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Lessons from Biosphere Reserves in the Asia-Pacific Region, and a Way Forward

A regional review of biosphere reserves in Asia & the Pacific to achieve sustainable development

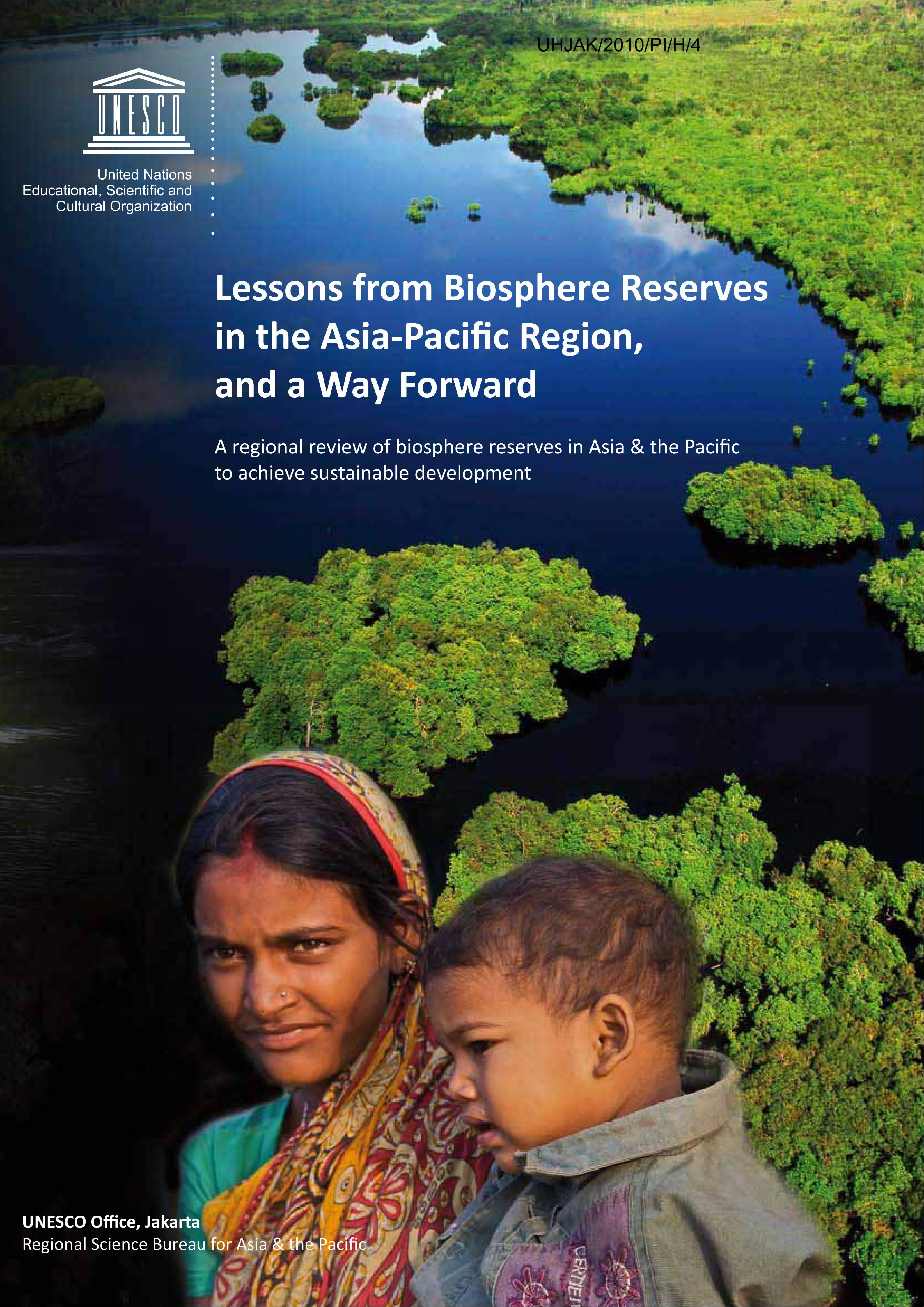

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TABLE OF CONTENTS

SUMMARY AND RECOMMENDATIONS

This report provides the results of a quantitative and qualitative review of the biosphere reserves in Asia and the Pacific through the UNESCO Man and Biosphere (MAB) Programme. The main objectives and critical questions that this review addressed focused on three topics:

- **Achievement of biosphere reserve functions:** Have biosphere reserves been an effective agent in carrying out the three functions of biosphere reserves?
- **Climate Change:** To what extent have biosphere reserves been the focus of climate change discussions?
- **Sustainable development:** The effectiveness of biosphere reserves in catalysing new initiatives concerning sustainable development.

The MAB Programme has been in existence for 35 years and in the Asia-Pacific region, leading to the establishment of 105 biosphere reserves in 28 countries, while additional reserves are being developed. There is therefore significant accumulated wisdom and experience in the region, providing good opportunities for lessons learned, identification of successes and failures, and assessments of common problems and solutions. This review aims to identify these common knowledge factors in the region, with a specific aim to galvanize and focus the accumulated acquired knowledge and experience in a well organized effort across the region and bring it to bear on the MAB program going forward.

Even though biosphere reserves are a powerful concept for conservation and sustainable development that suits the present-day need of balancing environmental and economic factors, involving multiple stakeholders and developing holistic management approaches, in the Asia Pacific region there is a need to expand beyond its achivements. Among participating governments and other organizations, there appears to remain a significant lack of understanding about what biosphere reserve are and are not meant to do. A main underlying issue appears to be the lack of clear branding of biosphere reserves. This again might be caused by a lack of information about biosphere reserves, insufficient monitoring and evaluation which could elucidate how biosphere reserve perform towards their stated functions and goals, and a lack of communication about biosphere reserves. Also there appear to be discrepancies between the goals of biosphere reserves and the legislation in individual countries regarding conservation and sustainable development, which hampers effectively implementation of biosphere reserve goals, and thus prevent them from getting national or international recognition.

These issues and challenges of biosphere reserves are recognized by UNESCO and biosphere reserve practitioners. The question is how to address them, and move forward in a way that will benefit member countries and its communities. It is recommended here that more effective use is made of the existing knowledge on biosphere reserves in the region, while also focusing on increasing understanding of biosphere reserves. Developing effective learning networks and capitalizing on the vast experience in the region will require that UNESCO fund the MAB program to make the institutional knowledge of the past 35 years more effectively serve the future of the MAB program in the region. Such a shared learning strategy might be a good way to begin implementing the high priority recommendations and to engage the targeted audiences of national and local government officials and key policy and scientific institutions.

Specifically it is recommended to target awareness building and branding towards the role of the MAB program in climate change and sustainable development. Individual biosphere reserves and country MAB programs could prepare white papers on the specific recommendations setting forth a deep dive analysis of the issues and problems. Guidance for specific actions that would help this process is given below.

MAIN RECOMMENDATIONS

On the basis of the findings of this review, all the recommendations given in the body of the review has been synthesized to several key recommendations on a way forward for strong biosphere reserve concept and its role in sustainable development and climate change. These are as follows:

Monitoring and evaluation with a goal to measure management effectiveness and improve information availability. It is presently very difficult to assess how well individual biosphere reserves are functioning. Not only is basic information on biosphere reserve management often lacking, also there appear to be few efforts to consistently monitor reserve performance. This makes it hard, both internally within UNESCO and its biosphere reserve partner organizations, as well as externally, to develop adaptive management approaches that build on past successes and learn from mistakes to improve overall performance. It is recommended that UNESCO develop a standardized set of socio-economic and environmental indicators, and cheap, simple methods to measure them. Some examples are given in this review as how this could be done. These measures programs should then be implemented by at least a subset of the best biosphere reserves. The results would feed into a national, regional, or global database on biosphere reserves to track whether the y are indeed contributing to the stated conservation, development, and logistical functions. If such a central database is too difficult or expensive to develop and maintain, a more dispersed approach could be considered, for example, based on participatory approaches such as those employed in Wikipedia, i.e., information about individual reserves is maintained by a broad range of informed contributors, including government staff, biosphere reserve management, local community groups, local private sector groups, NGOs, and others who have good knowledge about a particular reserve. Overall findings from these measures programs can then be actively used in UNESCO's communication strategy, as well as in adaptive management of the reserves. If MAB sets up strong monitoring and evaluation programs, these would help address the lack of information on biosphere reserves, including the availability of spatial information and reserve performance towards their conservation and development goals. If deemed useful, the information can also be used to develop and implement a rating system for biosphere reserves, allowing the differentiation between best managed reserves and those were this is still under development (or much like the World Heritage mechanism, even consider 'de-listing' or 'in danger list' reserves that are in serious trouble).

Alignment of biosphere reserve goals and local legislation. One reason why biosphere reserves might function less than optimal is because their integrated approach to conservation and development is not always easily reconciled with local land use legislation that rarely recognizes multi-functionality in land use. To investigate whether this is a major impediment to biosphere reserve functioning it is recommended that UNESCO, in collaboration with national MAB committees as well as regional networks, should implement an analysis of how well biosphere reserve targets are aligned with national legislation. The goal would be to identify areas of conflict between targets and legislation, guidelines on how to resolve this, and eventually develop a set of standardized management guidelines which can be used at the regional and global levels. Biosphere reserve management plans should also be part of the larger provincial and local development plans to ensure that their development objectives are in line with those developed at a regional scale. This prevents biosphere reserves ending up as isolated management units rather than local conservation and development strategies integrated into the broader objectives for the landscape or region. This issue is critical to the success of MAB program and to its objectives. In addition, it is a generic issue that cuts across the MAB program and is the kind of issue and question that can be usefully addressed across the region, where "lessons learned" in one country and biosphere reserve can be usefully applied more broadly.

Guidelines on multi-stakeholder management. Biosphere reserve management depends on involvement of various governmental and non-governmental interest groups in the planning and management implementation of the reserve. This is very hard to achieve, and few guidelines exist on the best way to go about developing these partnerships. It is recommended that UNESCO and their partners develop guidelines on how to set up and implement partnerships and what formal structures are needed for doing this work best. This should involve all national committees who should be required to develop a plan with a timeline to create country-specific legislation on biosphere reserve management and development of concomitant multi-stakeholder management structures.

Climate change. The landscape level, multi-stakeholder approach of biosphere reserves is ideal for implementing measures towards both climate change adaptation and mitigation. The climate change role of biosphere reserve is, however, under-reported and only a handful of examples exists in the region that have started to address climate change issues. It is recommended that UNESCO develop one or more pilot projects in which climate change adaptation and mitigation is specifically incorporated into the biosphere reserve management plans, and in which the specific contributions of environmental services from the reserve to climate change are closely measured and publicly demonstrated. The purpose is to promote biosphere reserve and related landscape-level management as an appropriate tool to address the drivers of climate change and minimize its environmental and socio-economic impacts.

Poverty alleviation and rural development. The sustainable development aspects of biosphere reserve management seem to focus most on eco-tourism, and sustainable resource use. It is questionable whether these economic activities will provide enough development impetus to effectively protect core conservation values in reserves. More recent models have focused on engaging industrial partners in reserve management, with economic activities in transition and buffer zones aiming to provide funding for conservation in the core zone, and assist in rural development of surrounding communities. Because the poverty alleviation and sustainable development goals of biosphere reserve are crucial goals there is a need to better test under which conditions and management structures the best results are achieved. Once these measures are found to be effective, they should be specifically incorporated in the biosphere reserve management plans for poverty alleviation and development.

Communication, branding and alignment. This review showed that compared to other international and national conservation designations, biosphere reserves get relatively little attention from media and thus reach a relatively small audience. Public awareness regarding biosphere reserves is still low, particularly in developing countries. It is recommended that MAB develop a very targeted communications strategy focused on key government officials—national and local—, i.e., the people that really have to adopt the biosphere reserve concept, and integrate the MAB program with national and local legislation and climate change and sustainable development strategies. In addition, a focused communication and "branding" strategy and an "alignment" strategy could be combined into a tight, specific recommendation with government officials and key academic institutions and policy organizations as the target audience. This targeted audience strategy also has the advantage of being applicable across the region and is amenable to "shared learning strategies" and programs. Practically, such a strategy would involve conducting a few high level global and regional conferences on raising awareness of key decision makers.

Development of a multi-faceted regional program. This review demonstrated that there is a real need for a regional program that reflects and addresses current biosphere reserve challenges. This recommendation merely synthesizes and encapsulates the previous six recommendations. Such a regional program would have to address issues on: standardizing and improving biosphere reserve management; climate change mitigation and adaptation efforts into biosphere reserve planning and management; stronger engagement with stakeholders across sectors including the private sector; incorporating poverty alleviation and rural development into biosphere reserve planning and management; and raising the profile and visibility of biosphere reserves. A regional program that is designed, developed, and implemented in partnership with Member State authorities, local communities, civil society organizations, and private sector parties would produce the intended benefits associated with biosphere reserves, stimulate dialogue among stakeholders, provide greater visibility to biosphere reserves, and, ultimately, contribute to regional and national sustainable development efforts.

Implementing these recommendations will require significant resources and time. Rather than trying to change the entire biosphere reserve system at once, it might be better to select some biosphere reserve to test new best management practices based on the above recommendations. If this works well, and conservation and development achievements are significantly higher than under a business-as-usual scenario, the improved models can be implemented more widely. The regional learning networks will be crucial in this process of scaling up best management practices to other reserves in the network.

INTRODUCTION

Biosphere reserves are 'living laboratories for sustainable development' and represent learning centers for environmental and human adaptability. Biosphere reserves are the only sites under the UN system that specifically call for conservation and sustainable development to proceed along mutually supportive paths. Such mutuality requires cultural sensitivity, scientific expertise, and consensus-driven policy and decision-making. To date, there are 531 terrestrial, coastal, and marine biosphere reserves throughout the world including 105 reserves in 28 Asian and Pacific countries (Figure 1).

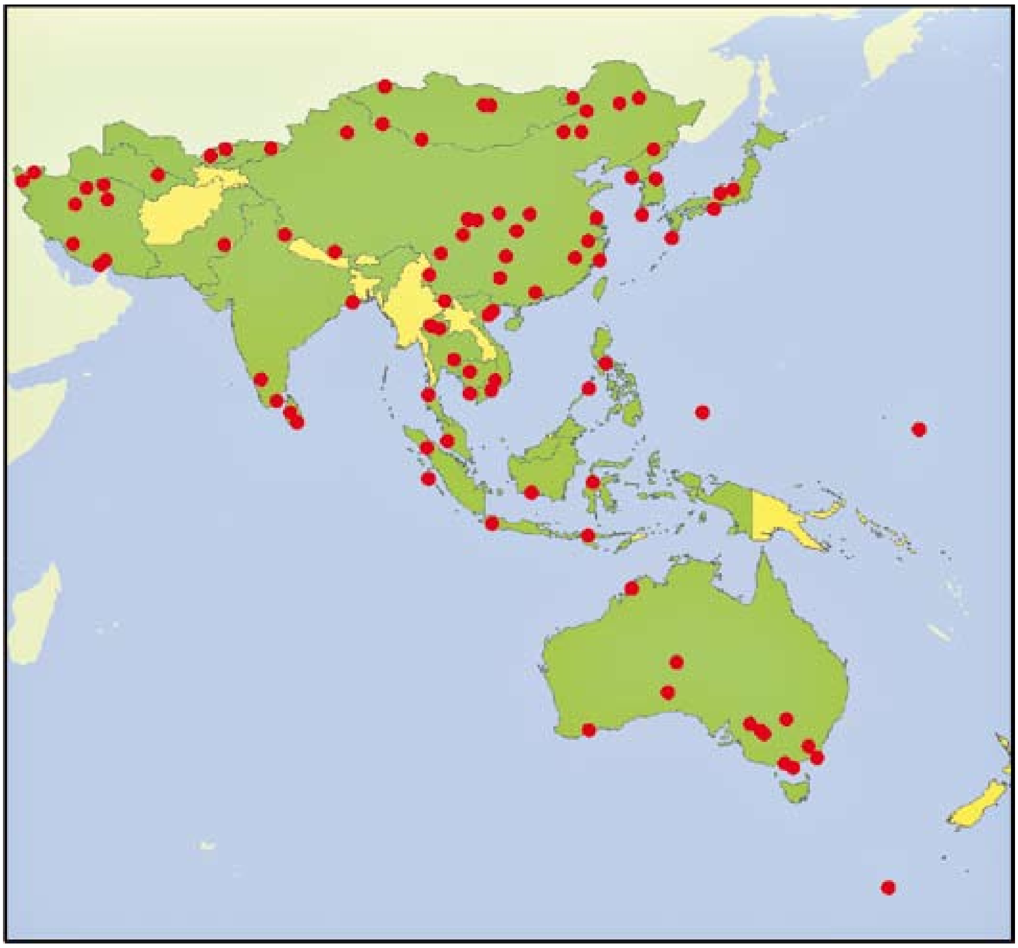

Figure 1. Map of the Asia Pacific region showing countries with biosphere reserves in green and those without in yellow. Red points are point locations of Asia Pacific biosphere reserves. Map by Rona Dennis.

History of the Man and Biosphere program

The Man and Biosphere Programme (MAB) is an intergovernmental program that emerged in the late 1960s and early 1970s, even before the convening in June 1972 of the United Nations Stockholm Conference on the Human Environment, which focused attention on global environmental problems. In 1971, at its first meeting, the International Coordinating Council (ICC, see below) that supervises MAB's programs decided that a mean theme of MAB's programs would be "conservation of natural areas and the genetic material they contain" (Dyer & Holland 1988). Thus, the focus from the start was firmly on habitat and species conservation. The biosphere reserve concept, the mainstay of MAB's conservation work was developed in 1974 to encourage establishment of protected areas. Initiated by the Task Force of UNESCO's Man MAB Programme, the first 10 biosphere reserves in the Asia Pacific were established in 1976 (of which 9 in what is now the Islamic Republic of Iran, and 1 in Thailand).

In 1983, UNESCO and the United Nations Environment Programme (UNEP) convened jointly the First International Biosphere Reserve Congress in Minsk (Belarus), in co-operation with the Food and Agriculture Organization of the United Nations (FAO) and the World Conservation Union (IUCN). The Congress's activities gave rise in 1984 to an "Action Plan for Biosphere Reserves", which was formally endorsed by the UNESCO General Conference and by the Governing Council of UNEP. Much of the overall design for MAB grew from the scientific studies organized for the International Biological Programme (IBP) following the lead of the International Council of Scientific Unions. However, MAB came to put greater emphasis of human concerns because many scientists and international organizations found IBP to be too restricted to scientific issues and not sufficiently sensitive to practical problems (Dyer & Holland 1988).

In the mid-1980s UNESCO experienced considerable turbulance. In 1984, the United States of America had withdrawn financial support to the organization, and other countries threatened to follow (Dickson 1985). Britain and Singapore followed suit in 1985 (Colwell & Pramer 1994), on similar grounds as the USA. These three countries expressed concern that trends in policy, ideological emphasis, lack of budgetary constraints, and poor management diminished the organization's effectiveness and caused UNESCO to stray from the principles on which it was originally constituted (Colwell & Pramer 1994). Some countries, particularly in the West, saw UNESCO as an agency that should primarily be concerned with intellectual, as distinct from political, debates. Others, notably in developing countries, saw it more in terms of an important channel for development assistance. A third group, dominated by the Eastern bloc countries but also including several Arab and developing countries, argued that the distinction between intellectual, developmental, and political issues is false, and that the agency should explicitly address all three simultaneously (Dickson 1985). It seems that the thinking in the last group set the scene for an updated mission of UNESCO in general and its MAB program in particular. Slowly, a shift started to occur in the development and management of biosphere reserve from a strict focus on research and conservation to one in which sustainable development as an integral part of conservation took over.

In the decade since the 1983 UNEP Congress in Minsk, the link between conservation of biodiversity and the development needs of local communities has become recognized as a key feature of the successful management of most national parks, nature reserves and other protected areas. At the Fourth World Congress on National Parks and Protected Areas, held in Caracas, Venezuela, in February 1992, the world's protected-area planners and managers adopted many of the ideas (community involvement, the links between conservation and development, the importance of international collaboration) that are now essential aspects of biosphere reserves. The Congress also approved a resolution in support of biosphere reserves.

There were also important innovations in the management of biosphere reserves themselves. New methodologies for involving stakeholders in decision-making processes and resolving conflicts were developed, and increased attention was given to the need for regional approaches. For this purpose, new kinds of biosphere reserves, such as cluster and transboundary reserves, were devised and the management and design of many biosphere reserves had evolved considerably, from a primary focus on conservation to a greater integration of conservation and development, through increasing co-operation among stakeholders. In the context of these changes, the Executive Board of UNESCO decided, in 1991, to establish an Advisory Committee for Biosphere Reserves. This Advisory Committee considered that it was time to evaluate the effectiveness of the 1984 Action Plan, to analyze its implementation and to develop a strategy for biosphere reserves as we move into the 21st Century.

To this end, and in accordance with Resolution 27/C/2.3 of the General Conference, UNESCO organized, at the invitation of the Spanish authorities, the 2nd World Conference on Biosphere Reserves, held in Seville (Spain), from 20 to 25 March 1995. The conference was organized to enable an evaluation of the experience in implementing the 1984 Action Plan, a reflection on the role for biosphere reserves in the context of the 21st century (which gave rise to the vision statement, see below) and the elaboration of a draft Statutory Framework for the World Network. The Conference drew up the Seville Strategy.

The Seville Conference concluded that, in spite of the problems and limitations encountered with the establishment of biosphere reserves, the program, as a whole, had been innovative and had had much success. In particular, the three basic functions of conservation (preserving genetic resources, species, ecosystems and landscapes), development (fostering sustainable economic and human development); and logistic support (support demonstration projects, environmental education and training, and research and monitoring) would be as valid as ever in the coming years.

UNESCO's Seville Strategy 1995 set out objectives for the appropriate functioning of the World Network of Biosphere Reserves.

Table 1. Goals and objectives for biosphere reserves as defined in the Seville Strategy.

GOALS	OBJECTIVES
Utilize Biosphere Reserves as models of land management and of approaches to sustainable development	Secure the support and involvement of local people
	Ensure better harmonization and interaction among the different biosphere reserve zones
	Integrate biosphere reserves into regional planning
Use Biosphere Reserves for research, monitoring, education and training	Improve knowledge of the interactions between humans and the biosphere
	Improve monitoring activities
	Improve education, public awareness and involvement
Implement the Biosphere Reserve Concept	Improve training for specialists and managers
	Integrate the functions of biosphere reserves
	Strengthen the World Network of Biosphere Reserves

These objectives were defined in the context of broad goals and recommendations at three organizational levels: international, national and individual reserves. The objectives for individual reserves are described in Table 1.

Ten years after the Seville Conference, the 3rd World Congress of UNESCO's biosphere reserves was held in Madrid, Spain. It reviewed the progress of the Seville Strategy and aim to further reinvigorate the biosphere reserve concept. The Madrid Conference ended with the adoption of a declaration that stresses the role of biosphere reserves as places "for investments and innovation to mitigate and adapt to climate change, (and) to promote the greater use of renewable energy".

The Madrid Declaration further broadens to scope of biosphere reserves in its call for capitalization of "the potential for action of biosphere reserves to address new challenges". These new challenges include the loss of traditional knowledge and cultural diversity, demography, loss of arable land and climate change, thereby further adding to the long list of goals that biosphere reserves seek to achieve. In comparison with the Seville Strategy of 1995, the Madrid Action Plan that resulted from the 2008 Madrid Conference aimed to demonstrate and emphasize the role of biosphere reserves as learning sites for local and regional sustainable development practices as well as the importance of biosphere reserves as regional and global hubs for exchange of information, ideas, experience, knowledge and best practices in sustainability sciences. It is interesting to note that this emphasis takes us back to the discussion in the mid-1980s of the intellectual role of UNESCO and its Man and Biosphere Reserve program.

Several concrete activities called for by the Action Plan include facilitating the integration of urban areas of biosphere reserves; organizing training related to different ecosystems; establishing pilot reserves in order to evaluate their economic contribution at local level; involving the private sector; and promoting the biosphere reserve brand for products. In conclusion, the strategic scope of biosphere reserves has broadened considerably over the four decades since their initial inception. This review will examine how biosphere reserves have and have not effectively carried out these functions.

Organizational structures in MAB

The MAB governing body, the International Coordinating Council (ICC) of the Man and the Biosphere (MAB) Programme, usually referred to as the MAB Council or ICC, consists of 34 member states elected by UNESCO's biennial General Conference. In between meetings, the authority of the ICC is delegated to its Bureau, whose members are nominated from each of UNESCO's geopolitical regions.

The MAB Council normally meets once every two years, usually at UNESCO Headquarters in Paris. Although each Member State has only one vote, it can send as many experts or advisers as it wishes to the Council sessions. In addition, other Member States of UNESCO, which are not members of the Council, can send representatives as observers. UN Agencies such as UNEP, FAO, UNDP, WMO, WHO are also invited as well as representatives of the International Council for Science (ICSU), the International Social Sciences Council (ISSC) and the World Conservation Union (IUCN-as known as International Union for Conservation of Nature).

The role of the Council is:

- to guide and supervise the MAB program;
- to review the progress made in the implementation of the program (cf. Secretariat report and reports of MAB National Committees);
- to recommend research projects to countries and to make proposals on the organization of regional or international cooperation;
- to assess priorities among projects and MAB activities in general;
- to co-ordinate the international cooperation of Member States participating in the MAB program;

- to co-ordinate activities with other international scientific programs;
- to consult with international non-governmental organizations on scientific or technical questions

De facto, the MAB Council also decides upon new biosphere reserves and takes note of recommendations on periodic review reports of biosphere reserves. At its meetings, the Council elects a chairman, five vice-chairmen, of which one functions as a rapporteur; these form the MAB Bureau.

The International Coordinating Council of the Man and the Biosphere program met during the Madrid Congress and elected Henri Djombo, Minister of Forestry and Environment of the Republic of Congo, as President of the Bureau for 2008-2009. The five vice-presidents are representatives from Lebanon, Republic of Korea, the Russian Federation, Spain and Argentina.

At its 21st session held in the Jeju Island Biosphere Reserve, Republic of Korea from 25 to 29 May 2009, the ICC of MAB, set up an International Support Group (ISG), open to the participation of all Member States who have their Delegations at UNESCO Headquarters, to advise the MAB Secretariat on the implementation of the Madrid Action Plan (MAP) and other relevant aspects of the MAB program until the 22nd session of the MAB-ICC in 2010.

Design of Biosphere Reserves

Biosphere reserves are areas that are recognized by the UNESCO's program on MAB. One of the primary objectives of MAB is to achieve a sustainable balance between the goals of conserving biological diversity, promoting economic development, and maintaining associated cultural values.

Biosphere reserves are areas of terrestrial and coastal/marine ecosystems. Reserves are nominated by national governments; each reserve must meet a minimal set of criteria and adhere to a minimal set of conditions before being admitted to the World Network. Each biosphere reserve is intended to fulfill three complementary functions: 1) a conservation function, to preserve genetic resources, species, ecosystems and landscapes; 2) a development function, to foster sustainable economic and human development; and, 3) a logistic support function, to support demonstration projects, environmental education and training, and research and monitoring related to local, national and global issues of conservation and sustainable development.

Physically, each biosphere reserve should contain three elements: one or more **core areas**, which are securely protected sites for conserving biological diversity, monitoring minimally disturbed ecosystems, and undertaking non-destructive research and other low-impact uses (such as education); a clearly identified **buffer zone**, which usually surrounds or adjoins the core areas and is used for co-operative activities compatible with sound ecological practices, including environmental education, recreation, ecotourism, and applied and basic research; and a flexible **transition area**, or area of co-operation, which may contain a variety of agricultural activities, settlements and other uses, and in which local communities, management agencies, scientists, non-governmental organizations (NGO), cultural groups, economic interests and other stakeholders work together to manage and sustainably develop the area's resources (Figure 2). Although originally envisioned as a series of concentric rings, the three zones have been implemented in many different ways in order to meet local needs and conditions. In fact, one of the greatest strengths of the biosphere reserve concept has been the flexibility and creativity with which it has been carried out in various situations.

