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| Title | アジア・太平洋地域における、熱帯林研究の必要性と実績 : 現状と BIO-REFOR(熱帯林再生研究者連合)の始動 |
| Author(s) | 村上, 公久 |
| Citation | 聖学院大学論叢, 8(2): 223-248 |
| URL | http://serve.seigakuin-univ.ac.jp/reps/modules/xoonips/detail.php?item_id=656 |
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Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

—State of the Art and BIO-REFOR Trial—

Kimihisa MURAKAMI

アジア・太平洋地域における、熱帯林研究の必要性と実績

—現状と BIO-REFOR (熱帯林再生研究者連合) の始動—

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序言および謝辞

アジア・太平洋地域の熱帯で暮らすおびたしい数の人々が熱帯林に頼って生活しているが、この地域の熱帯林の減少・劣化の現状は深刻であり、先進各国の公的 (政府開発援助 ODA Official Development Assistance) また私的 (NGO Non-Governmental Organizations) な植林・森林保全などの活動は必ずしも元の森林状態を回復させる努力につながるとは限らず、場合によっては単一の早成樹種による原植生の破壊をもたらすことも少なくない。1991年に、著者は NGO である BIO-REFOR (熱帯林再生研究者連合 BIOTechnology assisted REFORestation project) を各国の研究者の協力を得て創設したが⁽¹⁾、この組織の目的は森林の再生に土着の樹種を用いることにある。その際、各地の固有の造林技術を尊重することが肝要であるが、開花・結実の周期の不安定性、種子採取および種子保存の困難性、などによる造林材料の確保の困難がある。そしてこれらの問題が、従来の植林活動が単一の早成樹種によらざるを得ない理由でもあった。BIO-REFOR は既存の各地の伝統的な土着の造林技術を尊重しつつ、科学的で適正な方法を最新の研究技術を援用することにより確立することを強く望んでいる。この報告は、当該地域の熱帯林再生のために必要な研究課題を特定すると共に、研究技術の現状を把握することを意図している。

この報告のためには、優れた研究者でありまた世界的な貢献を果たしてきた研究行政の管理者でもある二人の科学者の協力を得た。一人は、元アメリカ合衆国農務省森林庁次官、IUFRO (国際森林研究機関連合 International Union of Forestry Research Organizations) 前会長、現オレゴン州立大学森林学部教授の Dr. Robert E. Buckman、もう一人は、前国連 FAO のアジア・太平洋地

Key words; Tropical Forestry, Asia Pacific Region, Reforestation, Research Needs, NGO.

域森林資源局長，故 Dr. Y.S. Rao である。Dr. Rao は，BIO-REFOR の本格的な設立の機会となったわが国のつくば市で1992年5月に開催された国際集会⁽¹²⁾に参加し基調講演などによってこの NGO の基本路線の設定を指導したが，その直後インドでテロリストによって爆殺された。同博士の多大の貢献と惜しめない支援を想起し深甚なる感謝を捧げると共に，謹んで哀悼の意を表する。

Foreword and Acknowledgments

Impelled by population pressure and shortage of food, people's demand for land use extends rapidly, this stress accelerates deforestation or degradation of forest resources in Asia-Pacific region and causes environmental problems such as shortage of fuel wood, soil erosion, draught, frequent floods, climate change, desertification, etc. Suitable measures should be taken at an earliest possible time and the forestry scientists in the region are called for them.

IUFRO (International Union of Forestry Research Organizations, established in 1892, 700 member bodies, 15,000 scientists 112 countries) appealed 'Declaration of the XVII IUFRO World Congress 1981' at Kyoto City in Japan with the World Bank and FAO of UN for a reappraisal of forestry research situation in developing countries. IUFRO responded by creating its SPDC (Special Program for Developing Countries). Japanese forestry scientists have been preparing a research project for 'Rehabilitation of Degraded Tropical Forest Land in Developing Countries in Asia-Pacific Region'. The author established a NGO (Non Governmental Organization) titled BIO-REFOR (BIOTEchnology assisted REFORestation project) in 1991 as a major action of SPDC of IUFRO with the colleagues of thirteen countries in the region. This report deals with the regional research needs and achievements so far in the field of tropical forestry to clarify the object of our trial.

In preparing this report, the author had kind cooperations of his colleagues, Dr. Robert E. Buckman⁽³⁾, the former President of IUFRO and the late Dr. Y. S. Rao⁽¹⁹⁾ the former Director of Forestry, Regional Office of Asia Pacific, FAO of UN. Their contributions to this report have been great and I take pleasure in acknowledging the important and essential part played by them. After Dr. Rao participated in the second International Workshop of BIO-REFOR held at Tsukuba City, Japan he passed away by a terrorist bomb tragedy. The author would like to express his deepest condolences with his appreciation for Dr. Rao's kind contribution and support to BIO-REFOR.

Introduction ^{(8), (13), (15), (16), (20)}

Tropical forests (including closed broadleaved forests, fallow areas, open and savannah woodlands, and forest plantations) occupy about 1,937 million hectares, slightly more area (53 percent) than the combined total area of temperate and boreal forests of the world (Allan and Lanly, 1991). Latin America has more than half the world's tropical rain forests, Africa more than half the world's open and savannah woodlands ^{(1), (4), (5)}.

Forestry in Asia is in crisis. Deforestation is accelerating as rising populations and incomes increase the demand for land and wood products and as a new awareness of the importance of forest ecosystems is sweeping the region and the world. This loss of forest poses alarming economic and environmental costs.

One-third of Asia is covered with forests. That proportion is shrinking fast. On the basis of current trends, half the original 725 million hectares will be gone by the turn of the century. By 1980 they had already dwindled to about 460 million hectares. Between 1981 and 1985, forests vanished at the rate of about 2 million hectares a year, with the most dramatic declines in India, Nepal, the Philippines, Sri Lanka and Thailand. Preliminary FAO estimates for 15 countries suggest that, over the decade of the 1980's forests may have disappeared at a rate of 3.5 million hectares a year. Area, though, is only a crude indicator of loss, since much more may have been degraded. The status of Asian forests is outlined in (Table 1).

In the past, development policies encouraged or condoned deforestation. Forests were seen as contributing to economic growth mainly through the sale of timber and as a source of land for conversion to other productive uses. That view has been changing in the past 15 years, initially due to awareness of the importance of fuelwood as a source of energy, and more recently from greater understanding of the importance of nonwood forest products and services, such as fruit, game, and medicinal plants. Even in commercial forestry, the loss of trees is starting to generate more interest in sustainable management.

