Applying the DPSIR Approach for the assessment of alternative management strategies of Simen Mountains National Park Ethiopia

BY

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Abstract

Simen Mountains National Park (SMNP) is an area of outstanding natural beauty with many endemic animals and plants. It has an important role in environmental conservation studies and is of scientific interest. SMNP is having potential for international as well as domestic tourism and is a major water catchment area. However, SMNP faces numerous threats by human pressure. This research aimed to assess five different management strategies that assure a sustainable conservation of the SMNP. Quantitative and qualitative data were acquired through interviews and focus group discussions while secondary data were elicited from different sources. The analysis was done to understand the major cause and effect relationships of socio-economic and environmental factors. In this context, the Driving Forces-Pressures-State-Impacts-Responses (DPSIR) approach was used to provide and communicate knowledge on the state and change of causal factors regarding environmental issues. A total of 31 indicators were arranged according to the DPSIR framework where as 22 indicators were adopted from the SMNP General Management Plan (GMP), and the remaining was developed by an interactive discussion with different actors of SMNP. The indicators were used to evaluate the current and four alternative management strategies with regard to two time steps in 2020 and 2030. For the decision analysis, the Analytic Network Process (ANP) was applied. The overall ranking of the management strategies indicated that the ecological management alternative is the best performing strategy in comparison to the other four management alternatives in the context of the DPSIR approach. It is concluded that consideration of the ecological management strategies would be useful for the sustainable management of SMNP. Major limitations of the study were the data availability and the knowledge gaps regarding the understanding of the system dynamics and ecosystem functions of the park.

Key words: DPSIR framework, ANP, Management alternatives, national park, indicator

Zusammenfassung

Der Nationalpark im Simen Gebirge in Äthiopien ist ein Gebiet von außerordentlicher natürlicher Schönheit mit vielen endemischen Tieren und Pflanzen. Er spielt eine wichtige Rolle für wissenschaftliche und angewandte Naturschutzstudien. Der Nationalpark im Simen Gebirge (SMNP) hat ein Potential für internationalen wie auch nationalen Tourismus und stellt ein bedeutsames Wassereinzugsgebiet dar. Dennoch ist der Nationalpark mit einer Vielzahl von Bedrohungen konfrontiert die aus der menschlichen Nutzung resultieren. Die vorliegende Forschungsarbeit hatte die Analyse von fünf Managementalternativen zum Ziel, welche eine nachhaltige und langfristige Sicherung der natürlichen Ressourcen des Nationalparks sicher stellen. Die Grundlagendaten der vorliegenden Forschungsarbeit wurden in quantitativer und qualitativer Form erhoben. Interviews und Diskussionen mit Fokusgruppen wurden durchgeführt. Darüber hinaus wurden Sekundärdaten von verschiedenen Behörden und weiteren Quellen erhoben. Diese Daten wurden analysiert, um die wesentlichen Ursache-Wirkungs-Beziehungen von sozioökonomischen Faktoren und Umweltfaktoren zu verstehen. In diesem Zusammenhang wurde der DPSIR-Ansatz (die Abkürzung steht für Driving Forces-Pressures-State-Impacts-Responses) verwendet, um Wissen zu Status und Wandel von kausalen Faktoren betreffend Umweltthemen zu generieren und zu kommunizieren. Insgesamt 31 Indikatoren wurden nach dem DPSIR Ansatz klassifiziert, wobei 21 Indikatoren aus dem Generellen Management Plan (GMP) des Nationalparks abgeleitet und die Restlichen interaktiv mit verschiedenen Akteuren des SMNP entwickelt worden waren. Die Indikatoren wurden zur Evaluation der aktuellen Bewirtschaftungsstrategie und vier alternativen Strategien verwendet. Für die Entscheidungsanalyse wurde der Analytic Network Process (ANP) angewendet. Das Gesamtergebnis der Reihung der Managementalternativen unter Einbeziehung des DPSIR-Ansatzes_ergab, dass die ökologische Managementalternative am Besten im Vergleich zu den anderen vier Managementalternativen abschnitt. Diese Strategie erscheint demnach am geeignetsten, um die nachhaltige Nutzung des Nationalparks zu gewährleisten. Einschränkungen der Forschungsarbeit waren bedingt durch die mangelnde Datenverfügbarkeit und die vorhandenen Wissenslücken betreffend dem Verständnis der Dynamik und Funktion der Ökosysteme im Park.

Kennwörter: DPSIR Modell, ANP, Managementalternative, Nationalpark, indicator

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1.0 Introduction

Protected areas are important tools for the conservation of biological diversity and are cornerstones for sustainable development. Besides their environmental benefits, they can also generate significant economic resources. Currently about 11.6% of the Earth's terrestrial surface is under protection, this areas harbor great biological richness and are a major source of material and non-material wealth. They represent important stocks of natural, cultural, social and capital supporting the livelihood and wellbeing of many. For instance 33 of the world's 105 largest cities obtain a significant proportion of their drinking water from protected areas (SCBD, 2008). In addition, protected areas can help guard against environmental disturbances and the impacts of climate change by helping society to both mitigate and adapt to stressors (Noss 2001, Hopkins et al. 2007, Huntley 2007, Millar et al. 2007, Dunlop and Brown 2008, Araújo 2009). The world database on protected areas enumerates 113.851 protected areas worldwide covering about 19.65 million Km^2 or about 13% of the earth's terrestrial surface (world database on protected areas 2006). In comparison there is a sharp increase from 48,388 protected areas counted in 1992, covering about 12.8 million km^2. Unfortunately, many of them do not meet their stated objectives of protecting biodiversity (Oates 1999; Terborgh 1999).
Over exploitation of natural resources in protected areas such as national parks is a worldwide concern nowadays. This is particularly severe in developing countries. For instance, it is estimated that in South America, 86% of the parks have people living in them (Amend and Amend, 1995). Also in India 1.6million people live in parks (Kothari *et al*., 1989).

Ethiopia possesses considerable biodiversity and natural resources, as well as many endemic species. However, only limited success of protecting some of these natural assets since establishing the conservation and protected area program in 1965. Due to the country's prolonged engagement in various armed conflicts, there is an increase in the number of threatened and endangered species and deleterious habitat modifications.

Simen Mountains National Park (SMNP), which was established in 1966, was set up primarily to protect Capra walia and the impressive, rugged scenery. This park has international significance due to its biodiversity, its many endemic species, and its outstanding biophysical features. At present, however, the area is under heavy human pressure. Rural poverty is widespread and is undermining the traditional agricultural subsistence system at an accelerating pace (Hurni and Ludi, 2000).

Following this, SMNP is under a huge threat from agricultural encroachment, grazing and similar other pressures including construction of road through the park. In 1978, the park was inscribed to the United Nations Educational, Scientific and Cultural Organization (UNESCO) world heritage list (Hurni, 1986). In 1996 due to further use of the natural resources of the park and increasing degradation by uncontrolled use, the park was declared as a world heritage site in danger.

Many of the existing protected areas are considered to be merely "paper parks" since in reality they do not fulfill protected area functions (Cifuentes *et al.,* 2000). SMNP is one of the parks in Ethiopia where there is a management conflict. Many decisions have been made in the past to identify management strategy which can sustain the natural resource of the park and to meet the need of local people. However, many of the plans fail to address the situation from holistic point of view. Therefore, an approach is needed to assess management alternatives in order to understand the state and dynamics of the environment in relation to socioeconomic factors. Analysis of scientific data, adequate and suitable means of measurement need to be designed. There are varieties of tools, methods, and approaches to gain an idea about management sustainability, ranging from in-depth status assessments to rapid appraisals. These usually involve the use of indicators, according to their purpose of use, follow different terminologies: biodiversity indicators (e.g., Delbaere 2002), ecological indicators (e.g., Dale and Beyeler 2001; Sheil *et al.* 2004), sustainability indicators (e.g., Mendoza and Prabhu 2003), and several others. In this case, the Driving force, Pressure, State, Impact and Response (DPSIR) approach is identified as best suited for this study to view many of the factors from holistic point of view.

1.2 Theoretical Background

The Driving force, Pressure, State, Impact and Response (DPSIR) model has been adopted by the majority of the European Community nations as the best way to structure environmental information concerning specific environmental problems and to reveal existing causes, consequences, effective responses and trends and the dynamic relationships between these components (Pillman, 2002).This systematic approach enables the identification of the full range of empirical factors involved and prospective assessment of the direction, nature and strength of their interconnections. Indicators play a valuable role in terms of building the necessary knowledge, communication and awareness for integrated scientific, political and public input into effective decision-making processes for sustainability or other key societal objectives (Daniels, 1996).

According to OECD, 1994, the components in the DPSIR framework are defined as follows

Driving Forces: Driving forces are the factors that cause changes in the system. They can be social, economical or ecological and can have positive or negative influences on pressures. Examples of Driving Forces are the size of the human population, the use of resources, climatic change, the fishing sector and the tourism sector.

Pressure: Pressures are the human activities that directly affect the system and are generated by the driving forces. They change in environmental quality and the quantity of natural resources, e.g., pollution, harvesting.

State: State is the condition of the system at a specific time and is represented by a set of descriptors of system attributes that are affected by pressures. Examples of state descriptors could be the features or quality of water, sediment, species composition, habitat structure.

Impacts: Impacts are the effects on human health and/or ecosystems produced by a pressure. Common examples are disease incidence and the concentration of pollutants in biological populations, and reduction in abundance or biodiversity.

