Feasibility Assessment for Developing Conservation Corridors in the Kangchenjunga Landscape

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Effective management of protected areas relies on connectivity between separated areas and maintenance of the area surrounding PAs, which together ensure that a wider conservation complex is established suitable for long-term sustainability of ecological processes.

Introduction

Fragmentation of habitats is one of the most commonly cited threats to species' survival and causes loss of biological diversity, making it perhaps the most important contemporary conservation issue (Fuller et al. 2006). Over the previous decades, it has become generally accepted that spatial configuration of a habitat plays a crucial role in the conservation of biodiversity. Connecting a good patch to neighbouring patches lowers the extinction risk of the population. In heavily fragmented landscapes, species are only likely to survive within networks of patches that are sufficiently connected by dispersing individuals (Bennett 2003). A direct assessment of landscape connectivity must, therefore, incorporate aspects of movement of organisms through the landscape. Connectivity of habitat patches within a landscape has thus become a key issue in the conservation of biodiversity. Connectivity is a key concept of landscape ecology as it relates to flows and movements of organisms driven by landscape structure (Haddad et al. 2003). Several authors have promoted the idea that 'connectivity' of a landscape depends not only on the distance between habitat patches, but also on the presence of corridors and stepping stones and on the resistance of the surrounding matrix. In fragmented and heterogeneous landscapes, movement is a key process in the survival of plants and animals (Bennett 2003; Haddad et al. 2003; Dixon et al. 2006). Addressing fragmentation is one of the central concerns in the activities associated with the introduction of a landscape approach to support biodiversity conservation in the Kangchenjunga region (Sharma et al. 2007).

The proposed Kangchenjunga landscape is one of the richest landscapes in Asia; it is shared by Nepal, Bhutan, India, and China (Yonzon et al. 2000; WWF and ICIMOD 2001) and is a part of the Himalayan biodiversity hotspot, one of 34 hotspots in the world (Mittermeier et al. 2004). The part within Bhutan, India, and Nepal is situated between 87°40' and 89°19' N and 27°35' to 27°48' E, and covers an area of 14,432 sq.km from eastern Nepal through the Kangchenjunga region in Sikkim and Darjeeling in India to Toorsa Strict Nature Reserve (TSNR) in western Bhutan. There are 14 protected areas covering 6,032 sq.km within the landscape. Protected areas within reserves are essential for conserving biodiversity, but are often small and geographically scattered as 'conservation islands' (Table 1). Human-induced modifications such as monocultural farming, clear-cut forestry, and expanding urban developments (to name just a few) have rapidly altered the biodiversity levels of flora and fauna in the landscape. These alterations to the environment made the landscape more hospitable to aggressive species that could tolerate and even thrive in such disturbed habitats, in turn, reducing the amount of endemic flora and fauna and furthering the reduction of species. During the last four years of extensive research and consultation, the initiative identified potential conservation corridors (Sharma and Chettri 2005) and local and transboundary conservation and development issues (Chettri and Sharma 2006), and developed strategies for landscape planning that address potential social, economic, and political perspectives for developing corridors and the landscape (Chettri and Sharma 2006). This paper emphasises the participatory processes followed and the outputs of such processes in conceptualising corridors between the existing protected areas within the landscape.

The Corridor Concept

Corridors, as a conservation model, have gained acceptance over the past few years. The spatial scale of a corridor can range from very small to large in terms of the ground area covered. Many globally-threatened animals found in the Kangchenjunga landscape, such as the snow leopard (*Uncia uncia*), red panda (*Ailurus fulgens*), clouded leopard (*Neofelis nebulosa*), tiger (*Panthera tigris*), and takin (*Budorcas taxicolor*), are extremely susceptible to the effects of habitat fragmentation because of low population densities, wide-ranging movements, and the potential for conflicts with humans. The present protected area in the Kangchenjunga landscape is not enough for these charismatic species, however, and they use areas outside the existing protected areas as their habitat (CEPF 2005).

