the use of exotic species (especially animals) in various cuisines in the region.

Information and Action Needs

- Better methods of encouraging local communities to work with forests are needed. Certain government structures and policies, such as the land tenure system, need to be adapted to suit local community and forest conservation needs. Some method of experiences and research should be developed, especially regarding work with hill tribe groups.
- Poverty alleviation in rural areas should incorporate forest protection. However, current methods of forest conservation need to be re-evaluated, especially when surrounding communities are deprived of a significant source of income.
- Comprehensive land tenure policies should be implemented.
- More research on reforestation and native species is needed to help improve ecological understanding of forest systems.
- Any and all infrastructure development activities should be preceded by a comprehensive environmental impact assessment.
- Cross-border trade in forest products needs to be monitored more closely, and stricter enforcement of existing laws and treaties (i.e., CITES) should be encouraged.

Proposals

This group ran out of time before any proposals could be put forth.

Group 3. Environment and Development and the Environmental Impact Assessment

Issues

- Sustainable Development for EIA
- Complexity of EIA in different sectors

- Neccessity of exchange of experience and cooperation for EIA in the region: Among the countries in this region, each has different tools for sustainable development promotion.

Information and Action Needs

- It is necessary to do case studies in each country in order to learn from one another. TDRI has started to do national accounting in Thailand and CIDA is probably interested in case studies, training programs and participating in EIA activities.
- EIA needs to be acted upon quickly. Therefore, it is necessary to look into the decision making structure rather than policy. By raising the awareness of decision-makers they can act in time and the establish the priority of EIA
- We should identify the appropriate regional institutions and collaborate with them to work on EIA. EIA promotion requires cooperation with different institutions for decision making.
- EIA should start on a regional basis according to sector. For example, we need long term planning (i.e., mangrove forest conservation in Thailand, Cambodia and Vietnam).

Proposals

- To hold a regional workshop for EIA: TDRI should ask an international organization to organize a workshop for EIA.
- To set up a regional EIA network
- To establish protocols for EIA in different sectors.

Common Agreements among the Three Groups

To establish an informal forum for sustainable natural resources and environmental management in the Greater Mekong Basin. The Forum will represent a network of academic institutes, NGOs, government officials involved in NRE management. The members of the network aim to exchange information, policy tools, etc. Each Forum member will take the initiative to undertake regional collaborative activities and keep other members informed. The coordinating institute of the Forum ought to rotate among members. For this year, TDRI will provide information.

Annex II

Results of the Questionnaire Survey on Participants of the Conference

	Ranking					
	5 pts	4 pts	3 pts	2 pts	1 pt	Total[1]
Areas Willing to Collaborate						
Biodiversity	7	3	1	2	2	56
Forestry	4	3	6	2	-	54
Land use	1	6	5	1	2	48
Resource profile	2	3	2	4	-	36
Water resources	4	2	1	1	1	34
Environmental management*	3	-	-	-	-	15
Environmental policy*	2	-	-	-	-	10
Energy	-	-	1	3	-	9
Water quality	-	1	-	-	-	4
Hazardous waste	-	-	1	-	1	4
Air quality	-	-	1	-	-	3
Types of Collaboration						
Joint research	14	-	-	2	1	75
Symposia	3	6	5	1	2	58
Workshops	2	4	8	2	-	54
Receiving Training	3	2	1	3	3	35
Providing Training	1	3	3	1	2	30
Program Development*	2	-	-	-	-	10
Expected gains						
Experience of others	11	5	1	-	-	78
Regional awareness	3	8	2	1	1	56
Analytical techniques	1	3	4	4	1	38
Access to funding	1	1	7	2	1	35
Policy tools	1	3	1	2	2	26

Notes: [1] The total for each row is the sum of the products of the number of responses and the corresponding points.