Response: Responses are the efforts made by society as result of the changes manifested in the impacts. As directed actions, responses typically take the form of programme activities, such as the number of inspections done.

This framework is a functional analysis scheme for structuring the cause-effect relationships in connection with natural resource management problems (EEA, 1999; Bowen and Riley, 2003; Giupponi, 2002).The scheme helps to structure information and makes it possible to identify important relations as well as to develop an overview and understanding of a problem.

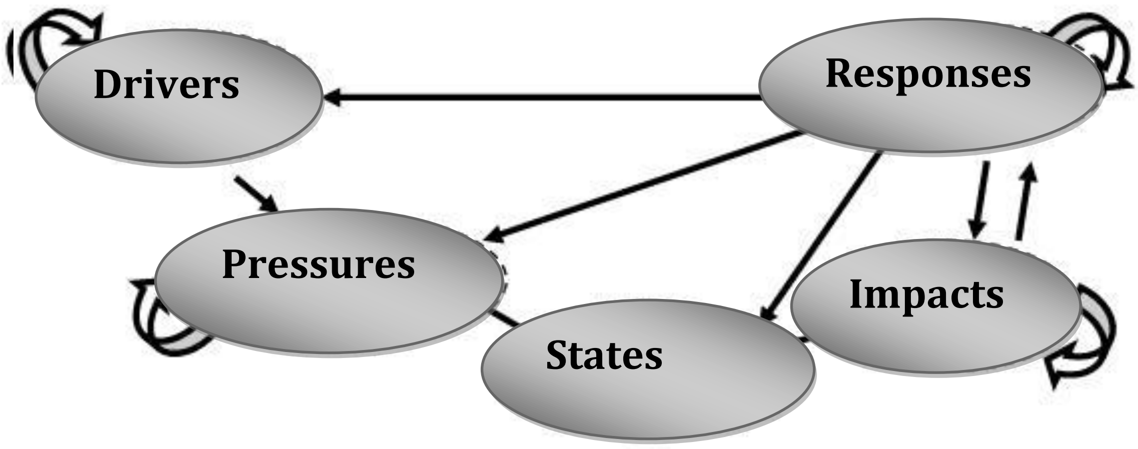

Figure 1: The DPSIR framework

The DPSIR framework has rapidly become popular among researchers and policy makers alike as a conceptual framework for structuring and communicating relevant environmental policy research (Svarstad et al. 2008). For this reason, it has been successfully implemented in different kinds of management issues, and its contribution to highlight the dynamic characteristics of ecosystem and socioeconomic changes has been validated (Turner et al. 1998). The DPSIR Commonly used framework for interdisciplinary indicator development, system and model conceptualization, and structuring of integrated research programs and assessments (OECD, 2003; UNEP, 2002; Walmsley, 2002). It can be used as a communication tool between scientists from different disciplines as well as between researchers, policy makers and stakeholders.

1.3 Objectives of Research

The main objective of this study was to assess different management alternatives that help to bring sustainable management to Simen Mountains National Park. In addition, the attitude of local people about natural resource conservation was assessed. The current state of the park, impacts and how these were changing through time were analyzed.

Based on this the following research questions were identified.

- Is it possible to quantify the current state of the park?
- Which indicators can be used to adopt the DPSIR framework in the context of SMNP?
- What is causing the problems? What are drivers to environmental problems?
- What is the attitude of local people towards natural resource conservation in the park?
- What kind of pressures exerted on the environment?
- What are the responses to the identified threats from the park authority and society?
- Are the current management plans working towards the targets or not?
- Is the park situation getting better or worse with respect to the identified indicators?
- Are there other management alternatives, which can overcome the identified threats of the park?

If there is, which management strategy is most promising?

2.0 SimenMountains National Park in Ethiopia

2.1. Background information

Ethiopia is located in the horn of Africa. The country is bordered in the north and northeast by Eritrea, in the east by Djibouti and Somalia, in the South by Kenya, and in the West and south-west by Sudan. It lies between latitude 3^0N to 18^0N and longitude 33^0 to 48^0E.

A dominant feature is the highlands which lie between 1500 and 4000 meters (MOA, 1984).The Ethiopian Highlands represent around 45 percent of all highland areas in Tropical Africa (Jahnke and Getachew, 1983).

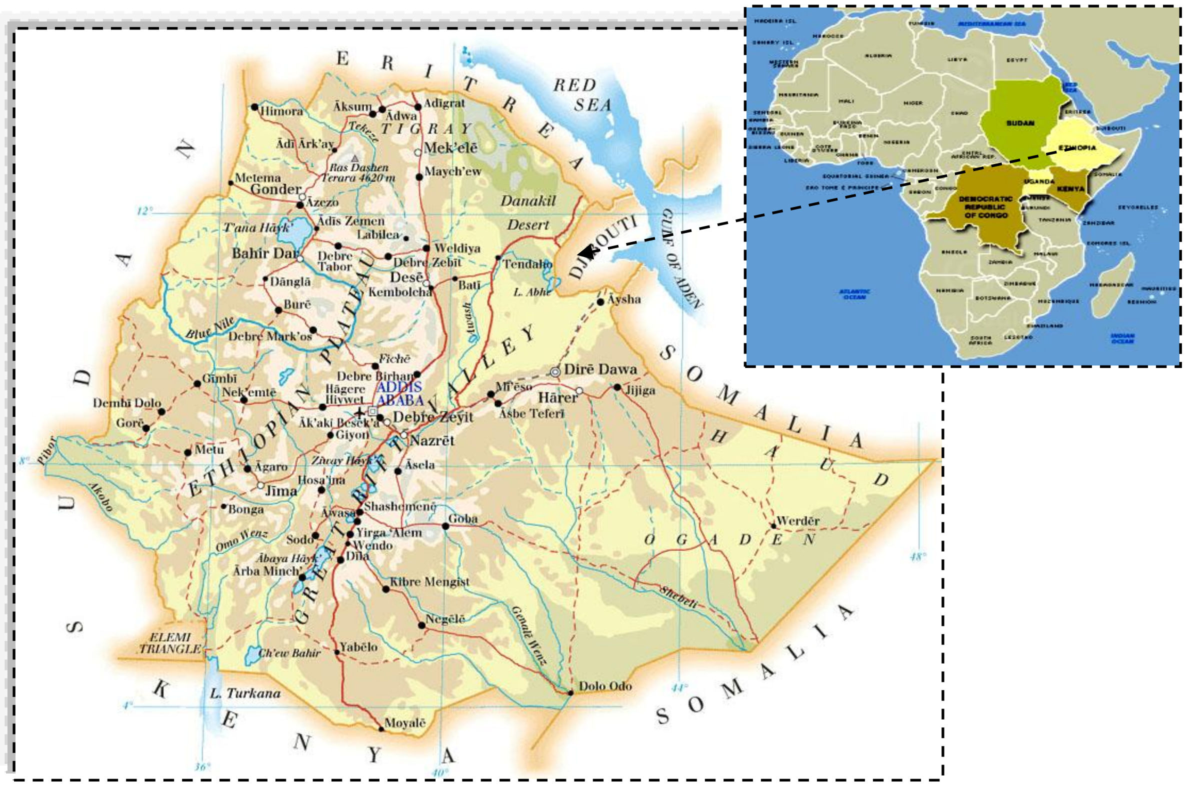

Figure 2: Map of Africa, Ethiopia, (Maz Ethiopia Tour Operator), Map of Africa (African food regions)

The country is one of the most physically and biologically diverse countries of the world with an area of over 1,023,050 km^2. This contains various wildlife and wildlife habitats ranging from alpine moorlands to lowland savannas and arid lands, and extensive wetlands (Yalden, 1983).

Most of the highlands harbor many endemic plants and animals. They have smaller species diversity than the lowlands in the country. The main reason for the presence of diverse wildlife and large number of endemic species is the rugged topography. This helped to create isolated ecological situations (Yalden *et al.,* 1996).

Ethiopia has been categorized as being one of the world's centers of unique biodiversity: with 861 species of birds, 277 species of mammals, 201 species of reptiles, 63 species of amphibians and 150 species of fish (Hillman, 1993a). Among these, 31 mammals, 16 birds, 24 amphibians, 9 reptiles and 40 fish are believed to be endemic (Hillman, 1993a).

For centuries, the natural ecosystems of Ethiopia have been changed because of human impacts (Hillman, 1993a, and b). Most of the highlands and some of the lowlands have been converted into agricultural and pastoral land. The vegetation has been used as fuel wood, for construction and other purposes. As a result, wildlife resources of the country are now largely restricted to a few protected areas (Hillman, 1993a, and b).

In 2009, Ethiopia has an estimated population of 85 million with a growing rate of about 3.2% (wiki.answers, 2010). Mainly the economy is mainly based on agriculture. It accounts for 45% of GDP, and 85% of total employment. The agricultural sector suffers from frequent drought and poor cultivation practices. Coffee is critical to the Ethiopian economy for export trade. (http://en.wikipedia.org).

2.2 Ecological conditions of Simen Mountains National Park

The Simen (also called: Simien, Semien and Semen) Mountains National Park is an area of 22,000 km^2 located in Amhara National Regional State (ANRS) in north Gonder, cover, 13° 11'N, 38° 04'E,. Debark, which is 886 km from the capital Addis abeba and 123 km from Gonder town. The park is surrounded by four Woradas.