Table 1: **Protected areas in the Kangchenjunga landscape**		
Protected Area	**Location**	**Area (sq.km)**
Kangchenjunga Conservation Area (KCA)	Taplejung, Nepal	2035
Khangchendzonga Biosphere Reserve (KBR)	Sikkim, India	2620
Barsey Rhododendron Sanctuary (BRS)	Sikkim, India	104
Fambong Lho Wildlife Sanctuary	Sikkim, India	52
Kyongnosla Alpine Sanctuary	Sikkim, India	31
Mainam Wildlife Sanctuary (MWS)	Sikkim, India	35
Singhba Rhododendron Sanctuary (SRS)	Sikkim, India	43
Pangolakha Wildlife Sanctuary	Sikkim, India	128
Jorepokhari Salamander Sanctuary	Darjeeling, India	0.4
Singhalila National Park (SNP)	Darjeeling, India	79
Senchel Wildlife Sanctuary (SWS)	Darjeeling, India	39
Mahananda Wildlife Sanctuary (MaWS)	Darjeeling, India	127
Neora Valley National Park (NVNP)	Darjeeling, India	88
Toorsa Strict Nature Reserve (TSR)	Bhutan	651
Total		**6032**

To be effective in the long term, the conservation of biodiversity on private and public lands needs to be addressed by integrated regional programmes (Dixon et al. 2006). The conservation value of reserves will increase significantly if they can be linked by environmentally-managed corridors beyond political boundaries. In addition to linking existing pieces of remnant vegetation and providing for wildlife movement, 'conservation corridors' can reduce soil and water degradation, provide a source of timber, provide shelter for stock, and contribute to recreational activities and tourism (Rouget et al. 2006).

Biological corridors can eliminate problems associated with island biogeography. These so-called 'islands' are created when distinct areas are placed into an environmental management plan while the surrounding environment is subject to the deleterious effects of human-induced pressures of non-management. The corridors proposed for the Kangchenjunga landscape connect individual protected places in order to place the management zone in a broader context.

The Strategic Process

During the last two decades, ICIMOD has been instrumental in developing consensus among various stakeholders on the need for transboundary landscapes and development of conservation corridors in the Southern part of the Kangchenjunga landscape, which covers parts of eastern Nepal, Darjeeling and Sikkim in India, and western Bhutan (Rastogi et al. 1997; WWF and ICIMOD 2001; Sharma and Chettri 2005; Chettri and Sharma 2006). The genesis of the process is illustrated in Figure 1. The initiative was inspired by a decision from the Conference of Parties (COP 7) to the convention on Biological Diversity (CBD) that recommended an 'ecosystem approach' to biodiversity conservation, and was inspired and guided by the conservation corridor development process (Sanderson et al. 2003) and systematic planning (Margules and Pressey 2000). Based on these guiding principles, we followed strategic criteria (see Sharma and Chettri 2005) to identify this key transboundary complex and develop a process for achieving the CBD decision.

Consultation, participatory tools and approaches, and action research for baseline information were used to develop awareness of the need for and importance of developing conservation corridors within the landscape. The use of geographical information systems (GIS) and remote sensing (RS) tools to locate and facilitate spatial contexts became instrumental in delineating the proposed corridors. Corridors were identified by analysing forest cover, biodiversity status, species' presence and movement patterns, and potential connectivity, thereby identifying the 'gaps' in management (Figure 2).

Results

The criteria for corridor identification were based on the 'compatible land' found in the area. Initially, participatory research was carried out based on local knowledge from farmers, conservationists, and civil society. This showed that there was an adequate area of compatible land available covered with forests to develop corridors. The strategic process identified six potential corridors in the landscape: i) a corridor in eastern Nepal adjacent to the Khangchendzonga Biosphere Reserve (KBR) and Barsey Rhododendron Sanctuary (BRS) in Sikkim, India; ii) a corridor linking Singhalila National Park (SNP) and Senchel Wildlife Sanctuary (SWS), iii) a corridor linking SWS and Mahananda Wildlife Sanctuary (MWS), iv) a corridor linking MWS and Neora Valley National Park (NVNP), all in Darjeeling, India; v) a corridor linking NVNP and Toorsa Strict Nature Reserve (TSNR), and vi) a corridor linking Toorsa Strict Nature Reserve and Jigme Dorji National Park (JDNP), both in Bhutan.

The land-cover analysis showed that about 42% of the proposed landscape was already protected in some way; a further 11% of the land was proposed to be included in conservation corridors. The area identified as potential corridors is covered by community, reserve, and other forest; agricultural land; and pasture. Land-use cover analysis showed two-thirds (67%) of the area is under natural forests and about 18 % of the corridors are still under compatible land-use classes such as cardamoms, cinchona, tea gardens, and broom-grass cultivation (Table 2). The natural forests have contiguous forest patches that connect tropical to alpine zones. The forests are of a diverse type, however, especially in terms of tenure and land rights (Table 2). This diversity is mainly a result of land-use practices and the socio-political differences amongst the three countries. The proposed corridor in Nepal is mainly covered with private forests and agroforestry systems, whereas those in India and Bhutan are mainly covered by reserve forest under government ownership. There is great potential for connecting the existing protected areas in the landscape by enhancing compatible land use in the corridors.