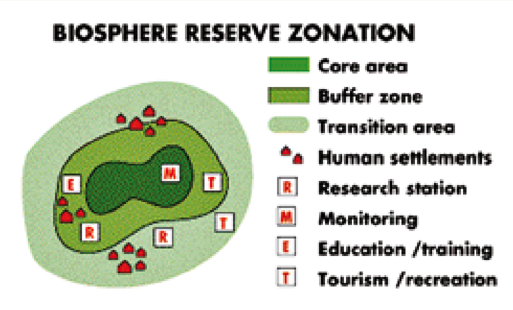

*Figure 2. Schematic diagram of the three zones (source: UNESCO 2007 (**www.unesco.org/mab/faq_br.shtml**)*

Some countries have enacted legislation specifically to establish biosphere reserves. In many others, the core areas and buffer zones are designated (in whole or in part) as protected areas under national law. A large number of biosphere reserves simultaneously belong to other national systems of protected areas (such as national parks or nature reserves) and/or other international networks (such as World Heritage or Ramsar sites).

Ownership arrangements may vary, too. The core areas of biosphere reserves are mostly public land, but can also be privately owned, or belong to non-governmental organizations. In many cases, the buffer zone is in private or community ownership and this is generally the case for the transition area. The Seville Strategy for Biosphere Reserves reflects this wide range of circumstances.

Biosphere reserves are seen as ‘living laboratories’ that have the potential to conserve genetic resources while fulfilling the tripartite functions of conservation (biodiversity and landscape), development (human and economic), and logical support (research, monitoring and training). Indeed, this initiative foreshadowed the present day principle that sustainability in requires the type of integrated land use where the whole exceeds the sum of the parts.

Biosphere Reserve categorization

IUCN (1998) explains the difference between protected areas and biosphere reserves: “biosphere reserves are areas that may include protected areas as well as areas that do not have protected status.” This distinction, however, is often not understood by protected area practitioners. For example, the World Database of Protected Areas lists the Riverland (or Bookmark) Biosphere Reserve as a 900,000 protected area, though Riverland comprises a cluster of protected areas (about 720,000 ha) as well as agricultural and inhabited lands. This situation of confusion between the biosphere reserve and the legally protected areas is common. The confusion lies partly due to the use of the term ‘reserve’ in the name, which indicate that this area is fully protected. Because of the development role of biosphere reserves this is clearly not always the case, which is why some have suggested to drop the term ‘reserve’, and simply call them “biospheres”. This proposal seems to make sense but for consistency sake the name “biosphere reserve” is used in this study.

UNESCO designed its Biosphere Reserve system as a landscape approach, which means that biosphere reserves are typically larger areas comprising both protected areas of varying IUCN categories as well as inhabited and agricultural/ industrial areas. Ideally, these inhabited and agricultural/industrial areas still have a strong connection with the more natural areas in the biosphere reserve, even though they do not have protected status. In this sense, biosphere reserves are related to eco-regional approaches and protected area network planning, which represents some of the added value of the biosphere reserve approach. Often, however, government agencies worked with UNESCO to give biosphere reserve status to areas that are already protected in their entirety (e.g. Komodo National Park in Indonesia). Whereas this is not necessarily a problem, this does mean that in such areas biosphere reserves add less value. To investigate to which extent biosphere reserves designated so far are portfolios or rather an endorsement of already designated protected areas, the surface area of each biosphere reserve was compared to the surface area of all protected areas it contains.

Biosphere Reserves consist of three different types:

- The entire biosphere reserve may be a protected area or,
- It may be made up of several protected areas (e.g., Figure 3); or,
- While the core and buffer zones are protected areas, the transition zone might have protected area status (e.g., Figure 4)

The zoning of biosphere reserve in which protected core areas potentially take up only a

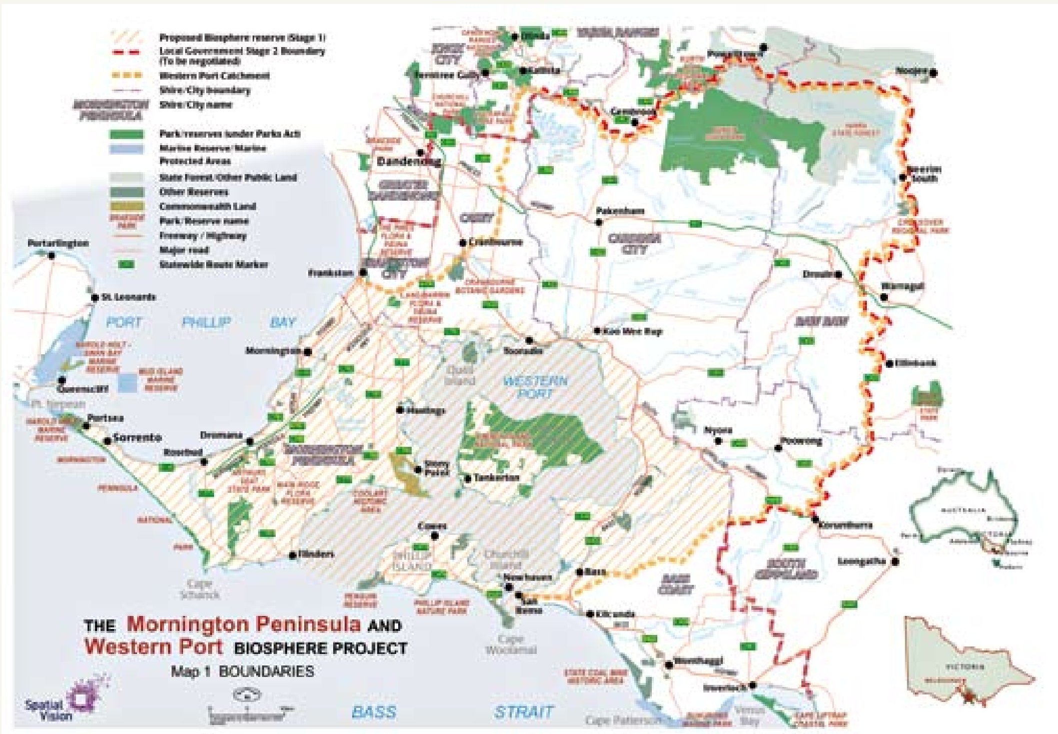

Figure 3. The Mornington Peninsula and Western Port Biosphere Project, which contains a range of different land uses, including several protected areas

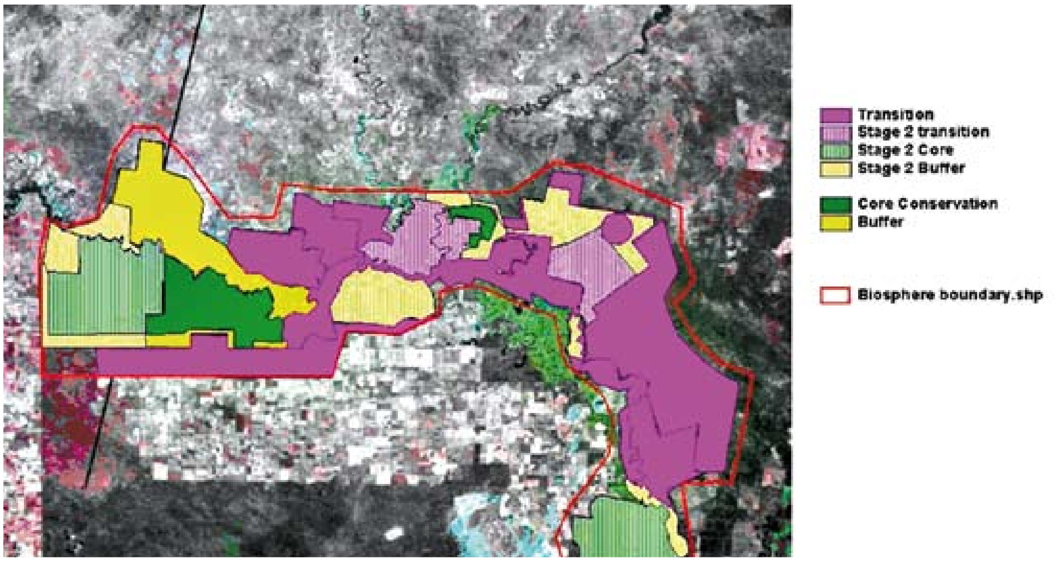

Figure 4. Example of a biosphere reserve in which not all of the reserve is protected. Barkindji Biosphere, Australia. Barkindji includes Ned's Corner, a former sheep and cattle station of 30,000 ha area that was purchased by Trust For Nature. The Department of the Environment, Water, Heritage, and the Arts now categorizes Ned's Corner as an IUCN IV protected area. The buffer zone includes some essentially untouched and some developed areas, including the Australian Inland Botanic Gardens, and agricultural regions where regeneration of the natural environment may take place. The transition zone is anticipated to include a range of activities, including grazing, wineries, sand and salt mining, and horticulture. There is some human habitation in both the buffer and transition zones but the areas do not include any towns or cities.

small part of the reserve allows for more flexible management of environmental resources with a view towards sustainable socio-economic development of the people that live and work in the buffer and transition zones. Also, the reserve design and management structure that involves a broader group of stakeholders than those normally involved in protected area management potentially allows biosphere reserves to cope better with outside threats, such as those posed by the impact of global warming. For example, a coastal area threatened by sea level rise could be managed so that mangroves are given more space to provide buffers to rising sea levels, inland levees are used by people to be less impacted by floods, low-lying lands are planted with cash crops that can cope with some level of flooding, while forests on hill slopes can provide products, cash and refuge for forest wildlife. Such management would require collaboration between forest managers, plantation owners, local communities, local government, and reserve managers, and a level of land use flexibility normally not provided in landscapes where land use boundaries are fixed. Then again, there is also considerable complexity in such management, raising the question whether biosphere reserves can even lead to effective management of both socio-economic and environmental goals. This review aims to assess the extent to which the biosphere reserve concept has been successfully implemented in the Asia Pacific region.

Regional Biosphere Reserve Networks in the Asia Pacific

East Asian Biosphere Reserve Network (EABRN)

Launched in 1994, this network consists of China, the Democratic People's Republic of Korea (DPRK), Japan, Mongolia, the Republic of Korea (ROK) and the Russian Federation. Its objective is to provide a mechanism for East Asian countries to exchange information on the three main functions of biosphere reserves within the sub-region. Several EABRN activities are carried out thanks to funding provided by the Republic of Korea. The Secretariat of EABRN is provided by the UNESCO Office in Beijing, which manages the EABRN website. The EABRN has recently produced an atlas of the biosphere reserves in the region, and has given several training courses, including ones on reservoir sedimentation management, on integrated river basin management, and on remote sensing and GIS for climate change adaptation in biosphere reserves. These activities indicate that the network has a strong focus on the scientific aspects of biosphere management.

Pacific Man and the Biosphere Network (PacMAB)

At a meeting in Pohnpei, Federated States of Micronesia, in December 2006, representatives of four Pacific island countries—Federated States of Micronesia, Kiribati, Palau and Samoa—currently working on the development of biosphere reserves, formally established the Pacific Man and the Biosphere Network (PacMAB). The meeting marked the first formal gathering of MAB focal points in the Pacific, signaling the interest of the region in fully participating in the World Network of Biosphere Reserves alongside other regional MAB networks.

Delegates at the meeting issued a formal Statement summarizing their key decisions to:

- Establish PacMAB as the MAB Network for the Pacific sub-region;
- Invite other Pacific island countries to identify MAB Focal Points and new potential biosphere reserves;
- Invite UNESCO to seek and provide support for the consolidation and development of the network;
- Draft a two-year work plan for the network and circulate it for comments and inputs from network members within three months.

It was expected that PacMAB would expand rapidly, as additional biosphere reserves would become established in the Pacific island countries. But since 2006, only one biosphere reserve has been added, the And Atoll Biosphere Reserve in Micronesia.

While early ecological studies under the MAB program took place in the Pacific sub-region in the 1970s, it was only in 2001 with the establishment of UNESCO's Asia-Pacific Cooperation for the Sustainable Use of Renewable Natural Resources in Biosphere Reserves and Similar Managed Areas (ASPACO) project that the Pacific sub-region as a whole actively engaged with the MAB program with a view towards establishing new biosphere reserves. The regional project on ASPACO is a joint initiative of the United Nations University (UNU), the International Society for Mangrove Ecosystems (ISTE), and UNESCO-MAB. The principal focus is on mangroves and other coastal ecosystems in Oceania and the Pacific Rim countries.

South and Central Asia MAB Network (SACAM)

On 15-18 October 2002, MAB-Sri Lanka hosted the "South and Central Asian MAB Meeting of Experts on Environmental Conservation, Management and Research" in Hikkaduwa, Sri Lanka, which was attended by representatives from Bangladesh, Bhutan, India, Islamic Republic of Iran, Maldives, Nepal, Pakistan and Sri Lanka. One important outcome of the meeting was the creation of a new sub-regional MAB network entitled "South and Central Asia MAB Network (SACAM)".

The objectives of SACAM are:

- To provide an institutional mechanism for South and Central Asian countries to exchange information on the three functions of biosphere reserves;
- To compare experience in the management of biosphere reserves in South and Central Asia, particularly in relation to zoning and harmonizing a biosphere reserve's goal of conserving biodiversity with its function of supporting socio-economic development of local economies and people;
- To exchange information with regard to institutional and administrative arrangements for the management of biosphere reserves of South and Central Asia and to make appropriate recommendations for improvement;
- To identify, design and implement short-term multi-disciplinary and inter-disciplinary studies that explore and demonstrate links between conservation of biodiversity and sustainable socio-economic development of local people in and around biosphere reserves of South and Central Asia;
- To provide opportunities for staff of biosphere reserves and coordinators of MAB National Committees in South and Central Asia to improve their knowledge and skills in implementing the Seville Strategy for Biosphere Reserves;
- To promote and strengthen co-operation between the SACAM Network and other UNESCO Member States in the Asia Pacific Region in the implementation of the Seville Strategy for Biosphere Reserves; and
- To promote and facilitate information exchange and inter-regional co-operation with similar networks in other parts of Asia and in the world and international organizations, such as IUCN, as well as any other interested international organization.

In September 2004, the Islamic Republic of Iran hosted the 2nd SACAM Network meeting in Zibakenar, which focused on "Sustainable Eco-tourism in Biosphere Reserves and Similarly Managed Areas". It is unclear what activities have been undertaken by SACAM in the 5 years following its most recent meeting.

Southeast Asian Biosphere Reserve Network (SeaBRnet)

Initiated in 1998, the SeaBRnet network comprises today Cambodia, China, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Thailand and Vietnam. Moreover, Australia, Republic of Korea and some South Asian countries (India, Sri Lanka) are associated with SeaBRnet and often participate in SeaBRnet activities. The network's objective is to foster cooperation on various scientific, ecosystem and biosphere reserve management related issues, such as ecotones, mangroves, coastal areas, quality economies, and rehabilitation of degraded environments. Thanks to funding provided by the Government of Japan since 2002, the interlinked MAB Ecotone and SeaBRnet initiatives are serviced by a Secretariat provided by the UNESCO-Jakarta Office.

In 2008, SeaBRnet published the Proceedings of the Joint Regional Seminar of the Ecotone-SeaBRnet 2007 and the 9th Conference of the China Biosphere Reserves Network (CBRN) (UNESCO 2008), a broadly attended conference with many representatives from the region. The conference addressed the linkage between cultural diversity and biological diversity, and explored the fundamental roles of cultural diversity in nature conservation, as well as the potentials of such a linkage in pursuing sustainable development goals.

REVIEW METHODS

The present review is part of a broader effort by UNESCO Office Jakarta, as the Regional Science Bureau for Asia and the Pacific, to understand the contribution and potential benefits of biosphere reserves and the MAB Programme, and plan out strategies for strengthening the Programme. In doing so, we hope to be able to:

- Understand the historical context of reserve establishment and management;
- Understand the social and economic context of reserve establishment and management;
- Understand the capacity of local authorities and stakeholders in carrying out sound biosphere reserve management;
- Determine the ways in which existing and emerging regional environmental and development challenges can be addressed by the MAB Programme in a systematic, timely, and relevant method.

The main objectives and critical questions that will be answered in this review exercise are listed below.

- **Achievement of biosphere reserve functions:** Have biosphere reserves been an effective agent in carrying out the three functions of biosphere reserves? To what extent have biosphere reserves been used in developing or implementing local, national, and regional policies on sustainable development? Have biosphere reserves had significant impact or influence on Millenium Development Goals at the national level? Specifically, have biosphere reserves had signficant impact or influence on poverty alleviation?

- **Climate Change:** To what extent have biosphere reserves been the focus of Climate Change discussions? Are there specific actions, plans, programs in place or are being planned to address Climate Change mitigation and adaptation measures?
- **The effectiveness of biosphere reserves in catalysing new initiatives concerning sustainable development:** What and how much facilitation have biosphere reserves had to bring together the main actors of local good environmental governance, namely government, parliament, civil society (including the business community) to synergistically initiate new initiatives to address sustainable development and environmental management challenges.

The results of the review will be used for preparing a comprehensive final review report that brings insight to UNESCO's framework for future MAB efforts in the Asia-Pacific region; ways to improve biosphere reserve management and Man and the Biosphere (MAB) Programme; documenting best practices and lessons learned; and serve as valuable feedback for UNESCO and other stakeholders.

The usefulness of a regional analysis

This study is designed to cover many different aspects of biosphere reserves in a relatively short time. It does not intend to delve deep into any particular aspects, but rather seeks to obtain a general picture of the functioning of biosphere reserves in the Asia Pacific region. Particular patterns are sought out through quantitative analysis at the regional level, and investigated more thoroughly by studying a sub-sample of all biosphere reserves.

The quantitative analysis uses an approach based on counterfactual evidence (see below). Basically, it compares certain characteristics of biosphere reserves (such as their focus on research), and compares these with randomly selected protected areas from the same country, to see whether biosphere reserve really add value to that particular characteristic.

The patterns that emerge from such analyses are broad and give an average view of biosphere reserves. Their generality precludes that all findings concur with specific conditions in particular biosphere reserves. But the analysis can point general areas of strength of weakness in biosphere design and management that can be addressed at a broader, regional level and helps increase the effectiveness of biosphere reserves for all.

Quantitative and Qualitative Analyses

To assess the added value that biosphere reserves have over normal protected areas, it

was determined how well biosphere reserves achieve their environmental and socio-economic goals and whether they do this better or more effectively than normal protected areas. For this two different approaches were used:

1. General analysis for Asia-Pacific biosphere reserves using several general indicators.
2. Detailed score-card based analysis of protected area effectiveness for a selection of biosphere reserves and a same number of non-biosphere reserve protected areas.

Biosphere reserves, human development, and poverty

One of the functions of biosphere reserves is to promote sustainable development. It is therefore of interest to assess whether governments with the help of international aid organizations use biosphere reserves for that purpose. To assess this biosphere reserve establishment at a country level was compared with a range of variables from the Human Development Report for that country (UNDP 2009). The Human Development Report provides country-based statistics for a large range of different variables. From this range those variables were selected which would likely correlate with either the number of biosphere reserves in a country or the area of each country encompassed in a biosphere reserve. The selected variables were:

- Human development Index
- Gross Domestic Product (GDP) per capita (2005)
- Population using an improved water source (%), 2004
- Human poverty index value (%)
- Population, urban (% of total population), 2005
- Population undernourished (% of total population), 2002-04
- Public expenditure on education (% of GDP), 2002-05
- Researchers in R&D (per million people), 1990-2005
- GDP (current US$ billions), 2005
- Forest area, average annual change (%), 1990-2005
- Hydro, solar, wind and geothermal power (% of total primary energy supply), 2005
- CO_2 emissions per capita (tonnes), 2004

Variables were log-transformed where necessary and simple bivariate correlation assessments were conducted to see which of these variables showed statistically significant correlation with the number and area of biosphere reserves. These correlations were further explored by plotting variables in scatterplot graphs, to assess what the underlying patterns could be, and whether there is likely causality in the relationship or whether it arises by chance.

Score-card analysis

The effectiveness of randomly selected biosphere reserves to non-biosphere reserves was compared by developing scores for each area using a score card system. Using the above mentioned list of biosphere reserves in Asia-Pacific, this dataset was subsampled by randomly generating numbers for each Biosphere Reserve and sorting these. Then the top three biosphere reserves from this randomly sorted list were selected. For a detailed description of the score card approach, refer to Appendix 4.

A forest cover change analysis to test the effectiveness of biosphere reserves in reducing forest loss

An analysis was piloted using low-resolution imagery time series for 2000-2005 (Hansen et al. 2006; Hansen et al. 2003). A part of this global dataset was used covering the area of southern China to Cambodia and Vietnam. This forest cover change dataset was overlaid with a vegetation map for the region to look for two biosphere reserves within a generally forested matrix. The selected area was Xishuangbanna Biosphere Reserve.

Availability of geographic information on biosphere reserves

Biosphere reserves are supposed to be geographically delineated and zoned to guide their conservation and development goals. Having clear boundaries makes it easier for the stakeholders and managers to decide what particular management should be implemented where. To what extent have biosphere reserves in the Asia-Pacific region been delineated and zoned and have these boundaries been incorporated into spatial planning at the regional or national level, i.e. are biosphere reserves managed in isolation from broader (e.g. national level) management systems or are they fully incorporated in such systems? Also, are the geographic data on boundaries and zonation readily available to the public? This was investigated this by assessing the following:

- Within the UNESCO database on biosphere reserves, is there a data layer that contains the boundaries of biosphere reserves and their zones? This was checked by first assessing the information from the World Database on Protected Areas (WDPA) to see which biosphere reserves were represented by point files and which by polygons.
- If not available from the WDPA, can the information be obtained from local biosphere reserve managers? This was checked by contacting the appropriate authorities or managers for individual biosphere reserves and ask them for spatial information.
- For a small number of biosphere reserves it was assessed whether their zones where in line with spatial planning categories used at the regional of national level, and whether this provided a commonly understood basis for natural resource management.

Achievement of Biosphere Reserves functions

Have biosphere reserves been an effective agent in carrying out the three functions of biosphere reserves? To what extent have biosphere reserves been used in developing or implementing local, national, and regional policies on sustainable development? Have biosphere reserves had impact or influence on Millennium Development Goals at the national level? Specifically, have biosphere reserves had impact or influence on poverty alleviation?

Climate Change

As large-landscape level management entities, biosphere reserves are potentially able to more effectively deal with the threats from global climate change and concomitant changes in sea level, weather patterns, agricultural productivity, water availability, and vegetation zones, to name a few. The inherent flexibility in management of biosphere reserves and the involvement of different stakeholders from a range of sectors provides opportunities for developing the types of management needed to effectively mitigate and adapt to the impacts of climate change. Here an assessment is made of the extent to which biosphere reserves have been the focus of climate change discussions? Are there specific actions, plans, programmes in place or are being planned to address climate change mitigation and adaptation measures?

To gain a better understanding of which parts of the region would be most affected by climate change a dataset was used that shows the areas in South East Asia that are most vulnerable to the impacts of global climate change. This provided insight as to which biosphere reserves are likely to be most affected by climate change and therefore provide the best testing ground for climate change adaptation. The forest cover change analysis mentioned above provides additional insights into the role that biosphere reserves could play in mitigating climate change through avoiding deforestation.

RESULTS

Quantitative analysis

Information was obtained for 105 biosphere reserves in the Asia-Pacific Region that are listed on the most recent UNESCO list of Asia-Pacific biosphere reserves. During the study, additional biosphere reserves were found that are not yet recorded on the UNESCO list, among others the Great Nicobar Biosphere Reserve and Khangchendzonga Biosphere Reserve, both in India. These additional areas were not incorporated in the study.

Representation of biosphere reserves on the World Wide Web

Our analysis of Google Scholar and Google scores for each of the biosphere reserves in the Asia-Pacific region revealed some interesting patterns. Several countries stood out for the large number of hits resulting from a Google Scholar search, with especially Australia (mean = 989, SD = 2508, N = 15) and Vietnam (mean = 976, SD = 1722, N = 8) apparently receiving a lot of attention from researchers (see Figure 5). China, Japan, and South Korea had remarkably low scores considering the many high quality research organizations in these countries. This might be because Google Scholar does not pick up titles in non-English script as easily as in English.

Google Scholar searches only provide an approximation of the interest of the academic community for particular biosphere reserves. More detailed searches in the academic literature would be required to determine whether indeed researchers in certain countries focus more on biosphere reserves than in others. Still, the geographic patterns are of interest. Why do Australia and Vietnam score so much higher on average than other countries in the Asia-Pacific? One reason might be that the names of Australian and Vietnamese biosphere reserves have additional meanings. The 3 highest scoring areas on Groups Scholar were Great Sandy biosphere reserve, Red River Delta Biosphere Reserve, and Cat Ba Biosphere Reserve, and the words "great", "sandy", "red", "river", and "cat", together with "Biosphere Reserve" generate many results that are not related to the relevant biosphere reserves. The analysis was therefore repeated by omitting any of the Biosphere Reserves with names that could result in non-relevant search results (Figure 6). This revealed that indeed the Google Scholar searches were strongly biased by ambivalent words in the biosphere reserve's name. Overall there appears to be little geographic variation in the attention that biosphere reserves get from researchers, with India and Cambodia as possible exceptions.

It was next checked whether there was any difference in Google Scholar scores for biosphere reserves vs non-biosphere reserves in four randomly selected countries (Table 2). This was done without including biosphere reserves or other protected areas with ambivalent names. The four countries for which it was tested whether being a biosphere reserve would lead to increased attention from research and the academic community suggests that this wasn't the case. There were no statistically significant

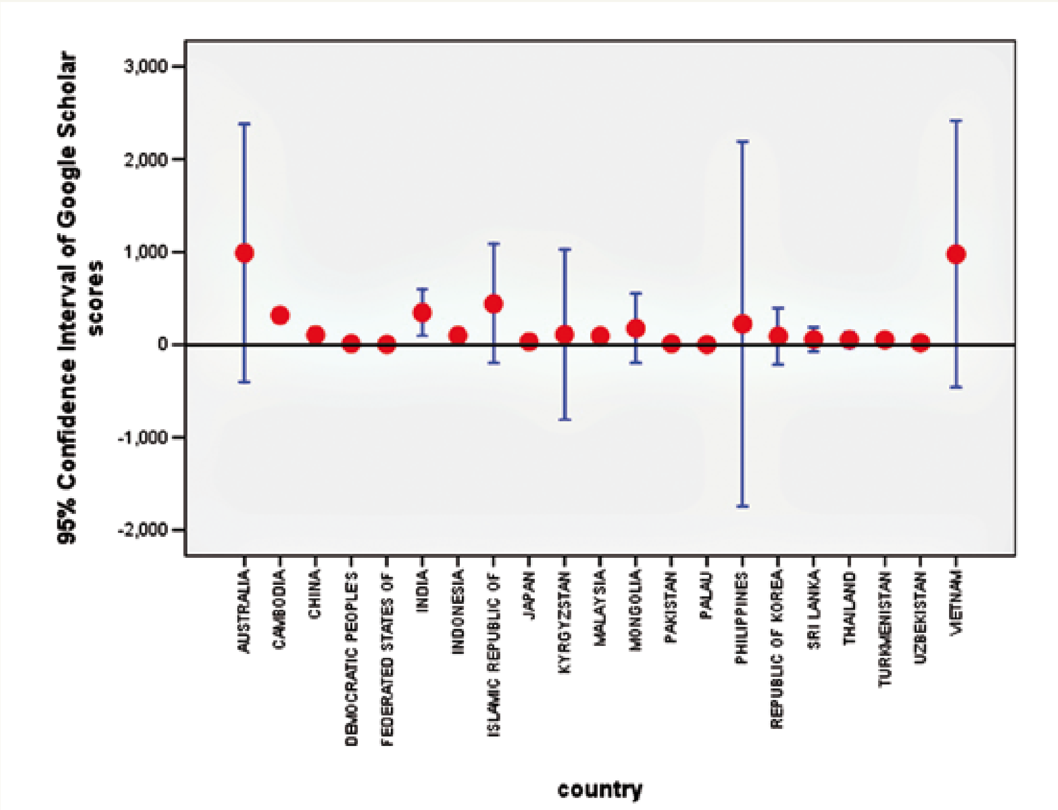

Figure 5. Means (red dots) and 95% confidence intervals of numbers of hits per country in a Google Scholar search of individual Biosphere Reserves. Australia and Vietnam stand out for the large average hits per search, while also India and the Islamic Republic of Iran score relatively high.