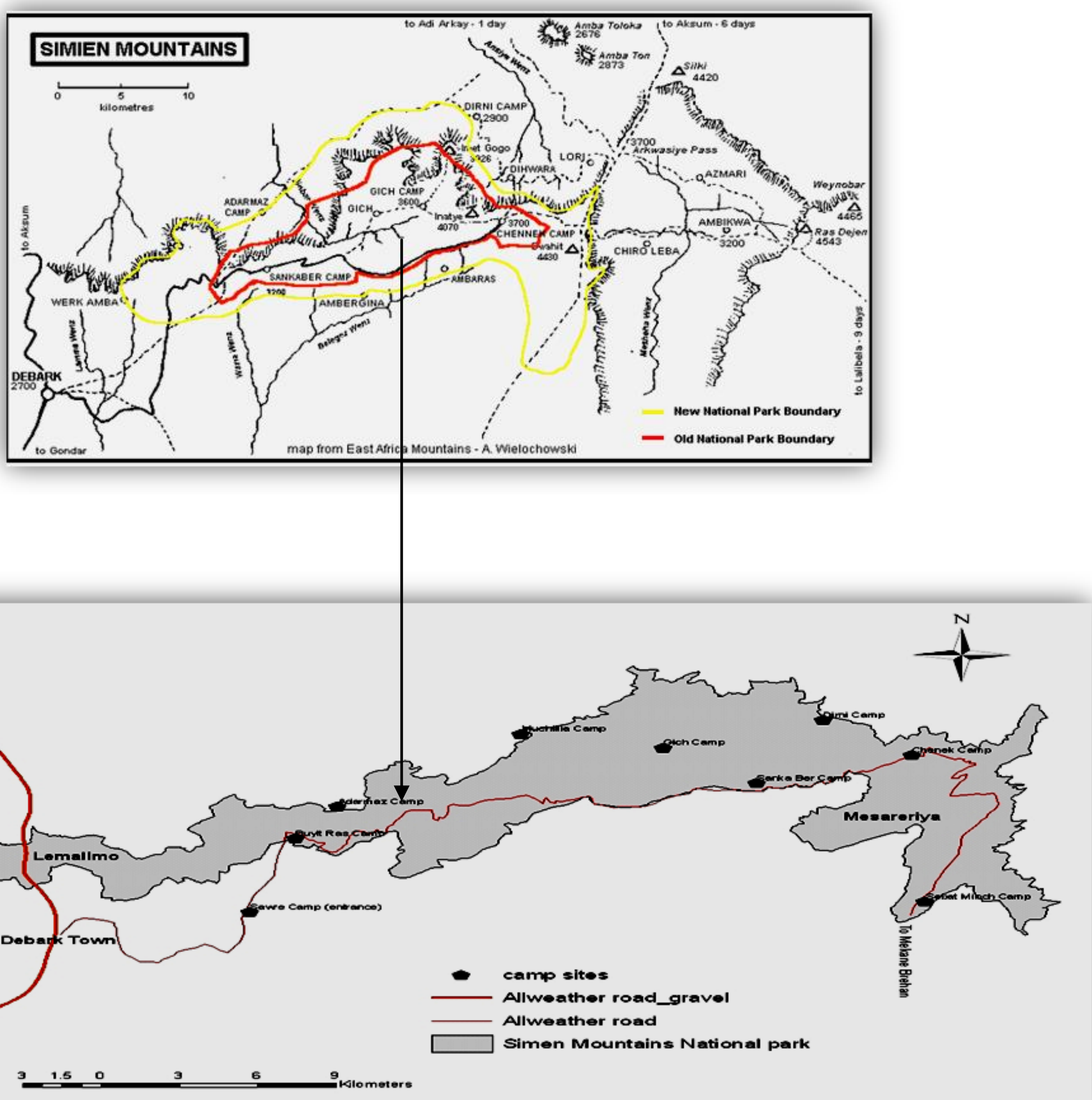

Figure 3: SMNP Map (Parks Development and Protection Authority of Amhara Region, 2006)

The climatic condition of Simen Mountains could be classified in to four major climatic zones based on altitude (Falch and Keiner, 2000).

- Wurch zone (above 3700 m.a.s.l), alpine climate cultivation impossible
- High dega zone (3400-3700 m.a.s.l), cool climate, upper limit of barely and potato cultivation is 3700 m.a.s.l.
- Temperate climate (2400- 3400 m.a.s.l), upper limit of wheat and pulses cultivation is 3150 m.a.s.l.

- Woina dega zone (1500- 2400 m.a.s.l), sub tropical climate, upper limit of maize and teff cultivation, maize and pulses cultivated.

SMNP area has different soil associations. The Humic Andosols are the dominant soil type at the altitude of 3000 m.a.s.l.; above where cultivation is less spread. The other types of soil are shallow Andosols and Lithosols that are mainly common in the area between 2500 and 3500 m.a.s.l., below 3000 m.a.s.l, the typical soils are Haplic Phaeozems associated with Cambisols (Falch and Keiner, 2000).

2.3 Socioeconomic value of SMNP

Simen Mountains are sources of historical and cultural records of local features in the 18th and 19th century. The area was at the crossing of old trade routes (Hurni, 1986), being located at the centre of the three old cultural and historical centres namely, Axum, Gondar and Lalibela. Simen Mountains have been refugees for people since prehistoric times (Kirwan, 1972). Ancient monasteries and churches such as Aba Saduk, Amba Mariam, Kidus Yared and Deresge Mariam have long been located for hundreds of years.

SMNP is playing a great role from the economic point of view too. In 2008, 7,685 foreign and 775 local tourists visited the park. Tourists that visited SMNP (Walta information, 2008) have spent more than 2.1 million birr (Ethiopian currency). Through generating income, employment and economic opportunities for local communities SMNP becoming a driver of the local economy (tourism plan report, 2003)

2.4 Biodiversity of SMNP

SMNP is part of the conservation international (CI) eastern afro-mountain hotspot. This is mainly due to two aspects:

Biodiversity hotspot: it has an Outstanding global importance for biodiversity in the area (some 97% of the natural vegetation of the Ethiopian high land is estimated to have been already lost. Although expanding human activities threaten biodiversity still (Hurni, 1987), SMNP is the high land refuge of Ethiopian unique biodiversity and priority to global conservation.

World heritage site: UNESCO design places on earth with outstanding universal value to human and benefits to current and future generation.

SMNP is known for its rich biodiversity where unique botanical and zoological combinations of species have been able to resist human interference because of the extreme topography and altitudinal range. It is a place where the highest mountain in Ethiopia, Ras Dashen, with an altitude of 4620 meters above sea level. Twenty-one mammals have been recorded, including seven endemic species. The Walia ibex and Capra walie (CR) are nearly endemic to the Simien Mountains (Ashine, 1982).

The Park lies within one of the world's Endemic Bird areas (Stattersfield et al., 1998). The 137 recorded bird species noted in (Fishpool and Evans, 2001) include 16 endemic to Ethiopia. There are also 25 species of raptors including lammergeier Gypaetus barbatus, four other vultures and four species of eagle (Hillman, 1993).

The floristically rich vegetation grows in four belts related to the altitudinal zones: Afromontane forest, Hypericum woodland, Afromontane grassland and Afro-alpine moorland (Debonnet et al, 2006).

More than 70 species of butterfly, 27 species of aquatic invertebrates living in the park (Hurni, 1986; Nievergelt et al., 1998; Endalkachew, 1999) and more than 522 flora species can be found (Puff and Sileshi,2000).

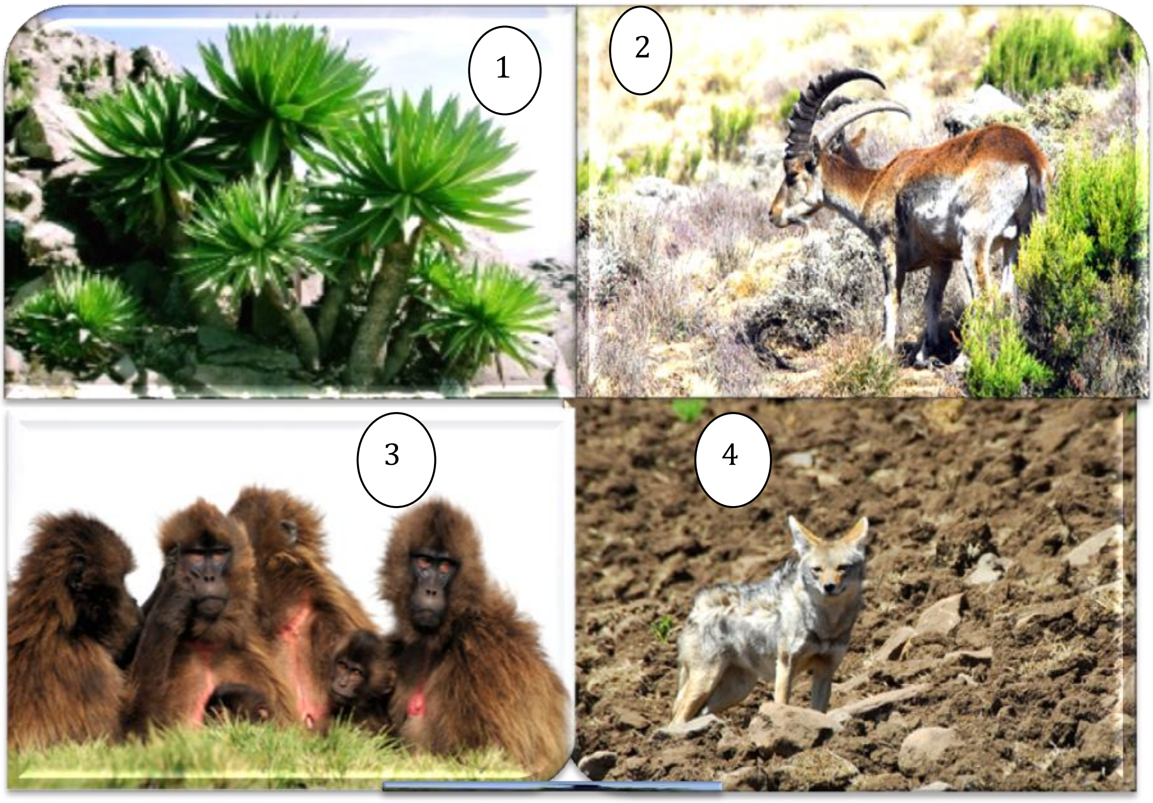

Figure 4: Pictures from SMNP (Brian J. McMorrow 1999-2010), (Peter van Zoest 2008), No 1, Giant lobelia, No 2, walia ibex, No 3, Gelada Baboon, No 4, Abyssinian fox