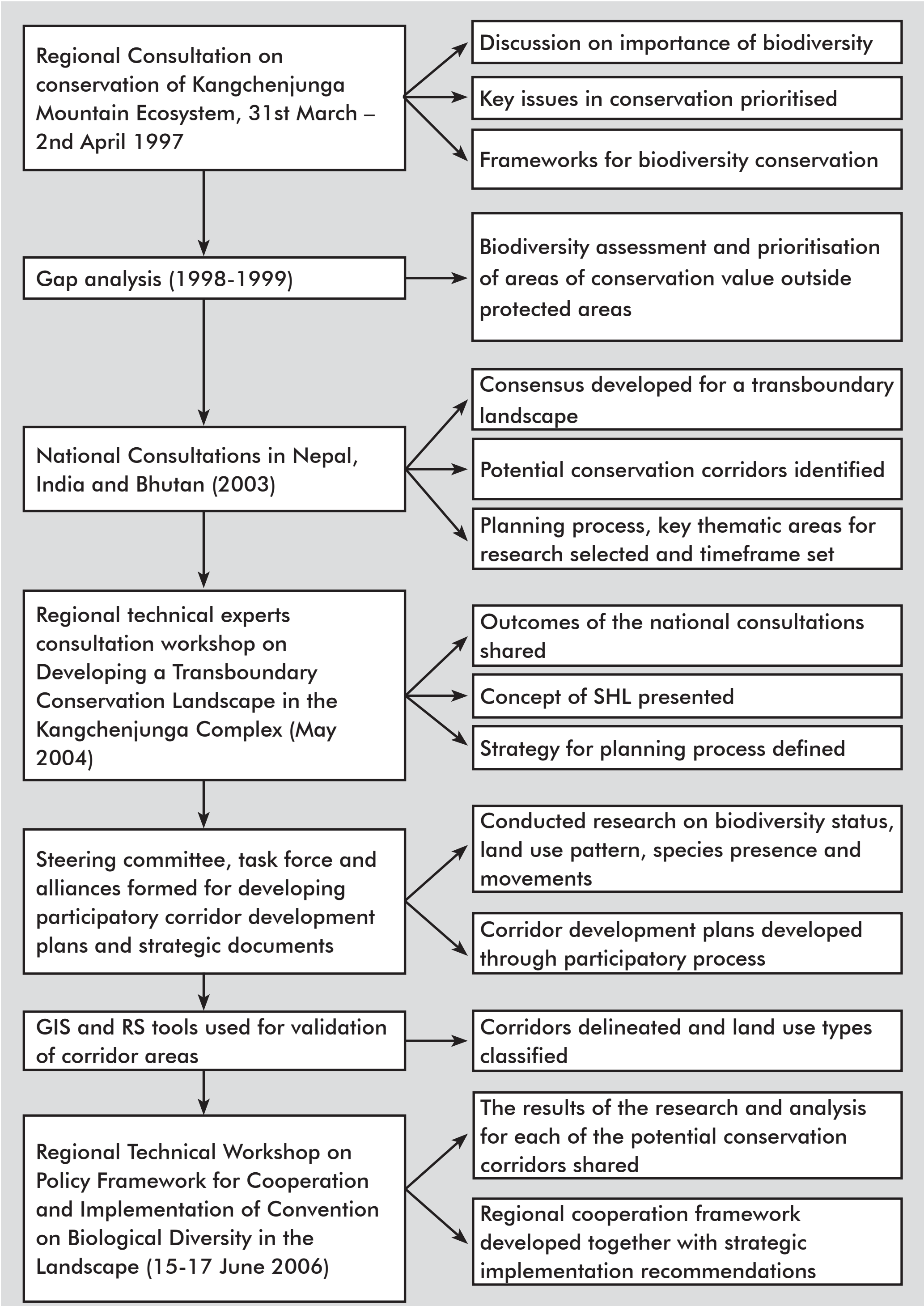

Figure 1: Chart showing the process adopted in the development of the Kangchenjunga landscape concept