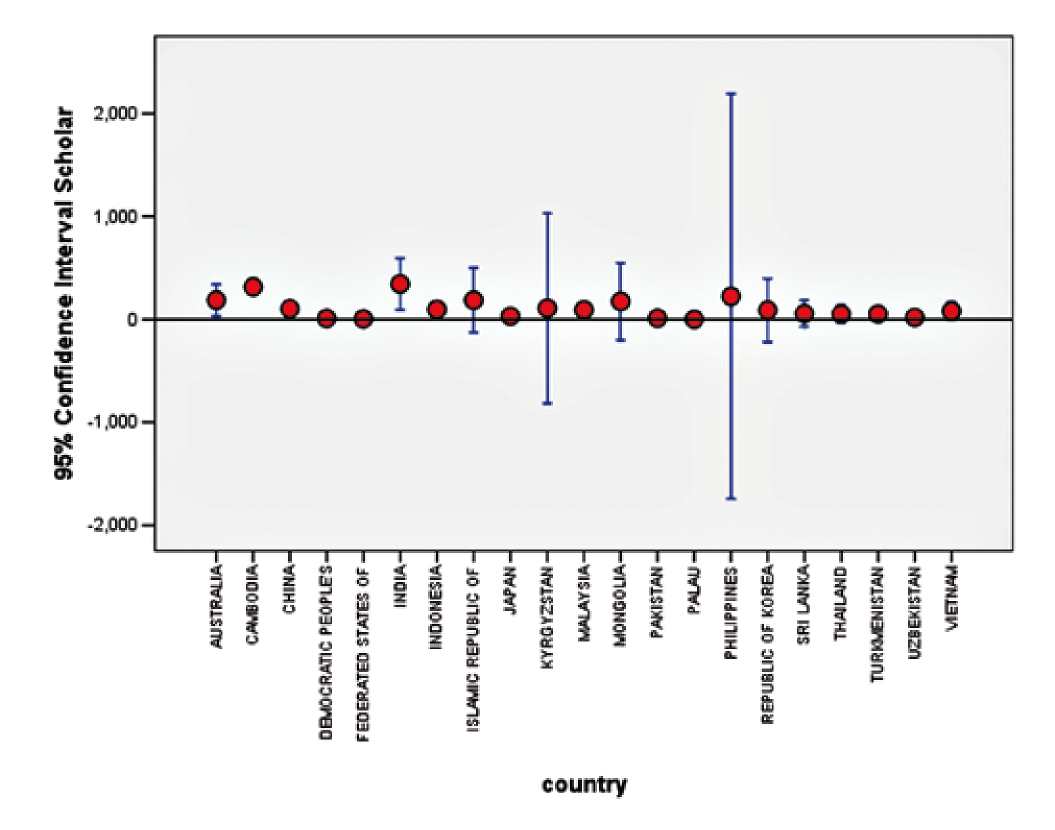

Figure 6. Google Scholar search of Biosphere Reserves in the Asia-Pacific in which names that could lead to spurious results were omitted from the search.

differences between biosphere reserves and non-biosphere reserve protected areas (although for India the difference approached significant with p = 0.06), suggesting that the research role of biosphere reserve is not approached much more different than in non-biosphere reserves. Note that this is a preliminary study and only involves 4 of the 28 countries. More detailed studies would be required to assess whether the research goals of biosphere reserves are fulfilled more frequently than in other protected areas.

Country	Average Google Scholar score for Biosphere Reserves	Average Google Scholar score for non-Biosphere Reserves protected areas
Australia	187.9 (n = 12)	424.7 (n = 13)
Vietnam	344.6 (n = 7)	281.1 (n = 7)
India	80.5 (n = 6)	1905.7 (n = 6)
South Korea	89.7 (n = 3)	90.0 (n = 4)

Table 2. Google Scholar scores for biosphere reserves and non-biosphere reserves protected areas in 4 randomly selected countries.

A check was done to ascertain whether the geographic patterns from a Google Scholar search are also reflected in a broader Google assessment, which identifies the number of any internet links related to the names of particular biosphere reserves, not just those related to research (Figure 7). The patterns are broadly similar to those in Google Scholar, with Australia, Cambodia (only Tonle Sap Biosphere Reserve), and India standing out for the large number of search hits. This suggests that these countries are actively promoting their biosphere reserves via internet websites, probably to attract visitors, but, as shown by the Google Scholar scores, they also succeed in attracting researchers who conduct their studies in these biosphere reserves, thereby addressing the learning center objective which is one of the functions of biosphere reserves. However, the authorities in these countries do not succeed to attract any more attention to biosphere reserves than they do to ordinary protected areas, or in the cases of Australia and India, biosphere reserves actually seem to get less attention.

Are the relatively high search scores for Australian, Indian, and Cambodian Biosphere Reserves specific to biosphere reserves, or do they apply to any protected areas? This was checked for Australian biosphere reserves by comparing them to a random sample of non-biosphere reserve national parks in Australia. Even though on average the non-biosphere reserves were better represented both on Google Scholar and Google searches (see Table 2), there were no significant differences in a non-parametric analysis. In Australia, it appears that having biosphere reserve status does not lead to more publicity or attention from researchers compared to other national parks. Also, for Indian biosphere reserve and non-biosphere reserve protected areas the differences in Google and Google Scholar search returns were not significant: Google (BR, mean = 24,018; SD = 22,531.2; N = 7, and non-BR, mean = 45,050; SD = 56,584.3; N = 7), and Google Scholar (BR, mean = 344.6; SD = 272.6; N = 7, and non-BR, mean = 281.1; SD = 276.8; N = 7).

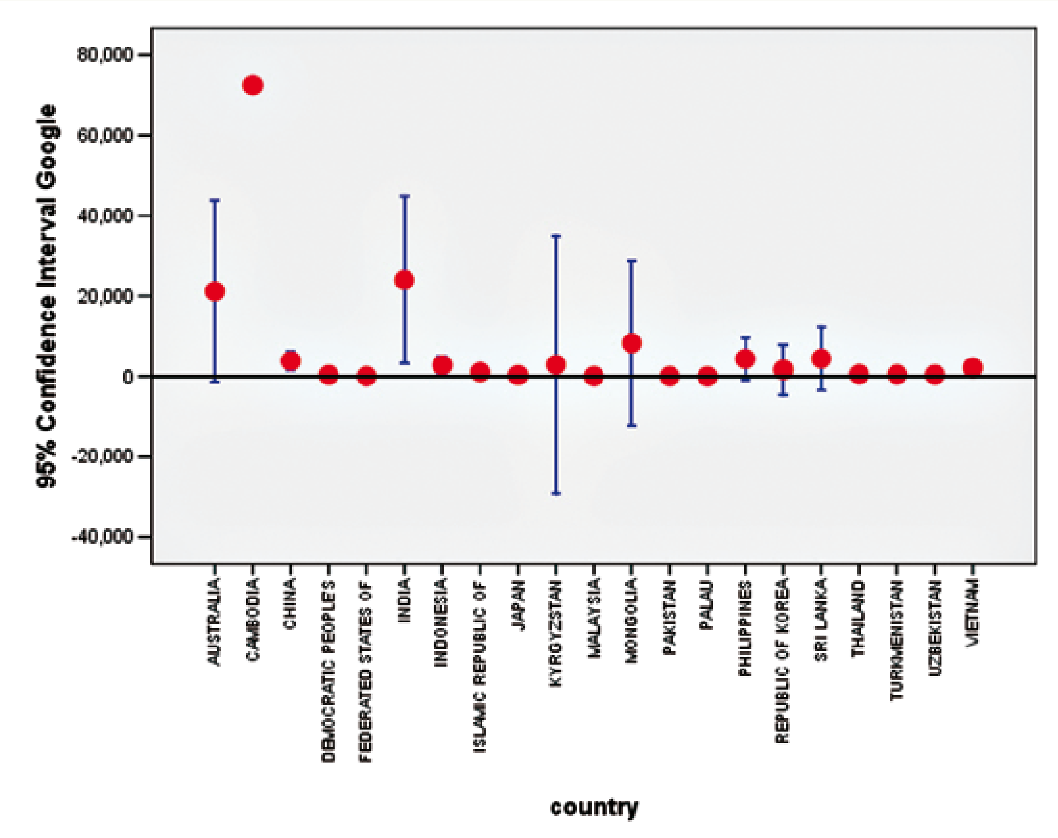

Figure 7. Means (red dots) and 95% confidence intervals of numbers of hits per country in a Google search of individual Biosphere Reserves from which biosphere reserve names with potential double meanings were omitted. Australia, India and Cambodia stand out for the large average hits per search.

Histograms of the number of hits on Google and Google Scholar searches for the names of Australian biosphere reserves and randomly selected non-biosphere reserves. Google counts: A. mean = 21197.8, SD = 35579.5, N = 12; B. mean = 19473.6, SD = 21528.7, N = 15; Google Scholar counts: C. mean = 187.9, SD = 241.3, N = 12; D. mean = 424.7, SD = 1192.8, N = 13.

The low scores for biosphere reserves are even more pronounced when compared to World Heritage Areas (which was only done for Australia). The 14 Australian World Heritage Areas had an average Google Scholar score of 6,541 and an average Google score of 85,045.

Biosphere Reserve categorization

One of the findings of our internet search of the 105 biosphere reserves in the Asia-Pacific region was that it was generally difficult to find details about individual reserves. Clearly there are examples of biosphere reserves that are well described, but overall even basic information such as which protected areas they contain is hard to come by. The UNESCO MAB central database does contain information on almost all biosphere reserves, but this information is rather general and cannot be used for deeper analysis. Still, our internet search revealed some interesting patterns that indicate how the biosphere reserve concept in the Asia-Pacific region has evolved over time.

Our analysis of all biosphere reserves in the Asia-Pacific region revealed that as of September 2009, the 105 biosphere reserves covered 49,329,428 ha of land and sea in the region of which over half (26,747,527 ha) was included in officially protected areas (see Table 3 for summary, and Appendix 2 for complete data set) (Note that no data were available for the newly established Shenon Dadohae Biosphere Reserve). To assess the progress biosphere reserve have made towards the goal of the Madrid Action Plan (UNESCO 2009), the percentage of biosphere reserves that have been zoned was assessed. Of the 105 biosphere reserves, 70 had some form of zonation, and 39 none (at least not according to the UNESCO data base). Of the 52 biosphere reserves established before 1995, 50% had been zoned and 50% had not been zoned. Of the remaining 57 areas established after 1995, 2

Table 3. Overview of size of biosphere reserves and different zones in the Asia-Pacific Region.

	N	Minimum Area (ha)	Maximum Area (ha)	Mean Area (ha)	Sum of all Areas (ha)	Standard Deviation (ha)
BR Total Area	108	950	8,429,072	456,754	49,329,428	1,072,700
BR Core Area	77	96	1,032,485	78,820	6,069,146	177,194
BR Bufferzone Area	73	220	3,501,516	194,075	14,167,465	565,921
BR Transition Zone Area	63	0	6,786,477	286,302	18,036,999	879,717
Protected Area within BRs	105	0	5,221,000	254,738	26,747,527	667,404

Country	Total BR area (ha)	Mean BR area (ha)	Number of BRs	Percentage of total country area
Australia	5,631,088	402,221	14	0.73%
Cambodia	1,481,257	1,481,257	1	8.18%
China	6,669,761	238,206	28	0.69%
India	4,198,417	599,774	7	1.28%
Indonesia	2,766,147	395,164	7	1.49%
Islamic Republic of Iran	2,753,361	305,929	9	1.69%
Japan	115,958	28,990	4	0.31%
Democratic People's Republic of Korea	259,216	86,405	3	2.15%
Republic of Korea	122,443 *	61,222 *	3	1.23% *
Kyrgyzstan	4,335,456	2,167,728	2	21.68%
Malaysia	6,952	6,952	1	0.02%
Federated States of Micronesia	2,723	1,362	2	3.88%
Mongolia	16,078,072	2,679,679	6	10.28%
Pakistan	65,791	65,791	1	0.08%
Palau	13,674	13,674	1	29.79%
Philippines	1,174,047	587,024	2	3.91%
Sri Lanka	81,664	20,416	4	1.24%
Thailand	158,800	39,700	4	0.31%
Turkmenistan	34,600	34,600	1	0.07%
Uzbekistan	57,360	57,360	1	0.13%
Vietnam	3,322,641	415,330	8	10.03%

*Table 4. List of Asia-Pacific countries that contain biosphere reserves, the total area of these reserves, their mean area, and the percentage of each country designated as biosphere reserves. * note that for the Republic of Korea no data were available for the area of the recently established Shinon Dadohea biosphere reserve.*

(4%) had not been zoned and 55 (96%) had been zoned. This is in line with the global average of 98% (UNESCO 2009).

The biosphere reserves have been established in 28 countries in the Asia-Pacific region (Table 4). As a percentage of the total country area (Wikipedia 2009), however, a different set of countries are at the top of the list, including Kyrgyzstan which has 21.68% of its country included as biosphere reserve, Mongolia with 10.28%, and Palau which has given nearly one third of its country area biosphere reserve status (Table 4).

There are some interesting patterns regarding the size of biosphere reserve and the year when they were established. Over the years there has been a slight increase in mean area of the biosphere reserves at the time of their establishment (Figure 8), with the 48 biosphere reserves that were established up until 1990 having a mean size of 252,451 ha, and the 60 areas that were established between 1990 and the present having mean size of 620,197 ha; statistically the difference is not significant however.

What is a much clearer trend is the percentage of biosphere reserves that is also an officially protected area. Since the 1970s this percentage has steadily dropped, from an average 139.6% (i.e., protected area is on average 1.4 times as large as the biosphere reserve it contains) between 1975 and 1990, to an average of 49.9% (i.e., protected area is on average about half the size of the total biosphere reserve) (Figure 9). This statistically significant change seems to indicate a strategy trend in which biosphere reserves are increasingly seen as large, sustainably managed landscapes, where protection (in legally protected areas) is only part of the objectives, while sustainable use of especially buffer zones is becoming more important (Figure 10).

To reiterate what these changes in zonation and allocation to protection mean, the original definition is revisited (after Phillips 1998):

- A core area is devoted to long-term protection
- A buffer or support zone is where activities are permitted providing they are compatible with conservation objectives
- A transition zone is where sustainable resource activities are promoted and developed

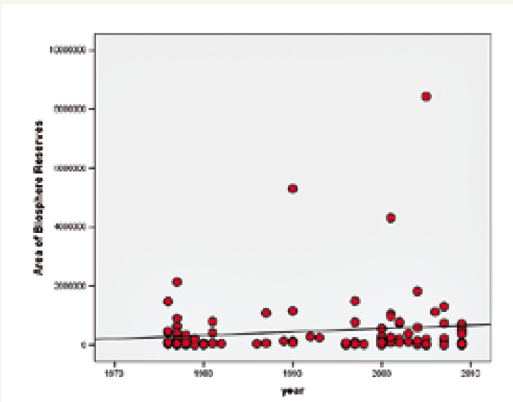

Figure 8. Graph of the year of establishment of Biosphere Reserve in the Asia-Pacific and their total area. A slight increase in average size is indicated by the linear fit through the data points.

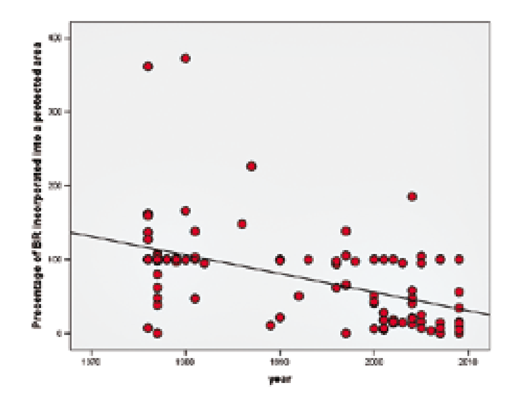

Figure 9. Graph of the change over time of the percentage of biosphere reserves are incorporated into a protected area (Shiga Highland was excluded as an outlier).

Protected areas are defined by the IUCN as areas of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and or natural and associated cultural resources, and managed through legal or other effective means. The changes illustrated in Figure 9 and Figure 10 therefore indicate an overall shift in biosphere reserve management in the Asia-Pacific towards use of the reserves' resources in a manner compatible for conservation objectives. The increasing importance of the transition zone in biosphere reserves is in line with key direction number 6 in the Seville Strategy, that aimed to extend the transition area to embrace large areas suitable for approaches, such as ecosystem management.

Most of the biosphere reserves in the Asia-Pacific region have been established in terrestrial biomes (forests, deserts, mountains etc.) (Figure 11). Since 2001, several new biosphere reserves have been established in freshwater wetland areas, while marine and coastal ("terrestrial-marine" in Figure 11) biotopes being less commonly represented.

The addition of new biosphere reserves to the existing portfolio in the Asia-Pacific regions seems to come in relatively short surges of reserve establishment, with initial establishment of areas in 1976 and 1977, then a period of

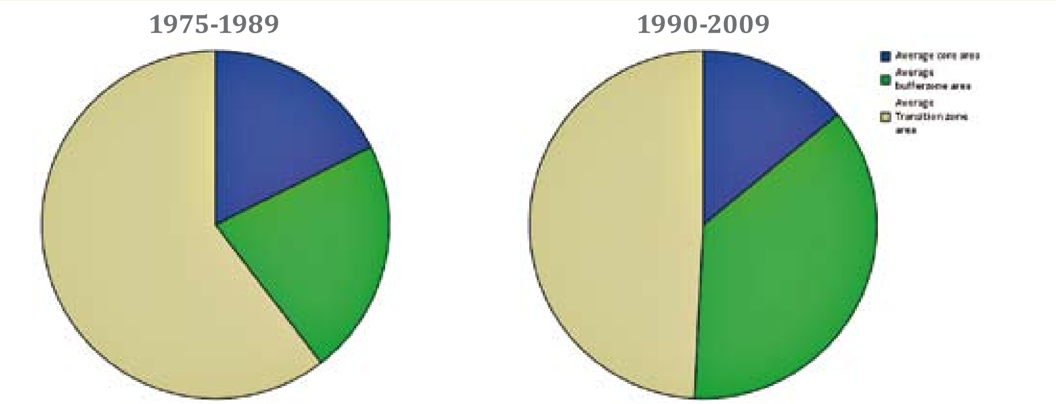

Figure 10. Pie charts of the average percentage that core, buffer, and transition zones take up in biosphere reserves in the periods 1975 – 1989 and 1990 to 2009.

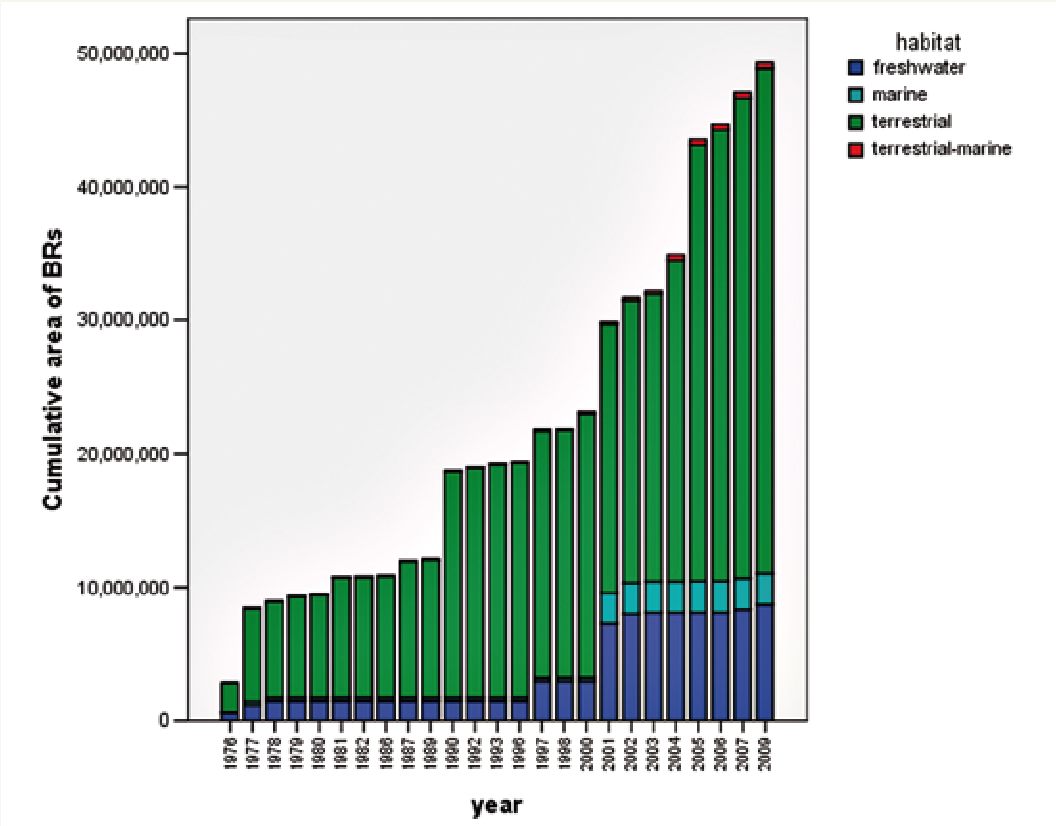

Figure 11. Cumulative change of total area of biosphere reserves between 1976 and 2009, and how new areas were allocated to 4 different biomes.

relative stasis. After this, alternate periods followed characterized by rapid expansion in 1990, 2001, and 2005, and intermediate periods of relatively slow expansion in total biosphere reserve area (1992-2000 and 2002-2004, see Figure 11). Overall the area expansion seem to be speeding up with the cumulative area more resembling an exponential rather than linear curve, with 91.6% of the variation explained in an exponential model with e = 0.75 (Figure 12).

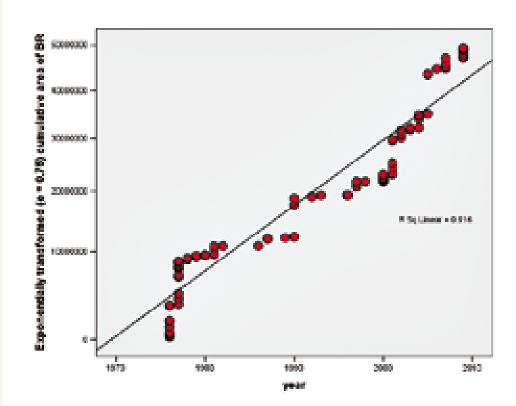

Figure 12. Exponential fit for growth in cumulative area of biosphere reserves in Asia-Pacific

Social and economic context of biosphere reserves establishment

To better understand the social and economic context of reserve establishment and management, an analysis was conducted comparing biosphere reserve country characteristics (number of BRs per country, percentage of country area included in BR) to a range of socio-economic variables as reported in the Human Development Report.

Most bi-variate comparisons did not show clear correlation, but some combinations indicated statistically significant trends. Whether there are causal relationships underlying these trends is not always clear, or even if such relationships exist one can speculate on different interpretations of these relationships. For example, there is a statistically significant correlation between the Gross Domestic Product (GDP) per capita of countries that have biosphere reserves and the number of biosphere reserves in each of these countries (Figure 13, pearson's R = 0.509, p = 0.031, n = 18). This could be interpreted as more developed countries having more funds to spend on conservation than poorer countries, and having therefore been more likely to develop biosphere reserves. And there are likely to be other explanations. Still, finding these trends provides some useful information. For example, because one of the goals of biosphere reserves is poverty alleviation, one would hope that the slope of the line in Figure 13 would level off over time, with biosphere reserves in poorer countries helping to reduce poverty, and increasing GPDs per capita. This could also be used as a specific indicator for successful biosphere reserve management: If GDP per capita of people living within a biosphere reserve rises more rapidly than that of the entire country (or of the more comparable rural part of the population), the reserve would clearly be achieving its poverty alleviation and economic development goals.

Another interesting correlation is that between the annual rate of forest decline per country and the number of biosphere reserves in that country (Figure 14), which is statistically significant (pearson's R =0.493, p = 0.037 (n = 18), r^2 = 0.243). Again, the causal relationship can only be guessed at. Do countries with forest gain, such as China or Vietnam, see biosphere reserves (and other protected areas) as a tool to regenerate forests, and are they therefore being actively established. Or have the many biosphere reserves in these countries led to better protection and regeneration of forests? And, vice versa, are governments in countries with high forest loss, such as the Philippines and Indonesia, less concerned about forest protection and therefore also less inclined to develop biosphere reserves (and other protected areas). Again, this relationship requires further study to see whether biosphere reserves have actively contributed to increased forest gain or reduced forest loss.

A final relationship of interest is that between the number of endangered species of plant and animals (recorded as Vulnerable, Endangered, or Critically Endangered on the IUCN Red List of Endangered Species, 2008) and the percentage of a country included in biosphere reserves (Figure 15). This relationship is interesting because it shows a negative correlation with a positive one might have been expected. One would think that the more endangered species there are, the more a country would invest in protected areas, including biosphere reserves, but it turns out to be the other way around.

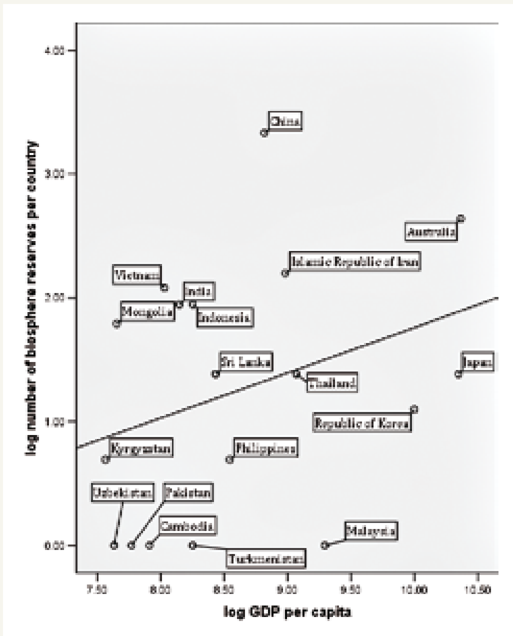

Figure 13. A comparison of the log GDP per capita versus log number of biosphere reserves shows a positive trend with richer countries having more biosphere reserves.