2.5 Current Situation of the park

During the time of establishment of the park, a number of villages and tracts of land used by local communities were included within the park boundary. The situation remained the same until this time. Consequence Impact from villages inside the park causes the intensive use of natural resources of the park. Agriculture, livestock grazing, fuel wood, timber use, poaching as well as the construction of a new road inside the National Park has led to a severe decline of the natural resources. Soil erosion strongly decreased vegetation regeneration potential and caused an obvious loss of biomass and wildlife habitats. The overexploitation of the carrying capacity of the natural resources, particularly deforestation, cultivation, domestic overgrazing and population are identified as the main problems (ANRS, 2007).

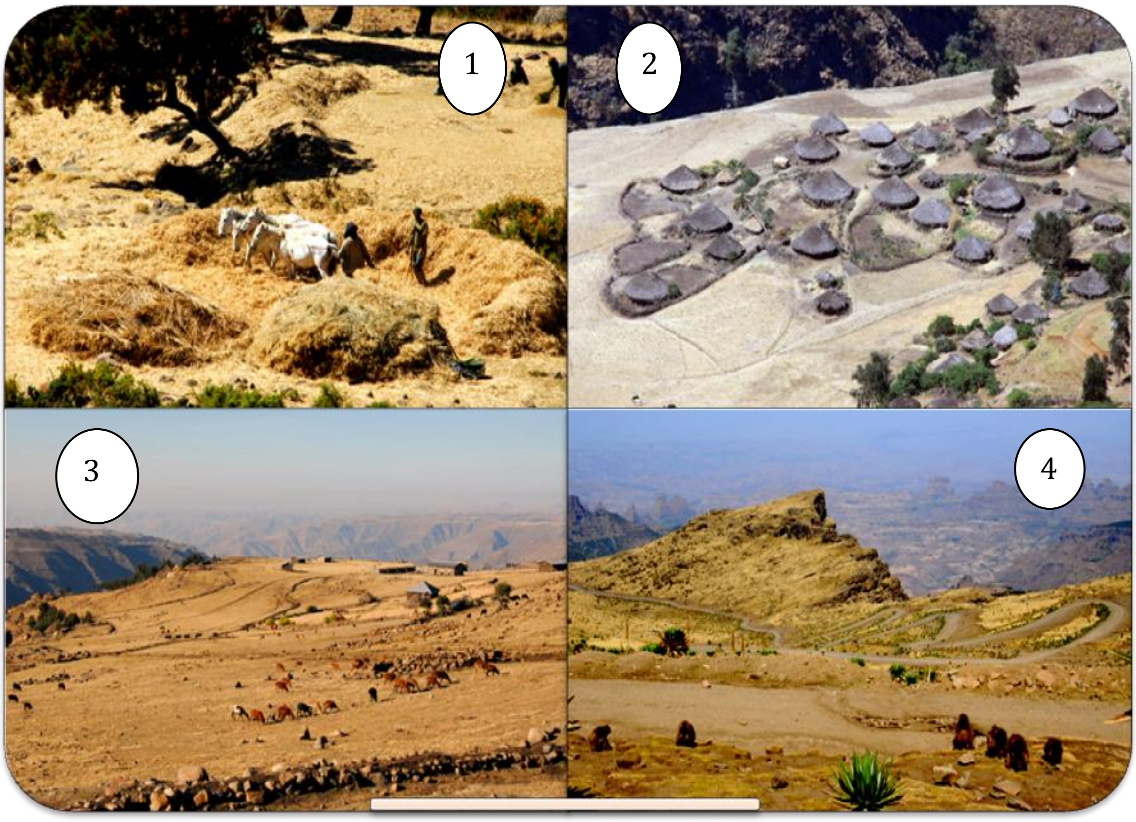

Figure 5: Pictures of SMNP (Brian J. McMorrow 1999-2010.) Number 1, Farmers on cultivation Number 2, densely populated village, No 3, highly degraded grazing land, No 4, Road cutting the habitat of baboons.

- Deforestation

Deforestation has been causing a serious degradation of natural resources in and around SMNP (ANRS and PaDPA, 2007). The area is susceptible to soil erosion by water and wind. The degradation and its ecological impacts have forced both the Walia Ibex and Ethiopian to wolf shift from their original ranges and to move further up in the less disturbed highlands. To tackle the issue of deforestation a ban was imposed by the national park authorities on felling Erica trees. Nevertheless, there is still some deforestation ongoing due to fuel wood collection in spite of the heavy punishment such as imprisonment (ANRS and PaDPA, 2007).

- Cultivation

The dominant characteristics of farming systems in and around SMNP area is family or house hold base, predominantly mixed cultivation of cereals pulses and oil seeds, integrated with livestock husbandry, use of highly adapted and low cost technology, (e.g. ox drawn plough) and very low integration in a larger economic system. This poor farming system is highly hindered by high input costs (fertilizers and seed), poor soil quality (erosion is intense), pest, frost, unpredictable rain and crop loss by wild animals particularly Baboons. Cultivation inside the park remains a serious concern. This form of land use is incompatible with the conservation objectives of the park and therefore will have to be phased out in the future. For the moment, the park authorities are enforcing a ban on further extension of areas cultivated in the park, and this seems to be well respected. However, as villages in the park depend on the cultivated land for their livelihoods, it will be difficult to phase out cultivation in the short term (ANRS and PaDPA report 2007). Soil degradation has been identified as a major problem on cultivation land inside and around the SMNP. Based on the Simen Mountain Baseline Survey (SMBS) findings it was concluded that soil erosion not only leads to diminishing soil depth and physical alteration of the soil, but also to selective removal of specific nutrients, thereby causing chemical degradation and loss of soil productivity. It was also estimated that soil erosion rates in some areas are 20 times higher than the annual soil formation rate.

- Domestic over grazing

The stocking density inside SMNP is very high. The number of livestock is increasing with the population (Marin, 2001). The high numbers of grazing cattle and other domestic animals have an extremely devastating effect on the afro-alpine grassland ecosystem. Because of overstocking, there has been some deterioration with an increase of the unpalatable grasses like Festuca. The animals grazing in the park are not just those of local people but also from relatives far from the park. Overgrazing has negative consequences for the vegetation, for the soil preservation and for the chances of survival of the Simen fox in the SMNP by sustaining the food chain. Grazing in the Erica-belt reduces the density of Erica plants. (ANRS and PaDPA report, 2007).

According to Nievergelt 1996, who has mapped roughly 900 ha of the afro-alpine grassland, 60 % are heavily grazed, 25 % are seriously overgrazed respectively. Only 15% show still a more or less natural status. In the areas close to the Gich village, the meadows are heavily grazed and the soil quality is decreasing. On lying the very East, towards Imet Gogo and south of Jinbar Wenz near Shayno Sefer and Inatye, there are some areas of untouched grassland left. Long-grass vegetation has more or less disappeared (Nievergelt *et al*., 1998).

- Over Population

The surrounding region of SMNP is highly populated, with an estimate of 44.4 point four people per km2 (Hurni and Ludi, 2000). Originally, some 2,500 Amhara people lived in the area, where the people are very poor but the conditions favour agriculture. In 1979 and 1986, the population was reduced by the forced relocation of approximately 1,800 people from the lower slopes of the northern escarpment. Following civil unrest in the 1980s and 1991, the villagers returned (Nievergelt et al., 1998). A total population of about 85.000 people lives within 17 Kebeles administration in the park and vicinity of the park (SMNP _ IDP 2004). Over the past 30 years, the population was estimated to have increased by two percent per year (Hurni and Ludi, 2000).

3.0 Methodology

3.1 Indicators and the DPSIR framwork

Various projects or institutions sought to identify properties for good indicators. According to ICES 2001, indicators should be relatively easy to understand by non-scientists and those who will decide on their use; sensitive to a manageable human activity; relatively tightly linked to that activity; easily and accurately measured with a low error rate; responsive primarily to a human activity, with low responsiveness to other causes of change; measurable over a large proportion of the area to which the indicator is to apply; and based on an existing body or time series of data to allow a realistic setting of objectives.