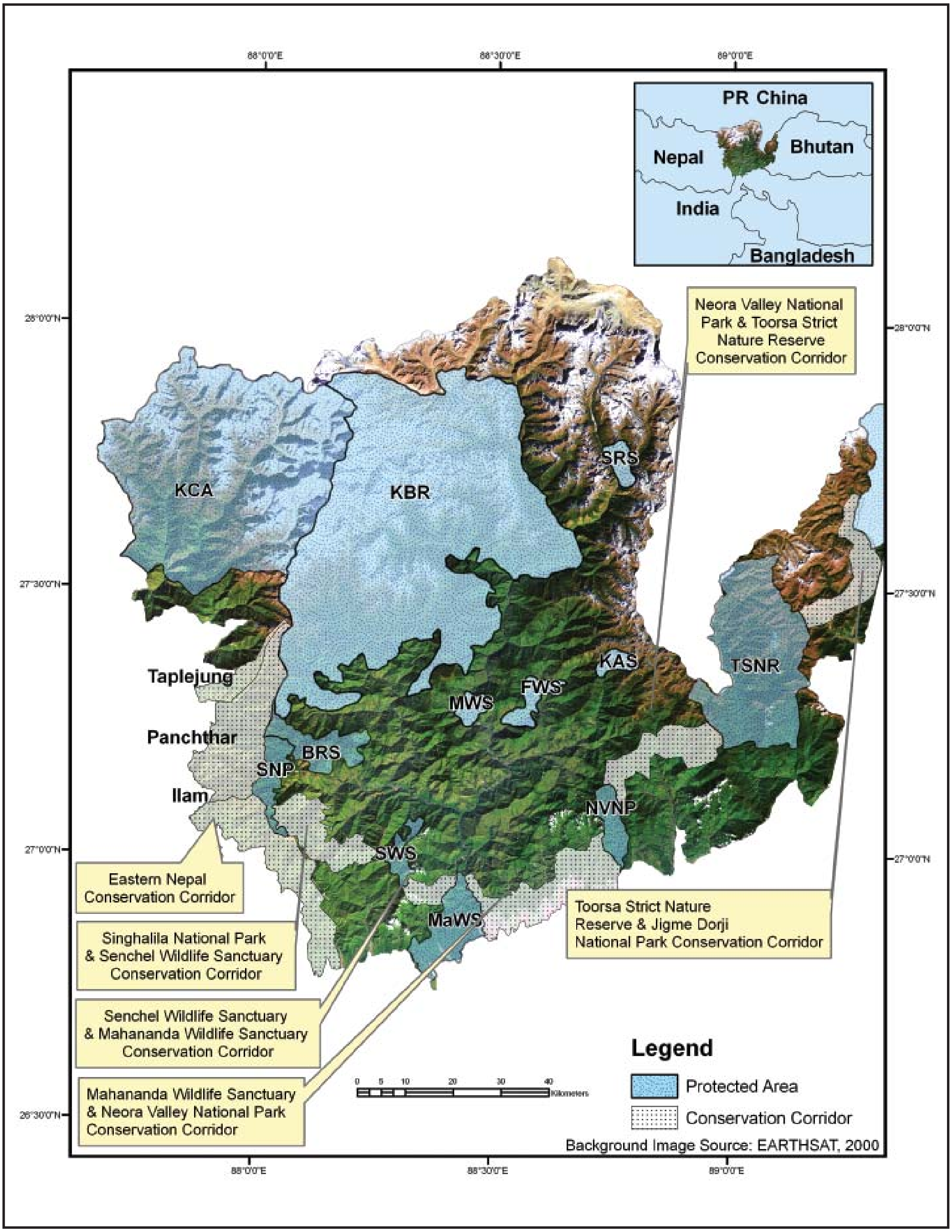

Figure 2: Protected areas and proposed conservation corridors in the Kangchenjunga landscape

KCA = Kangchenjunga Conservation Area, Nepal; KBR = Khanchendzonga Biosphere Reserve, BRS = Barsey Rhododendron Sanctuary, FWS = Fambong Lho Wildlife Sanctuary, SRS = Singba Rhododendron Sanctuary, MWS = Mainam Wildlife Sanctuary, KAS = Kyongnosla Alpine Sanctuary, Sikkim, India; SNP = Singhalila National Park, SWS = Senchel Wildlife Sanctuary, MaWS = Mahananda Wildlife Sanctuary, NVNP = Neora Valley Nationa Park, Darjeeling, India; and TSNR = Toorsa Strict Nature Reserve, JDNP = Jigme Dorji National Park, Bhutan