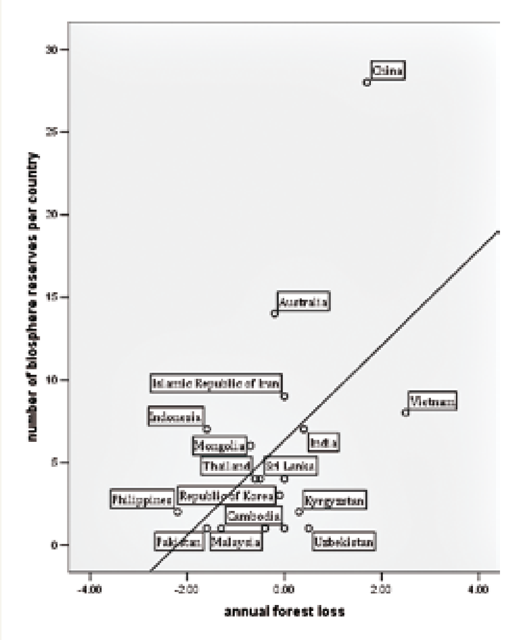

Figure 14. Annual forest loss versus number of biosphere reserves per country

Countries such as Australia, China, Sri Lanka, and Indonesia with many endangered species have included a relatively small part of their country in biosphere reserves (0.73%; 0.69%; 1.24%; and 1.49%, respectively), whereas countries with few endangered species such as Kyrgyzstan and Mongolia have included large parts of their country in biosphere reserves (21.68% and 10.28%, respectively). This could indicate that countries do not primarily seek to use biosphere reserves for species conservation, but use other protected area categories and management structures. It could also mean that countries that have a relatively small area incorporated in biosphere reserves have many competing land uses, such as agriculture, and these competing land use are an important agent in the decline of rare species.

Availability of geographical information on biosphere reserves

At present, UNESCO does not have a GIS dataset containing all the boundaries and zones of all the region's biosphere reserves. The spatial data used in publications appears to be same as the spatial data in the World Database on Protected Areas (WDPA). Of the 105 biosphere reserves in the Asia-Pacific region, 38 (=35%) were represented by a polygon boundary in the WDPA, 57 (=52%) were represented by point files (i.e. the location of the approximate center point of the reserve, but not the boundary), and 14 had no spatial data associated with them. Still, it is also clear that the WDPA is an incomplete dataset. For example, a map exists of all the Australian biosphere reserves and their boundaries (Figure 16) even though the WDPA provides point locations only for 12 of the 15 Australian biosphere reserves. Better data sharing and compilation is needed to ensure that UNESCO and other international data managers have access to the relevant geographic data and accompanying metadata, so that complete GIS coverage of all biosphere reserves can be obtained.

A first example of this is from the Yakushima Biosphere Reserve in Japan where it appeared to be unclear how the zone boundaries presently coincided with the boundaries of the local national park, wilderness area, and forest ecosystem reserve. These different areas had been added over the years, and there were no recent maps available of the most recent zonation. The second reply, from Croajingolong Biosphere Reserve in Australia, suggested a similar situation, in which the biosphere reserve boundaries were not entirely clear (they may or may not include some recently established marine parks according to one informant), and no recent map of the reserve was available. Both replies suggest that the biosphere reserve is considered a concept rather than a specific land use allocation for a specific area. This concept can change over time, indeed providing the flexibility in management envisaged for biosphere reserves, but it also makes it hard to geographically nail down where the actual biosphere reserve is located. There is a need to find a solution to this conundrum: how do you design zonation in an area where adaptive management and flexibility are key concepts?

The zonation issue also brings up the question as to how governments should align biosphere reserve zonation with their spatial planning. For example, in the Indonesian context there is no land use allocation for a buffer zone,

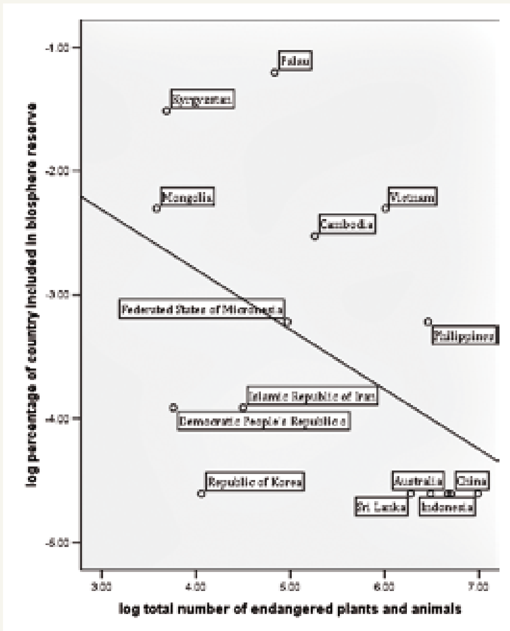

Figure 15. Correlation between the log number of endangered plant and animal species in a country, and the percentage of that country included in biosphere reserves.

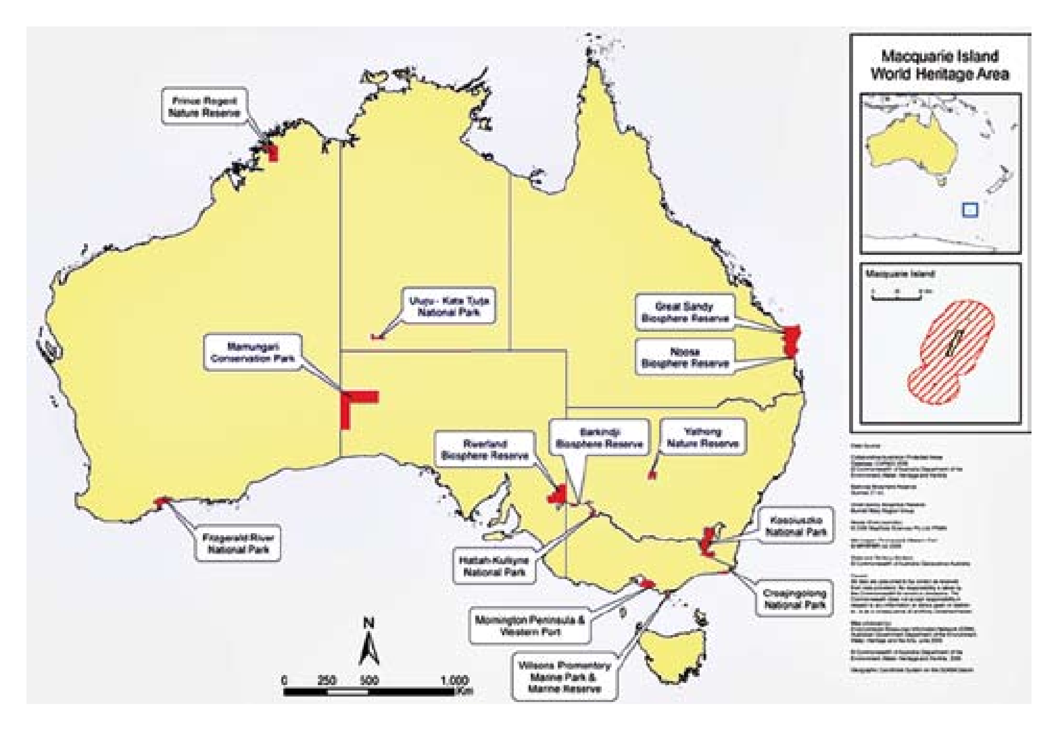

Figure 16. Location of Biosphere Reserves in Australia (www.environment.gov.au/parks/biosphere/map.html).

which is usually used for co-operative activities compatible with sound ecological practices, including environmental education, recreation, ecotourism, and applied and basic research. That poses the government with a challenge. If they designate all of the biosphere reserve as protected area, then certain economic activities such as plantation development, which could normally be considered in a transition zone, would not be legally allowed. If, however, only the core (and buffer) zone(s) would be gazetted as a protected area, then the transition zone would either have to be allocated to permanent production forest or conversion forest, or agricultural land, and often such land uses have little legal consideration of sustainability. If such mismatches between national land use categories and biosphere zone functions are common, it may be one of the reasons why governments find it hard to define where exactly the zone boundaries are and which type of management would be legally required.

Rapid Techniques for Assessing Biosphere Reserve Management Effectiveness

Score card analysis

Because of time limitations we selected a small sample of three biosphere reserves to test whether the score card provided a valuable tool for assessing the management effectiveness of particular biosphere reserves: Yathong Biosphere Reserve in Australia, Baotianman Biosphere Reserve in China, and Bundala Biosphere Reserve in Sri Lanka (for details see Appendix 3. Detailed methodology).

The overall score suggests that Yathong Biosphere Reserve scored highest on most criteria (Table 5), but in the more detailed results below is it clarified that these scores are influenced by the online availability, or lack of it, of key information, such as management plans and monitoring reports. The many missing values, especially for Baotianman but also for Bundala Biosphere Reserves lowered their overall scores. Still, the available information did provide useful information about major conservation goals, the actions put into place to address this, the trends in threats and conservation targets, involvement of non-governmental stakeholders, and the financial budgets for the reserves. As a rapid assessment it therefore has value to assess generally strengths and weaknesses of biosphere reserves and the gap in knowledge or data that are needed to make more accurate management effectiveness assessments.

Yathong Biosphere Reserve

The 1-hour review of the Yathong Biosphere Reserve provided a significant amount of

Count of Score	PA			
Process Element	Baotianman	Bundala	Yathong	Maximum possible score
A. Context	7	11	11	12
B. Planning	5	7	10	10
C. Inputs	5	7	7	7
D. Process	8	10	10	11
E. Outputs	12	13	16	16
F. Outcomes	7	7	11	11
Grand Total	44	55	65	67

Table 5. Results of a rapid score-card analysis for three randomly selected biosphere reserves. Minimum score for each process element is 0.

information, including various management plans (reserve management, fire management etc.), documents on stakeholder input, and a range of scientific papers regarding key indicators of biosphere reserve targets. This is a relatively information-rich reserve for which the rapid assessment provides some useful guidance as to the strengths, weaknesses and particular achievements of the reserve. Still, the rapid assessment provides only a glimpse of total reserve achievements.

Baotianman Biosphere Reserve

The 1-hour review of the Baotianman Biosphere Reserve revealed some of the limitation of the rapid score-card analysis. A management plan was not found online, making it difficult to answer many questions, beyond making educated guesses. Indirect sources indicated that the management plan exists though, and several other documents provided supporting information within a short time frame (Xianghui et al. 2006; Yunlan et al. 2002). Still, in this case the score-card analysis does not provide acceptable outcomes. A better use of the score-card approach would have been to do a more detailed analysis together with the reserve authorities. The reserve management could fill in the score card, and their input could be reviewed by an independent panel to come to a jointly agreed score for that particular reserve.

Bundala Biosphere Reserve

The rapid review of Bundala Biosphere Reserve revealed a surprisingly large amount on conservation and development targets, threats, management approaches, monitoring and evaluation, organizational issues, and funding. The reserve clearly has some problems with several threats, such as invasive species, unsustainable use of resources by surrounding villagers, and changes in hydrology and water pollution, but at the moment the resources are insufficient to address these issues effectively.

Biosphere reserve land cover change rapid assessment methodology

Land cover change analysis in and around biosphere reserves is potentially a good proxy for assessing effectiveness of biosphere reserve management. Land cover change, such as forest to non-forest, within a biosphere reserve core zone would indicate ineffective or poor management while land cover change in close proximity to the boundaries of a biosphere reserve core zone should raise concerns of encroachment or secondary impacts.

Remotely sensed data offers the most cost and time effective method to rapidly assess large and often inaccessible areas. In addition, many medium to low resolution satellite image data and global datasets are now freely available on the Internet thus making this technology more readily accessible to a wide range of users.

Case Study: Xishuangbanna Biosphere Reserve, southeast China

In order to establish a basic land cover change methodology using readily available spatial data, the Xishuangbanna Bioshere Reserve was randomly selected as a test site. This reserve is located in southeast China bordering Laos and Myanmar, in a transition zone between the tropics and subtropics. Xishuangbanna is a biologically diverse region that covers only 0.2% of the land area of China yet contains 25% of all plant species in the entire country (Guan 1998). Over the last decades, forest cover has decreased dramatically from 63% to 34% (Yan & Chen 1992). Currently, forests remain primarily in nature reserves and state forests, whereas previously forested lands have been largely converted into rubber plantations.

Land cover change analysis

In order to assess land cover change in Xishuangbanna Biosphere Reserve a number of datasets were selected to test the hypothesis that readily available spatial datasets could provide a rapid assessment of land cover change in biosphere reserves at a regional scale.

1. WDPA (World Database on Protected Areas)

This online database provides downloadable boundaries of protected areas; some as point and some as polygon data compatible with commonly used GIS software. This site can be found at www.wdpa.org. The latest version is WPDA 2009. This dataset, however, is of variable accuracy when assessed at the site-level. For example the polygons for Xishuangbanna contained one extra polygon. In addition, the data from WPDA does not contain any information on protected area zoning, e.g. core zones etc. In the absence of better data the WDPA data was used in this analysis.

2. Map of functional divisions of the Xishuangbanna Biosphere Reserve

An electronic map of the accurate biosphere reserve boundaries and functional zones was provided by reserve management. This was a useful map which provided much needed information on boundaries and zones (Figure 17). Unfortunately the GIS shapefiles were not readily available.

3. Rapid land use change in and around protected areas (RALUCIAPA)

This dataset is based on a global dataset called the MODIS Vegetation Continuation Fields (VCF) tree cover product (Hansen et al. 2001, 2006). Produced by UNEP-WCMC Senior Fellow, Mark Mulligan, from Kings College London, the RALUCIAPA is a land use change alert system for

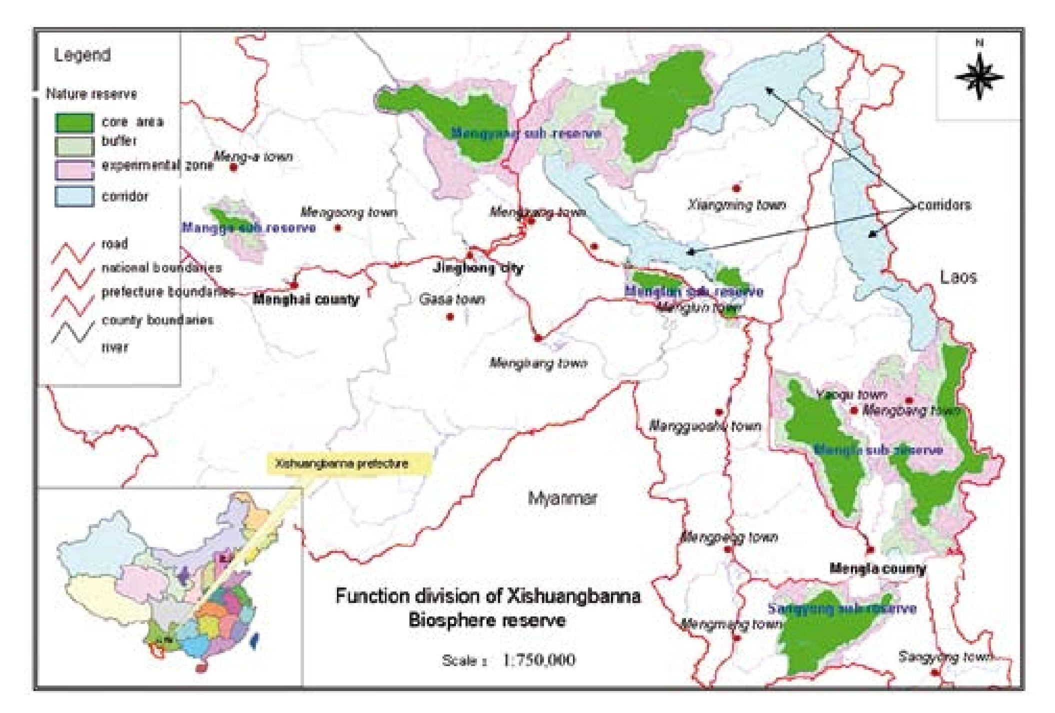

Figure 17. Official map of the Xishuangbanna Biosphere Reserve, its core, buffer and transition ("experimental") zones, and connecting corridors. Map by Chen Mingyong.

the world's protected areas based on the VCF tree cover product produced by Hansen et al. RALUCIAPA can be viewed at www.unep-wcmc.org/protected_areas/raluciapa/.

The VCF data for 2000 to 2005 are mosaiced and processed to calculate the following globally:

- Global change in tree cover percentage from 2000-2005, and
- Change in tree cover percentage from 2000-2005 in and around areas defined as protected according to the 2007 World Database of Protected Areas (WDPA)

RALUCIAPA is designed to allow rapid regional and local visualization of areas of forest cover loss and gain over recent years. RALUCIAPA provides an easy mechanism for hot-spotting land use change in and around protected areas and it envisaged as a functional hot-spotting tool for those who do not have ready access to remotely sensed data. It is important to note that the data are at 500m resolution and so do not pick up small scale change in forest cover. These data can be viewed directly through Google Earth, although they cannot be downloaded.

The remotely sensed data used in RALUCIAPA[1] are the MODIS Vegetation Continuous Fields tree cover product (Collection 4, release 3). The Vegetation Continuous Fields collection contains proportional estimates for vegetative cover types: woody vegetation, herbaceous vegetation, and bare ground. The product is derived from all seven bands of the MODerate-resolution Imaging Spectroradiometer (MODIS) sensor onboard NASA's Terra satellite. The continuous classification scheme of the VCF product may depict areas of heterogeneous land cover better than traditional discrete classification schemes. While traditional classification schemes indicate where land cover types are concentrated, this VCF product is great for showing how much of a land cover such as "forest" or "grassland" exists anywhere on a land surface.

4. Landsat TM remotely sensed imagery

Landsat 5 TM imagery was used as a visual accuracy check of the VCF tree cover product in and around the Xishuangbanna Biosphere Reserve. Landsat TM is considered high resolution imagery at 30 m pixel size in comparison to the MODIS imagery (source of the VCF tree cover product) at 500m pixel size. The Landsat TM imagery was downloaded free of charge from the United States Geological Survey (USGS) Earth Resources Observation and Science (EROS) Data Center using the Global Visualization Viewer (GLOVIS) http://glovis.usgs.gov/. Using GLOVIS Landsat 5 TM imagery was browsed for good quality imagery close to 2005 (final year in the VCF tree cover change series). The most suitable image was dated 26 March 2007; this image was selected from the USGS website and took approximately 38 minutes to download. The image was downloaded as individual bands (7 in total) which were processed using PC ERDAS Imagine to produce one multi-band image.

ESRI PC ArcGIS and ArcView software was used for viewing and analysis, and PC ERDAS Imagine was used to process the Landsat TM image.

The VCF tree cover change percent 2000 -2005 data is a raster or grid cell data set with each pixel containing a percentage value for tree cover change between 2000 and 2005. These data were grouped into 8 classes and color coded; negative values indicating tree cover loss

[1] Dr Mark Mulligan kindly sent a subset of the RALUCIAPA dataset (mosaiced VCF data 2000-2005) for two areas in Asia/SE Asia.

varying from 0 to -75% and color coded in red shades, and positive values indicating tree cover gain varying from 0 to + 68% and color coded in green shades. A value of zero indicates no change and color-coded pale yellow.

Results

Visual interpretation of the tree cover change percent 2000-2005 map shows that rapid vegetation cover change (shades of red) has occurred within the boundaries of the BR, in particular Mengyang, Menglun and Mengla sub-reserves (Figure 18).

Comparison with the higher resolution Landsat TM imagery confirms that there is good correspondence between areas of tree cover loss as shown on the VCF tree cover product data and areas of no vegetation on the Landsat TM imagery. Figure 19 and Figure 20 highlight the areas of vegetation cover loss on the VCF tree cover change data and the corresponding area on the Landsat TM image for the Mengyang sub-reserve.

Comparison of vegetation loss directly with the functional zoning map shows that within Mengyang, Mengluh and Mengla sub-reserves areas of highest vegetation loss correspond reasonably well with the buffer and experimental zones. Similarly areas of no change (pale yellow) are found within the core zones of Sangyong, and to a certain extent in Mengla. However, it should be noted that within the core zone areas of Mengyang, Mengluh and Mengla there is evidence of vegetation loss, to verify this would require more detailed boundary data. Assessment of the corridor zones shows that these areas tend to show disturbance with vegetation loss and gain. Vegetation gain is most likely to be a result of agricultural or plantation activities, and does not necessarily indicate growth of natural vegetation.

The results of this brief analysis indicate that the tree cover change percent data has high potential as a tool for rapid assessment of the condition of biosphere reserve at a regional scale. The correspondence between areas of tree cover loss and non-forest on the high resolution Landsat TM image was high. The method employed in this study is simple and cost effective and would be easily understood by non-GIS specialists using desktop GIS software. As a tool for carrying out 2005 baseline country or regional assessments the tree cover change dataset offers good potential. The addition of accurate BR zone maps would further increase the accuracy of the assessment and allow for identification of areas of management concerns.

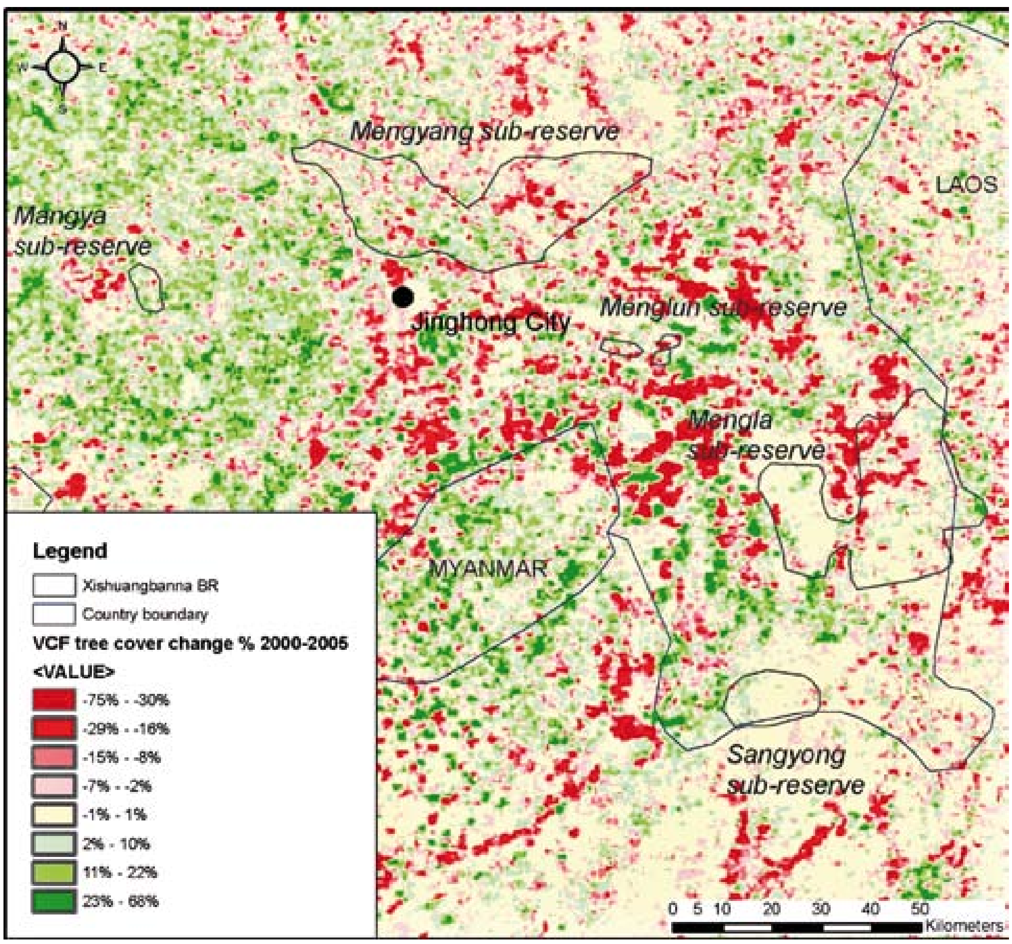

Figure 18. VCF tree cover change % 2000-2005 in and around Xishuangbanna Biosphere Reserve. Map by Rona Dennis.

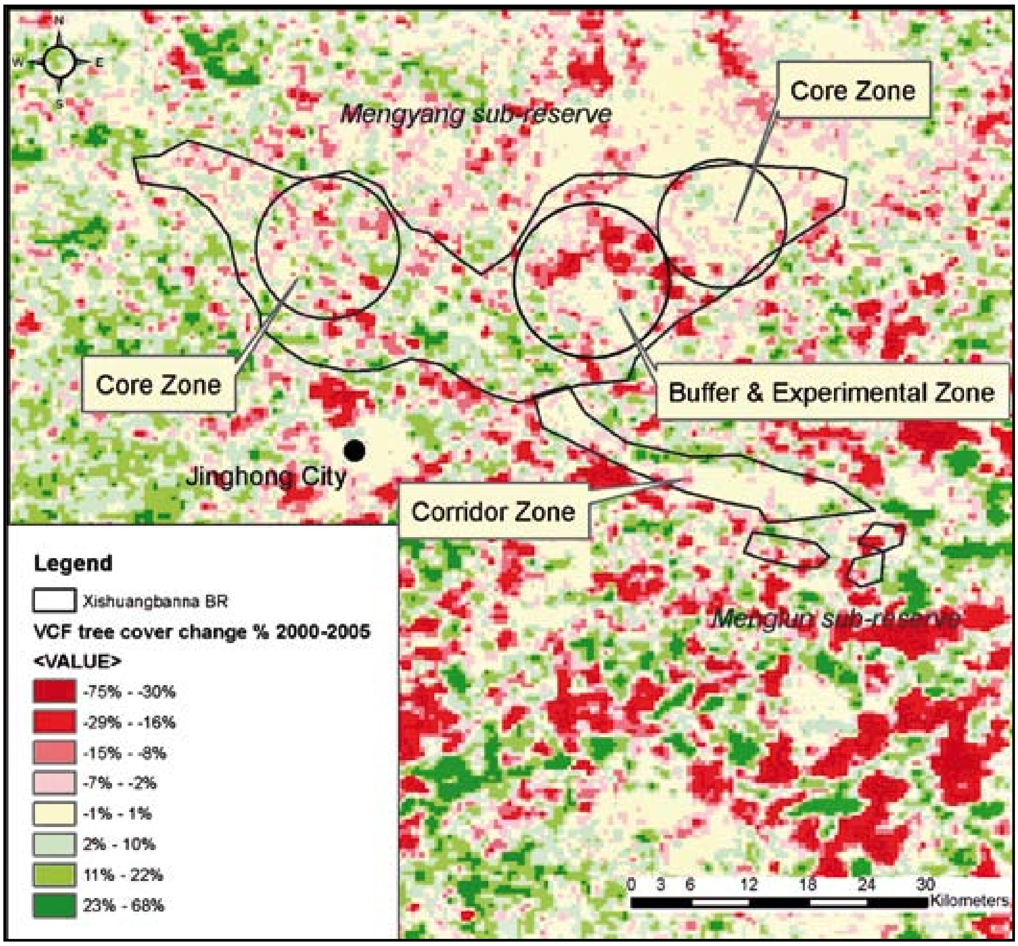

Figure 19. Tree cover change % 2000-2005 for Mengyang sub-reserve. Map by Rona Dennis.

The VCF tree cover change dataset does have a number of limitations. The data are most accurate in areas with tree cover which means that there would be little application in BRs in grassland areas or with very sparse tree cover, although this should be tested. In addition, at the present time the latest tree cover change product is for the 2000 – 2005 period, which would mean that recent change (2005 – 2009) is not captured.

Qualitative analysis

The role of biosphere reserves in climate change adaptation

In combining human and natural environments, biosphere reserves have considerable potential to play a role in climate change adaptation as well as mitigation. Through a literature search it was assessed whether specific climate change adaptation measures have been implemented in any biosphere reserves in the Asia-Pacific region. Examples of biosphere reserves were identified that are promoted as effective systems in climate change adaptation. For such areas to play a role in climate change adaptation, they need to: 1. contain environments that are expected to be significantly affected by global climate change; 2. effectively address goals of sustainable development and poverty alleviation while maintaining the ecological integrity of the biosphere reserve; and 3. be planned in a way that allows ecological shifts that occur because of climate change to be absorbed by the biosphere reserve system.