According to the OECD 2003, an indicator is a parameter, or a value derived from parameters, which provides information about or describes the state of a phenomenon/environment/area. An indicator can be defined as a measured or observed parameter that provides a simplified view of a more complex phenomenon, or provides insight about a trend or event that cannot be directly observed. However, there is no universal set of indicators applicable to every situation. The indicators selected therefore needs to be useful to different users and applicable to different requirements and circumstances. The indicators need to be responsive to the goals of managers and decision makers, as well as to the expectations of stakeholders. Generally speaking, communication is the main function of indicators: they should enable or promote information exchange regarding the issue they address. Furthermore, indicators focus on certain aspects that are regarded as relevant and on which data are available, and their significance goes beyond that obtained directly from the observed properties. In other words, an indicator is an observed value that is representative of a phenomenon of study. In general, indicators quantify information by aggregating different and multiple data. This study used 31 indicators most of them are adopted from the SMNP General Management Plan (GMP). The rest of them are developed by the participation of different actors, after a brief discussion with SMNP park experts and kebelle representatives, reviewing literature and from the data collected on field. Almost all of the response indicators were developed in this procedure.

Table 1: Indicators

Drivers	PRESSURE	STATE	IMPACT	RESPONSE
1.1 – population	2.1 – Deforestation	3.1–land degradation	4.1– Cropyield decline	5.1–voluntary settlement
1.2 – negative impact tourism	2.2 – forest fire	3.2–vegetation cover	4.2–loss of biodiversity	5.2 – family planning
1.3-agriculture expansion	2.3 – illegal hunting	3.3–threatened species	4.3 – wild life habitat destruction	5.3 – reforestation
1.4 – population of domestic animals	2.4. Negative impact of road	3.4.endemic species	4.4. human wild life conflict	5.4 – soil and water conservation
	2.5 – production of waste	3.5 - regeneration potential of plants	4.5- hybridization	5.5 – minimize domestic grazing
	2.6 -noise disturbance			5.6 – minimize Agriculture expansion
	2.7- domestic grazing			5.7 – prevention of hybridization
	2.8 wild life disease			5.8 –fire monitoring and controlling mechanism
				5.9– wild life disease monitoring strategy

3.2 Application of DPSIR in SMNP context

The DPSIR framework is an effective and simple framework for illustrating ecosystem-based management. Relating large-scale drivers of change (for instance increase in population or human activity) to the pressures they exert (e.g. domestic grazing, deforestation) which cause changes in the state of the park environment (e.g. habitat degradation) resulting in impacts on biodiversity, human wellbeing and socio-economics (wild life habitat destruction), there by leading to institutional responses, policy, target setting, measures (e.g. Reforestation).

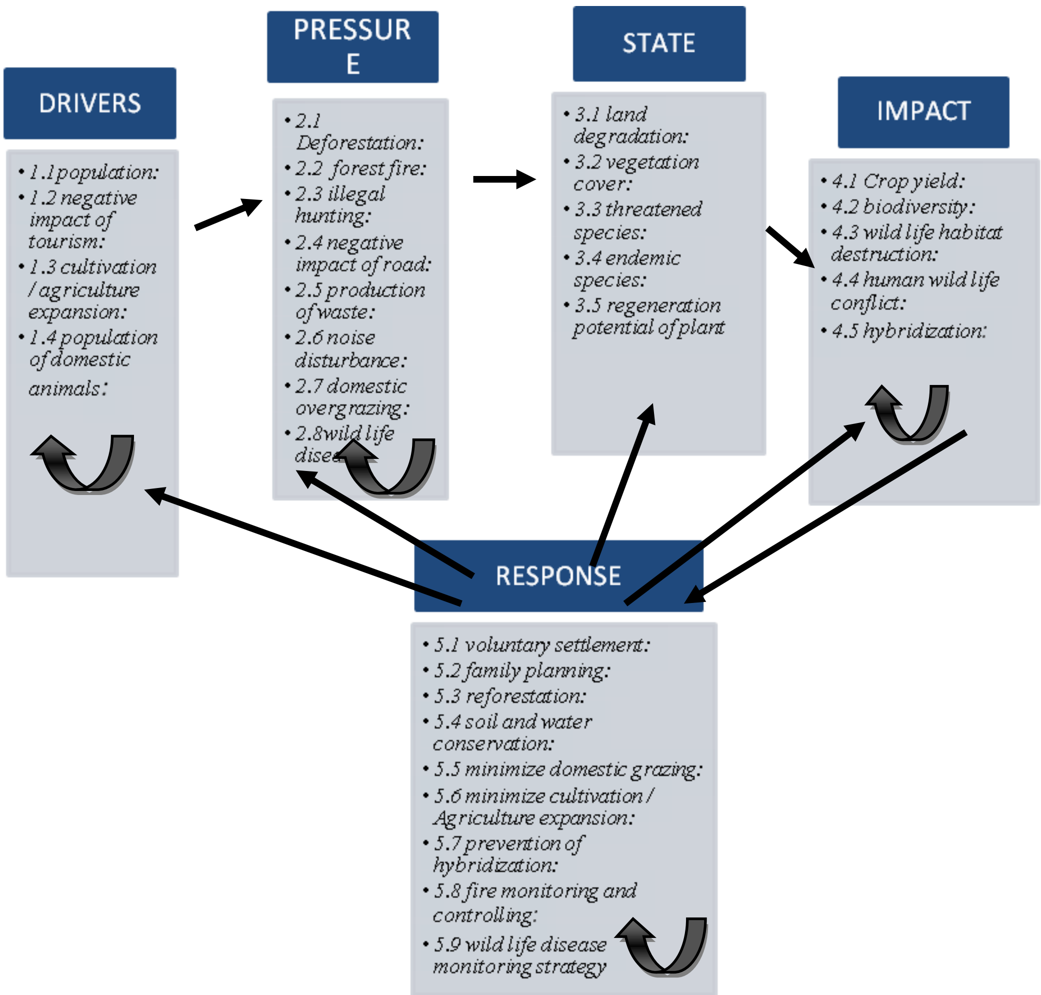

Figure 6: DPSIR conceptual model of indicators

Indicators are categorized in five clusters within the DPSIR framework according to their nature. The management strategies are integrated bi-directionally both influencing the performance of the indicators and being influenced by a preconditioned and changing environment. As an exception, there is no influence of strategies on driving forces stated since they are assumed to be external (Vacik *et al.*, 2007)

Driving forces (D), the unprecedented growth of population and tourism as well as agriculture expansion and population of domestic animals, are the identified major driving forces that exert pressure and cause changes on the park ecosystem. Growth in population size and density has increased the demand for resource consumption, which leads to over use of natural resource of the park.

Pressures on the park (P), deforestation, forest fire, illegal hunting, negative impact of road, production of waste, noise disturbance, domestic overgrazing and wild life diseases are identified as the main pressures in SMNP.

Changes in the state of the park (S), the current state of the park is highly affected through excessive pressure of over grazing and population pressure. Land degradation, deterioration of vegetation cover, a change in state of threatened species and endemic species as well as regeneration potential of plant are identified as state indicators.

Impacts on the park (I), crop yield decline, biodiversity loss, wild life habitat loss, human wild life conflict and hybridization are identified as the main impacts on the park ecosystem.

Responses to park threats (R), problems on the park ecosystem are often detected because of their impact on the environment. Voluntary settlement, family planning, reforestation, soil and water conservation, minimize domestic grazing and Agriculture expansion, preventing hybridization, apply fire monitoring and controlling and wild life disease monitoring strategies are among the identified responses.

Table 2: The description of Indicators, their measurement units, the goal dimension and its performance for two time periods

	Indicator	Description	Category	Unit	1968 - 1990	1991-2009	Remark
1	Population	Number of people	D	No	low	High	↑
2	Negative impact of tourism	Pollution	D	Extent	low	High	↑
3	Agriculture expansion	% of cultivated land	D	%	1986(50%)	No further expansion	↓
4	Population of domestic grazers	Number of domestic grazers	P	No	no statistics, but in general low	In 2007 38,270 cattle, 59,639 sheep 17,414 goats 13,490 equines (High)	↑
5	Deforest-ation	Cleared forest area	P	High	High 1980 (1000 ha of	Slightly increase	↑

					forest cleared)		
6	Forest fire	Frequency of occurrence	P		High	Low	↓
7	Illegal hunting	population status of animals(key species walia ibex)	P	No	1969(150) 1976(210) 1983(280)	2009 (>500)	↓
8	negative impact of road	Habitat disturbance and fragmentation by roads	P		Low	High	↑
9	production of waste	Landfills and other wastes in the park	P	Extent	Low	High	↑
10	noise disturbance	Extent of noise disturbance on wild life habitats	P	Extent	low	High	↑
11	domestic grazing	% of over grazed land	P	%	1973 (25 %) 1998(60 %)	High (increased)	↑
12	wild life disease	Frequency of disease occurrence per year	P	No	High	Low	↓
13	land degradation	bare ground	S	Extent	High	Very high	↑
14	vegetation cover	Area of vegetation cover	S	Area	High	Low	↓
15	threatened species	Number of Abyss. wolf	S	Number	1977(20)	2003(40) 2005(71)	↑

16	endemic species	Population of gelada baboon	S	Extent	High	Very High	↑
17	Regen-eration potential of plants	Failure of establishment of seedling	S	Extent	Low	High	↑
18	Crop yield	Dependency on food aid	I	High	low	From 4 to 6 months per year	↑
19	biodiversity	Biodiversity loss	I	Extent	Low	low	↓
20	wild life habitat destruction	Change of wild life habitat to other land use	I	Extent	High	Very high	↑
21	human wild life conflict	Extent of conflict between farmers and baboons	I	Extent	Low	High	↑
22	Hybrid-ization	Occurrence of hybrids between wild and domestic animals	I	Extent	Low	Very low	↓
23	voluntary settlement	Number of people shifted to another area	R	No	low	medium	↑
24	family planning	Change in population growth rate	R	%	more >2% year	Low	↓
25	Reforest-ation	Area of new forestation	R	Area	Low	Medium	↑
26	soil and water conserv-	soil and water conservation practices on	R	Extent	Low	Very low Low	↓

	ation	bare land					
27	minimize domestic grazing	Area protected for Area closer	R	Area	Low	Medium	↑
28	minimize Agriculture expansion	Sanction	R	Extent	Low	high	↑
29	Preventing of hybrid-ization	change Occurrence of hybrids	R	Extent	Low	High	↑
30	fire monitoring and controlling mechanism	Change in fire frequency	R	No	low	High	↑
31	wild life disease monitoring strategy	Frequency of Wild life health assessment	R	No	Low	High	↑

3.3 Description of the alternatives

Different management strategies can help to overcome the threats of the SMNP and these strategies have positive and negative impacts on the overall livelihood of the local people. To identify the most promising alternative the following five management strategies have been selected.