Some of the economic costs of deforestation are obvious. Timber has long been an important export for several Asian countries. Forest products generated export revenues of \$8.25 billion in 1988. But Asia is increasingly becoming a wood-deficit region. Based on current trends, imports of timber and forest products will cost the region nearly \$20 billion a year by 2000. The three countries which have accounted for nine-tenths of the region's log exports and revenues, Indonesia, Malaysia, and the Philippines and Thailand are virtually exhausted. India, historical-

Table 1: Areas of Natural Forest and Plantations, and Rates of Deforestation in Asia

(000' ha)

| | <i>Gross Land Areas</i> | <i>Natural Forest Closed 1980</i> | <i>Plantation Areas est. 1990</i> | <i>Deforestation rate, 1971-1980 average annual %</i> |
|--|-----------------------------|---------------------------------------|---------------------------------------|---|
| South Asia | | | | |
| Bangladesh | 13,390 | 927 | 338 | 0.9 |
| Bhutan | 4,700 | 2,300 | 17 | 0.1 |
| India | 297,320 | 51,841 | 3,798 | 2.5 ¹ |
| Nepal | 13,680 | 1,940 | 69 | 4.3 |
| Pakistan | 72,830 | 2,185 | 106 | 0.4 |
| Sri Lanka | 6,470 | 1,659 | 272 | 3.5 |
| East Asia | | | | |
| China | 932,640 | 97,847 | 58,253 | 0.6 ² |
| Japan | 37,643 | — | 10,800 | n.a. |
| Korea Rep. | 9,820 | 4,887 | 2,468 | n.a. ⁶ |
| Mongolia | 156,500 | 9,528 | — | n.a. |
| Continental South East Asia | | | | |
| Kampuchea | 17,550 | 7,548 | — | 0.3 |
| Lao PDR | 23,080 | 8,410 | 31 | 1.3 |
| Myanmar | 65,770 | 31,941 | — | 0.3 |
| Thailand | 51,180 | 9,235 | 424 | 2.8 |
| Viet Nam | 32,540 | 8,770 | 564 | 5.0 |
| Insular South East Asia | | | | |
| Brunei | 590 | 323 | — | n.a. |
| Indonesia | 181,160 | 113,895 | 3,558 | 0.9 ³ |
| Malaysia ⁷ | 32,860 | 18,500 | 276 | 1.2 |
| Philippines ⁸ | 29,860 | 6,710 | 930 | 2.7 ⁴ |
| Pacific Islands | | | | |
| Fuji | 1,930 | 811 | 130 | 0.2 |
| PNG | 45,170 | 34,230 | 42 | 0.5 ⁵ |
| Solomon Islands | 2,750 | 2,423 | 27 | n.a. |
| Total | 2,029,433 | 415,910 | 82,103 | |

Deforestation figures calculated data in FAO reports, 1980 or 1987 interim report if not otherwise indicated.

1. Latest deforestation figure from J.B. Lal India's Forest Myth or Reality. Based on new surveys using remote sensing, etc. This figure taken as a percentage of remaining forest area.
2. S.D. Richardson Forests and Forestry in China: Changing Patterns of Resource Development, 1990.
3. Source: "Indonesia; Forest, Land and Water." Issues in Sustainable Development", World Bank, 1989.
4. Source: DENR, RP—German Forest Resources Inventory (1987).
5. Source: S.M. Saulei, 1990: Forest Research and Development in PNG, Ambio Vol 19, No. 8.
6. Source: "Timber from the South Seas", F. Nectoux and Y. Kuroda, 1989.
7. Source: Malaysia: Forestry Subsector Review, Green Cover, September 1991.
8. Source: Philippines Environment and Natural Resource Management Study, World Bank, 1991.

ly self-sufficient in wood products, has become a large importer.

Other costs are harder to measure. Many of the benefits that trees and forests provide are not captured by the market. These include their role as a source of fuelwood, which accounts for four-fifths of Asia's timber demand, and of the nonwood products which are frequently important sources of protein and shelter for the poor. Forests provide goods, incomes, services and homes to local populations. The nonmarketed benefits of trees also include the prevention of soil erosion and moderation of streamflows.

Some of the losses from deforestation are of concern to people outside the region. Four of the 12 "mega-diversity" countries of the world, in which half the earth's plant and animal species are found, lie in Asia — China, India, Indonesia, Malaysia. In addition, Papua New Guinea and the Philippines are among the countries with the highest number of endemic species. Much of this biological wealth is found in the region's greatest variety of animals. Finally, the destruction of forests unlocks carbon dioxide whose release into the atmosphere contributes to global warming. Asian deforestation is estimated to account for over 6% of recent increases in the atmospheric concentration of carbon dioxide.

Causes of Deforestation²⁰

The immediate causes of deforestation are the clearing of land for farming, the demand for firewood and fodder, and excessive commercial logging. These are aggravated by population and income growth. All are likely to continue for the foreseeable future. Asia's forests are unique in their proximity to areas of rapid population and economic growth, which makes them particularly vulnerable to exploitation. But other forces have helped to foster deforestation. Behind the crisis in Asian forestry lie three basic and inter-related sets of problems: economic, institutional, and technical. None is unique to Asia, but some are particularly acute.

At the core of the economic problem lies the divergence, typical of many environmental issues, between private and social costs. Those who destroy forests, whether for agriculture, fuel or logging, enjoy private benefits but do not carry the full costs of their actions, whether soil erosion, losses of biodiversity, or release of carbon dioxide from forest fires. Often, the problem is aggravated by poorly defined property rights. If the forest is open to all or belongs to the state, it is not likely to be as well protected or as sustainably managed as if it has clear private or collective ownership. Open access to forests allows fuelwood and other products to be gathered at zero cost, thereby undervaluing the resource and perpetuating its loss. Although this

benefits some of today's consumers, the incentive to replant trees is reduced, ultimately imposing a heavy cost on future generations¹⁷.

Equally typical are institutional problems. After independence, Asian forests almost invariably came under state ownership and control. Forest-management institutions were originally designed to enforce technical regulations on loggers, collect licensing fees and royalties, and prevent people from trespassing. With their roots in colonial forestry, they developed a centralized and bureaucratic approach. Trying to administer their large estates as a source of raw material for large industries, this heritage has frequently agencies unskilled in managing the external costs which should be among their main concerns. It has not trained them to involve local people in the management of forests, or to mediate among the many, often-conflicting demands from agriculture, industry and now environmentalists. The accounting systems and procedures they have developed are, in general, not appropriate for managing forests as economic assets, producing and marketing output, undertaking investments or introducing technical innovations.