On a regional basis, the environmental impacts of climate change have been modeled by Fischlin et al. (2007) (Figure 21). This study indicates that the Asia-Pacific ecosystems that will be most affected by climate change are primarily located in South, Central, and East Asia and in Australia. Forest ecosystems in South-East Asia appear in two different climate change models to be relatively unaffected. A different study by the Economy and Environment Programme for the

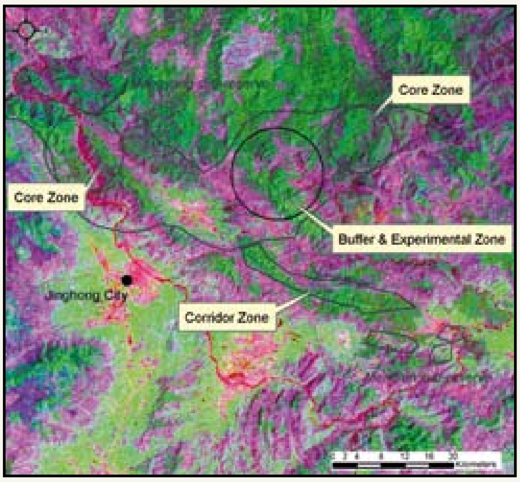

Figure 20. Landsat TM 26 March 2007 for Mengyang sub-reserve. Dark green – forest; light green – crops; purple – no/little vegetation cover; pink – bare soil. Map by Rona Dennis.

South-East Asian part of the region highlighted several areas where climate change would have the most severe impacts. The resulting map (not shown) indicated that the combination of climate-related hazards (tropical cyclones, floods, landslides, droughts, and sea level rise) would be concentrated in several hotspots (Table 6).

The South-East Asia study also combined a number of factors, including the adaptive capacity of particular areas, as well as their vulnerability to climate change to produce overall vulnerability maps for the South-East Asian region. It is clear that in the region coastal wetlands including salt marshes and mangroves are projected to be negatively affected by sea-level rise especially where they are constrained on their landward side, or starved of sediment.

Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. Those densely-populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk. The numbers affected will be largest in the mega-deltas of Asia, like the Mekong and Chao Phraya, while small islands are especially vulnerable.

A comparison was made of the climate change vulnerability maps for South-East Asia with the biosphere reserve maps to see the extent to which these biosphere reserves overlap with the most vulnerable areas (Figure 23). Overlaying the climate change map with the location of South-East Asian biosphere reserves, as we have done in Figure 23 indicates that certain

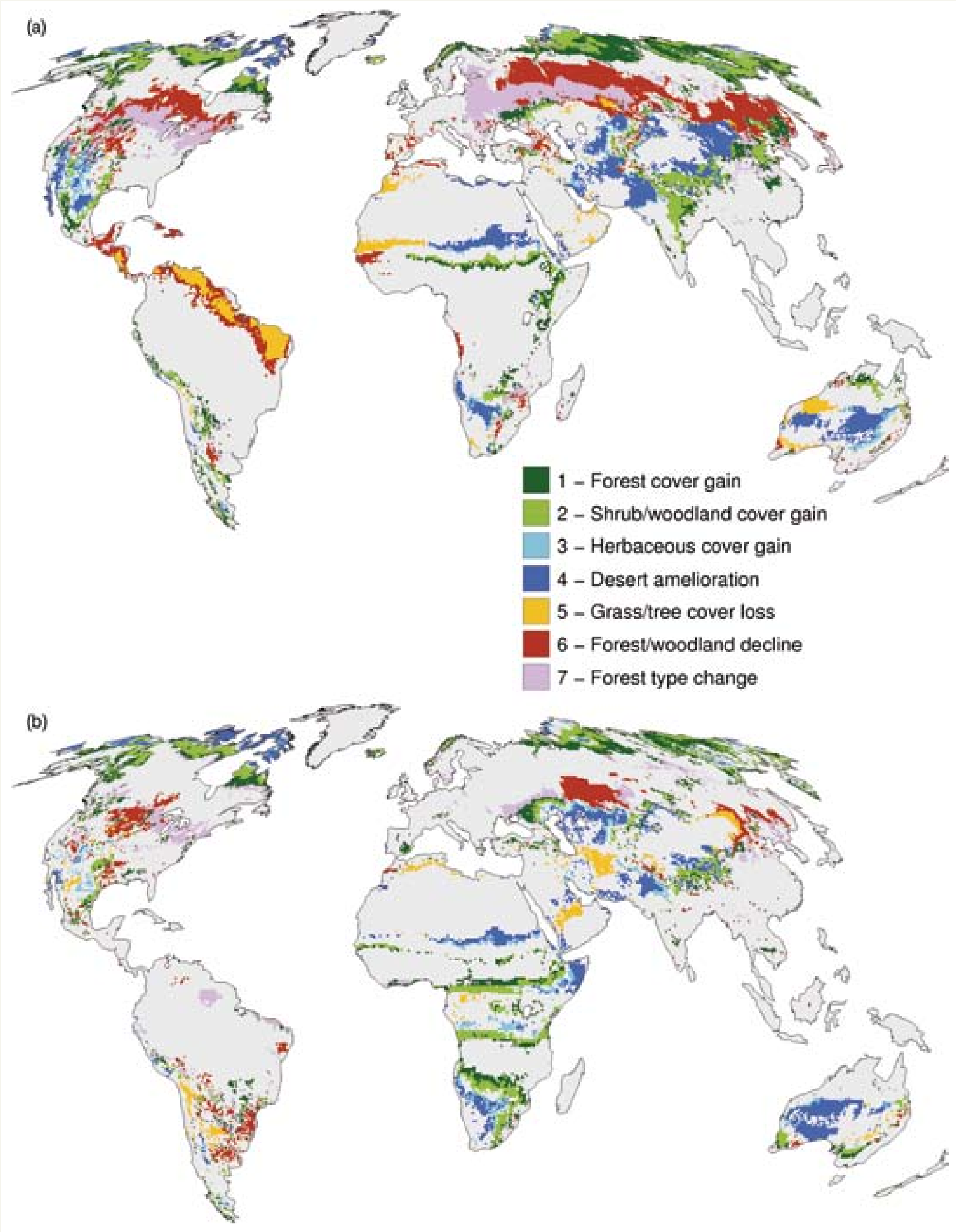

Figure 21. Projected appreciable changes in terrestrial ecosystems by 2100 relative to 2000 as simulated by two SRES emissions scenarios forcing two climate models: (a) HadCM3 A2, (b) ECHAM5 B1. Changes are considered appreciable and are only shown if they exceed 20% of the area of a simulated grid cell (Fischlin et al. 2007).

Climate hazard hotspots	Dominant hazards
Northwestern Vietnam	Droughts
Eastern coastal areas of Vietnam	Cyclones, droughts
Mekong region of Vietnam	Sea level rise
Bangkok and its surrounding area in Thailand	Sea level rise, floods
Southern regions of Thailand	Droughts, floods
The Philippines	Cyclones, landslides, floods, droughts
Sabah state in Malaysia	Droughts
Western and eastern area of Java Island, Indonesia	Droughts, floods, landslides, sea level rise

Table 6. Climate hazard hotspots and dominant hazards

biosphere reserves are particularly well located to address the most severe impacts of climate change, or at least test the suitability of these areas to cope with these threats. Biosphere reserves in coastal northern Vietnam, the Mekong Delta, Palawan Island and elsewhere in the Philippines, and west Java are in the areas which will likely be most affected by climate change, and these could become focal points for developing model approaches in climate change adaptation and mitigation. Further studies in the region, outside South-East Asia are needed to identify other biosphere reserves that will be particularly affected by climate change.

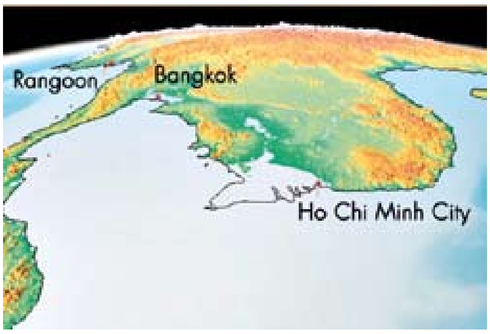

Figure 22. The potential impact of a 5-metre sea level rise in Southeast Asia. Note the black lines show the current coast lines. The reconstruction shows that with a 5-meter sea-level rise, the coastlines would recede drastically, and cities such as Bangkok, Ho Chi Minh City, and Rangoon would disappear from the land map (Bounford.com & UNEP/GRID-Arendal 2009).

The impact of climate change on the people of Asia

About 2.5 to 10% decrease in crop yield is projected for parts of Asia in 2020s and 5 to 30% decrease in 2050s compared with 1990 levels without CO2 effects.

Freshwater availability in Central, South, East and South-East Asia, particularly in large river basins such as Changjiang, is likely to decrease due to climate change, along with population growth and rising standard of living that could adversely affect more than a billion people in Asia by the 2050s.

It is estimated that 120 million to 1.2 billion will experience increased water stress by the 2020s, and by the 2050s the number will range from 185 to 981 million people. Accelerated glacier melt is likely to cause increase in the number and severity of glacial melt-related floods, slope destabilisation and a decrease in river flows as glaciers recede.

An additional 49 million, 132 million and 266 million people of Asia, projected, could be at risk of hunger by 2020, 2050 and 2080, respectively (Cruz et al. 2007)

A specific search for Asia-Pacific biosphere reserves and climate change resulted in several relevant results for the region. An area that has had considerable attention in relation to climate change is the Nanda Devi Biosphere Reserve in India, where the impact of global warming on the areas glaciers, alpine vegetation, and hydrology has attracted a lot of attention from researchers. Maikhuri et al. (2009) report that degradation of the soil and soil moisture is one of the major challenges for agriculture in high altitude regions. Recently the decline in soil moisture due to early snow melting, glaciers recession and more exposed to heat stress has an adverse impact on the performance of agricultural crops in the high altitudes. The researchers also notice a change in plant diseases and pests, as well as grazing regimes and the use of forest, grassland, alpine meadows and scrub lands. The authors do not directly point out the value of a biosphere reserve system in mitigating these impacts, but the solutions they propose all require fine-tuned integration of human and environmental factors. It remains unclear though whether climate change adaptation and mitigation has been officially incorporated into the management of Nanda Devi Biosphere Reserve.

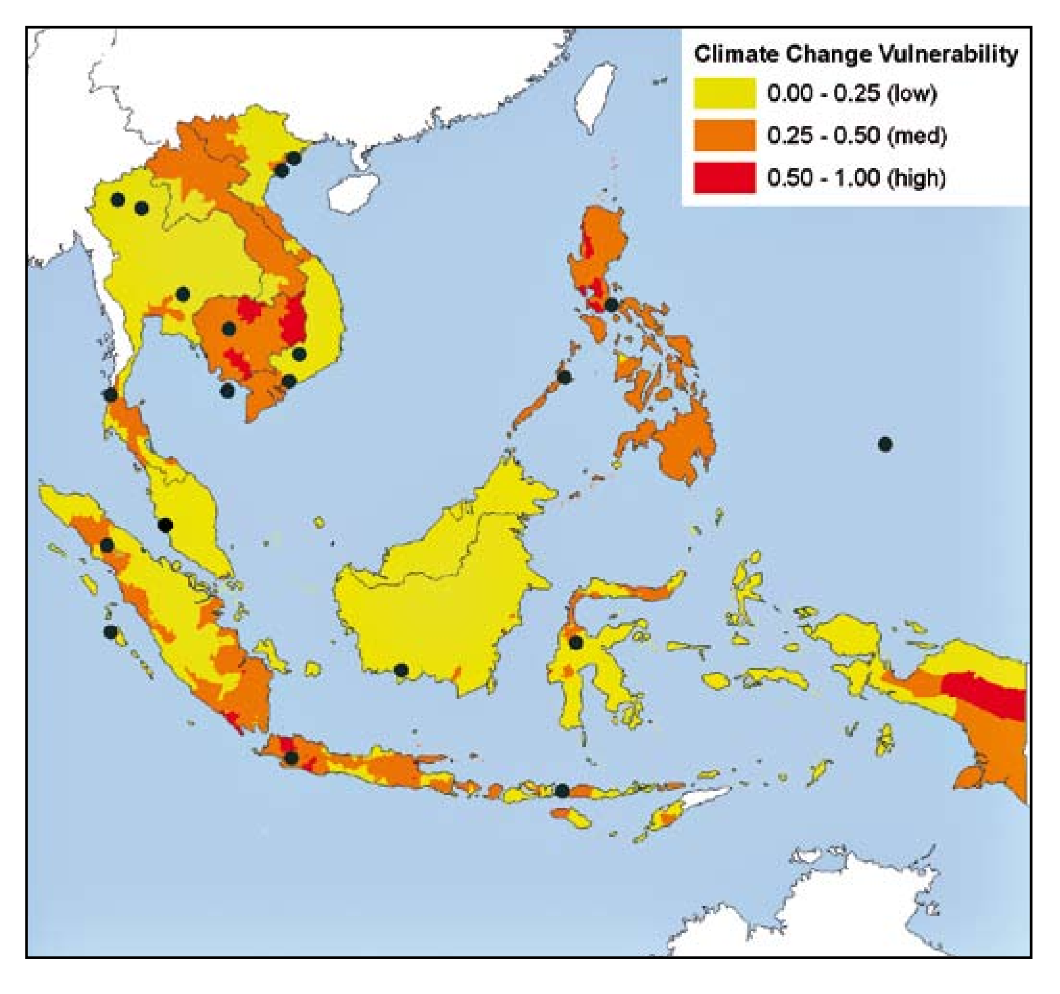

Figure 23. Climate change vulnerability map of South-East Asia in relation to the location of biosphere reserves. Map by Rona Dennis. Data courtesy of Economy and Environment Programme for the South-East Asia.

Another biosphere reserve that has been considered in the context of climate change is Palawan Island. Palawan's governor gave an opening speech in June 2009 titled "The Role of Palawan Biosphere Reserve in Climate Change" (Reyes 2009) in a conference dedicated to the management of Palawan as a biosphere reserve in the face of threats from global climate change. The governor recognized the vulnerability of Palawan to climate change, but considered Palawan well positioned to face these challenges using the principles of biosphere reserve management. He stated that "the important and distinct characteristic of the Palawan Biosphere Reserve among other declared biosphere reserves in the world is that, its goals and strategies for actions are deeply embedded into the Strategic Environmental Plan for Palawan Act or the SEP." Such integration of biosphere reserve planning into broader environmental planning is indeed rare in the region. There is recognition though that Palawan still faces many problems, even without the challenges posed by climate change: deforestation, hunting, small-scale mining, and other activities all threaten the ecological stability of the island. In reference to the Madrid Action Plan, the governor suggests to actively implement management in Palawan in line with biosphere thinking. With additional political attention required to anticipate the impacts of climate change, he calls for the following specific actions, among others:

- Set up a provincial body that will initiate discussions, organize research and plan adaptation and mitigation measures relative to climate change;
- Formulate a provincial Environmentally Critical Areas Network map that shall be endorsed by the Provincial Board. It should shore up a cohesive land use planning for the sustainable development of Palawan.
- Protect and maintain our forest cover of 46% and establish forests for municipalities where these are nonexistent.
- Target to establish at least 25% of each of our coral reef, seagrass beds, estuarine and beach areas as strictly protected "no-take" replenishment zone OR core zone to ensure long term sustainable supply of fisheries.
- Mangrove forests, Palawan's first line of defense against the effect of climate change, should be strictly protected with the more decisive implementation of Presidential Proclamation 2152 especially by the local government units.
- Researches and monitoring of climate and hydrology, of sea level rise and the composition of flora and fauna in important ecosystem should be more given emphasis and information should be used in proactive

planning. A research on alternative use of energy in the province should also be given importance.

- Review the status of the implementation of the Provincial Solid Wastes Management Plan.
- Formulate a sustainable agricultural program for the province of Palawan that emphasises on organic farming
- Create and implement a program for the education of communities vulnerable to the effects of climate change at the soonest time possible.

This is an ambitious agenda, very much in line with the principles of biosphere reserve management. The Philippines were hit by two major cyclones since the conference on climate change in Palawan, possibly creating a greater sense of urgency of the problems and the need to find solutions quickly.

A third specific example of how biosphere reserves can be used comes from the Australian Capital Territory (ACT), which is considered for proposal as a biosphere reserve in its entirety. The proposal specifically addresses climate change as a threat to the integrity of Canberra and the ACT: “Individual biosphere reserves can function in future as nodes experimenting in living with and, as far as possible, ameliorating climate change, “ and “the biosphere reserve program itself now needs to adapt its classical model to take climate change more into account. The protected core of a classical biosphere reserve, such as a national park, has been used in the past as the benchmark against which any impact of sustainable development in the outer transition zone could previously be measured. The core itself can no longer be taken to be a constant in times of rapid climate change. Even so, changes in protected core areas as a result of climate change should provide valuable intrinsic data. There will be opportunities for innovation to ameliorate the effects of climate change, using the buffer and transition zones of the classical biosphere reserve.“ (www.natsoc.org.au/ html/projects/br.htm#climate).

Climate change mitigation in biosphere reserves through environmental services and carbon trade

In addition to developing working models for climate change adaptation through the flexible zonation and management models in biosphere reserves, these reserves could also play a direct role in the mitigation of climate change. Because mitigation involves reductions in the concentrations of greenhouse gases, either by reducing their sources or by increasing their sinks, there are different ways for biosphere reserves to function in climate change mitigation. To reduce carbon sources in biosphere reserves, a policy of energy efficiency and carbon conservation could be considered. This could include better building design, energy-efficient heating/cooling and transport, the use of renewable energy from wind, solar heat or hydropower, the elimination of waste methane, and the reduction of use of fossil fuels. Reforestation and reduced deforestation could both reduce carbon sources, and boost the capacity of the landscape to function as carbon sinks. With many biosphere reserves in the Asia-Pacific region located in forest areas with high carbon storage value (Figure 24), an effective biosphere reserve network could make important contributions to reducing carbon emissions. This is especially important for biosphere reserves in tropical and subtropical forest areas, such as those found in Indonesia, Malaysia, Thailand, Vietnam, Cambodia, and also southern China (Figure 25).

Within the tropical region, peat lands may be some of the most important stores of carbon. A recent study indicated that the combined contribution of deforestation, forest degradation and peat land emissions to total anthropogenic CO_2 emissions is about 15% (van der Werf et al.

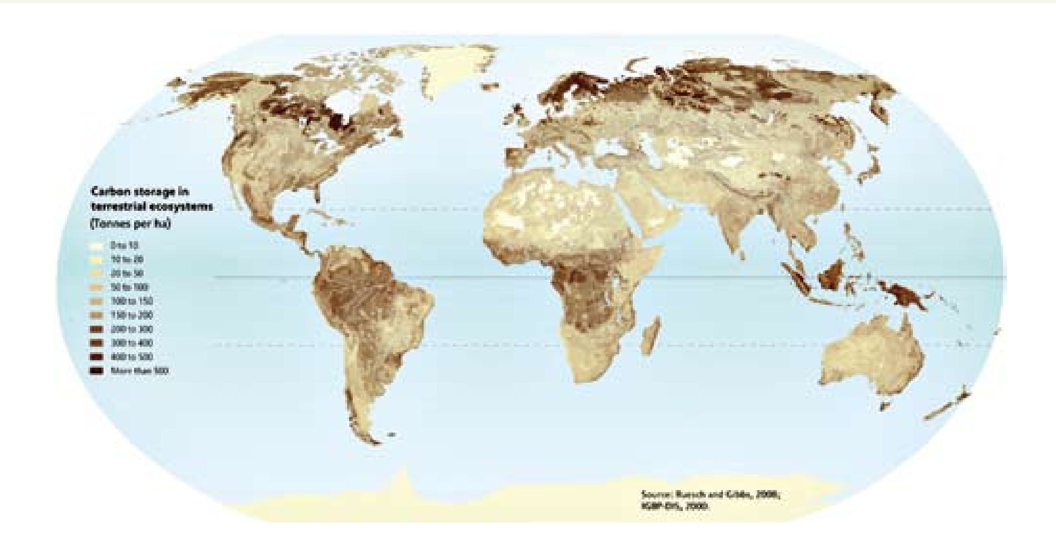

Figure 24. Carbon storage in terrestrial ecosystems. Terrestrial ecosystems store about 2100 Gt C in living organisms, litter and soil organic matter, which is almost three times that currently present in the atmosphere. Tropical South East Asia is a very carbon-dense part of Asia-Pacific region. (Pravettoni 2009a)

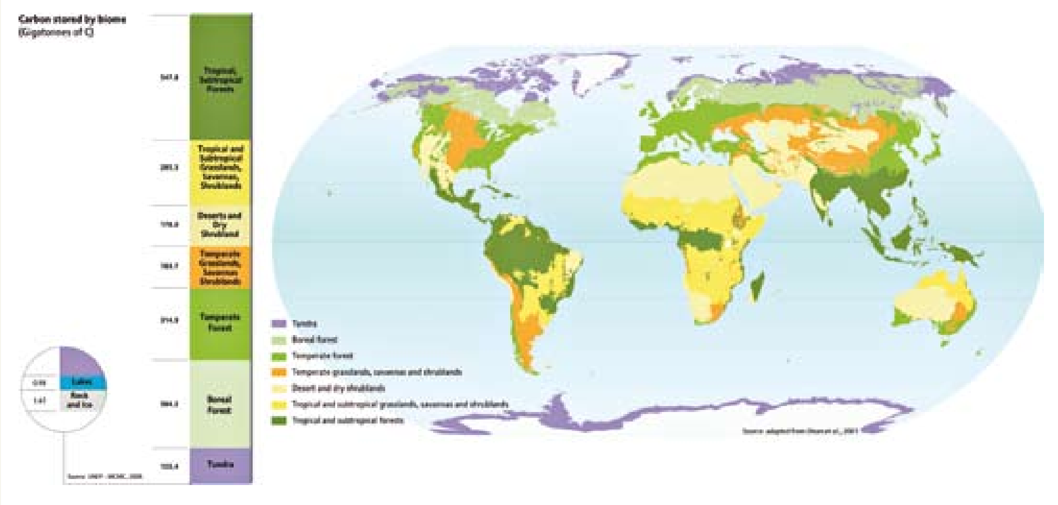

Figure 25. Carbon stored by biome. Dividing the world into seven biomes, it was estimated that tropical and subtropical forests store the largest amount of carbon, almost 550 Gt (Pravettoni 2009b).

2009). Improving the management of tropical forests and especially those on peat lands is therefore a key strategy to reduce carbon emissions and the impact these have on global warming. With regard to biosphere reserves, there is a real need to capitalize on private sector interest and involvement in biosphere reserve management, as part of environmental services and increased employment. The new Giam-Siak Kecil Biosphere Reserve (see Appendix 2) is an example of how climate change mitigation concepts can be built into biosphere reserve design. Whether or not it will succeed very much depends on the extent to which peat degradation can be prevented in this reserve.

Poverty alleviation in biosphere reserves and the role of microfinance

Poverty alleviation through sustainable development is one of the goals of biosphere reserves, but there are very few studies that specifically address the extent to which poverty goals are reached, and none of these in the Asia-Pacific region. To demonstrate positive impact of certain management strategies on poverty is difficult which may be one explanation why few scientifically robust studies have measured the impact on poverty alleviation in biosphere reserves. This does not mean that the issue has not been studied in the region. In several Asia-Pacific biosphere reserves more general socio-economic studies have been conducted. These include the Tonle Sap Biosphere Reserve in Cambodia (Bonheur 2001), where apparently the establishment of a biosphere reserve has led to improving economic opportunities and providing concrete benefits for the local communities. Two other areas of significant socio-economic study are Nanda Devi Biosphere Reserve in India and Wolong Biosphere Reserve, in southwestern China (see relevant case studies below). Attitudinal surveys undertaken in Wolong indicate that the principal social development benefit of the reserve is that of increased social stability and cultural identity (Lü et al. 2003). Whether or not the development in Tonle Sap and Wolong has longer term benefits for reducing poverty was unclear.

To address this lack of knowledge of the link between biosphere reserve functioning and sustainable development UNESCO has recommended the launch of pilot projects. In several biosphere reserves in the region, ecotourism programs have been set up and some success has been claimed for increasing community income. One example is Tonle Sap Biosphere Reserve where a small Global Environment Facilities and United Nation Development (GENUND) grant has provided a foundation for an eco-tourism project that has had some documented positive impact on the income of a few families. It is unclear to what extent such projects can be replicated and scaled up and make significant contributions to reducing poverty while maintaining environmental values.

More substantial impacts on poverty alleviation might be expected from experiments such as those in the Sierra Gorda Biosphere Reserve, in Mexico, which has been named the world's leading laboratory for the two emerging trends in the social capital marketplace: Social and Environmental Return on Investment Analysis and the markets for Environmental Services, which build on carbon credit markets. Once the monetization of environmental services on local and global markets takes off, significant benefits could flow to communities living in areas which protect and maintain these services. These markets, however, are in their early stages of development and it is unclear what real benefits they can bring in the long term.

Microfinance, i.e., the provision of financial services to low-income clients, who traditionally lack access to banking and related services, is another potential approach to significantly increase income of poor people in biosphere reserves. In a number of biosphere reserves microfinance-based approaches have been initiated. One example outside the region is the financing of community enterprise of forest services in the Maya Biosphere Reserve in Guatemala, which supports the sustainable management of the communitarian forest concessions in the multiple use and buffer zones of the biosphere reserve. Another example is the microfinance program in the Bosawa Biosphere Reserve in Nicaragua. No clear examples of microfinance project in biosphere reserves in the Asia-Pacific region were encountered during this review.

After three decades of microfinance activities, some important lessons have been learned. Recent studies have caused microfinance practitioners to reconsider a key aspect of the microcredit paradigm: that poor people get out of poverty by borrowing, building microenterprises and increasing their income. The new paradigm places more attention on the efforts of poor people to reduce their many vulnerabilities by keeping more of what they earn and building up their assets. While they need loans, they may find it as useful to borrow for consumption. A safe, flexible place to save money and withdraw it when needed is also essential for managing household and family risk. These new ideas were encapsulated in new microfinance principles n 2004 by the Consultative Group to Assist the Poor (CGAP):

- Poor people need not only loans, but also savings, insurance and money transfer services.
- Microfinance must be useful to poor households: helping them raise income, build up assets and/or cushion themselves against external shocks.
- Microfinance can pay for itself. Subsidies from donors and government are scarce and uncertain, and so to reach large numbers of poor people, microfinance must pay for itself.
- Microfinance means building permanent local institutions.
- Microfinance also means integrating the financial needs of poor people into a country's mainstream financial system.
- The job of government is to enable financial services, not to provide them.
- Donor funds should complement private capital, not compete with it.
- The key bottleneck is the shortage of strong institutions and managers. Donors should focus on capacity building.
- Interest rate ceilings hurt poor people by preventing microfinance institutions from

covering their costs, which chokes off the supply of credit.

- Microfinance institutions should measure and disclose their performance – both financially and socially.

To what extent has microfinance contributed to poverty alleviation? Some proponents of microfinance have asserted that microfinance has a strong potential to alleviate poverty, particularly for the poorest of the poor. The data are inconclusive but the general conclusion is that micro-finance through access of financial resources to the poor is a strong tool but is insufficient to alleviate poverty on its own. Micro-finance must be part of a long-term and comprehensive economic development framework to provide financial access and services, particularly financial planning, to the poor. Biosphere reserve communities may be able to gain financial access and services through micro-finance and other rural financial services, and in doing so, establish a community-based financial network that can ultimately strengthen their livelihoods. However, these financial services and networks need an overarching sustainable development framework under which they can address both poverty alleviation and environmental management.

In conclusion, the impact that sustainable development in biosphere reserves has had on poverty alleviation remains largely undocumented. It is therefore near to impossible at the moment to judge which management approaches are most suitable to reducing poverty and under which circumstances. To gain a better understanding, UNESCO should seriously consider developing a program of concrete measures and monitoring programs that uses socio-economic indicators to establish whether the biosphere management has made a positive contribution to people's livelihoods.