Table 2: **Land use and land cover of the potential conservation corridors**

Land use	Corridor (i)	Corridor (ii)	Corridor (iii)	Corridor (iv)	Corridor (v)	Corridor (vi)	Total area	%
Tea gardens	34.93	5.07	0.51	54.68			95	6.1
Broom-grass field	2.2	0.57	3.75				7	0.4
Cinchona plantation			1.68				2	0.1
Large cardamom	164				12		176	11.3
Agricultural land	132.1	2.14	0.99	60.5		5.64	201	12.6
Tropical forest	95.91		17.86	120.32			234	15.0
Pine forest	54.57	19.6	2.89		9.42	85	171	11.0
Temperate mixed forest	180	116.65	4.94	10.99	125.22	0.69	438	28.1
Shrubland	42.47	1.84	4.26	0.5	12.2	25.8	87	5.6
Alpine meadow	1.41				9.11		11	0.7
Settlement	9.03	1.01	0.7	1.04			12	0.8
Degraded, rock, and unused areas	34.62	11.12	8.22	42.35		29.6	126	8.1
Lakes and rivers	0.04			1.15	0.55	0.53	2	0.1
Snow and ice	0.35						0	0.1

Discussion

Enormous conservation measures have been undertaken in the Kangchenjunga landscape. Some 42% of the landscape is included in protected areas that range from 0.4 sq.km to 2,620 sq.km. However, these areas are scattered and isolated, and mostly represent the alpine region, (Sharma and Chettri 2005; Chettri et al. 2006). In the past, the focus of conservation has been on addressing the critical habitats of key species that are remotely located and economically unproductive. There is a major gap in understanding of the ecological process and the importance of areas that are valuable but under represented in biodiversity conservation measures (Margules and Pressey 2000). Protected areas are increasingly being complemented by reserves established principally for the protection of biodiversity, including ecosystems, biological assemblages, species, and populations, but holistic conservation targets, that is the ecological processes, are not considered. In such instances, it is evident that the basic role of reserves is to separate elements of biodiversity from processes that threaten their existence in the wild. This is done within the constraints imposed by large and rapidly increasing numbers of human settlements and their attendant requirements for space, resources, and infrastructure.

Many species occurring in productive landscapes or landscapes with development potential are not protected, even though disturbance, transformation to intensive uses, and fragmentation continue. This is mainly due to under representation of the extended habitat in the protected area regime (Chettri et al. 2006). The extent to which reserves protect all species depends on how well they meet two objectives: protected areas must have representation of all vegetation and habitat types needed for population and persistence (Soule 1987) and reserves, once established, should promote the long-term survival of the species and other elements of biodiversity they contain by maintaining natural processes and viable populations and excluding threats (Margules and Pressey (2000). The proposed corridors, with their substantial areas under compatible land use, can definitely fill the gaps and enhance conservation not only by providing contiguous habitats for some of the charismatic species in the landscape but also by covering under-represented areas and naturalising the process of migration across political boundaries. Such international corridors foster new levels of transboundary conservation, elevating corridors from an ecological to a political and socioeconomic tool (Zimmerer et al. 2004). In additional, corridors that provide west-east, south-north, and altitudinal linkages might serve to provide routes and habitats for movement of organisms responding to climate change (Channell and Lomolino 2000). Further, most conservationists acknowledge that the purpose of corridors is to counter the effects of habitat loss and fragmentation, which are important causes of biodiversity loss worldwide, and they are expected to slow these effects down by increasing the movement of individuals among otherwise isolated populations, thereby rescuing populations from stochastic local extinction, maintaining genetic diversity, and retaining ecological processes (Bennett 2003; Chetkiewicz et al. 2006).

Conclusion

The realisation of conservation goals requires strategies for managing whole landscapes, including areas allocated to both production and protection. Reserves alone are not adequate for nature conservation, but they are the cornerstones on which regional strategies are built. Reserves have two main roles. They should be samples of, or represent, the biodiversity of each region, and they should buffer biodiversity from processes that otherwise threaten its persistence. Existing reserve systems throughout the world contain a biased sample of biodiversity, usually that of remote places and other areas that are unsuitable for commercial activities. A more systematic approach to connecting and designing reserves has been evolving, and this approach will need to be implemented if a large proportion of today's biodiversity is to exist in a future of increasing numbers of people and their demands on natural resources. The present initiative is moving in the right direction to counteract the 'isolation' of species and enhance conservation in the long run.

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