As the forests have shrunk, the number of civil servants supposedly managing them has grown continuously with no improvement in the sector's performance. In many countries, their work has been expanded by the proliferation of legislation is often counterproductive. Intrusive regulations on the felling of privately owned trees, on the transport of logs and on land ownership put unintended obstacles in the way of responsible private investment. Laws meant to protect the rights of local people and forest dwellers are often inadequate and overridden by contradictory regulations. Legal obstacles to the activities of nongovernmental organizations are also common.

Some of the difficulties of forest management are technical. Research in forestry has lagged behind that in agriculture; so has the adoption of new technologies. One estimate is that in Asia, not including China, fewer than 1,000 scientists conduct forestry research. In India, forestry research expenditures are less than 0.01% of the value of forest products consumed each year. As a result, scientists are only beginning to understand how to manage tropical forests, and policy is often based on an inadequate understanding of the biological and physical consequences of different approaches.

Improvements in technology, quickly adopted in farming, are introduced much more slowly in forestry. The reason may be partly that forestry's long time horizon increases the risk—a new planting practice for a tree, unlike one for an annual crop, may take at least a decade to prove its value. Another obstacle may be the predominance of state ownership. Officials, already unnerved by the multiplicity of new objectives for forestry, are not rewarded for the risks taken ex-

perimenting with new methods.

Asia and the Pacific Islands have only about 18 percent of the tropical forests of the world, but their lowland Dipterocarp forests, on a per hectare basis, are the most valuable natural forests anywhere in the tropics for commercial and industrial purposes. This, combined with high population pressures and expanding agriculture, put these forests under relatively greater threat than any of the closed or rain forests of the world.

Open or savannah woodlands occupy 720 million hectares (about 37 percent) of the world's tropical forests, only about 31 million hectares of which are in the Asia/Pacific region. Still, these are the lands where human needs for trees and forests are high, and yet they tend to be overlooked by people of the industrialized world. Shortly the author will comment on still other forest lands (i.e., fallow and plantations) of the tropics.

Several observations concerning research and development related to natural forests:

—Following forest clearing, both closed and open forests often revert to undesirable vegetation (i.e. *Imperata spp* in Asia). These disturbed and degraded lands are attractive targets for accelerated reforestation programs the world over, a fact fully recognized by BIO-REFOR.

—While there have been many experiments and trials to develop suitable silvicultural systems for closed tropical rain forests, it is estimated that less than one percent of these natural forests are under sustained management (Poore, 1989). This is due in part to the complexity of the forests themselves, and in part because once opened to entry, the land is available to agriculture, ranching, mining, repeated logging and other uses. Nevertheless, research must continue on sustainable silvicultural systems for closed tropical forests.

—Silvicultural systems for open or savannah woodlands is a woefully neglected area of forestry research. This research, for example, was accorded high priority for Sahelian Africa by a 1985 IUFRO workshop aimed at identifying forestry needs for that region.

—Fallow areas, generally resulting from shifting agriculture, occupy 228 million hectares of about 20 percent of the area of closed tropical forests (Allan and Lanly, 1991). Of this about 30 percent is in Asia, 20 percent Africa and 15 percent in Latin America. Rehabilitation of these areas and of secondary forests resulting from other disturbances is also an attractive area for accelerated research. Enrichment plantings are an interesting alternative for research and implementation.

—A variety of renewable extractive reserves and other benign systems of development for natural tropical forests are under consideration and deserve more attention from research. Emphasis here is generally on non-timber products.

These observations are but a sample of the possibilities for research concerning natural forests in the tropics. In the end many observers, including the author, conclude that the most effective strategy is to set aside as much land as is politically and economically possible in parks, wildlife refuges and other protected areas. In order to do so, however, we must find alternatives elsewhere to satisfy the needs of people and otherwise reduce the need to exploit undisturbed forests. What follows are several areas for which forestry research can make a substantial contribution.

Forestry in Areas of High Human Use

Where human dependence on forests and trees is high—in rural villages, on farming and grazing lands, on water and wind-erosion prone areas—new areas of research specialization are developing. These include agroforestry, community and social forestry, and a variety of specialties to reduce the impact of such natural disasters as floods, wind erosion and conflagrations.

So important are these people-related forestry problems that a number of specialized research agencies have been created to deal with them. These include the International Center for Research in Agroforestry (ICRAF) in Nairobi, the Social Forestry Network in London; the Forestry/Fuelwood Research and Development Project headquartered in Bangkok; and the Regional Community Forestry Training Center, also in Bangkok. We are likely to see enlargement of some of these institutions and creation of new ones to address this critical family of forestry concerns. Especially important here are the contributions to be made by the social sciences, including sociology, anthropology, and ethnology.

Intensive Forest Management

Intensive forestry, generally with plantations of native or introduced species, offers an important strategy to satisfy local needs for energy and construction materials, to provide raw material for industrial development, and otherwise to reduce impacts on natural forests. Plantation forestry is an especially attractive use for already fallow and degraded lands. Today plantations occupy less than one percent of the total forest land of the tropics.

North America and Australia have been especially rich sources for woody plant germplasm for use elsewhere in the world. From North America these include several species of pines and other conifers, and a number of broadleaf trees. From Australia are many species of *Eucalyptus*,

Acacia, and *Casuarina*. Productivity gains often have been spectacular following appropriate species selection, tree breeding, and improved nursery, planting, and standing-tending techniques. Volume growth gains of 10 to 15 fold have been reported as compared to native forests. In many respects, the forestry technologies here are the equivalent of the "green revolution" in agriculture.

Plantation management of native trees, too, deserves more attention. Some success has been demonstrated for plantation management of Teak (*Tectona grandis*), Mahogany (*Swietenia macrophylla*), *Terminalia* spp., *Triplochiton scleroxylon*, and several species of *Acacia*. Much more needs to be done to speed the growth and quality of these trees, in part because native trees often perform better than introduced species in areas of low soil fertility and rainfall, and may be less prone to pest risks.