CASE STUDIES

Below are several reviews and case studies of Asian Pacific biosphere reserves. This information is far from comprehensive, but aims to provide a broader picture of the implementation and management of biosphere reserves in the region. The case studies contribute further to the quantitative and qualitative analyses above, and will help in the development of recommendations for improving the effectiveness of biosphere reserves in the region.

A review of Australian Biosphere Reserves

In a study in 2007, Buckley (2007) described the history of Australian biosphere reserves, using a review of Australian Biosphere Reserves by Matysek et al. (2006), as well as a detailed study of the Fitzgerald Biosphere Reserve (for locations see Figure 16 on page 38). She stated that during the period 1977 to 1982, Australia established 12 biosphere reserves in all States except Queensland. Since this time, three newly designated reserves were added while one reserve, the South-West National Park in Tasmania was delisted. Some three decades since the initial flurry of biosphere establishment, progress slowed for the Australian Biosphere Reserve Programme. Buckley suggests that the model from the outset had been characterized by problems in perception and application. Some specific explanations for this slowing down included: 1. national and international prioritizing of World Heritage areas over the MAB program; 2. resource competition at both Commonwealth and State environmental tiers; and 3. devolution of responsibility at the local level without adequate resourcing.

Buckley states that early in the life of the program, there had been little public understanding or appreciation about the concepts and the opportunities offered by biospheres. More recent developments indicate renewed interest, which Cochrane and Muldoon (cited in Matysek et al 2006) outline in terms of complimentary activities such as greater private sector involvement and philanthropic partnerships in some reserves leveraging off the concept and opportunities offered by the biosphere model. While these initiatives have merit, Matysek et al (2006) concluded in their review of the Australian program that there has been *'a multi-jurisdictional failure to foster local participation and stewardship, and regional and national leadership and management'* of the Australian biosphere reserve network.

Following the second review of the program in the early 1990s, actions identified to fulfill the requirements of the MAB Programme and advance the biosphere concept, led to the selection of two sites to be resourced by Commonwealth and State authorities as benchmark biosphere reserves (Matysek et al 2006). These reserves, the Riverland Biosphere Reserve (then Bookmark) in South Australia and the Fitzgerald River Biosphere Reserve in Western Australia, were considered to be the most important examples of an integrated protective framework, interpreted locally and evolving in application.

Despite, these negative reviews, there is a strong constituency in Australia for further development of the biosphere reserve network. The 2008-2009 annual report of the Mornington Peninsula and Western Port Biosphere Reserve mentions that even though the biosphere reserve concept remains poorly understood, there is increasing support and a new wave on enthusiasm for the concept in Australia. The report states that "here is now interest in the formation of an "Association of Australian Biospheres" in an effort to help coordinate biosphere activities, education, awareness, marketing and promotion of biospheres both in Australia and internationally, and to act as a lobby group to increase Biosphere awareness and support from all levels of government." (Note that in the Australian context the "Reserve" prefix is often dropped and the areas are often referred to as "Biospheres", in an apparent attempt to take the emphasis away from the 'conservation/reservation' aspects of biosphere reserves.

It remains to be seen how much this recent promotion of biosphere reserves in Australia will improve their national recognition and optimize their potential to address a range of environmental and socio-economic issues. An ambitious proposal in 2008 to declare all of the Australian Capital Territory, with an area of 2,358 km^2, a biosphere reserve has not had much political attention. This proposal by the Nature and Society Forum anticipates that a number of benefits will flow to the ACT from nomination as a biosphere reserve, ranging from a higher international profile, and an increased involvement of Australia in the UN Decade for Education for Sustainable Development, for which UNESCO is the lead agency. Also, the forum anticipates that making the ACT a biosphere reserve could give more focus in the ACT to the development of intermediate technology and smaller scale production, both of which should have relatively low environmental impacts. There could be greater scope for sustainable horticultural production of food in the ACT and surrounding region, despite current shortfalls in arrangements for providing water.

Cat Ba Biosphere Reserve, Vietnam as an example of Vietnam's commitment to biosphere reserves

In their review of the biosphere reserve concept Ishwaran and colleagues (2008) paid particular attention to the progress that has been in Vietnam regarding the development of biosphere reserves. The very active Vietnam National Committee of the MAB program has developed a vision that emphasized the notion of biosphere reserves as learning laboratories for sustainable development. The core features of Vietnam's vision for biosphere reserves are (after Ishwaran et al. 2008):

1. The focus is on the whole biosphere reserve, i.e., the core, buffer and transition areas.
2. Conservation and development must be seen as interdependent and applicable to the functioning of all three zones; integration of these elements needs to be considered in all zones.
3. Piloting climate change mitigation through programs for clean energy and zero-emission of greenhouse gases in buffer and transition areas of biosphere reserves is an important target of Vietnam's government for developing working models that can be applied elsewhere in the country.
4. Education, research and long-term monitoring continue in biosphere reserves remains a focus; together they constitute the link that promotes an iterative and learning interaction between policy and practice.

Cat Ba Archipelago Biosphere Reserve is one of the most important testing grounds for Vietnam's vision on conservation and sustainable

development. To effectively test this model of biosphere reserves as learning laboratories, the MAB National Committee of Vietnam is turning to the Chair and the Vice-Chair of the People's Committees of the Provinces where its biosphere reserves are located as well as working with the School of Integrative Systems at the University of Queensland, Australia. The Vietnam MAB National Committee feels that effective coordination of all biosphere reserves functions in all three zones is only feasible through the active involvement of governance, management and administrative professionals in charge of the overall province where the biosphere reserve is located.

Vietnam seems to provide a very good testing ground for biosphere reserves because a lot of the pre-conditions appear to be in place. For a start, In the early 1990s, decollectivisation of agriculture, allocation of forestry land to households, and the development of market networks transformed land use in the mountains of Vietnam, leading to an increase in forest area (Meyfroidt & Lambin 2008a, 2008b). Involvement of local communities in the decisions about land use has also played an important role in realizing net forest increase. For example, local communities around the degraded forests of the proposed Phong Dien Nature Reserve in Central Vietnam identified the need for, at least, limited extractive activities in the protected area. They also stressed their willingness to participate in the monitoring and control of the area, and in the selection of local species for reforestation programs (Boissiere et al. 2009). If such programs are well developed and accepted in Vietnam, the integrated development approach of biosphere reserves is likely to work well in this country.

Tonle Sap Biosphere Reserve, Cambodia

The Tonle Sap Lake in Cambodia is country's only biosphere reserve, and the most productive wetland in Asia, providing a resource base for the country's economy and rural livelihoods. But these rich resources are under growing human pressure driven by rapid change of social, natural, economic and political dimensions, and several economically important species are in decline (Brooks et al. 2007; Platt et al. 2008; Yen et al. 2009). In 1997 the government designated the Tonle Sap Lake as a Biosphere Reserve, potentially developing management approaches that could reconcile biodiversity conservation as an integral part of the management regime. The Prek Toal Core Area is the most important biodiversity hotspot of the Lake, where a large number of wildlife species of global significance are found. Conservation and ecotourism still face some constraints and risks associated with limited knowledge, ineffective policy, lack of participation from key social groups, socio-economic needs and limited human capacity (Bonheur 2001). The lack of knowledge appears to be addressed effectively with a considerable number of researchers working in Tonle Sap on a range of disciplines (also see Google Scholar analysis on page 27). Still, this is a complex area to manage with a high number of poor people using the reserve's resources, and developing and implementing sustainable management strategies will be a major challenge.

An overview of Indonesian biosphere reserves

All but one of the seven Indonesian biosphere reserves were set up in the late 1970s and early 1980s. The ones established in the late 1970s overlap with the boundaries of the national parks they are associated with, and the core, buffer and transition zones have not yet been clearly identified. This might be because the buffer and transition zones do not easily coincide with existing land use categories in the Indonesian spatial planning systems.

Considering the important role Indonesia plays in regional and global discussions on the conservation of terrestrial, freshwater and marine biodiversity, deforestation and forest degradation, sustainable development, and poverty alleviation, further development and promotion of the biosphere reserve concept appears logical.

Indonesia is addressing the poor understanding of biosphere reserves with a new approach. The Giam-Siak Kecil – Bukit Batu (GSKBB) Biosphere Reserve, which was officially estabblished in 2009, specifically promotes the balance between economic development (in this case the development of acacia plantations) and conservation functions (the core reserve part of the landscape). Furthermore, the establishment of the reserve and it management, as it is being planned at the moment, are being carried out jointly between the government and forestry industry. Such a partnership with forestry businesses theoretically reduces the probability that private sector will engage in harmful practices, and leverage its influence with government and its employees to promote sound management of their ecosystem and resources. Such an approach reflect's Indonesia's recent government administrative change from a centralized mode to a decentralized mode, promoting a multi-stakeholder approach to arrive at localized participation and solution. New achievements by the MAB National Committee concerning the establishment of a multi-stakeholder management board for Cibodas Biosphere Reserve represent Indonesia's new approach in managing and promoting biosphere reserves.

Overall, forest cover change analysis suggest that the Indonesian biosphere reserves are relatively effective in preventing deforestation, as shown for an analysis for Siberut and Gunung Leuser Biosphere Reserves on Sumatra (Gaveau et al. 2009), as well as Lore Lindu Biosphere Reserve, Sulawesi (the Nature Conservancy, unpubl. data). For Cibodas in Java forest cover monitoring data are unavailable, while for Tanjung Puting Biosphere Reserve, recent forest cover change analysis (Orangutan Conservation Services Programme, unpubl. data) suggests continuous forest loss. As with many protected areas, the biosphere reserve in mountainous areas are performing better in regard to preventing deforestation than those in lowlands, but this may be more the result of their relative isolation as of their biosphere management.

Biosphere reserves in China

China appears to be among the countries in the region that take the biosphere reserve concept very seriously. The country established the China Biosphere Reserve Network (CBRN), which is a network established by the Chinese National Committee for UNESCO Man and the Biosphere Programme in 1993. At present there are 136 "China Biosphere Reserves" within the CBRN, including 28 UNESCO Biosphere Reserves; another seven reserves joined the China Biosphere Reserves in November 2009. Membership in the CBRN serves as a prerequisite for joining the World Network of Biosphere Reserves.

Research plays an important role in Chinese biosphere reserves, as well as a focus on cultural diversity. The latter was the theme of a 2007 joint regional seminar of the Ecotone-SeaBRnet 2007 and the 9th Conference of the CBRN:

"Cultural diversity: a foundation for biodiversity conservation and sustainable development. The importance of research in biosphere reserves is evident with a Google Scholar search on "China" and "Biosphere Reserve" resulting in 4400 publications. The most cited papers among these focus on ecosystem dynamics, species conservation, biosphere reserve design, and general protected area management. With that the Chinese authorities appear to effectively address one of the core goals of biosphere reserves. A good example of this is the Wolong Biosphere Reserve, where issues such as local people's perceptions as decision support for protected area management (Xu et al. 2006), human disturbances on landscapes in protected areas (Zeng et al. 2005), the complexity of protected area management (Fu et al. 2004), and effectiveness monitoring of protected areas (Lu et al. 2003) have been studied. These examples also indicate another strong focus of Chinese Biosphere Reserves, i.e., the integration of China's long-term agricultural experience with sustainable development needs through new approaches to agro forestry and agro-ecological farming systems.

Judging several period reviews of China's biosphere reserves (Fenglin, Maolan, Nanji Islands, Tian Mu Mts.), the Chinese National Committee for UNESCO Man and the Biosphere Programme takes adaptive management seriously. The reports clearly state weaknesses in present management and recommend relevant action for addressing these issues. Admittedly, these four reports only provide a snap shot of the broader biosphere management issues in the country, but they are at least a positive indication that biosphere reserve management effectiveness is taken seriously by the Chinese authorities.

Biosphere reserves in India

Similar to China, India has developed a network of its own biosphere reserves, some of which are also part of the World Network of Biosphere Reserves. So far, the Indian government has established 15 Biosphere Reserves of India. These categories roughly correspond to IUCN's Category V Protected areas, which protect larger areas of natural habitat than a more strictly defined protected area (national park or wildlife sanctuary). Like the MAB areas, these Biosphere Reserves of India often include one or more National Parks and/or preserves, along buffer zones that are open to some economic uses. Protection is granted not only to the flora and fauna of the protected region, but also to the human communities who inhabit these

regions, and their ways of life. Seven of the 15 Indian biosphere reserves are part of the World Network of Biosphere Reserves.

India has a strong history of ongoing research programs in their biosphere reserves. Especially the Nanda Devi Biosphere Reserve has been extensively studied, especially regarding the role of local communities in the management of these reserves, conflict resolution, and tourism as a source of revenues to communities (for a list of relevant literature see Literature Cited).

A 2003 review of Indian biosphere reserves, using a set of indicators related to community participation, legal and institutional mechanisms, management capacity and management effectiveness, concluded that "Indian biosphere reserves have, by and large, failed to resolve or even added to resource conflicts due to inter agency disputes or imposition of an inappropriate model of development" (Ganguly et al. 2003). Moreover, the review states, "major management decisions seem to be taken at higher bureaucratic levels without reference to the livelihood concerns of local people and traditional resource management systems followed in local areas". On the other hand, "Indian biosphere reserves have been successful in areas like supplementary income generation". It is unclear to what extent these conclusions are supported by the wider Indian biosphere community and whether the concerns have been addressed.

DISCUSSION AND RECOMMENDATIONS

This review of the biosphere reserves of the Asia-Pacific shows that the concept has been widely taken up in the region. More than half of the countries in the region have established biosphere reserves or are planning these in the near future. For several countries, such as Vietnam, biosphere reserves have become the guiding model for protected area management, or even broader sustainable development. Other countries such as India and China are actively developing their own biosphere reserve networks, some only within a national framework and others within the context of the broader international MAB network. In countries, such as the Philippines, the biosphere reserve concept is promoted as a possible solution to the tension between development and conservation, which is likely to grow under the pressures of climate change, population growth, and poverty. Australia, is also fast tracking the biosphere reserve concept in areas such as Noosa and Mornington Peninsula where more holistic sustainable development solutions are sought, balancing environmental conservation needs with development.

Despite these positive developments, however, the biosphere reserve model remains underutilized and does not get the attention from governments and the public that it deserves. The simple Google search revealed that neither researchers nor the public are more likely to find information about biosphere reserves than about ordinary protected areas, whereas the World Heritage designation, for example, does that much better in that regard. Access to information about individual biosphere reserves also remains difficult, even though UNESCO now runs a centralized data system. Furthermore, even though there is a periodic review system for biosphere reserves, access to such monitoring information is hard to come by and rarely provides good insight in how effective individual biosphere reserves are managed.

These issues are further discussed below and an attempt will be made to recommend actions that could improve the present situation.

Lack of understanding about the biosphere reserve concept

Biosphere reserves do not get sufficient public attention. They are rarely mentioned outside the networks that specifically with biosphere reserves, get limited media attention, and are sometimes largely ignored by the national governments that are responsible for managing them. Despite the considerable efforts by UNESCO and other organizations, biosphere reserves remain in somewhat of an identity crisis. This is very unfortunate, because as shown in this review, the biosphere reserve concept is very relevant to many of the situations in the region where conservation and development goals need to be balanced, and will likely become a standard model for sustainable development. Whether or not the name 'biosphere reserve' will be associated with that model is a different issue. As it is now, biospheres get too little attention, and there remains a significant lack of understanding of what they stand for.

In recognition of this, UNESCO has made progress in promoting the concept of biosphere reserves as living laboratories or landscapes rather than as strictly protected areas. When the first biosphere reserves were established in the region, they largely coincided with protected areas. Since, the launch of the Seville Strategy, new biosphere reserves have taken the basic steps towards aligning reserve design and management with the updated biosphere reserve concept. What is needed next is a much broader evaluation and communication strategy that measures the benefits of the biosphere reserve for people and nature and informs a wide audience including governments, media, and the public about this. This requires addressing several issues:

- Availability of information about individual biosphere reserves as well as the broader, participatory biosphere reserve concept. This should include emphasizing the role of communities in managing biosphere reserves and their resources to counter present anti-conservation/pro-community development.
- Insight in the effectiveness with which biosphere reserves attain their various goals on conservation, poverty alleviation and development. This would also provide better scope for quality control.
- Some standardization is needed about how biosphere reserves should be run, what qualifies as a biosphere and what doesn't. This will help in the marketing of the concept.

These issues will be addressed below.

Data availability

Although UNESCO has a dataset of all Biosphere Reserves in the Asia-Pacific region, with nearly complete data on ecological conditions, social-cultural information, zonation, and a range of other factors, it remains very difficult to obtain any further information about these areas. This is not unique to biosphere reserves, but characterizes all global datasets on protected areas. The World Database on Protected Areas that was consulted, and which is apparently the state of the art dataset for protected areas, has many mistakes and omissions, to the extent that it could not be used it for the present study.

Still, it shouldn't be a major effort from UNESCO to further improve data availability for the biosphere reserves. At least, shapefiles of the area boundaries and also reserve zones should be made available to UNESCO, kept in a central, publically accessible database, and be regularly updated. This would facilitate future analysis of the effectiveness with which biosphere reserves attain their social and environmental goals.

Even though, UNESCO has compiled a lot of information about individual reserves and makes this available on their website, finding out more detailed information, such as maps, species list, management plans, etc is more difficult. Many of the contact details provided by UNESCO could no longer be used, and trying to obtain data from managers at the field level during this review frequently led to long, often unsuccessful, email chains. Again, it would be useful if one person in the region was responsible for maintaining contact details up to date.

Recommendation 1:
To increase the accessibility of information regarding biosphere reserves, UNESCO should further improve systems to compile information on individual biosphere reserves, including maps and GIS files, reserve descriptions, and information on monitoring and evaluation of the effectiveness of individual reserves.

Communication and PR

Biosphere reserves remain relatively poorly known by the public, as was, for example, indicated by the Asia-Pacific Google search for individual biosphere reserves. Just for comparison, a simple Google search on "Biosphere Reserve", "World Heritage Area", "National Park", and "Nature Reserve" returned respectively 643,000; 23,300,000.; 154,000,000; and 37,700,000 hits., confirming that biosphere

reserves do not get much public attention. In addition, many of the communities that live near or in biosphere reserves do not know of their existence.

This is clearly indicated in some of the Asia-Pacific countries assessed in this review, in which there is hardly any awareness of the existence of biosphere reserves, even if some of them have been around for decades. There is clearly a need to blow new life into the biosphere reserve concept, especially because as a tool in conservation and sustainable management it seems more relevant than ever.

One option would be to highlight demonstrable successes of biosphere reserves attaining conservation and development goals, especially in areas where new approaches are being implemented and tested for effectiveness. Specifically targeting certain areas, with a media angle in mind, might help attract attention. This could include areas with a strong private sector role, or very well organized local communities who take an active role in reserve management, or with a popular species such as orangutans (Pongo spp.) or Giant Panda (Ailuropoda melanoleuca). But these are local efforts and a much broader communications strategy is needed build on these specific examples and get conservation practitioners, donor organizations, government agencies, and the public more aware of and interested in biosphere reserves.

Recommendation 2:
To raise the visibility of biosphere reserves through media campaigns, awareness material, and promotional activities, so that people understand and appreciate what a biosphere reserve is and how they can get involved.

Monitoring and evaluation

Conservation in general is notorious for its poor record on transparency and accountability. Few organizations or programs can state which specific and tangible conservation outcomes have been achieved. Biosphere reserves are no different from other protected areas or other conservation strategies in that they lack regular performance reviews. The 10-year reviews that are presently asked for by UNESCO are a step in the right direction, and some of these review reports assessed during the present review were of good quality. Still, this information is hard to obtain and it is unclear whether these 10-year reviews have been produced for all Asia-Pacific biosphere reserves.

Monitoring and evaluation is a crucial part of the process of making conservation and sustainable development strategies more effective. Getting direct feedback from the impact that certain strategies have on overall goals allows adaptive management changes to be made and optimizes resource allocation. Even though the cause-effect relationships between certain strategies and ultimate goals might be complex, regular monitoring and evaluation might highlight that certain are or aren't working as well as expected, and thus demand closer attention from managers. Not having the monitoring information in hand often leads to situations in which management approaches are rarely changed, potentially perpetuating poorly performing conservation and sustainable development programs.

Monitoring and evaluation studies are also needed to address a key question regarding biosphere reserves: Is the zonation system in biosphere reserves (core, buffer, transition) resulting in more positive conservation and sustainable development outcomes than in traditionally managed landscapes where conservation focuses on protected areas and development outside them? This question is fundamental to the biosphere concept but has never been properly tested. An experimental set up would be required in which conservation and development achievements in well-designed and managed biosphere reserves are compared to independent control site with similar socio-economic, political, and environmental characteristics. If indeed it can be proven that the more holistic, multi-stakeholder-based approach in biosphere reserves delivers superior outcomes compared to other approaches, this would be of significant promotional value.

Lack of good monitoring and evaluation information might partly be because methodologically such processes are thought to be complex. Reserve or program managers are generally already busy enough dealing with the many demands of conservation and sustainable development. Adding a complex monitoring task is the last thing they need. This review, however, has demonstrated that with very simple tools a quick, cheap quantitative overview can be obtained for some key conservation measures, such as management effectiveness or impact on key conservation indicators such as forest cover. This demonstration does not necessarily

mean that UNESCO should exactly follow these methods. Rather, it is recommended that UNESCO invest some time and thinking to develop their own simple conservation and development measures, and implement these in at least their model biosphere reserves.

Recommendation 3:
UNESCO should develop a standardized set of socio-economic and environmental indicators, and cheap, simple methods to measure them. These should then be implemented by at least a subset of the best biosphere reserves. The results would feed into a national, regional, and global database on biosphere reserves to track whether they are indeed contributing to the stated conservation, development, and logistical functions. Overall findings can then be actively used in UNESCO's communication strategy, as well in adaptive management of the reserves.

The UNESCO World Heritage Center maintains a list of World Heritage in Danger, in accordance with Article 11 (4) of the Convention. This indicates that while nations recognize the duty of ensuring the identification, protection and conservation of World Heritage sites belongs primarily to them, the nation state signing the treaty also agrees to do "all it can" to protect these sites. Article 6 clarifies this statement even further by stating, "Whilst fully respecting the sovereignty of the State [nation]...State Parties to this Convention recognize that such heritage constitutes a world heritage for whose protection it is the duty of the international community as a whole to cooperate." Article 4 goes on to state that a nation signing the treaty is "to the utmost of its own resources, and where appropriate, with any international assistance and co-operation" protect these sites. Biosphere reserves presently do not have a similar system, either legal or administrative, in place that can notify member governments that something isn't right about certain biosphere reserves, and to press on them to improve the management of endangered biosphere reserves.

Having a monitoring and evaluation system in place would allow UNESCO to distinguish between the good and poor performers among biosphere reserves, making it easier to highlight the good examples, and address resources, such as technical assistance, towards biosphere reserves in trouble. One possibly constructive approach would be to develop a rating system for biosphere reserves, with indicators to measure performance, as for example, in Table 7.

A rating system could build on some of the measures methods tried in this review, such as the management effectiveness score card or forest cover monitoring, although there are many other different approaches. The rapid management score card assessment as used in this review is probably too simplistic to really guide biosphere reserve management, but with a little bit more effort and input from local reserve managers, the score card could be incorporated into UNESCO biosphere reserve system. The advantage of the score card is that it standardizes effectiveness measures across different biosphere reserves thus allowing for objective comparisons between reserves, countries, or regions.

Standardization of management and alignment with national legislation

Biosphere reserve management goals and objectives are clearly described, but the only major tool for management implementation seems to be the zonation of the biosphere reserve, with individual management goals for

Table 7. Possible indicators for a rating system for biosphere reserves.

Rating	Indicator 1 - design	Indicator 2 - conservation	Indicator 3 - poverty
Level 1	Zoning not yet developed	Conservation targets not clearly identified	Poverty alleviation targets not clearly identified
Level 2	Zoning developed but not effectively implemented	Conservation target identified but not reached	Poverty alleviation targets identified but not reached
Level 3	Zoning effectively implemented	Conservation targets reached	Poverty alleviation targets reached

each zone. Giving more specific management guidelines might be considered difficult because these are often context specific. For example, the management guidelines for different biosphere reserve zones may not be in line with available land use management options in a specific country. If the whole biosphere reserve would be designated as a national park, then sustainable development objectives in the transition zone might not be allowed under the country's legal framework. If instead, the core zone would be designated as an officially protected area, the buffer zone for limited use, for example for commercial forestry, and the transition zone for development, then the latter zone might have to fall into an agriculturally land use category where sustainable uses are not legally required, thus not meeting the biosphere reserve's sustainability targets. Such incompatibilities between national land use regulations and biosphere management appear to be common and it would be helpful to reserve managers if general guidelines existed about how biosphere targets can be reconciled with national legislation. One step in that direction is to ask national MAB committees to do a gap analysis between biosphere reserve targets and national legislation. This would give UNESCO an overview of the most common areas of conflict. These could then be translated into guidelines about how to address such conflict situations (apart from revising national legislation) to ensure that biosphere targets can still be met. A gap analysis would also identify commonalities between biosphere reserves and how they are managed under national legislation. These commonalities could be to provide standardized management guidelines at the regional and global levels.

Recommendation 4:
UNESCO should develop a rating system for biosphere reserves to distinguish different levels of performance, allowing the promotion of best management practice examples, and targeted assistance to biosphere reserves in trouble. Such a rating system, although potentially politically sensitive would improve the biosphere reserve brand.

Multi-stakeholder nature of biosphere reserves

One of the most difficult challenges in conservation is to develop and effectively implement multi-stakeholder management of conservation targets. Solid partnerships are required between a range of governmental and non-governmental groups, each of which with their own conservation and development agenda. Avoiding the potential conflicts of interests that occur in such partnerships is most easily done by minimizing the number of stakeholders, for example, by setting up areas under only one management authority, e.g. a strict nature reserve under national government management. It has become increasingly clear though that exclusion of other partners (local communities, business groups, local government etc.) is counterproductive in the long term. However difficult, multi-stakeholder management seems to be a requirement for successful integrated conservation and development. The biosphere reserve management goals acknowledge this and multi-stakeholder management is a core concept. Still, acknowledgement does not automatically lead to implementation, and many biosphere reserves reviewed in the present study struggle to effectively develop management structures that incorporate the objectives of various interest groups. Many questions need to be addressed to go beyond the relatively simple conservation objectives of a protected area. What are the best processes to develop conservation and development targets (short-, mid-, and long-term)? How are conservation and development goals balanced, and how is a common vision developed that represents that balance? What kind of management structures are required to plan, implement, guide, and monitor the different processes? Who determines the role of different stakeholders and how is this decided?

Answers to the above questions are highly context specific. They depend on national and regional legislation, the country's or region's culture on governance and multi-stakeholder management, the level of education of different stakeholders, etc. Despite these differences it might be worthwhile to explore what communalities exist between different

countries and what general guidelines could be developed that would help all biosphere reserve management groups. Such guidelines might prevent that approaches are used that in most other experiences have failed to perform effectively. Also, having some idea of the different options in multi-stakeholder management might speed up reserve development (although going too fast in development multi-stakeholder structures has its own dangers).

In addition, most countries in the Asia-Pacific region have yet to develop national legislation on the development and implementation of biosphere reserves. The multi-stakeholder nature of these reserves, might be a major stumble block, and providing general UNESCO guidelines would help governments to speed up country-specific guidelines for biosphere reserve management.

Recommendation 5:
UNESCO in collaboration with MAB National Committees as well as regional networks should implement an analysis of how well biosphere reserve targets are aligned with national legislation. The goal would be the identify areas of conflict between targets and legislation, guidelines on how to resolve this, and eventually develop a set of standardized management guidelines which can be used at the regional and global levels. Also biosphere reserve management plans should be part of the larger provincial and local development plans to ensure that its development objectives are in line with those developed at a regional scale. This prevents biosphere reserves ending up as isolated management units rather than local conservation and development strategies integrated into the broader objectives for the landscape or region.