* = topic written in by participants

Annex III

List of Distinguished Guests and Participants

I. Distinguished Guests

1. H.E. Mr. Zhao Shumin, Vice Governor, Yunnan Provincial Government
2. Mr. Wu Guanfan, Secretary-General, Yunnan Provincial Government
3. Mr. Li Ren, Vice-Director, Division for Agriculture and Forestry, Yunnan Provincial Government
4. Mr. Zhao Songliu, Vice Director, Foreign Affairs Office, Yunnan Provincial Government
5. Mr. Lin Wenlan, Vice Director, Committee of Science and Technology of Yunnanb Province
6. Mr. Liu Shishong, Vice Director, Committee of Science and Technology of Yunnan Province
7. Mr. Sun Lanlan, Director, Division for International Cooperation, Committee of Science and Technology of Yunnan Province
8. Mr. Zhou Hengfang, Forestry Department of Yunnan Province
9. Mr. Long Yongchun, Director, Policy Research Department, People Congress of Yunnan Province
10. Mr. Cao Weiming, Vice Director, Yunnan Provincial Planning Committee
11. Mr. Su Zhe, Programme Officer, Division for International Cooperation, Committee of Science and Technology of Yunnan Province

II. Participants

A. Cambodia

1. Dr. Gregory Woodsworth, International Development Research Centre (IDRC), Phnom Penh; and Advisor to the Ministry of Environment, Cambodia
2. Mr. Sil Vineth, President, Socio-Economic Development Organization of Cambodia (SEDOC), Phnom Penh

B. Canada

1. Dr. Frank Flatters, Queen's University and TDRI, Thailand
2. Dr. David Turpin, Queen's University

C. China:

1. Prof. Zhang Borong, President, Chinese Academy of Sciences (CAS)/Kunming
2. Mr. Zhang Jiahe, Vice President, Chinese Academy of Sciences (CAS)/Kunming
3. Mr. Zhang Zhuangxin, Vice President, Chinese Academy of Sciences (CAS)/Kunming
4. Prof. Xu Zhaifu, President, Kunming Institute of Botany (KIB), Kunming
5. Prof. Sun Handong, Director Emeritus, KIB, Kunming
6. Dr. Nu Chunchao, Deputy Director, KIB, Kunming
7. Prof. Hao Xiaojiang, Deputy Director, KIB, Kunming
8. Prof. Li Zhengan, Deputy Director, Department of Planning, KIB, Kunming

9. Prof. Li Heng, KIB, Kunming
10. Dr. Guo Huijun, KIB, Kunming
11. Mr. Chen Shukun, Vice Professor, KIB, Kunming
12. Mr. Dao Zhiling, KIB, Kunming
13. Mr. Long Chunlin, KIB, Kunming
14. Mr. Su Yong-ge (Brian Su), KIB, Kunming
15. Mr. Wang Shide, Vice Director,Division for International Cooperation, CAS/Kunming
16. Mr. Tang Bin, Director, Academy Office, CAS/Kunming
17. Prof. Ou Bing-rong, Research Institute of Resource Insects, Yunnan Academy of Forest Science
18. Ms. Yin Jiaqing, Deputy President, Yunnan Academy of Forest Science
19. Mr. Sheng Lixin, Yunnan Academy of Forest Science
20. Mr. Yang Huancheng, Forestry College of South-West China
21. Mr. Sun Dongchu, Forestry Surveying and Planning Institute of Yunnan Province
22. Mr. Tao Jing, Forestry Surveying and Planning Institute of Yunnan Province
23. Mr. Zhang Jiabin, Forestry Surveying and Planning Institute of Yunnan Province
24. Mr. Cai Chuantao, Kunming Institute of Ecology (CAS) , Kunming
25. Mr. Hu Huabin, Kunming Institute of Ecology (CAS), Kunming
26. Mr. Xie Shouchang, Kunming Institute of Ecology (CAS), Kunming
27. Mr. Song Qishi, Kunming Institute of Ecology (CAS), Kunming
28. Mr. Ou Xiaokun, Institute of Ecology and Geobotany, Yunnan University
29. Ms. Gu Fang, Institute of Ecology and Geobotany, Yunnan University/University of Toronto, Canada, International Development Studies
30. Mr. Qiu Minjiang, Kunming Institute of Zoology
31. Mr. Zhao Juqian, Yunnan Institute of Geography
32. Mr. Chen Sheming, Yunnan Institute of Geography
33. Mr. He Daming, Associate Professor, Yunnan Institute of Geography
34. Dr. Yang Weimin, Yunnan Institute of Environmental Science
35. Mr. Huang Yuzhe, Yunnan Institute of Environmental Science
36. Mr. Li Yingnan, Yunnan Institute of Environmental Science
37. Mr. Liu Xiaohai, Yunnan Institute of Environmental Science
38. Mr. Yang Linchun, Yunnan Agricultural University
39. Mr. Yang Yongkang, Yunnan Agricultural University
40. Prof. Jin Zhengzhou, Yunnan University, Kunming
41. Mr. Lu Shugang, Yunnan University, Kunming
42. Mr. Wu Zhaolu, Yunnan University, Kunming
43. Mr. Qian Deshan, Deputy Director, Economic and Technical Center, Yunnan Provincial Government
44. Mr. Shen Jingfang, Director, Institute of South-East Asian Studies, Yunnan Academy of Social Science