The current management strategy (CMP) has many plans and benchmarks to achieve. This management plan is working towards all the threats of the park; however, it gives more emphasis to keep the biodiversity of rare and endemic species of the park.

The ecological management (MP1), this program will deliver a key component of an adaptive approach to park management by providing ecological management and monitoring information. This programme has been formulated using the latest international conservation planning methods and best practices. Eight principal ecosystem components have been identified by technical experts; together capture the unique biodiversity of SMNP. If all theses principal ecosystem components are conserved, then the long-term health of the park's ecosystem will remain intact. Other prioritised threats are addressed, a suite of actions have been developed to minimize the ecological impacts of population , cultivation and grazing including soil and water conservation and fire monitoring and controlling mechanisms. Furthermore, actions under this programme will rehabilitate degraded habitats including grasslands where soil erosion has taken place, reforestation where overharvesting of trees and bushes has occurred for fuel and building, as well as strategies to minimize the negative environmental impacts of road and introduction of alien species. Direct threats to wildlife such as disease, genetic inbreeding and persecution due to human wild life conflict will be addressed. Finally efforts will be made both to understand and mitigate potential future changes due to global warming.

The grazing and settlement Management (MP2), strategy provides a framework for managing settlement and natural resource use in SMNP. The program aims to convert currently unsustainable levels of grazing and other natural resources use in SMNP to sustainable levels of resource use through a participatory process where users enter into joint natural resource management agreements with the park management. Sustainable natural resource management and community resource management agreements are facilitated and negotiated between park management and community resource management groups. They will specify the type and amount of grazing and other resource use that can occur, and will lay out the methods, roles and responsibilities for community monitoring, regulation and resource protection. Human settlement, cultivation will be controlled. In the short term, the negative impacts of roads will be reduced.

The tourism development and management (MP3) aims to develop, diversify and manage tourism in SMNP, through government private community partnerships in a culturally and environmentally sustainable manner. The revenue generated should contribute both to conservation management and diversifying the livelihood opportunities of the park associated communities. Attempt to increase visitors in number, marketing and promotion of SMNP tourism will be done.

The outreach Program (MP4), strategy aims to build stakeholder support and reducing pressure on the exceptional resource values of SMNP. All community development initiatives are undertaken principally to support a sustainable livelihood, family planning, resource protection and land use planning, conflict management, and environmental friendly agriculture.

3.4 Application of Analytical Network Process

The Analytical Network process (ANP) introduced by Saaty, is a generalization of the Analytical Hierarchy Process (AHP) (Saaty, 1996). Whereas the Analytical Hierarchy process (AHP) represents a framework with a uni-directional hierarchical relationship. The ANP allows complex interrelationships among decision levels and attributes. The ANP feedback approach replaces hierarchies with networks in which the relationships between levels are not easily represented as higher or lower, dominated or being dominated, directly or indirectly (Meade and Sarkis, 1999). The ANP provides a solution for problems, which cannot be structured hierarchically. Not only does the importance of the criteria determine the importance of the alternatives, as in a hierarchy, the importance of the alternatives themselves determine the importance of the criteria. Therefore, many problems can be modeled using a network (Figure 6). The term level in the Analytical Hierarchy Process is replaced by the term cluster in ANP. The network model has cycles connecting its clusters of elements and loops that connect a cluster to itself. The ANP enables such inter-dependences to be surveyed and measured by generalising the approach of the super-matrices introduced by the AHP. The ANP is therefore a theory of relative measurement on absolute scales of both tangible and intangible criteria based on both the judgment of experts and on existing measurements and statistics needed to make a decision. As far as the ANP is concerned, the literature is more recent and some publications can be found in the field of environmental assessment. Some very recent works can be found in the field of waste management (Promentilla et al., 2006), and in the fields of transport infrastructure assessment (Tuzkaya and Onut, 2008), strategic policy planning (Ulutas, 2005), market and logistics (Agarwal et al., 2006), economics and finance (Niemura and Saaty, 2004) and in civil engineering (Piantanakulchai, 2005; Neaupane and Piantanakulchai, 2006). At a national level, the application of the ANP method in the assessment of urban and territorial transformation scenarios (Marta Bottero, Valentina Ferretti, 2010) can be maintained.

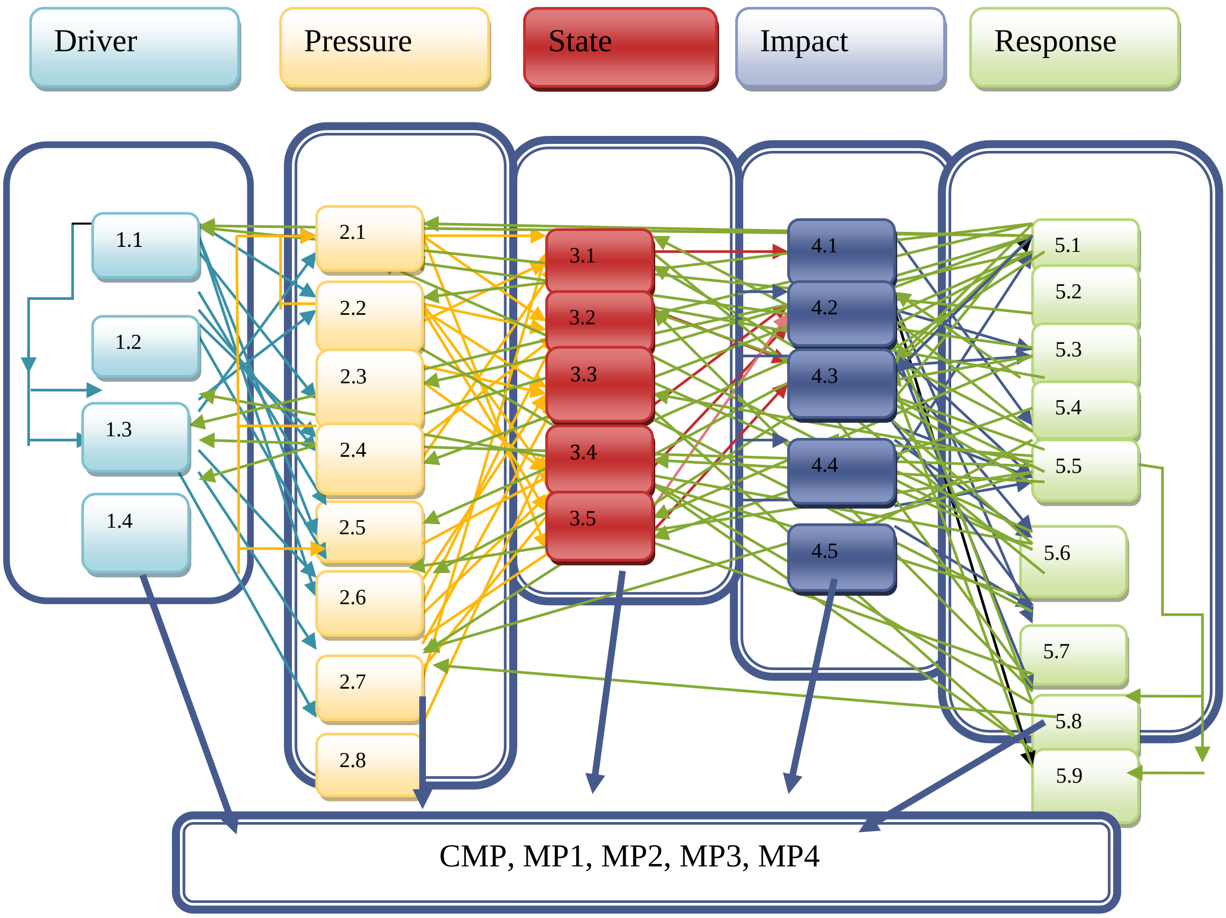

Figure 7: Structure of the ANP-DPSIR model for the study case

In practice, many decision problems involve feedback to avoid complexity resulting from feedback; ANP is a tool to meet this necessity by enabling a systematic and comprehensive approach. There are four general steps in ANP applications, including model construction, paired comparisons between each two clusters or nodes, super matrix calculation based on results from paired comparisons, and result analysis for the assessment (Saaty, 1996/2005). Once the network has been identified and all the relationships between the elements have been established, called system-with-feedback (Richardson, 1991), it is necessary to develop the pair wise Comparisons. The information used for the compilation of the pair wise matrices has been drawn from expert knowledge in the field of sustainability assessment; in other words, different experts worked together in order to derive indications about the environmental system of the area under examination and about the impacts. The first operational step in the model development consists of a comparison between the clusters. For example, if the cluster of the alternatives is considered as the parent node, the questions that must be solved to compile the matrix are using pair wise comparisons. All kinds of subcomponents are being evaluated through the ANP clusters. The pair wise comparisons are measured based on the scale from 1 to 9 (Saaty, 2005).