Guidance on area designation

During this review, a conference was attended in South Korea about the appropriate designation of a particular site. Preference for a particular designation (e.g., Biosphere Reserve, World Heritage Site, or Geopark) reflected the background of the individual rather than the overall management structures associated with the different designations. Governments and other interest groups in the Asia-Pacific can choose from a considerable range of different international land designations (e.g., World Heritage, Biosphere Reserve, national park, geopark, Ramsar, ASEAN Heritage, strict protected area, industrial site such as a plantation with protected zones). There is, however, relatively little guidance on which designation is most suitable under certain circumstances. It would be very helpful if a key was available that would allow governments to make informed choices between different categories. A list of questions could steer governments to make the best choice for sites at different scales. Not only would this lead to a more effective and efficient process of land use designation, but it would also improve public profile of biosphere reserves.

Recommendation 6:
Given the multi-stakeholder nature of biosphere reserves, it is recommended that UNESCO and their partners develop guidelines on how to set up and implement partnerships and what formal structures are needed for doing this work best. This should involve all national committees who should be required to develop a plan with a timeline to create country-specific legislation on biosphere reserve management and development of concomitant multi-stakeholder management structures.

Biosphere reserves and climate change

It is now clear that climate change is the most critically important issue facing the planet today. The associated sea level rise, precipitation change, and resulting droughts and floods will require adaptation to minimize the impact on human and natural systems, including food and water resources.

Adaptation to global warming consists of initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects (IPPC 2007). This is in contrast with the

Recommendation 7:

UNESCO in collaboration with other international groups should work towards clearer definition of the organizational, socio-economic, environmental, geo-political, and geographical characteristics of biosphere reserves versus other international designations, eventually resulting in a key that can be used by governments to inform their choices of international site designation.

mitigation of global warming. Adaptation has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts, but will incur costs and will not prevent all damages. Human and natural systems will to some degree adapt autonomously to climate change, but in many cases planned adaptation will be needed as a supplement to autonomous adaptation. In general it appears that there are more options and greater possibility for offering incentives in the case of adaptation of human systems than in the case of adaptation to protect natural systems (Climate Change Working Group 2001), not in the least because the financial losses to human systems are potentially so much larger than those in natural systems, especially because environmental services are rarely monetized.

Biosphere reserves effectively combine the human and natural systems. This makes them potentially highly suitable to facilitating a climate change adaptation role in threatened ecosystems, if indeed climate change adaptation activities are recognized to benefit human systems. Many communities and regions that are vulnerable to climate change are also under pressure from forces such as population growth, resource depletion, and poverty. If biosphere reserve management can lessen pressures on resources, improve management of environmental risks, and increase the welfare of the poorest members of society it can simultaneously advance sustainable development, and enhance the adaptive capacity of a particular area, thus reducing vulnerability to climate changes and other threats (Climate Change Working Group 2001).

Well managed biosphere reserves can also play a significant role in climate change mitigation, primarily through reducing deforestation and forest degradation, but also by maintaining healthy coastal and marine environments.

The specific role of biosphere reserves in climate change adaptation and mitigation needs to be further explored and tested. Sound management of biodiversity and ecosystem services can be a highly cost-effective way to adapt to climatic change, for example through:

- Agriculture: Maintaining diversity of local varieties, crops and agricultural systems contributes to risk distribution, decreased vulnerability, and increases the ability of the agricultural system to adapt. Increased levels of organic matter in soil contribute to increased harvests and improved ecosystem services, such as nutrient cycling and water retention.
- Coastal zones: Conservation of mangrove forests and coral reefs is a cost-efficient measure to protect coastal zones against weather-related catastrophes (storms and typhoons). It also benefits biodiversity and fisheries since spawning grounds for fish are preserved, and it is favourable for tourism.
- Lowland tropical forests including peatlands play a significant role in absorbing CO_2, and therefore will serve a key role in climate change mitigation.
- Forested mountain areas are important as water sources, but also for their capacity to absorb and moderate the consequences of flooding (and increased water flows from glacial melting).
- Wetlands have a buffering effect (e.g. against drought and flooding), as well as a rich species diversity, and also contribute to other ecosystem services such as removal of nitrogen from agricultural runoff.

Biosphere reserves should specifically start to address some of the above issues to demonstrate the impact these reserves can have on reducing the effects of global climate change, while maintaining sustainable development goals.

Recommendation 8:
It is recommended that UNESCO develop one or more pilot projects in which climate change adaptation and mitigation is specifically incorporated into the biosphere reserve management plans, and in which the specific contributions of environmental services from the reserve to climate change are closely measured and publicly demonstrated. The purpose is to promote biosphere reserve and related landscape-level management as an appropriate tool to address the drivers of climate change and minimize its environmental and socio-economic impacts.

Biosphere Reserves and poverty alleviation

There is insufficient information available to judge whether biosphere reserves are indeed a useful tool in sustainable development and poverty alleviation. As pointed out above, under the header "Monitoring and Evaluation" there is a need to scientifically test whether biosphere reserves are a superior tool for targeting poverty alleviation, and under what circumstances that is the case. In that regard, it is especially important to establish the links between economic contributions that core zones make to the people and overall economic development of the remainder of the biosphere reserve. This includes the value of environmental services, tourism revenues, climate regulation, climate change mitigation properties, as well as products obtained by people from the core zone. Vice versa, a system should be put in place in which revenues obtained in the buffer and/or transition zone contribute to the maintenance of the core zone, for example through a taxation system. In very poor areas where taxation and other financial mechanisms might be poorly developed this could be difficult. Other opportunities could be assesses, including micro-finance to see to what extent a levee could be added to loans that would be used to manage the values of the core zone.

Recommendation 9:
The impact that biosphere reserves have on poverty alleviation and rural development should be better tested, and once found to be effective, poverty alleviation and development should be specifically incorporated in the biosphere reserve management plans.

Development of a multi-faceted regional program

This review demonstrated that there is a real need for a regional program that reflects and addresses current biosphere reserve challenges such as: standardizing and improving biosphere reserve management; climate change mitigation and adaptation efforts into biosphere reserve planning and management; stronger engagement with stakeholders across sectors including the private sector; incorporating poverty alleviation and rural development into biosphere reserve planning and management; and raising the profile and visibility of biosphere reserves. At present, although biosphere reserve networks – both global and regional – have contributed to sound communication between biosphere reserve practitioners, coordination and standardization is rather loose. While this allows for flexibility and adaptation, a lack of standardization and coordination at the regional level leads to a weak system. A regional program that is designed, developed, and implemented in partnership with Member State authorities, local communities, civil society organizations, and private sector parties would produce the intended benefits associated with biosphere reserves, stimulate dialogue among stakeholders, provide greater visibility to biosphere reserves, and, ultimately, contribute to regional and national sustainable development efforts.

Recommendation 10:
UNESCO should develop a regional program that reflects all the issues and concerns articulated in this review, particularly focusing on: climate change mitigation and adaptation; poverty alleviation; and stimulating and promoting greater cohesion among different biosphere reserves and biosphere reserve networks. Such a program can also bring in the unique set of expertise that UNESCO possesses in the sciences (environmental, hydrology, basic, social), education, culture, and communication and information.

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INDEX

Appendix 1.

List of Biosphere Reserves in the Asia and Pacific regions, and the Google and Google Scholar search scores

No	Country	Biosphere Reserve	Date of approval	Google Scholar	Google
1	AUSTRALIA	Croajingolong	1977	19	818
2	AUSTRALIA	Kosciuszko	1977	165	86600
3	AUSTRALIA	Macquarie Island	1977	715	96900
4	AUSTRALIA	Prince Regent River	1977	91	1520
5	AUSTRALIA	Unnamed	1977	1590	4730
6	AUSTRALIA	Uluru (Ayers Rock-Mount Olga)	1977	290	6090
7	AUSTRALIA	Yathong	1977	12	456
8	AUSTRALIA	Fitzgerald River	1978	1090	7250
9	AUSTRALIA	Hattah-Kulkyne & Murray-Kulkyne	1981	6	267
10	AUSTRALIA	Wilson's Promontory	1981	617	48100
11	AUSTRALIA	Riverland	1977	215	2100
12	AUSTRALIA	Mornington Peninsula and Western Port	2002	53	7440
13	AUSTRALIA	Barkindji	2005	17	333
14	AUSTRALIA	Noosa	2007	55	3750
15	AUSTRALIA	Great Sandy	2009	9900	83500
16	CAMBODIA	Tonle Sap	1997	316	72500
17	CHINA	Changbaishan	1979	286	23500
18	CHINA	Dinghushan	1979	638	7350
19	CHINA	Wolong	1979	314	9310
20	CHINA	Fanjingshan	1986	35	99
21	CHINA	Xilin Gol	1987	30	898
22	CHINA	Wuyishan	1987	61	2550
23	CHINA	Bogeda	1990	252	21700
24	CHINA	Shennongjia	1990	61	2490
25	CHINA	Yancheng	1992	202	1360
26	CHINA	Xishuangbanna	1993	400	4750
27	CHINA	Maolan	1996	29	2180
28	CHINA	Tianmushan	1996	27	1230
29	CHINA	Fenglin	1997	58	771
30	CHINA	Jiuzhaigou Valley	1997	56	7120
31	CHINA	Nanji Islands	1998	17	329
32	CHINA	Shankou Mangrove	2000	11	681
33	CHINA	Baishuijiang	2000	15	74
34	CHINA	Gaoligong Mountain	2000	19	326
35	CHINA	Huanglong	2000	63	7840
36	CHINA	Baotianman	2001	11	86
37	CHINA	Saihan Wula	2001	2	44
38	CHINA	Dalai Lake	2002	187	9850
39	CHINA	Wudalianchi	2003	7	81
40	CHINA	Yading	2003	3	492
41	CHINA	Foping	2004	23	740
42	CHINA	Qomolangma	2004	72	2070
43	CHINA	Chebaling	2007	9	62
44	CHINA	Xingkai Lake	2007	13	189
45	INDIA	Nilgiri	2000	724	67000
46	INDIA	Gulf of Mannar	2001	364	31200
47	INDIA	Sunderban	2001	438	18700
48	INDIA	Nanda Devi	2004	638	33800
49	INDIA	Nokrek	2009	74	1540
50	INDIA	Pachmarhi	2009	68	8650

No	Country	Biosphere Reserve	Date of approval	Google Scholar	Google
51	INDIA	Similipal	2009	106	7240
52	INDONESIA	Cibodas	1977	64	1350
53	INDONESIA	Komodo	1977	265	7840
54	INDONESIA	Lore Lindu	1977	99	845
55	INDONESIA	Tanjung Puting	1977	76	2580
56	INDONESIA	Gunung Leuser	1981	85	3220
57	INDONESIA	Siberut	1981	83	3120
58	INDONESIA	Giam Siak Kecil – Bukit Batu	2009	2	676
59	ISLAMIC REPUBLIC OF IRAN	Arasbaran	1976	22	395
60	ISLAMIC REPUBLIC OF IRAN	Arjan	1976	238	2810
61	ISLAMIC REPUBLIC OF IRAN	Geno	1976	1090	2190
62	ISLAMIC REPUBLIC OF IRAN	Golestan	1976	40	1310
63	ISLAMIC REPUBLIC OF IRAN	Hara	1976	2470	6050
64	ISLAMIC REPUBLIC OF IRAN	Kavir	1976	45	949
65	ISLAMIC REPUBLIC OF IRAN	Lake Oromeeh	1976	8	66
66	ISLAMIC REPUBLIC OF IRAN	Miankaleh	1976	25	306
67	ISLAMIC REPUBLIC OF IRAN	Touran	1976	26	436
68	JAPAN	Mount Hakusan	1980	6	99
69	JAPAN	Mount Odaigahara & Mount Omine	1980	0	46
70	JAPAN	Shiga Highland	1980	26	495
71	JAPAN	Yakushima Island	1980	92	755
72	DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA	Mount Paekdu	1989	13	664
73	DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA	Mount Kuwol	2004	7	57
74	DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA	Mount Myohyang	2009	7	531
75	REPUBLIC OF KOREA	Mount Sorak	1982	36	382
76	REPUBLIC OF KOREA	Jeju Island	2002	231	4560
77	REPUBLIC OF KOREA	Shinan Dadohae	2009	2	63
78	KYRGYZSTAN	Sary-Chelek	1978	36	391
79	KYRGYZSTAN	Issyk Kul	2001	181	5430
80	MALAYSIA	Tasik Chini	2009	93	88
81	FEDERATED STATES OF MICRONESIA	Utwe	2005	4	85
82	FEDERATED STATES OF MICRONESIA	And Atoll	2007	1	9
83	MONGOLIA	Great Gobi	1990	903	48200
84	MONGOLIA	Boghd Khan Uul	1996	14	77
85	MONGOLIA	Uvs Nuur Basin	1997	77	989
86	MONGOLIA	Hustai Nuruu	2002	7	49
87	MONGOLIA	Dornod Mongol	2005	32	348
88	MONGOLIA	Mongol Daguur	2007	15	92
89	PAKISTAN	Lal Suhanra	1977	11	80
90	PALAU	Ngaremeduu	2005	1	55
91	PHILIPPINES	Puerto Galera	1977	69	4780
92	PHILIPPINES	Palawan	1990	379	3950
93	SRI LANKA	Hurulu	1977	9	222
94	SRI LANKA	Sinharaja	1978	175	9600
95	SRI LANKA	Kanneliya-Dediyagala-Nakiyadeniya (KDN)	2004	6	96
96	SRI LANKA	Bundala	2005	36	7680
97	THAILAND	Sakaerat	1976	69	699

No	Country	Biosphere Reserve	Date of approval	Google Scholar	Google
98	THAILAND	Hauy Tak Teak	1977	3	63
99	THAILAND	Mae Sa-Kog Ma	1977	19	252
100	THAILAND	Ranong	1997	119	1230
101	TURKMENISTAN	Repetek	1978	52	529
102	UZBEKISTAN	Mount Chatkal	1978	19	457
103	VIETNAM	Can Gio Mangrove	2000	132	3260
104	VIETNAM	Cat Tien	2001	221	5000
105	VIETNAM	Cat Ba	2004	2810	36200
106	VIETNAM	Red River Delta	2004	4520	74600
107	VIETNAM	Kien Giang	2006	69	2300
108	VIETNAM	Western Nghe An	2007	26	705
109	VIETNAM	Mui Ca Mau	2009	31	693
110	VIETNAM	Cu Lao Cham – Hoi An	2009	4	967

Name MAB	Year of establishment	Main Biome	Area of BR (ha)	Area of Core Zone (ha)	Area of Buffer Zone (ha)	Area of Transition Zone (ha)	Name of Protected Area	Area protected (ha)	Remarks	Percentage of BR protected
Croajingolong	1977	terrestrial	101,000				Croajingolong National Park, Nadgee Nature Reserve, Sandpatch Wilderness Area	108,171		107.1%
Kosciuszko	1977	terrestrial	625,525				Kosciuszko National Park	673,492		107.7%
Macquarie Island	1977	terrestrial and marine	12,785				Macquarie Island, a Tasmanian State Reserve	12,785		100.0%
Prince Regent River	1977	freshwater	633,825				Prince Regent Nature Reserve	633,825		100.0%
Unnamed	1977	terrestrial	2,132,600				Mamungari Conservation Park	2,100,000	"Unnamed" is outdated	98.5%
Uluru (Ayer's Rock – Mount Olga)	1977	terrestrial	132,550				Uluru-Kata Tjuta National Park	132,500		100.0%
Yathong	1977	terrestrial	107,241				Yathong Nature Reserve	107,240		100.0%
Fitzgerald River	1978	freshwater	329,039	329,039			Fitzgerald River National Park	329,039		100.0%
Hattah-Kulkyne & Murray Kulkyne	1981	terrestrial	51,500	5,680	45,820		Hattah-Kulkyne National Park, Murray-Kulkyne Regional Park	51,530		100.1%
Wilson Promontory	1981	terrestrial	49,000				Wilsons Promontory National Park	50,460		103.0%
Riverland (Bookmark Biosphere Reserve)	1977	terrestrial	900,000				Portfolio, incl. Calperum Station, Taylorville Station, Chowilla Regional Reserve, Danggali Conservation Park, Gluepot Reserve	717,780	Probably, the list of PAs within Bookmark is incomplete	79.8%
Mornington Peninsula and Western Port	2002	terrestrial	214,200	9,300	63,600	141,300	Portfolio, incl. Mornington Peninsula National Park, Arthurs Seat State Park, Western Port Ramsar Site	29,530		13.8%
Barkindji	2005	terrestrial	191,823	41,521	14,302	136,000	Portfolio, incl. Ned's Corner	30,000		15.6%
Noosa	2007	terrestrial	150,000	24,870	28,050	28,820	Portfolio			0.0%
Tonle Sap	1997	freshwater	1,481,257	70,837	510,768	899,652	Portfolio			0.0%
Changbaishan	1979	terrestrial	196,465	139,681	20,985	35,800	Changbaishan Nature Reserve	190,000		96.7%
Dinghushan	1979	terrestrial	1,133	625	350	158	Dinghushan Nature Reserve	1,155		101.9%

Appendix 2.
List of Biosphere Reserves in the Asia and Pacific regions, and their areas and zonations

Name MAB	Year of establishment	Main Biome	Area of BR (ha)	Area of Core Zone (ha)	Area of Buffer Zone (ha)	Area of Transition Zone (ha)	Name of Protected Area	Area protected (ha)	Remarks	Percentage of BR protected
Wolong	1979	terrestrial	200,000	119,460	53,020	27,520	Wolong National Nature Reserve	200,000		100.0%
Fanjingshan	1986	terrestrial	38,300	25,000	13,300	0	Fanjingshan National Nature Reserve	56,700		148.0%
Xilin Gol	1987	terrestrial	1,077,450	1,850	5,600	1,070,000	Xilingol National Nature Reserve	?		
Wuyishan	1987	terrestrial	56,527	34,771	21,756		Wuyishan National Nature Reserve	127,974		226.4%
Bogeda	1990	terrestrial	128,690	48,690	40,000	40,000	Tianshan Tianchi National Park	?		
Shennongjia	1990	terrestrial	70,467	34,845	11,202	24,420	Shennongjia National Natural Reserve	70,467		100.0%
Yancheng	1992	terrestrial	280,000	17,400	36,700	225,900	Yancheng National Natural Reserve and Yancheng NNR and Dafeng NNR	141,330		50.5%
Xishuangbanna	1993	terrestrial	241,700	126,500	5,200	110,000	Xishuangbanna National Nature Reserve	241,000		99.7%
Maolan	1996	terrestrial	21,330	8,350	8,130	4,850	Maolan National Nature Reserve	20,000		93.8%
Tianmushan	1996	terrestrial	4,284	1,191	381	2,712	Tianmushan National Nature Reserve	4,200		98.0%
Fenglin	1997	terrestrial	28,353	9,607	8,558	10,188	Fenglin National Nature Reserve	18,400		64.9%
Jiuzhaigou Valley	1997	terrestrial	106,090	58,915	5,382	41,793	Jiuzhaigou National Park	70,000	unclear information	66.0%
Nanji Islands	1998	marine	20,629	663	6,698	13,268	Nanji Islands National Nature Reserve	20,106		97.5%
Shankou Mangrove	2000	terrestrial and marine	8,000	800	3,600	3,600	Shankou Mangrove National Nature Reserve	8,000		100.0%
Baishuijiang	2000	terrestrial	213,750	97,329	17,018	99,403	Baishuijiang National Nature Reserve	213,750		100.0%
Gaoligong Mountain	2000	terrestrial	293,564	62,577	61,882	169,105	Gaoligong Mountain National Nature Reserve	120,000	unclear information	40.9%
Huanglong	2000	terrestrial	138,000	68,500	58,000	1,500	Huanglong National Nature Reserve	70,000		50.7%
Baotianman	2001	terrestrial	90,950	25,250	30,600	35,100	Baotianman Nature Reserve Area	5,413		6.0%
Saihan Wula	2001	terrestrial	100,506	15,800	33,800	50,906	Saihan Wula Nature Reserve	100,400		99.9%

Name MAB	Year of establishment	Main Biome	Area of BR (ha)	Area of Core Zone (ha)	Area of Buffer Zone (ha)	Area of Transition Zone (ha)	Name of Protected Area	Area protected (ha)	Remarks	Percentage of BR protected
Dalai Lake	2002	freshwater	740,000	45,082	22,816	672,102	Dalai Lake National Nature Reserve	740,000		100.0%
Wudalianchi	2003	freshwater	106,000	10,615	13,546	81,839	Wudalianchi National Nature Reserve	100,800		95.1%
Yading	2003	terrestrial	381,506	72,600	42,500	266,406	Yading Nature Reserve	56,000		14.7%
Foping	2004	terrestrial	72,443	10,326	6,139	55,978	Foping National Nature Reserve	29,240		40.4%
Qomolangma	2004	terrestrial	1,823,591	1,032,485	625,493	165,613	Qomolangma National Nature Reserve	3,380,000		185.3%
Chebaling	2007	terrestrial	7,545	2,512	2,331	2,701	Chebaling Nature Reserve	7,545		100.0%
Xingkai Lake	2007	freshwater	222,488	40,051	7,923	233,808	Xingkai Lake Nature Reserve	222,488		100.0%
Nilgiri	2000	terrestrial	552,000	124,000	357,400	70,600	6 national parks and wildlife santuaries	234,935		42.6%
Gulf of Mannar	2001	marine	1,050,000				Gulf of Mannar Marine National Park	56,000		5.3%
Sunderban	2001	marine	963,000	169,200	223,300	570,500	Sunderban National Park + 3 wildlife sanctuaries	173,600		18.0%
Nanda Devi	2004	terrestrial	586,069		514,857		Nanda Devi National Park and Valley of Flowers National Park	71,212		12.2%
Nokrek	2009	terrestrial	4,748	4,748			Nokrek National Park	4,748		100.0%
Pachmarhi	2009	terrestrial	492,600				Bori, Satpura, and Pachmarhi Wildlife Park and Satpura Tiger Reserve	169,649		34.4%
Similipal	2009	terrestrial	550,000	84,500	212,900	2,595	Similipal Tiger Sanctuary	84,500		15.4%
Cibodas	1977	terrestrial	57,532	15,196	42,336		Gede Pangrango National Park	21,975		38.2%
Komodo	1977	marine	173,300	31,258			Komodo National Park	181,700		104.8%
Lore Lindu	1977	terrestrial	217,982				Lore Lindu National Park	229,000		105.1%
Tanjung Puting	1977	terrestrial	415,040				Tanjung Puting National Park	415,040		100.0%
Gunung Leuser	1981	terrestrial	792,675				Gunung Leuser National Park	1,094,692		138.1%

Name MAB	Year of establishment	Main Biome	Area of BR (ha)	Area of Core Zone (ha)	Area of Buffer Zone (ha)	Area of Transition Zone (ha)	Name of Protected Area	Area protected (ha)	Remarks	Percentage of BR protected
Siberut	1981	terrestrial	405,070	46,533	314,145	44,392	Siberut National Park	190,500		47.0%
Giam Siak Kecil – Bukit Batu	2009	terrestrial	704,548	178,000	222,425	304,123	Giam Siak Kecil Wildlife Reserve	100,000		56.2%
Arasbaran	1976	terrestrial	72,460				Arasbaran Protected Area	72,460		100.0%
Arjan	1976	terrestrial	52,800				Arjan Reserve - information unclear	191,000		361.7%
Geno	1976	terrestrial	27,500				Geno Protected Area	44,598		162.2%
Golestan	1976	terrestrial	91,875				Golestan National Park + Protected Area	125,895		137.0%
Hara	1976	marine	85,686				Hara Protected Area	85,686		100.0%
Kavir	1976	terrestrial	420,000				Kavir National Park + Protected Area	670,000		159.5%
Lake Oromeeh	1976	freshwater	463,600				Lake Uromiyeh National Park	463,600		100.0%
Miankaleh	1976	freshwater	68,800				Miankaleh Willdlife Refuge	68,800		100.0%
Touran	1976	terrestrial	1,470,640				Touran Wildlife Refuge + Protected Area	1,872,750		127.3%
Mount Hakusan	1980	terrestrial	48,000	18,000	30,000		Mount Hakusan National Park	47,700		99.4%
Mount Odaigahara & Mount Omine	1980	terrestrial	36,000	1,000	35,000		Yoshino-Kumano National Park	59,798		166.1%
Shiga Highland	1980	terrestrial	13,000	1,000	12,000		Joshinetsu Kogen National Park	189,062		1454.3%
Yakushima Island	1980	terrestrial	18,958	7,559	11,399		Kirishima-Yaku National Park, Yakushima Wildlife Area and Yakushima Forest Ecosystem Reserve	70,652		372.7%
Mount Paekdu	1989	terrestrial	132,000	18,600	29,700	83,700	Paekdu Nature Protection Area	14,000		10.6%
Mount Kuwol	2004	ter	52,715	1,245	2,940	48,530	Mount Kuwol Nature Reserve	11,000		20.9%
Mount Myohyang	2009	terrestrial	74,501	9,682	19,050	45,769	Myohyang Natural Park	7,000		9.4%

Name MAB	Year of establishment	Main Biome	Area of BR (ha)	Area of Core Zone (ha)	Area of Buffer Zone (ha)	Area of Transition Zone (ha)	Name of Protected Area	Area protected (ha)	Remarks	Percentage of BR protected
Mount Sorak	1982	terrestrial	39,349	16,429	22,385	535	Mount Seorak National Park	37,300		94.8%
Jeju Island	2002	terrestrial and marine	83,094	15,158	14,601	53,335	Mount Halla National Park + Hallasan National Park	14,900		17.9%
Shinan Dadohae	2009	marine					Dadohae National Park	232,151		#DIV/0!
Sary-Chelek	1978	terrestrial	23,868	18,080		2,394	Sary Chelek National Park	23,868		100.0%
Issyk Kul	2001	terrestrial and freshwater	4,311,588	145,072	3,501,516	665,000	2 national preserves, 1 national park, and 5 game reserves	295,023		6.8%
Tasik Chini	2009	freshwater	6,952	6,415		537	no protected area found	0		0.0%
Utwe	2005	marine	1,773	96	517	1,159	Utwe-Walung Marine Park	1,850		104.3%
And Atoll	2007	marine	950	115	220		And Atoll Area of Biological Significance	0		0.0%
Great Gobi	1990	terrestrial	5,300,000	985,000	3,172,200	1,142,800	Various strictly protected areas	5,221,000		98.5%
Boghd Khan Uul	1996	terrestrial	67,300	41,651	13,433	12,216	Bogd Khan Uul Strictly Protected Area	41,651		61.9%
Uvs Nuur Basin	1997	terrestrial	771,700	366,080	405,620		Mongun Taiga, Aryskannyg, Yamaalyg, Tsugeer els, Ular, Tsagan Shuvuut, Turgen, Uvs Nuur and Altan els Reserves	1,068,854		138.5%
Hustai Nuruu	2002	terrestrial	778,000	50,000	350,000	378,000	Hustai National Park (area not entirely clear)	120,000		15.4%
Dornod Mongol	2005	terrestrial	8,429,072	570,374	1,072,221	6,786,477	Dornod Mongol Preserve	570,374		6.8%
Mongol Daguur	2007	terrestrial	732,000	51,400	51,600	629,000	Mongol Daguur Preserve	103,016		14.1%
Lal Suhanra	1977	terrestrial	65,791	17,935	47,856		Lal Suhanra National Park	31,355		47.7%
Ngaremeduu	2005	marine	13,674	210	13,085	379	Ngaremeduu Conservation Area	12,960		94.8%
Puerto Galera	1977	terrestrial and marine	23,247				proposed Iraya Mangyan Ancestral Domain Watershed Forest Reserve - status unclear	0		0.0%
Palawan	1990	terrestrial	1,150,800	55,625	636,550	458,625	several protected areas and game reserves, area unclear	246,017		21.4%

Name MAB	Year of establishment	Main Biome	Area of BR (ha)	Area of Core Zone (ha)	Area of Buffer Zone (ha)	Area of Transition Zone (ha)	Name of Protected Area	Area protected (ha)	Remarks	Percentage of BR protected
Hurulu	1977	terrestrial	25,500				Hurulu Forest Reserve	25,218		98.9%
Sinharaja	1978	terrestrial	11,187				Sinharaja National Heritage Wilderness Area	11,187		100.0%
Kanneliya-Dediyagala-Nakiyadeniya (KDN)	2004	terrestrial	20,139	5,139	5,000	10,000	Kanneliya, Dediyagala, and Nakiyadeniya Forest Reserves	9,714		48.2%
Bundala	2005	terrestrial and marine	24,838	6,218	8,568	10,052	Bundala National Park	6,216		25.0%
Sakaerat	1976	terrestrial	82,100				Sakaerat Environmental Research Station	5,800		7.1%
Hauy Tak Teak	1977	terrestrial	4,700				Huai Tak Teak Reserve in Ngao Demonstration Forest	4,700		100.0%
Mae Sa-Kog Ma	1977	terrestrial	42,064				Doi Suthep-Pui National Park	26,106		62.1%
Ranong	1997	terrestrial and marine	29,936	19,148	4,279	6,509	Njao and Laem Son National Park	31,500		105.2%
Repetek	1978	terrestrial	34,600				Repetek Reserve	34,600		100.0%
Mount Chatkal	1978	terrestrial	57,360	45,160	12,200		Chatkal National Park	57,360		100.0%
Can Gio Mangrove	2000	terrestrial and marine	75,740	4,721	41,139	29,880	unclear whether the core is officially protected	4,721		6.2%
Cat Tien	2001	terrestrial	257,357	73,878	169,269	14,210	Cat Tien National Park	71,920		27.9%
Cat Ba	2004	terrestrial and marine	26,241	8,500	7,741	10,000	Cat Ba National Park	15,200		57.9%
Red River Delta	2004	terrestrial and marine	137,261	14,842	36,951	85,468	Xuan Thuy National Park + Tien Hay Nature Reserve	27,600		20.1%
Kien Giang	2006	terrestrial	1,118,105	36,935	172,578	978,591	U Minh Thuong National Park, the Phu Quoc National Park, and Kien Luong-Kien Hai	39,931		3.6%
Western Nghe An	2007	terrestrial	1,303,285	191,922	503,270	608,093	Pu Mat National Park	91,113		7.0%
Mui Ca Mau	2009	freshwater	371,506	17,329	43,309	310,868	Mui Ca Mau National Park and U Minh Thuong National Park	49,915		13.4%
Cu Lao Cham – Hoi An	2009	terrestrial	33,146	2,471	8,455	22,220	Cu Lao Cham Nature Reserve	1,535		4.6%

Appendix 3.