45. Mr. Yang Huanzong, Senior Agronomist and Deputy Director, Yunnan Provincial Planning Committee
46. Mr. Wu Xuechao, Forestry Bureau of Baoshan Prefecture
47. Mr. Zhao Xiaodong, Director, Gaoligongshan Natural Reserve, Forestry Bureau of Baoshan Prefecture
48. Mr. Cui Jingyun, Engineer, Xishuangbanna Tropical Botanical Garden, CAS
49. Prof. Li Tianchi, Chengdu Institute of Mountain Hazards and Environment, Chengdu
50. Prof. Wang Huijong, Development Research Center of the State Council, Beijing

D. Lao PDR:

1. Mr. Phonechaleun Nonthaxay, Science, Technology and Environment Organization (STENO), Vientiane
2. Mr. Sombath Somphone, RIFS, Vientiane
3. Dr. Phouy Vongkhamchandr, Department of Forestry, Ministry of Agriculture and Forestry, Vientiane

E. Singapore:

1. Dr. David Glover, EEPSEA (IDRC), Singapore

F. Thailand:

1. Dr. Ammar Siamwalla, Thailand Development Research Institute (TDRI), Bangkok
2. Dr. Mingsarn Kaosa-ard, Thailand Development Research Institute (TDRI), Bangkok
3. Dr. Kanok Rerkasem, Chiang Mai University, Chiang Mai
4. Dr. Wilaiporn Liwgasemsan, National Economic and Social Development Board (NESDB), Bangkok
5. Ms. Sayamol Kaiyoorawongs, Toward Ecological Recovery and Regional Alliances (TERRA), Bangkok
6. Dr. Sitanon Jesdapipat, Maejo Institute of Agricultural Technology (MIAT), Chiang Mai
7. Mr. Peter Marriott, Canadian International Development Agency (CIDA), Bangkok
8. Dr. Julie Otterbein, United States Agency for International Development (USAID), Bangkok
9. Mr. Kim DeRidder, The Asia Foundation, Bangkok
10. Ms. Pathanie Chapman, The Asia Foundation, Bangkok
11. Dr. David Thomas, The Ford Foundation, Bangkok

G. U.S.A.:

1. Dr. Walter Arensberg, World Resources Institute (WRI)
2. Dr. Kirk Talbott, World Resources Institute (WRI)

H. Vietnam:

1. Dr. Le Thac Can, National Environmental Protection Research Program, University of Hanoi
2. Dr. Vo Quy, Center for Natural Resources Management and Environmental Studies (CRES)

3. Dr. Le Tu Trinh, Vietnam Institute for Tropical Technology and Environmental Protection (VITTEP)
4. Dr. Nguyen Ngoc Nhi, Vietnam Forestry Association
5. Dr. Nghiem Vu Khai, Foreign Affairs Dept, Office of the National Assembly
6. Mr. Bach Tan Sinh, Institute of Science Management