Plantation management both of introduced and native trees and shrubs (for arid regions) is a research and development strategy that deserves further support; in fact, it is likely to be an important strategy for the forestry research centers (ICRAF and The International Center for Forestry Research—CIFOR) in the newly enlarged system of International Agricultural Research Centers. We need to recognize that plantation management must be used with caution: some plantations on erosion-prone slopes fail to protect watersheds; some plantation species suppress grasses and forbes useful to livestock; and most plantation species are heavy users of groundwater. However, in the absence of land-conserving plantation practices, people in many parts of the tropics will be forced to exploit here-to-fore undisturbed forest lands.

Improved Utilization of Timber and Non-timber Products

Fuelwood and charcoal consume more than half of the world's total wood production, more than 80% of this in the developing world (WRI 1990). Hundreds of designs for improved cooking stoves, charcoal kilns, and solar cooking and drying devices are available. The principal obstacles are not the lack of technology for improved efficiency and conservation of wood for energy, but the cultural and economic barriers to widespread adoption. Still, because the consumption of wood for energy looms so large in tropical regions, it deserves more attention from forestry sciences¹⁸.

Beyond wood for energy, one is always impressed in the developing world by opportunities for better conservation of wood from improved harvesting and transport systems, more efficient wood processing to increase yields and quality of sawnwood and plywood, and increased service

life of wood through better construction practices and wood preservation methods. Many of these gains can be achieved through training and relatively modest capital investments. This is also an area likely to provide rapid pay-off because the technologies are already available and need only to be adopted to local situations.

Non-timber and non-traditional forest products also offer promise, such as rattans, bamboo, medicinal and edible plants, rubber, oleoresin extracts, tannins, and other forest-derived products, many of which are yet to be discovered. Utilization of these products provide sources of income for rural people while leaving the overstory forest largely intact. A caution: while these uses can provide a livelihood for the some rural poor, it is often only a marginal existence and one highly vulnerable to fluctuating market demand⁽³⁾.

Improved housing for urban and rural dwellers—and the use of wood therein—is accorded high priority in many development programs. Here again, improved construction practices, use of lesser-known species, and simple but environmentally acceptable wood preservation techniques could rapidly increase the supply and quality of housing, all at relatively low cost.

Institution Building and Resolution of Policy Impediments

Institutional and policy issues often lie outside the forestry sector itself, but must be addressed concurrently with other research and development efforts if forests are to contribute fully to the economic, social and environmental well-being of countries. Indeed, resolution of some of these questions will do as much or more to enhance the protection and sustainability of tropical forest as will forestry technologies themselves.

Institutional challenges are many. Few developing countries have trained and reliable Forest Services. Corruption tends to be high among agencies responsible for forestry. Educational and science capacity is woefully lacking. Facilities, transportation, and other institutional questions must be addressed concurrently with accelerated research programs. Japan, to its credit, has been and continues to be a significant contributor to facilities and infrastructure development related to forestry.

Among policy issues affecting the well being of forests (and almost every aspect of life in developing countries) none loom larger than population questions. The developing world, much of it synonymous with countries containing tropical forest, contains 80 percent of the world's population, and an annual population increase of 3.00 percent in Africa, 2.07 percent in Latin America and 1.85 percent in Asia (WRI 1990). This compares to considerably less than 1 per-

cent population increase in the industrialized countries. Forests and natural resources of the developing world simply cannot stand up to these growing populations pressures.

Other policy issues affect the well-being of natural resources and many other aspects of life. Harmful economic policies include artificial currency exchange rates and protectionist trade policies both by the industrialized countries and developing countries. Sugar and peanut quotas in the U.S. and subsidized food and charcoal prices to mollify urban dwellers are examples. Unwise economic development policies (i.e. subsidized land clearing in tropical forests of Brazil) and lack of sound pricing for timber and other natural resources are other failures which could be corrected by open market mechanisms. Social and government policy-induced distortions include bloated government bureaucracies, absence of land tenure and property rights, lack of opportunities for women, and many others. Forestry has the opportunity to borrow from agricultural research, where similar policy questions have been under investigation for a longer time than in forestry. The payoffs for this kind of research could be high.

Asia-Pacific Region: the Setting

The Asia-Pacific Region, with 2,800 million people, is the home for half the world's population. The land area of the region is close to 3000 million ha. and comprises a mosaic of ecosystems ranging from the Himalayas which straddle the main land of Asia, to the flood plains washed by the river systems and the island ecosystems in the Indian Ocean and the South Pacific. Agricultural land accounts for about 500 million ha., which is 30 percent of the world's arable land. Permanent pastures occupy 963 million ha., of which 90 percent occur in three countries: Australia, China, and Mongolia. Forests and woodlands occur on some 650 million ha. and represent 16 percent of world's total in this category. In tropical forestry, the Region commands a special status: extending over 445 million ha. tropical forests constitute a quarter of the world's resources of this kind⁽⁶⁾.

During the past two decades the response of the governments of developing countries in this region to the problem of feeding the growing population has been to intensify agricultural production on a more or less fixed land resource base. The intensification of agricultural production has itself led to many problems and widespread land degradation and loss of soil fertility. Only 14%-18% of the region's soils have no serious limitations and are suitable for agricultural production on a sustained basis. More than 80% of the land in the region is affected in varying degrees by such factors as: steep slopes, drought, severe nutrition deficiencies, shallow depth,

waterlogging and secondary salinization. Inefficient water management and over-exploitation of water resources are proving to be intractable problems.

As the 20th century draws to a close, developing countries of the Asia-Pacific Region face an unprecedented environmental crisis in the shape of forest destruction. In the last decade, the rate of deforestation more than doubled. About 4.7 million hectares of forest are stripped of vegetation every year to make way for spontaneous and unplanned human settlements and marginal agriculture.

In several countries of the region, eroded water catchments are causing widespread adverse downstream effects, damaging arable lands and infrastructures. Fuelwood shortages are causing untold hardship to the rural poor, while the rapid decline in industrial wood supplies are crippling wood-based industries.

Although 80% of the population in the developing countries in the region work and survive in the villages, the development strategies in the past three decades were focussed on large-scale industrialization, urbanization, big dams, hydro projects and irrigation networks. Capital intensive strategies and energy intensive technologies which polluted the environment, endangered the ecology and uprooted the people were the order of the day. And although economic development did take place, the gap between the rich and the poor, the rural and the urban, grew. Village development, village industries, village health and strengthening of village institutions received scant attention. Rural poor have been pushed into marginal lands and landlessness forced them to overuse the resources to survive.

Given the above context, the region can move towards sustainable forestry development only by recognizing the realities of land use. Forestry development supported by forestry research and research extension should address the problems at the level of microwatersheds, eroding hill slopes, miss-used arid and semi-arid lands and soils drained of nutrients.