Detailed methodology

The value of counterfactuals. Comparing biosphere reserves to non-biosphere reserves to assess their contribution to conservation and sustainable development

There are various direct and indirect causes of declining environmental or socio-economic values. The complex interactions between threats and values makes it difficult to determine what strategy is most suitable for any particular threat. The situation is not helped by the fact that there are few scientific evaluations of conservation programs that could potentially elucidate relationships between conservation strategies and conservation goals. This lack of monitoring data appears to exist for biosphere reserve as much as it does for other conservation and development strategies. To better understand what biosphere have and haven't achieved, it is therefore important to increase scientific monitoring and evaluation, as is recognized in UNESCO's Madrid Action Plan for Biosphere Reserves (UNESCO 2009). This is especially important when certain tools have been used for a long time, without their being a good understanding of how effective they actually are in achieving their goals. Biosphere reserves are one of them. They have been around for over 3 decades but how much do we actually know about the extent to which they reach their social and environmental goals. Here various measures are tested to see what they can show us about the performance of biosphere reserves.

Deciding what type of measure is required is important for successful implementation. Monitoring data and indicators should not be gathered with a vague hope that somehow they will prove useful for conservation. Instead, monitoring needs to identify precisely the information needed to make conservation decisions (Nichols & Williams 2006). A clear understanding is needed of the relationship between conservation and socio-economic goals and the direct and indirect factors that influence the extent to which those goals are reached. Once this is known, an appropriate indicator can be selected as a measure of conservation success. For example, a reduction in fish stocks may be caused by over-fishing, loss of suitable spawning areas, climate change, or disease. Measuring fish stocks before and after a particular conservation intervention, such as the establishment of no-take zones, indicates that the overall goal of that intervention, e.g., no further losses in fish stocks, has been achieved, but it is unclear whether that was caused by the conservation intervention (i.e. the no-take area). The effectiveness of a conservation intervention would be much clearer if other factors such as fish take-off levels, quality and area of spawning sites, sea temperatures, and occurrence of fish disease were also measured. Multivariate analysis can then determine which variable correlates best with the reduced decline in fish stocks. In data-poor areas, or areas with limited science capacity, multivariate approaches may be methodologically difficult. This can result in estimates with large standard errors, making it hard to figure out cause-effect relationships.

Another problem in monitoring of conservation effectiveness is that rigorous measurement of counterfactual evidence, i.e., the outcome that would have happened if there had been no conservation intervention, is almost nonexistent in the conservation literature (Ferraro & Pattanayak 2006). For example, would fish stocks have recovered even if there had been no conservation action? Often conservation organizations assume that the cause-effect relationships are clear and that the most effective ways to deal with declines in conservation value are obvious.

This study addresses some of the short-comings of conservation effectiveness studies in our analysis of the Biosphere Reserve network in the Asia-Pacific region. It presents a preliminary analytical framework that addresses the following questions:

1. How effective are Biosphere Reserves compared to ordinary protected areas in achievement their environmental and socio-economic goals?

2. Have Biosphere Reserves been an effective agent in carrying out their three functions? :
   - a conservation function - to contribute to the conservation of landscapes, ecosystems, species and genetic variation;
   - a development function - to foster economic and human development which is socio-culturally and ecologically sustainable;
   - a logistic function - to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development.

3. To what extent have biosphere reserves been the focus of Climate Change discussions?

The time available for this study was such that it was impossible to provide detailed answers regarding the effectiveness of all biosphere reserves in the region. A sub-sample of the biosphere reserves was therefore used and the present analysis should be seen as a pilot study for how more detailed and broader reaching analysis could be conducted.

Analysis of representation of biosphere reserves on the World Wide Web

As a measure of how well known biosphere reserves are among the general public and, more specifically, among researchers, two simple internet-based searches were conducted. For each of the biosphere reserve areas on Asia-Pacific list the value of two indicators was assessed:

1. International recognition. This was determined with Google searches. For each biosphere reserve the search terms “name of the biosphere reserve” + “Biosphere Reserve” were entered, and the number of hits per search noted.
2. Interest of the global research community. This was determined for each biosphere reserve using Google Scholar (http://scholar.google.com/). Google Scholar provides a simple way to broadly search for scholarly literature. It allows searches across many disciplines and sources, including peer-reviewed papers, but also theses, books, and reports. For each biosphere reserve, I entered the search terms “name of the biosphere reserve” + “Biosphere Reserve”, and requested return articles in all subject areas.

Results were scrutinized for geographic patterns to see whether any countries or biosphere reserves stood out with regard to representation on the World Wide Web.

To assess whether the Biosphere Reserve label boosted the recognition of protected areas compared to non-biosphere reserve protected areas, the Google and Google Scholar analyses were repeated using a randomly generated sample of non-biosphere reserve protected areas for comparison. This was done for three randomly selected countries: Australia, South Korea and Vietnam to see whether such an analysis would provide useful insights.

Quantitative assessment of Biosphere Reserve areas

Information on the surface area of biosphere reserves, as well as the surface area of Core, Buffer, and Transitional zones, was obtained from the UNESCO website (accessed in August and September 2009). To find surface areas of protected areas contained in the biosphere reserve, the following approach was followed:

1. If the UNESCO website provided any names of PAs and links to official institutions, these were used as primary source. If available, the management plans (e.g., Australia) were downloaded. Contents of official websites and management plans were scanned to find any other protected areas that may also be situated in the biosphere reserve. If a source references a surface area from the UNESCO website, it was tried to find another source, unless it is clear that the biosphere reserve was indeed congruent with the PA.

2. If official sources were not available or not accessible (a common problem in, for example, Chinese sites because of a different script and language), Wikipedia was used in combination with a source that was directly involved in the area (for example an environmental NGO such as WWF or a scientific paper presenting research on the area). Also the searchable database for Important Bird Areas at Birdlife International provided a useful and apparently accurate data source. Where surface areas differed the estimate from the source that seemed most authoritative was used. For larger biosphere reserves with many containing PAs, the Internet was searched until we felt confident that most Pas had been captured (typically within a one hour search time).

3. If (1) and (2) failed, but if Wikipedia or another authoritative source presented a formal PA with the same name as the biosphere reserve it was assumed that the biosphere reserve and the PA were congruent. This often happened with Chinese biosphere reserves, where there are often corresponding PAs with designation “National Nature Reserve” or “Nature Reserve”.

4. If (1), (2) and (3) failed the surface area was reported as missing. No surface area estimates were used from travel or news websites.

Note that the World Database on Protected Areas was not used for reasons explained earlier in this report [data quality, and furthermore WDPA by default considers biosphere reserves as PAs]

It is emphasize that the results present here can only be used to investigate overall patterns in surface area of biosphere reserves vs. surface area of containing PAs, they cannot be used to do more detailed analysis within biosphere reserves.

Score card analysis

Because Biosphere Reserves include both land and marine protected areas, a scorecard was used that applies to both biomes, and because this assessment was restricted to information published on the internet, the scorecard was kept as simple as possible. The scorecard used in this assessment is based on the one developed by the World Bank for Marine Protected Areas (Staub & Hatziolos 2004). The World Bank scorecard was based on a scorecard developed by the World Bank - WWF Alliance (Stolton et al. 2003) and from other tools (Hockings et al. 2000; Mangubhai 2002), which applied to land protected areas. The version by Stolton et al. (2003) was updated in 2007 as the Management Effectiveness Tracking Tool, second edition (WWF 2007). Like its predecessor, this updated version pertained to land protected areas, and it added detail on threat assessment. Generally speaking, the WWF 2007 scorecard requires more detail than the Marine Protected Area scorecard, which is why the scorecard used for this assessment resembles the marine scorecard more closely than the WWF 2007 scorecard.

Some important differences between the World Bank 2004 scorecard and the WWF 2007 scorecard are:

- The WWF 2007 scorecard does not have questions on recent (past three years) progress.
- The WWF 2007 scorecard does not have questions on level of compliance or on stakeholder perceptions

The World Bank 2004 scorecard was adapted as follows:

- Questions on recent (past three years) progress were omitted (questions 20 and 21)
- Questions on the level of user compliance with PA regulations (question 33) and on stakeholder perceptions (question 7 and 34) were omitted. These questions require estimation of a percentage (e.g. percentage of stakeholders that is satisfied with PA process and outputs, and this information is only rarely published.

Normally the score cards are filled in through interviews with key stakeholders in the protected area management. Tracking down those stakeholders, getting them to agree to interviews, and then interviewing them is very time consuming. Because of these time considerations it was decided to use a different approach. Score cards were filled in using internet-based searches regarding the questions in the score card. For each protected area/biosphere reserve a maximum amount of time was set that could be spent searching for information about a particular area. A trial indicated that 60 search minutes per area gave us a good balance between level of detail with which the score cards could be filled in, and the number of biosphere reserves and non-biosphere reserves that could thus be analyzed within the allotted time. This obviously means that many aspects of biosphere reserve management could not be assessed in detail. Again, this is justified because this assessment is a pilot only to see whether score-card based analyses could be used more widely in the assessment of biosphere reserve management effectiveness.

Geographic stratification and area selection for score card analysis

A list of all biosphere reserves in Asia-Pacific from UNESCO website was downloaded from: http://www.unesco.org/mab/doc/brs/Asia.pdf, which lists 110 biosphere reserves in 28 countries (see Appendix 1).

Because biosphere reserve management was expected to differ between the richer and poorer countries in the region, the Biosphere Reserves were stratified by GDP per capita, for which the following sources were used: The list from the International Monetary Fund (2008), and the CIA World Factbook (2008) for the estimated values from the Democratic People's Republic of Korea, the Federates States of Micronesia, and Palau. The cutoff point between richer and poorer countries was taken at 20,000 US$, which separates Australia, South Korea, and Japan from the rest. China was treated as a separate case because it has a much larger number of biosphere reserves (26) than any of the other countries. Thus three biosphere reserves were randomly selected in the three strata: Yathong BR in Australia, Baotianman BR in China, and Bundala BR in Sri Lanka.

Forest cover change analyses of selected biosphere reserves

To assess the effectiveness of biosphere reserves in reducing deforestation we used an existing data set of forest cover change in and outside of protected areas (Mulligan 2008), and tested these for several biosphere reserves in the forested parts of the Asia-Pacific region. The Mulligan analysis is based on the raw datasets created by Hansen and colleagues (Hansen et al. 2006; Hansen et al. 2003)

Appendix 4.

Score card questions

Process Element			
A. Context	Q	**1a. Legal status of protected area(s) inside biosphere reserve**	
	A	0 - Not gazetted 1 - Government agrees to gazet, but process not yet started	2 – Process towards gazettement started, but not completed 3 - Gazettement completed
	Q	**1b. (Inter-)national recognition as judged by a Google score**	
	A	0 - 0 - 10,000 hits 1 - 10,000 - 25,000 hits	2 - > 25,000 hits
	Q	**2. Mechanisms for enforcement?**	
	A	0 - There are no mechanisms (no zoning) 1 - Zoning exists, but there is no enforcement.	2 - Zoning exists, but enforcement is insufficient 3 - Zoning exists, and there is sufficient enforcement
	Q	**3a. Resources for enforcing regulations?**	
	A	0 – Management unit has no resources 1 – Management unit has extremely limited resources	2 – Management unit has acceptable, but still insufficient resources 3 – Management unit has sufficient resources
	Q	**3b. Additional controls (communities, NGOs, etc.)?**	
	A	0 - No	1 - Yes
	Q	**3c. Legal prosecution?**	
	A	0 - No	1 - Yes
	Q	**4. Boundaries and demarcation?**	
	A	0 - Boundaries are unknown by management authority and stakeholders 1 - Boundaries are known by management authority, but not by stakeholders	2 - Boundaries are known, but they are not demarcated 3 - Boundaries adequately demarcated
	Q	**5a. Biosphere reserve is part of a land use / coastal management plan?**	
	A	0 - Inclusion in a land use / management plan is not discussed 1 - There are discussions, but process is not yet started	2 – Process has been started, but is incomplete 3 - Biosphere reserve is plan of a coastal management plan
	Q	**5b. Biosphere reserve is part of an ecological network?**	
	A	0 - No	1 - Yes
	Q	**5c. Biosphere reserve is part of a representative network?**	
	A	0 - No	1 - Yes
	Q	**6. Knowledge of biophysical and socio-economical conditions?**	
	A	0 - Little or none 1 - Insufficient	2 - Sufficient, but not regularly updated 3 - Sufficient, and regularly updated
	Q	**7. Percentage of stakeholders concerned about biosphere reserve issues?**	
	A	0 - 0 - 25% 1 - 25 - 50%	2 - 50 - 75% 3 - 75 - 100%
B. Planning	Q	**8. Objectives?**	
	A	0 - Objectives were not yet formulated 1 - Objectives were agreed upon, but they are not implemented	2 - Objectives were agreed upon, and they are partially implemented 3 - Objectives were agreed upon, and they are fully implemented
	Q	**9a. Management plan?**	
	A	0 - Plan was not yet formulated 1 - Plan is (nearly) completed, but is not implemented	2 - Plan exists, and is partially implemented 3 - Plan exists, and is fully implemented

Process Element			
B. Planning	Q	9b. Is there is a long-term plan in addition to a short-term plan?	
	A	0 - No	1 - Yes
	Q	9c. Is there stakeholder involvement in management planning?	
	A	0 - No	1 - Yes
	Q	9d. Are stakeholders properly represented (gender, ethnic, etc.)	
	A	0 - No	1 - Yes
	Q	9e. Are socio-economic effects considered in the planning process?	
	A	0 - No	1 - Yes
	Q	9f. Are cultural aspects considered in the planning process?	
	A	0 - No	1 - Yes
	Q	9g. Is there a periodic review of the management plan?	
	A	0 - No	1 - Yes
	Q	9h. Are results from monitoring and evaluation routinely considered in management planning?	
	A	0 - No	1 - Yes
	Q	9i. Does the management plan address enforcement of protected area regulations?	
	A	0 - No	1 - Yes
C. Inputs	Q	10a. Is there research and surveying?	
	A	0 - No 2 - Yes, but it is not oriented to management support	1 - Yes, but ad-hoc only 3 - Yes, and it directly informs management
	Q	10b. Were carrying capacity studies conducted to establish sustainable use levels?	
	A	0 - No	1 - Yes
	Q	11a. Are human resources available for biosphere reserve management sufficient?	
	A	0 - There is no staff 1 - HR are far from sufficient for critical management tasks	2 - HR are sub-optimal for critical management tasks 3 - HR are adequate
	Q	11b. Are there additional resources besides those from the technical management unit (communities, NGOs, etc.)	
	A	0 - No	1 - Yes
	Q	12a. Is the current budget sufficient?	
	A	0 - There is no budget for management of the biosphere reserve 1 - There is a budget, but it is far from sufficient	2 - The budget is almost sufficient 3 - The budget is sufficient for effective biosphere reserve management
	Q	12b. Is the budget secured for multiple years?	
	A	0 - No	2 - Yes
	Q	12c. Is the budget from government only, or are there other sources (NGOs, fees) as well?	
	A	0 - Only from government	1 - There are additional sources of funding
D. Process	Q	13a. Is there an education and awareness program?	
	A	0 - No 2 - Yes, and it is planned, but there are some gaps	1 - Yes, but it is limited and unplanned 3 - Yes, and it is sufficient for the needs of the biosphere reserve

Process Element			
D. Process	Q	**14a. Is there communication between stakeholders and biosphere reserve managers?**	
	A	0 - Little or none 1 - Yes, but it is insufficient and unplanned	2 - Yes, there is a communications plan, but it is only partly implemented 3 - Yes, there is a fully implemented communications plan
	Q	**14b. Is there communication with other reserve managers?**	
	A	0 - No	1 - Yes
	Q	**15a. Do stakeholders have meaningful input on management decisions?**	
	A	0 - No 2 - Direct, but not in all management decisions	1 - Some, but not directly 3 - Stakeholders directly influence all important management decisions.
	Q	**15b. Are there agreements to share tourism revenues between operators and local communities?**	
	A	0 - No	1 - Yes
	Q	**16. Do indigenous and traditional peoples have input on management decision?**	
	A	0 - No 2 - They influence some decisions	1 - They participate in discussions, but they do not influence decisions 3 - They influence all important decisions
	Q	**17 . Is there enough training for staff?**	
	A	0 - Staff are untrained and unskilled. 1 - There is little training and staff skills are inadequate	2 - Training and skills are almost sufficient 3 - Training and skills are sufficient for management now and in the future
	Q	**18. Is the biosphere reserve adequately equipped?**	
	A	0 - There are little or no facilities and equipment 1 - There are some facilities and equipment, but they are inadequate	2 - Equipment and facilities are almost sufficient 3 - Equipment and facilities are sufficient and they are well-maintained
	Q	**19a. Are biophysical, socio-economical, and governance indicators monitored and evaluated?**	
	A	0 - No 1 - There is some ad-hoc monitoring, but there is no routine program	2 - There is a routine monitoring program, but results are under-utilized 3 - Yes, and results are used for adaptive management.
	Q	**19b. Does the biosphere reserve participate in (inter-)national monitoring initiatives?**	
	A	0 - No	1 - Yes
	Q	**19c. Is there capability to respond to unanticipated threats?**	
	A	0 - No	1 - Yes
E. Outputs	Q	**20a. Did legal status improve?**	
	A	0 - No	1 - Yes
	Q	**20b. Did regulations improve?**	
	A	0 - No	1 - Yes
	Q	**20c. Did law enforcement improve?**	
	A	0 - No	1 - Yes
	Q	**20d. Did boundary demarcation improve?**	
	A	0 - No	1 - Yes
	Q	**20e. Have steps been taken to integrate the biosphere reserve in a land use / coastal management plan?**	
	A	0 - No	1 - Yes

Process Element			
E. Outputs	Q	**20f. Do we know more about biophysical and socio-economical conditions?**	
	A	0 - No	1 - Yes
	Q	**20g Did concern for the biosphere reserve improve among stakeholders?**	
	A	0 - No	1 - Yes
	Q	**21a. Have signs been improved?**	
	A	0 - No	1 - Yes
	Q	**21b. Have eco-tourism trails / mooring buoys been installed?**	
	A	0 - No	1 - Yes
	Q	**21c. Has availability of education materials been improved?**	
	A	0 - No	1 - Yes
	Q	**22. Are mechanisms for stakeholder participation available?**	
	A	0 - No 1 - Some, but insufficient	2 - Yes
	Q	**23. Have environmental education activities been developed for stakeholders?**	
	A	0 - No 1 - Some, but insufficient	2 - Yes
	Q	**24. Have the two critical management activities been implemented?**	
	A	0 - No 1 - To some extend	2 - Yes, fully
	Q	**25. Does the biosphere reserve have sufficient visitor facilities?**	
	A	0 - No, there are no visitor facilities 1 - Yes, but facilities are insufficient or they are still under construction	2 - Yes, and they are almost sufficient 3 - Yes, and they are fully sufficient
	Q	**26. Do user fees directly support biosphere reserve management?**	
	A	0 - A fee system exists, but fees are not collected yet. 1 - Fees are collected, but revenues go to a central government agency.	2 - Fees are collected, but revenues go to a local government agency 3 - Fees are collected and directly contribute to the MPA budget
	Q	**27. Were staff trained?**	
	A	0 - No 1 - Yes, but insufficiently	2 - Yes, but more training would have further improved management 3 - Yes, and training was optimal
F. Outcomes	Q	**28 Have the two primary management objectives (see datasheet) been addressed?**	
	A	0 - No 1 - Yes, to some extend	2 - Yes, sufficiently 3 - Yes, significantly
	Q	**29. Have the two most important threats (see datasheet) been reduced?**	
	A	0 - No, threats have increased 1 - No, threats have stabilized	2 - Yes, to some extend 3 - Yes, significantly
	Q	**30. Have resource conditions (see datasheet) improved?**	
	A	0 - No, conditions have declined 1 - No, conditions remained the same	2 - Yes, to some extend 3 - Yes, significantly
	Q	**31a. Has community welfare improved?**	
	A	0 - No, welfare has declined 1 - No, welfare remained the same	2 - Yes, to some extend 3 - Yes, significantly
	Q	**31b. Is biosphere reserve management compatible with local culture?**	
	A	0 - No	1 - Yes
	Q	**31c. Have resource conflicts reduced?**	
	A	0 - No	1 - Yes

Process Element						
F. Outcomes	Q	**31d. Are benefits from the biosphere reserve equitably distributed?**				
	A	0 - No		1 - Yes		
	Q	**31e. Have non-monetary benefits for the biosphere reserve been maintained or enhanced?**				
	A	0 - No		1 - Yes		
	Q	**32. Has community environmental awareness improved?**				
	A	0 - No, awareness has declined 1 - No, awareness remained the same		2 - Yes, to some extend 3 - Yes, significantly		
	Q	**33. Which percentage of users complies with biosphere reserve regulations?**				
	A	0 - 0 - 25%	1 - 25 - 50%	2 - 50 - 75%	3 - 75 - 100%	
	Q	**34. Which percentage of stakeholders are satisfied with the process and outputs of the biosphere reserve?**				
	A	0 - 0 - 25%	1 - 25 - 50%	2 - 50 - 75%	3 - 75 - 100%	

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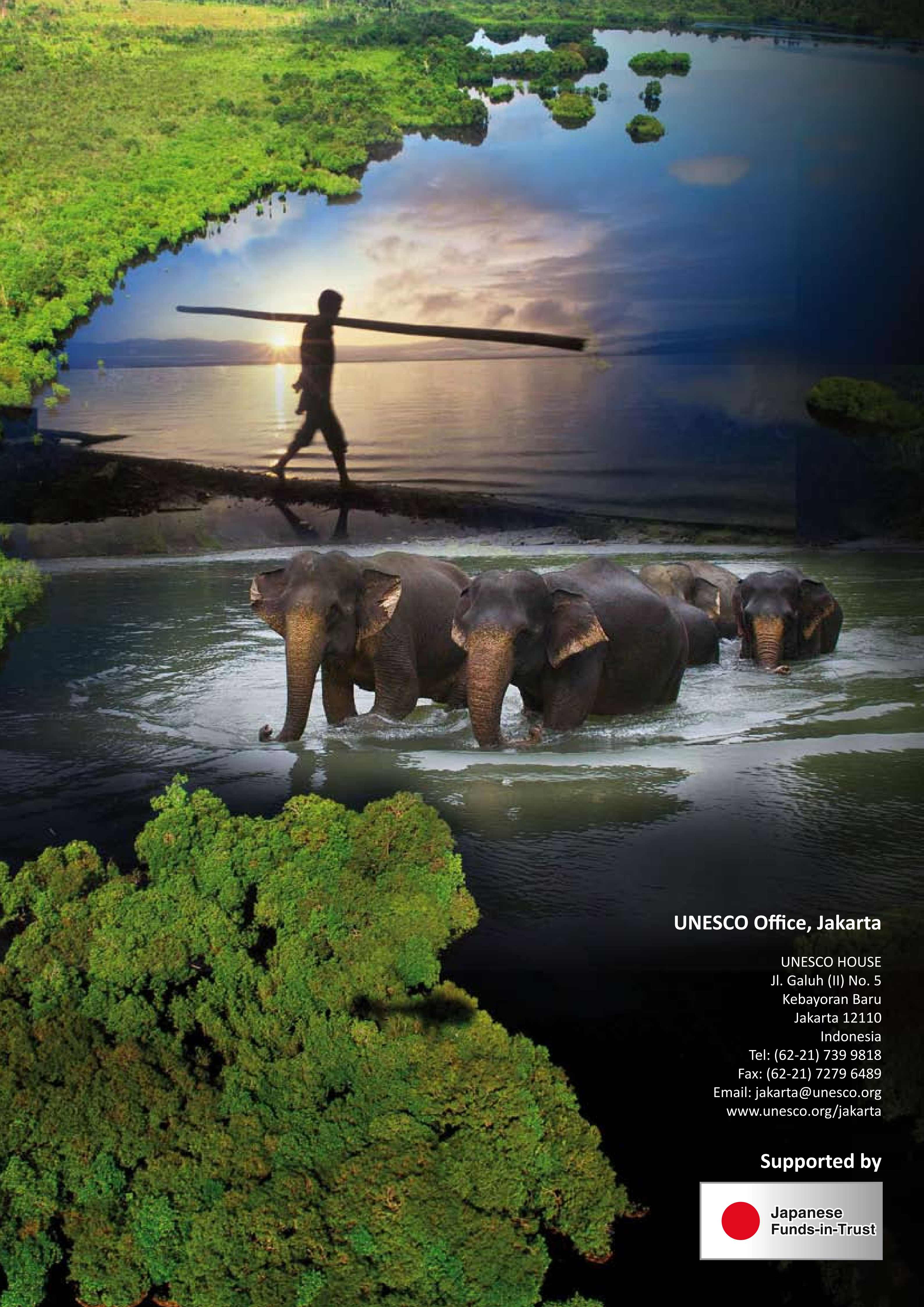

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