Table 3: Saaty's rating scale for pair wise comparisons (Saaty, 2005).

Numerical Rating	Verbal Judgment of Preference
1.	Equally important
2.	Equally to moderately more important
3.	Moderately more important
4.	Moderately to strongly more important
5.	Strongly more important
6.	Strongly to very strongly more important
7.	Very strongly more important
8.	Very strongly to extremely more important
9.	Extremely more important

ANP approach allows decision makers to set up their decision-making models based on entire considerations about complex inter-relation among all indicators and their clusters, and reliable collection and reuse of experts' knowledge in related domains. The

ANP models can be regarded as a practical interpretation of expertise to support decision-making.

Therefore all the information collected in the field was organized as a set of ideas or concepts framed as DPSIR cluster and nodes within clusters (see figure 6). The complex entities are represented as nodes and the causal links are indicated by arrows. The direction of the arrow is indicating the direction of influence. Interaction and feedback within clusters of elements are called (inner dependence) and between clusters outer dependence (Figure 7). Feedback captures the complex cause and effects of interplay in society and environment. Based on expert assumptions, priorities are calculated for each of the alternatives and each of the drivers, pressure, state, impact and response. The qualitative assessments have been transformed to pair wise comparison ratios for evaluating both the importance and influence between indicators and the performance of the alternatives with regard to each indicator. Finally super decision software developed by Thomas L. Saaty, (Designed by Bill Adams and the creative design foundation, version number 2.0.8, 01 June /2009) was used for decision analysis. Priorities of indicators and alternatives were modelled with the ANP resulting from the interconnections to other indicators and their respective cumulative importance.

3.6 Data collection

The primary data used for this study were collected during the fieldwork from July to September 2009. First, background information was gained from literatures about the study area. In addition, there was a meeting and discussion with management authorities, experts of the park and representatives of the kebelles. Focus group discussions were held with six to eight participants (in four groups). Thereafter, household interviews have been undertaken by questionnaires in two Kebelles namely Arginjona and Abergina with in 18 km distance. 85 respondents participated; the respondents were randomly selected through the list of local farmers by the head of Kebelles. The final step was an in-depth interview, which was used as a reference checklist. The questionnaire survey for people in both villages was carried out indoor-to-door basis. The descriptive statistics of the respondents shows that predominantly male (72%) and female (28%) between the ages of 17 -70. The households' size ranged from 1 member to 7 members with an average of 5.

Table 4: Age group of respondents of Arjingona and Ambergina Kebelle

Age group	Arginjona Kebelle		Ambergina Kebelle	
	Male	Female	Male	Female
<20	6	2	9	3
21-30	5	2	3	2
31-40	7	3	5	1
41-50	8	5	9	3
51-60	3	1	3	1
61-70	2	0	1	0
>70	0	1	1	0

The majority of households were directly engaged almost exclusively on subsistence agriculture and rearing of livestock. On average 90% of the respondents in the two villages have farmlands, 91% from Arginjona kebelle and 87 from Ambergina kebelle respectively. They mainly produce barely, wheat, oilseeds and potato. From household interviews, it is shown that the main income source relies on agriculture production, in general, their livelihood depend on farm out puts. The rest of respondents were traders or participating in other non-farm employment opportunities. Farm land size varies from 0.9 to 1.5 hectares per household, and is on average 1.2 hectares.

3.7 Methodological approach

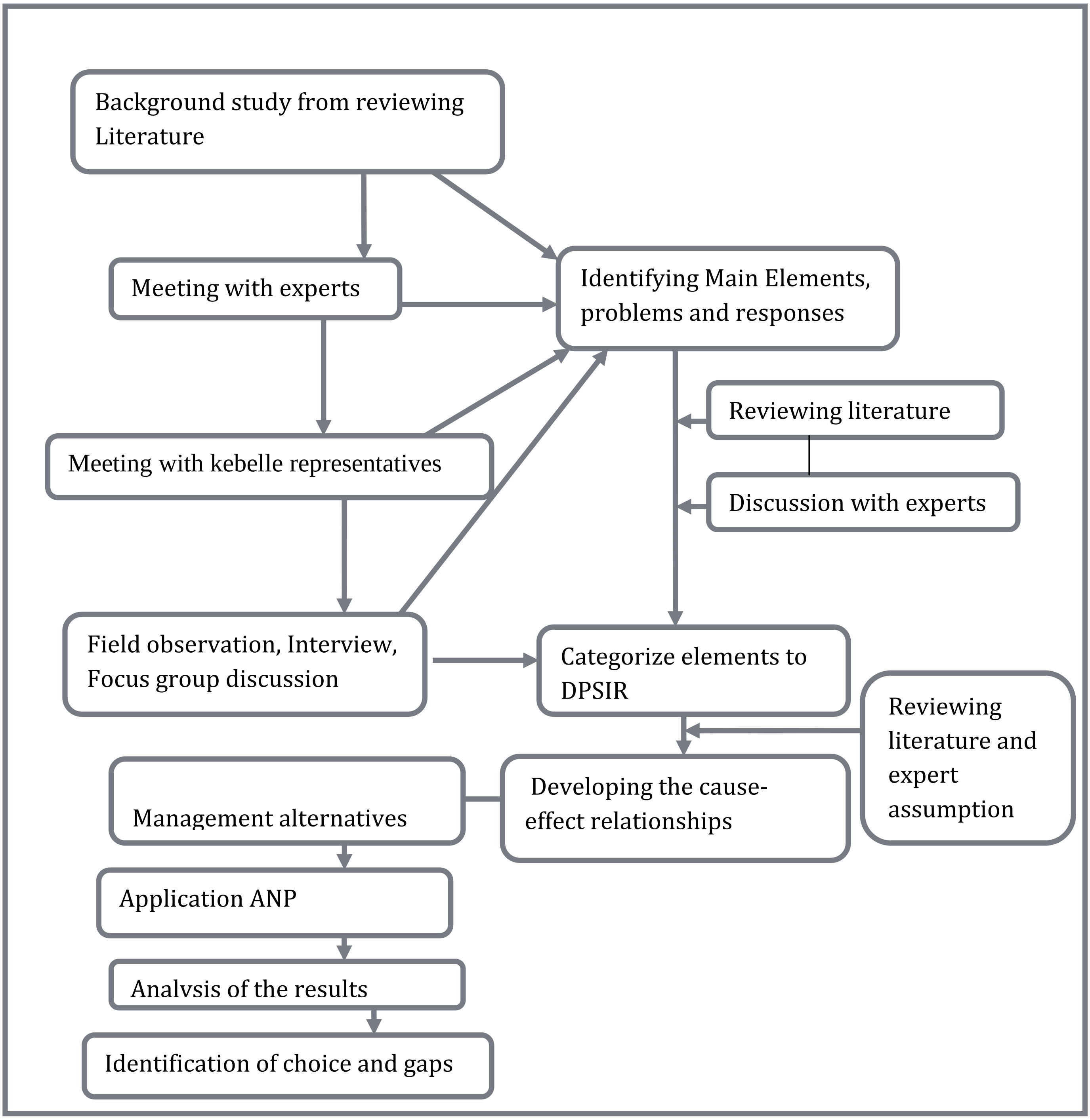

Figure 8: Methodological framework

The methodological approach started with a background study on literatures. Then a meeting was held with Simen Mountains National Park experts and kebelle representatives. The main objective of this meeting was to define the key elements of the ecosystem that are susceptible to be affected by any of the elements generated by human activity, exploring the main driving forces affecting the environment, societal response (policy measures) to such unwanted impacts and to consider local people viewpoints about the park. There after the DPSIR framework was developed by catagorizing each element according to its cluster and nodes. Each element was studied in detail, based on the experience of the experts, discussion and on a deep search of literature, field observations, interviews and focus group discussions. Finally based on expert assumptions and literatures priorities were calculated for each of the alternatives and for each of the DPSIR clusters. To evaluate the importance of influences between indicators and the performance of alternative with regard to each indicators. The importance and weights of indicators were transformed to the ANP matrix. Qualitative assessements have been transformed to pair wise comparision based on the information from key informants and experts. Finally, alternatives were assessed qualitatively for two periods 2020 and 2030. In general, the aim of using the DPSIR approach (within time series) was to provide scientifically based results using information collected to help managers and decision-makers to evaluate previously adopted policies as well future response scenarios.

4.0 Result and Discussion

4.1 Perceived attitude of local people towards supporting Natural Resourse conservation

The main findings from the field descriptions showed that population in both kebelles are highly dependent on natural resources of the park (IUCN n.d). The respondents in Arginjona and Ambergina Kebelles for example had 91% and 87% of farmlands inside the park respectively (Table 5). Due to this high-dependency on the park resources, most of the respondents in both kebelles admitted to undertake illegal activities inside the park. However the response patterns from interview in both kebelles indicated that more than 50% of respondents believed in conservation of natural resource of the park (Table 5), most of them wished to see the park protected and conserved well. The reason for this attitude could be related to the benefits earned from the park which include incomes from the tourist, employment opportunities, enjoyment derived from viewing wildlife and its value for future generation. Historic links between wildlife and traditional, cultural practices are important in influencing attitudes as well (Tessema *et al*., 2007; Badola et al., 1998; 2000). Also high expectations of improved livelihoods which might be brought by development –based conservation activities could be the reasons to perceive positively towards conservation.