Since the nexus, food-energy-environment, determines and impacts the survival strategies of house-holds and their aspirations, solutions should be socioeconomically compatible, economically viable and ecologically sound.

Forestry Research Needs

In response to the growing environmental crisis associated with deforestation and the socioeconomic disruptions, Governments in the region are increasing their commitment to forestry sector development. Forestry programs in many Asia Pacific countries have undergone a

radical shift: the environmental protection, rehabilitation of degraded forests, attaining self-sufficiency of fuelwood and forest industrial raw material supplies are now accorded higher strategic importance. Many countries have embarked on large scale high yielding plantations, communal tree planting and greening programmes with the active involvement of local populations⁽⁹⁾.

There has been a substantial and significant increase in the reforestation efforts by the development countries of this region in recent years. According one estimate, current efforts exceed 3 million ha per year and the investment surpasses US \$ 1,000 million a year. However, the percentage of survivals and the productivity of plantations need to be improved. For these programmes to succeed a corresponding concerted increase in research inputs, technological back-up and extension at the grass root level are of pivotal importance.

Although development assistance in the forestry sector has expanded rapidly in the past few years, the total funding for forestry research in developing countries is only 5 percent. By comparison, the percentage of assistance allocated for agricultural research rose from around 4 percent during the 70's to about 10 percent in the 80's.

Forestry research needs are often not fulfilled because of the many constraints faced by national forest research organizations. Among them are:

- (a) Little or no political support for forestry research within country;
- (b) Lack of funding stability from year to year;
- (c) Negligible interaction among researchers/users and potential users of research results;
- (d) Lack of "research extension" and transfer of research results to the field;
- (e) Low level of researcher training;
- (f) Poor library and information services;
- (g) Little interaction with other related research organizations within the country;
- (h) No coordination of research efforts among countries.

Forestry Research in Selected Countries

The forestry research situation in some of the developing countries of the region is briefly reviewed here.

Bhutan

Forestry research in Bhutan is in its infancy. The Forest Research Division was established in 1987 under the Department of Forestry, Ministry of Agriculture and has a staff of Five Re-

Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

gional Stations are planned to be established. Research studies on stem analysis, regeneration trials and species trials are in progress. Bhutan is just embarking on forest research and the data base is small.

People's Republic of China

The Chinese Academy of Forestry, rehabilitated in 1978, has 9 research institutes, 3 experimental bureaus and 1 centre for research analysis across 8 regions in China. Forestry Research Institutes attached to the Provincial Forestry Departments and forestry universities/colleges also carry out location specific research. The Research Institute of Forestry (RIF), is the largest amongst the institutes under the Academy. Currently RIF is undertaking 66 research projects which are national in character, often inter-regional and multidisciplinary. In China, funds for forestry research account for about 6 per cent of the total outlay in forestry. The main impediments to forestry research are: (i) limited funds; (ii) inadequate research in basic sciences; and (iii) shortage of expert staff.

Fiji

Research divisions within the Ministry of Forests deal with tree breeding, the growth of fuelwood crops, agroforestry techniques and timber utilization research. Due to lack of adequately trained local staff, research has tended to neglect many fields and concentrated on biological problems of tree production.

India

In India, the Indian Council of Forestry Research and Education (ICFRE) and its constituent institutes, the State Forest Departments, the Indian Council of Agricultural Research and the State Agricultural Universities carry out forestry and related research. The ICFRE has six research institutes: Forest Research Institute, (Dehradun); Institute of Forest Genetics and Tree Breeding (Coimbatore); Institute of Wood Sciences and Technology, (Bangalore); Institute of Deciduous Forests, (Jabalpur); Institute of Arid Zone Forestry Research, (Jodhpur); and the institute of Rain and Moist Deciduous Forests, Jorhat.

In addition to the traditional FRIs, institutions concerned with social sciences, non-governmental organizations and private establishments are exhibiting a growing interest in forestry related research issues.

The problems of forestry research are: (i) weak research extension services; (ii) low priority and inadequate allocation of resources for research extension; (iii) lack of networking and linkages with State Forest Departments, NGOs and private sector resulting in an inadequate delivery system, preventing dissemination of research results of users.

Indonesia

The Agency for Forestry Research and Development (AFRD) under the Ministry of Forestry (MOF) is responsible for coordinating and supervising nation wide forestry research activities. The main research centers are the Forest Research and Development Centre (FRDC) and the Forest Products Research and Development Centre (FPRDC) both in Bogor, West Java. The regional research institutes are located in Pematang Siantar (North Jewabu), Samarinda (East Kalimantan) and Ujung Pandang (South Sulewesi). Research priority is given to: timber stand improvement; tree improvement; timber harvesting techniques; wood processing techniques; non-wood products. Research problems are: limited capital and operating funds; lack of infrastructure facilities; lack of trained staff; lack of coordination between the agency and other scientific authorities; and lack of delivery system.

Malaysia

Basically, four forestry institutions in Malaysia carry out forestry research. These are: (i) Forest Research Institute Malaysia (FRIM), Kepong; (ii) Faculty of Forestry, University of Agriculture (UPM), Serdang; (iii) Forestry Department, Sabah; (iv) Forestry Department, Sarawak. FRIM attempts to have close interaction with both the Forest Department which is the clientele for forest research and the forest industries which are the main users of forest products research results. FRIM's activities are covered under ten research programs. Three broad areas however receive priority. These are: (i) Management and Silviculture of Natural Forests; (ii) Management and Silviculture of Plantation of Tree Species; (iii) and Downstream Processing and Utilization. The major problems of forestry research in Malaysia are: low policy support, lack of career development opportunities and high turn over of research workers.

Myanmar

The Forest Research Institute at Yezin is the primary institute responsible for research work in forestry. The Timber Corporation, Forestry Department and Agriculture Institute also have their own research units to solve forestry problems. Current research programs cover at least eight major areas: Forest Management and Silviculture; Soil Science and Agroforestry; Forest Production; Forest Genetics and Botany; Timber Processing; Timber Mechanics; Wood Anatomy; and Minor Forest Products. Problems in forestry research relate to frequent transfer of research personnel, lack of trained manpower and a weak infrastructure for carrying out research and disseminating research results.

Nepal

The Department of Forests and Plant Research (DFPR) under the Ministry of Forest and

Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

Soil Conservation is responsible for forest research. Species and provenance trials are the main thrust of forestry research in Nepal. The main problem of forestry research in Nepal is uncoordinated activities scattered over several projects under various departments and institutions. The human resources for carrying out forestry research need to be strengthened.