Annex IV

Conference Schedule

Regional Dialogue on Biodiversity and Natural Resources Management in Mainland Southeast Asian Economies
Kunming Institute of Botany, Kunming, China
February 21-24, 1995

DAY 1 (Tuesday, 21 February) **Arrival and Welcoming Dinner at the Hotel**

DAY 2 (Wednesday, 22 February) **at KIB**

09:00-09:30 **Opening Remarks. Chair- Mr. Lu Chunchao, KIB**

- The Honorable Governor of Yunnan Province, China
- Dr. Zhang Borong, Director, Chinese Academy of Sciences, Kunming, China
- Prof. Hao Xiaojiang, Executive Vice-President, Kunming Institute of Botany, China

09:30-10:30 **Opening Lectures**

The Diversity of Plant Genetic Resources: An Economic Perspective
- Dr. Ammar Siamwalla, President, Thailand Development Research Institute, Thailand

Implementing the Convention on Biological Diversity: Legal and Policy Strategies for Linking with Local Communities
- Dr. Kirk Talbott, World Resources Institute, U.S.A.

10:30-10:45 **Coffee Break**

10:45-12:30 **Opening Lectures, continued. Chair - Mr. Peter Marriott, CIDA**

Prioritizing Investments in Biodiversity: A Scientific Viewpoint
- Dr. David Turpin, Queen's University, Canada

The Impact of Land Use Policy on Forest and Biodiversity in Yunnan
- Dr. Guo Huijun, Chairman, Kunming Institute of Botany, China

Agro-diversity and Natural Resource Conservation in Northern Thailand
- Dr. Kanok Rerkasem, Chiang Mai University, Thailand

12:30-13:30 **Lunch Break**

13:30-15:30 **Afternoon Lectures. Chair - Dr. Vo Quy, University of Hanoi**

Forestry Policy of Vietnam
- Dr. Nguyen Ngoc Nhi, Vietnam Forestry Association, Vietnam

Community Approach to Watershed Protection
- Chanthaviphone Inthavong, Department of Forestry, Lao PDR*

Present Status of Natural Ecosystems in the Mekong Delta
- Dr. Le Tu Trinh, Environmental Protection Center, Vietnam

15:30-15:45 **Coffee Break**

15:45-17:00 **Afternoon Lectures II. Chair - Dr. Walter Arensberg, WRI, USA**

Water Resource Development in the Upper Mekong Basin
- Dr. Donald Alford, Thailand Development Research Institute, Thailand

Water Resource Development for the Lancang River**
- Mr. Huang Yuze, Yunnan Environmental Science Institute, China

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* presented in absentia by Mr. Sombath Somphone
** Video presentation

continued...

DAY 3 (Thursday, 23 February)

08:30-17:30	**Field Visit to Stone Forest and Dianchi Lake**

DAY 4 (Friday, 24 February) in hotel

08:30-10:00	**Morning Lectures. Chair - Dr. Frank Flatters, TDRI** **Disappearing Lakes - What Is To Be Done?: A Case of Tonle Sap** - Dr. Gregory Woodsworth, IDRC-Cambodia **Environmental Conditions and Protective Counter-measures of Lake Dianchi, China** - Mr. Yang Weimin, Yunnan Environmental Science Institute, China
10:00-10:15	**Coffee Break**
10:15-11:15	**Future Agenda - Small Group Discussions** Group 1. Water Resources. Dr. Mingsarn Kaosa-ard Group 2. Forests, Landuse and Biodiversity. Dr. Guo Huijun Group 3. Environment and Development and the EIA. Dr. Le Thac Can
11:15-12:15	**Future Agenda - Plenary session. Chair - Dr. Ammar Siamwalla**
12:15-13:20	**Farewell Lunch**
13:20	**Bus leaves for airport**
15:20	**Flight departs for Bangkok**