Pakistan

The Pakistan Forest Research Institute (PRI) located in Peshwar conducts research into: watershed management issues; tree-crop interactions; economics of fuelwood plantations on private lands; water requirement of trees; biomass production and afforestation of arid and semi-arid lands. The major problems faced by forestry research system in the country are: non-availability of trained manpower; dearth of information systems; lack of coordination, linkages/and interaction with end users of research.

Papua New Guinea

The Papua New Guinea Forest Research Institute (PNGFRI) was established in April 1989. Three other institutions: The Department of Forestry (PNG University of Technology); Christensen Research Institute based at Madang, Madang Province; and the Wau Ecology Institute based at Marobe Province also carry out research. Research presently being carried out deal with timber stand improvement in logged over areas; exploration of biological diversity of flora and fauna; plantation silviculture: agroforestry trials: tree improvement, wood preservation: wood structure and properties: utilization of rattan: efficiency of sawmilling: and insect pests and diseases. The most important problems faced by PNG FRI concern the lack of trained manpower, finance and the land tenure issues.

Philippines

Some 34 institutions are engaged in research relating to natural resources. Only a few are active in forestry research: Ecosystem Research and Development Bureau (ERDB); Forest Productions Research and Development Institute (FPRDI); UPLB, College of Forestry; and several other universities. Presently ERBD is concentrating its work on ecosystems protection, genetics, tree improvement and protection and development of uplands. The FPRDI is mandated to undertake research to assist the forest based industries.

Sri Lanka

The Forest Department of Sri Lanka under the Ministry of Lands, Irrigation and Mahaweli Development is the key state institution responsible for forestry research. Currently the only functioning research unit is the Silviculture Research Branch. To facilitate field research, two field research stations have been set up one for the low lands and one for the high lands. Cur-

Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

rent research programs include: selection of species, varieties and provenances, production, storage and lasting of seeds, development and improvement of nursery and planting techniques, pests and discard control, silviculture and management practices, conservation and protection of environment; subsidiary task produce. The problems of forestry research are: lack of manpower, lack of career development opportunities and lack of linkages with other agencies.

Thailand

A Forest Research Institute with a well defined structure has not been established so far in Thailand. The Silviculture, watershed management, community forestry, Forestry Products and MFP divisions at the Royal Forest Department and the Forest Industry Organization are engaged in some research work. The Faculty and students of Kasetsart University conducts research into several aspects of forestry. There are two regional centers located in the Kasetsart University: Forestry/Fuelwood Research and Department Project and the Regional Community Forestry Training Center for Asia-Pacific. The ASEAN-Canada Tree Seed Centre is engaged in a program of long term research into tree seed issues. The non-institutionalization and fragmented nature of research efforts is hampering research extension work in the country.

Vietnam

The Forest Science Institute in its reorganized form is responsible for most of the research in the country. The Southern Forestry Research Station tackles the problems of the south. Vietnam is undergoing a rapid phase of transition to a more liberal economy. Many changes in structures and land tenure calling for a reorientation of forestry research are surfeiting.

Achievements: Reorientation and Regional Cooperation

National Efforts

At least some 120 research establishments in 14 countries of the Asia-Pacific region are engaged in research into various aspects of forestry. Out of these, 19 institutions are full fledged research institute or departments or specialized research bodies. The range of activities carried out by these institutions is extremely wide. Most of them deal with applied research in the fields of silviculture, mensuration, forest utilization, forest botany and genetics. Natural regeneration and growth studies in natural forests find prominent place in the research programmes of several of these institutions. Assessment of the properties and the uses of timber and research into such aspects as seasoning, treatment, wood working and basic processing is also carried out by several of these institutions. Research into wood technology, wood engineering and testing

Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

of the species for pulp and paper properties are among the dominant activities that have been reported. Applied aspects of forest entomology and forest pathology are listed by some of the institutions as principal fields of activities. The choice of species for plantations, introduction of exotic species, and tree breeding work finds prominent place in the work of some of the FRIs. Most institutions appear to have important collections of herbariums as well as insectoriums. By and large, an important conclusion which emerges from data received from several of the FRIs, with a few exceptions, indicate the need to strengthen and focus on research into problems of community participation; rehabilitation of degraded lands/problem soils; conservation of ecosystems; non-wood forest products; and policy aspects.

The achievements of national FRIs, as reflected in published research results are several. The F/FRED project conducted a survey in 1990 of research carried out and published in five countries; Bangladesh, Indonesia, Malaysia, Philippines and Thailand. They found that between 1976 and 1990 a total of 704 research articles have been published which incorporated findings on one aspect or other of 17 species.

A search of CABIs abstracts for the period 1976-90 revealed that on some of the topics selected for FORSPA funding (watershed management, shifting cultivation, soils, protected areas, community forestry, NWFP, policy and economics), some 2600 records of research findings exist.

Hundreds of universities, located in Asia and abroad award Msc and Phd degrees to students who carry out forestry research. Even in the fledgling forestry faculty of Sri Jaya-wardanapura in Sri Lanka, started in 1983, as many as 30 dissertations on forestry related subjects found academic acceptance during the period 1983 to 1990. Dissemination of research results contained in university dissertations remains a neglected task.

Research results published from China and Japan (often in their respective languages) are numerous. Although some are available as abstracts, written in English, it is difficult to assess their achievements in forestry research.

Reorientation and Regional Cooperation

During 1981, World Bank and FAO prepared the document "Forestry Research—a Time for Reappraisal", and presented it at the Kyoto Meeting of IUFRO. This document, endorsed by IUFRO, argued for reorientation of research priorities in favour of forestry for rural development, stimulated new interest among the international community in funding forestry research

Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

proposals, and heightened national awareness on the need for strengthening their FRIs.

During the decade of 1980s:

- the Asian Development Bank has supported research components in several of its community forestry programmes.
- the Australian Centre for International Agricultural Research (ACIAR) research Programme assisted in the use Australian trees in developing countries;
- the Canadian International Development Agency (CIDA) promoted the ASEAN/CANADA Tree Seed Centre in Thailand; and the ASEAN Forestry Management Institute in Malaysia;
- Centre Technique Forestier Tropical (CTFT) funded research projects on timber technology, seed collection, harvesting, etc.
- DANIDA funded projects on the development of forest genetics research;
- The EU supported research into the utilization of rubber-wood;
- FAO is executing such regional projects as Regional Wood Energy Development, Support to Watershed Management, Agroforestry Research Systems, Tree Improvement and Propagation—all of which promoting one aspect or the other of forestry research⁽⁷⁾.
- the Ford Foundation funded many small projects narrowly focussed on research into problems that arise at the local level;
- the Forestry/Fuelwood Research and Development Project (F/FRED) was developed by USAID;
- GTZ of Germany assisted Fiji with extension forestry research;
- the International Development Research Centre (IDRC) concentrated on bamboo, rattan and palm networks;
- the IUFRO/SPDC research programme was initiated;
- the ICRAF promoted agro-forestry research;
- the Integrated Mountain Development (ICIMOD) has started playing an active role in watershed research in the Himalayas;
- JICA assisted some countries with projects oriented to forestry research;
- The Overseas Economic Cooperation Fund (OECF) of Japan funded research projects on afforestation in India which contain research elements;
- the Man and Biosphere Programme (MAB) of UNESCO supported research on lowland Dipterocarp forests;
- the Nitrogen Fixing Trees Associations (NFTA) established demonstration plots and prom-

- oted information exchange on NFTA;
- New Zealand ODA, assisted the Pacific countries with research into reforestation etc.
 - The Overseas Development Administration (ODA) of UK has established international network of practitioners and researchers in social forestry programmes;
 - UNDP supported field projects which addressed selected research issues;
 - USAID, in addition to funding F/FRED supported research into community forestry, environmental issues both in Asian countries and also in the Pacific.
 - the World Bank funded several projects, some which incorporated research components in the developing countries.

Research Programmes eligible for funding

Five priority research areas have been identified for funding. These are:

- (i) upland watershed management; (ii) reforestation of degraded lands and problem soils; (iii) conservation of ecosystems and maintenance of biological diversity; (iv) improving the susceptibility of plantation forestry; and (v) promotion of community participation in forestry development.

Topic I: Research on Upland Watershed Management⁽²¹⁾

Objective

To understand the interdependence of forestry, agriculture and energy-related interventions in upland watersheds and demonstrate land use options which would enable upland dwellers to practice sustainable land use while maintaining productivity and reducing erosion and downstream damage.

Scope

The following research topics would be of interest and will be selectively funded after discussions with the participating research institutes:

- (i) Adopting a systems approach to understand and quantify linkages between upland management activities and downstream effects;
- (ii) Research into improved management of shifting cultivation areas including improved land preparation, controlled burning, terracing, introduction of cash crops into the system, etc.;
- (iii) Research into the economics of watershed management including the valuation of externalities and direct costs and benefits to upland dwellers and downstream inhabitants.

Topic II: Research into Reforestation of Degraded Lands and Problem Soils

Objective

To design more effective strategies and actions to increase the productivity of degraded lands and problem soils (e.g., saline/alkaline; acid sulphate; laterite; sandy soils; waterlogged areas; etc.) and to prevent the potential hazard of desertification.

Scope

Technologies for improved productivity through introduction of suitable species (to improve the nutritional and soil moisture status of degraded lands and problem soils) are urgently needed to reforest the wasted land resources in several DMCs of the Region. The following research would be of interest and will be selectively funded after discussions with the participating research institutes:

- (i) Biotechnology research to develop and introduce tree/shrub species adapted to degraded lands/problem soils including trials of nitrogen-fixing species.
- (ii) Policy reforms and socioeconomic changes needed to promote the technologies recognized as suitable.
- (iii) Understanding the requirements of local inhabitants and developing a system of incentives to encourage improved land use.
- (iv) Policy/Socioeconomic research on common property management issues.

Topic III: Research into Ecosystem Conservation and Maintenance of Biological Diversity

Objective

To improve the understanding of the structure and functioning of tropical forestry ecosystems and the value and role of wood and non-wood forest products in local and national economies⁰⁰.

Scope

The following research topics would be of interest and will be selectively funded after discussions with the participating research institutes:

- (i) Research concerning conservation of tropical forestry ecosystems.
- (ii) Economic analysis to better quantify the costs and benefits of conservation of forest resources.
- (iii) Policy and technical research to develop strategies for establishing buffer zones around protected areas.

Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

- (iv) Research into policies relating to promotion of non wood forest products, timber pricing, land tenure, agriculture settlement and industrial development.

Topic IV: Research into Improving the Sustainability of Plantation Forestry

Objective

To procure conclusive evidence of the impact of intensive plantation forestry and to enhance its sustainability.

Scope

The following research topics would be of interest and will be selectively funded after discussions with the participating research institutes:

- (i) To understand and quantify the nature and the extent of the potential contribution of plantation forestry in conserving natural forests and promoting national economies.
- (ii) Research into site specific assessments of the impact of large- scale plantations and monoculture on the ecology of the sites.
- (iii) Research into rapid propagation of commercially valuable tree species, particularly through clonal propagation.
- (iv) Policy studies in the area of plantation forestry, particularly regarding incentive policies and financing mechanisms used in different DMCs.
- (v) Research into wood utilization to make greater use of small-sized trees, lesser known hardwood species and developing technologies which might have rapid payoffs in tropical countries through adaptive research into wood technology, wood preservation, wood engineering.

Topic V: Research into Promoting Community Participation in Forestry Development

Objective

To determine the effectiveness and efficiency of alternative incentive mechanisms and other measures to stimulate local participation in tree growing and conservation activities.

Scope

The following research topics would be of interest and will be selectively funded after discussions with the participating research institutes:

- (i) Research into policies and administrative measures for closer integration of forestry with the other sectors of the economy such as agriculture, animal husbandry, irrigation, power, industry, etc.

Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

- (ii) Research into land and tree tenure policies.
- (iii) Research into incentives and mechanisms (including non-market issues) for securing community participation.
- (iv) Research into the role of local organizations and the private sector.

Implementing Procedures for the Above Research Programmes

The mechanisms for seeking specific project proposals from individual participating research institutes, identifying the shared nature of the problems and the possible solutions would be determined during the implementation of the research projects.

The effectiveness of expanded research will depend on an expansion of each national capacity to do productive research in these fields. Capacity at the present time is already being strained in many countries. Based on the assessment of weaknesses in existing capacity presented above, the author identified five major areas of institutional strengthening which require immediate attention. These are:

1. Strengthen the mechanisms by which public officials and political leaders become aware of the critical problems which tropical deforestation and degradation create in a broader development context and the important contributions which research can make to solving these problems.
2. Strengthen education and training systems which prepare researchers to work on tropical forestry problems.
3. Develop mechanisms to secure needed core funding for national and international tropical forestry research organizations. Success in addressing this issue will depend on the effectiveness of efforts to change the understanding and attitudes of political decision makers and efforts to improve the effectiveness of research so real benefits to society can be demonstrated.
4. Strengthen the efforts of national research organizations to build more effective incentives and management systems into their programs, in some cases through assistance in reorganization and in other cases through greater inputs of financial and other resources (including equipment).
5. Strengthen mechanisms for improving interaction between:
 - (a) forestry researchers and their peers at home and abroad. This would encourage scientific soundness and relevance of research work and stimulate research ideas. It will in-

Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

volve intensified efforts to support networks, scientific meetings, travel to visit with fellow researchers, exchanges, better access to scientific literature, and so forth;

- (b) forestry researchers and other non-forestry researchers and research organizations working on problems of relevance to the TFAP, e.g., agricultural research groups, and basic research organizations working on biodiversity, genetics, soils, energy, etc. This will help encourage interdisciplinary research needed to solve complex problems, such as those associated with integrated watershed management. Incentives for such interaction will have to be created along with establishment of lines of communication and concrete means to make interdisciplinary linkages relevant and attractive to researchers; and
- (c) forestry researchers and the clients of research, or those who will be disseminating or applying the results in the field. This will help to ensure the relevance of research to solving critical current and emerging problems. It involves intensification of field travel and contacts, attendance at non-scientific meetings, closer collaboration with NGOs, and other interaction mechanisms.

Special Task Forces comprising researchers specialized in the above issues and drawn from the participating research institutes will be set up. Periodic meetings of such Task Forces will be convened by the Program Advisor to:

- (i) determine the nature of the shared problems;
- (ii) identify and exchange common features of the research methodology to be adopted;
- (iii) ensure sustained interaction among cooperating researchers to achieve complementarity of research efforts and monitoring mechanisms;
- (iv) share research findings and disseminate results to users.

In putting forth the above priorities for research and for institutional strengthening, the Task Force is mindful of the fact that the relative importance of each field will vary between countries and regions, as will the needs for institution building.

Summary

The author emphasizes here that both the misuse and the wise use of tropical forests are consequences of human activity. In the absence of policy alternatives provided by a large increment of knowledge resulting from forestry research, the misuse exemplified by deforestation, destroyed productive potential, and lost biological diversity will prevail. Knowledge gained from an improved system of forestry research will enable society to choose wise use and thus to se-

cure the environmental, economic, and spiritual benefits of forests.

Tropical forestry research must become broader in its clients, participants, and the problems it examines, and at the same time it must conduct more in-depth research and become more rigorous in utilizing all of science and technology. The number of scientists and amount of resources devoted to forestry research are not enough, even as needs increase. To meet the challenge of rapid change, new approaches and new resources of the kind described in this report are required. The educational and fiscal systems that support forestry research must be restructured and revitalized; integrated research facilities must be created where public and private resources can be concentrated on basic questions, new technologies, and effective outreach and extension activities.

LITERATURE CITED

- (1) Alan, T. and J.P. Lanly. 1991. Overview of status and trends of world's forests, pp. 17-41. In D. Howlett and S. Caroline (ed.) Proceedings, technical workshop to explore options for global forestry management, Bangkok.
- (2) Buckman, R.E. Forestry research in the developing world: Problems and opportunities, Proceedings of Tsukuba-Workshop, BIO-REFOR, Tsukuba, Japan, 1992, pp. 19-23.
- (3) Durning, A.T., Redesigning the Forest Economy in Lester Brown et al., State of the World 1994, New York, W.W. Norton & Company, 1994.
- (4) FAO, Committee on Forest Development in The Tropics, Tropical Forestry Action Plan, Rome, Food and Agriculture Organization of the United Nations, 1985.
- (5) FAO, FRD, Forest Resources Assessment 1990: Tropical Countries, Forestry Paper 112, Rome, FAO, 1993.
- (6) FAO, Special study on forest management, afforestation and utilization of forest resources in the developing regions, Asia-Pacific region, Assessment of forest resources in six countries, Bangkok, PAPA, FAO, 1987.
- (7) FAO, TFAP, Summary of Investment, TFAP, Rome, FAO, 1989.
- (8) IBRD (World Bank), A Strategy for Asian Forestry Development, Washington D.C., IBRD, 1992.
- (9) Johnson, N. and Cabarle, B., Surviving the Cut: Natural Forest Management in the Humid Tropics, Washington D.C., World Resources Institute, 1993.
- (10) Miller, K. and Tangle, L., Trees of Life: Saving Tropical Forests and Their Biological Wealth, Boston, Beacon Press, 1991.
- (11) Murakami, K. Proceedings of Pre-Workshop, Bogor, Indonesia, BIO-REFOR, 1991.
- (12) Murakami, K. Proceedings of Tsukuba-Workshop, Tsukuba, Japan, BIO-REFOR, 1992.
- (13) Myers, N., The Primary source: Tropical forests and Our Future, New York, W.W. Norton & Company, 1992.
- (14) Myers, N., Vanishing Eden, The Plight of the Tropical Rainforest, Hong Kong, Barron's, 1991.
- (15) Newman, A., Tropical Rainforest, A World Survey of Our Most Valuable and Endangered Habitat with a Blueprint for Its Survival, New York, Facts on File, 1990.
- (16) Park, C.C., Tropical Rainforests, New York, Routledge, 1992.
- (17) Poore, D. 1989. No timber without trees; sustainability in the tropical forest. Earthscan Publica-

Research Needs and Achievements of Tropical Forestry in Asia Pacific Region

tions Ltd. London. 252 pp.

- (18) Postel, S. and Ryan, J.C., *Reforming Forestry* in Lester Brown et al., *State of the World 1991*, New York, W.W. Norton & Company, 1991.
- (19) Rao, Y.S. *Forestry research needs and achievements in Asia-Pacific region*, Proceedings of Tsukuba-Workshop, BIO-REFOR, Tsukuba, Japan, 1992, pp. 24-37.
- (20) World Resources Institute, *World Resources 1990-91*, New York, Oxford University Press, 1990.
- (21) WRI. 1990. *World Resources 1990-1991. A guide to the global environment*. World Resources Institute. Oxford University Press, 383 pp.
- (22) WWF (World Wide Fund for Nature), *Conservation of Tropical Forests, Special Report 1*, Gland, Switzerland, 1988.