However respondents expressed their frustration over the limited level of benefits received from the park. Restrictions in the free use of land and natural resources, unable to extend the farmland without coming to conflict with the park management, prohibition of cutting trees are additional limitations.

In a research conducted in 1994 at SMNP to investigate the attitude of local people towards natural resource conservation of the park was found ambivalent (IUCN n.d). It was mentioned that serious crop depredation and losing of the traditional ownership right was the main reason for the findings. The reasons why the positive attitude about natural resource conservation comes to grow while the problems are getting serious from crop depredation can be explained by the increase in literacy, better understanding of the young generation and increase in involvement of local people in the management of the park (Tessema *et al*., 2007). Mehta (2001) and Buer (2003) suggested that provision of direct and indirect benefits would promote incentives for people to perceive conservation positively.

Table 5: Perceived attitude of respondents about natural resource conservation

Location	Population (No)	Distance from Debark (Km)	People having farmland (%)	Positive Attitudes Toward Natural resource conservation (%)
Arginjona Kebelle	5161	60	91	58
Abergina Kebelle	4650	42	87	60

Regarding the question of who is responsible for the Natural resource management of SMNP, 64% of the respondents from both kebelles thought that the government should be more responsible in taking natural resources conservation initiatives, whereas 27% of the respondents indicated that government and communities living within the park have equal responsibility on natural resources conservation. 9% of respondents perceived that local communities should have more responsibility in taking SMNP conservation initiatives. Low scoring for the involvement of local communities to the management of the park could be explained by poorly developed and unsustainable use of natural resources and the lack of collaborative tradition between the government and local community (Farm Africa, 2007).

4.2 Priorities of indicators in the DPSIR model

The assessment from the current management alternatives reveals that 48% from the total 31 indicators were ranked as being in good condition showing a positive trend (compare Table 2). For instance the increase of threatened and endemic species, like the Walia ibex population which is increasing from 1969 (150), 1976 (210), 1983 (280) to 2009 (550) (IUCN, 1995) or the population of Abesinian fox which is increasing from 2003 (40) to 2005 (71) and 2009 (85) (Hurni and Stiefel, 2003). Additionally, forest fires, wild life diseases, agricultural expansion and biodiversity loss decreased (Table 2). However, there were also negative trends, for example increase of human and domestic animals population in the park (SMNP report, 2009). Based on the findings from the literature review the priorities of the indicators have been expressed for two different time steps (2020 and 2030). Two different DPSIR models have been developed. In the unweighted model the linkages between the indicators are the basis for deriving the individual priorities of the indicators. In the weighted model the importance of the linkages has been expressed additionally, meaning that the influence of a certain indicator on other indicators was expressed by pairwise comparisons.

Fig. 9 demonstrates the priorities of the unweighted indicators for time step 2020. The peak of this graph point at indicator 4.2 (biodiversity loss) followed by 5.3 (Reforestation) and 5.9 (wildlife disease monitoring) . On the other hand, family planning (5.2) was given low priority for the time 2020. Similar results were observed for the weighted indicators as illustrated on Fig.10. The results implies that biodiversity loss and reforestation programs will have the highest priority while family planning will have the least for the 2020 time period.

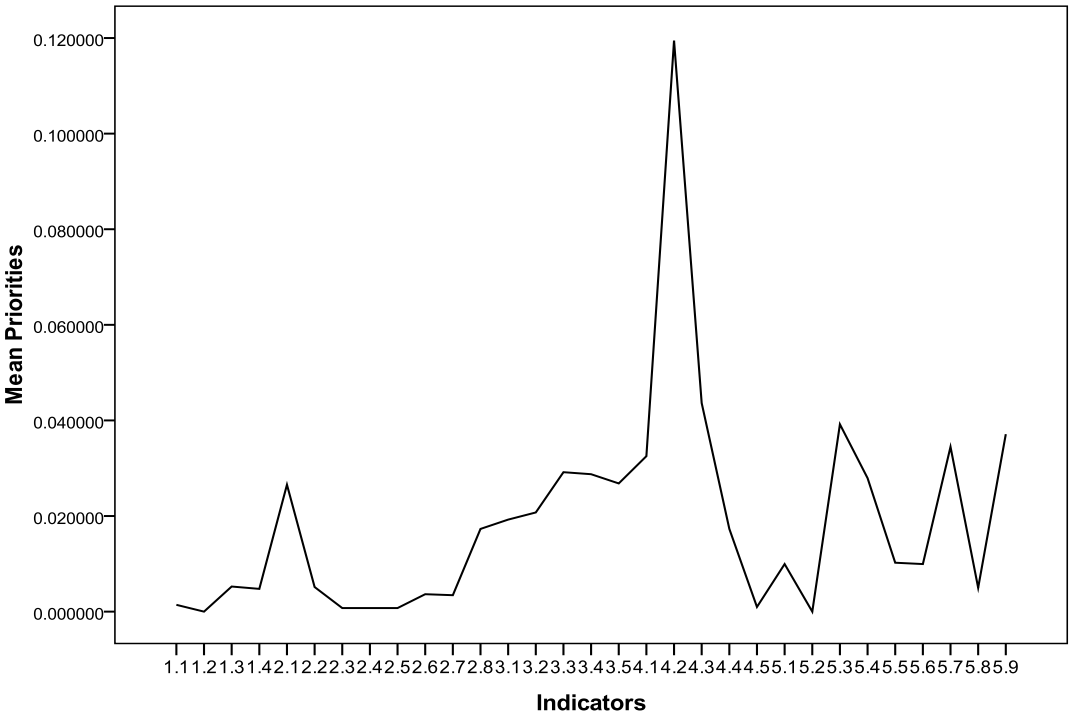

Figure 9: Priority of indicators for time step 2020 in the unweighted model

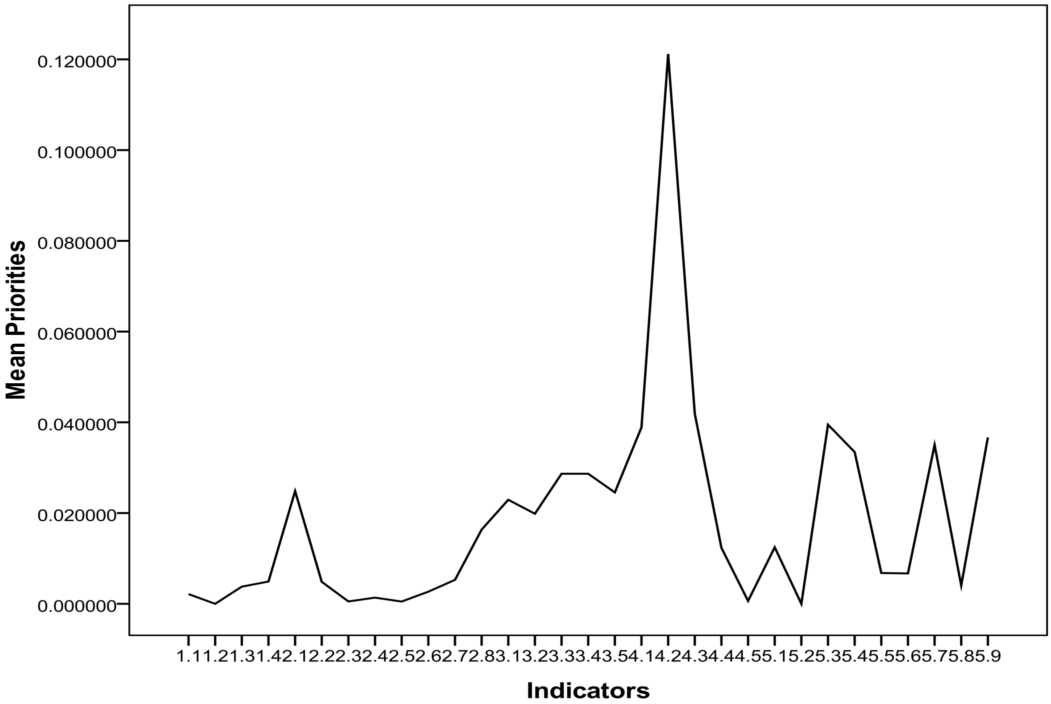

Figure 10: Priority of indicators for time step 2020 for the weighted model

It is evident that in 2020, indicator 4.2 (biodiversity loss) receives a high priority because of the ongoing high fragmentation and degradation of the natural environment in SMNP. There is an urgent need to protect this fragile and rare ecosystem from further degradation and loss (Gottelli and Sillero, 1992). Also high priority is given for reforestation activities to compensate the high rates of deforestation rates in the region (UNEP, 2009).

For the time period 2020, family planning is given low priority even though human population growth in the park has doubled (Oromia Regional State, n.d). This could lead to continued wildlife habitat fragmentation and loss as increased population will seek areas for settlement, agriculture and live stock keeping.

Figure 11.and 12 demonstrates the priorities for the unweighted and weighted indicators for time step 2030. The highest priorities are given to biodiversity loss (4.2), followed by reduction of land degradation (3.1) and deforestation (2.1). Similarly to the time step 2020, the lowest priorities are given for family planning (5.2) and control of agriculture expansion (1.2). Agriculture expansion is not given high priority probabily due to the already established programme to combat settlement and activities in the park, for example gazzetting the park (EARO, 2003)

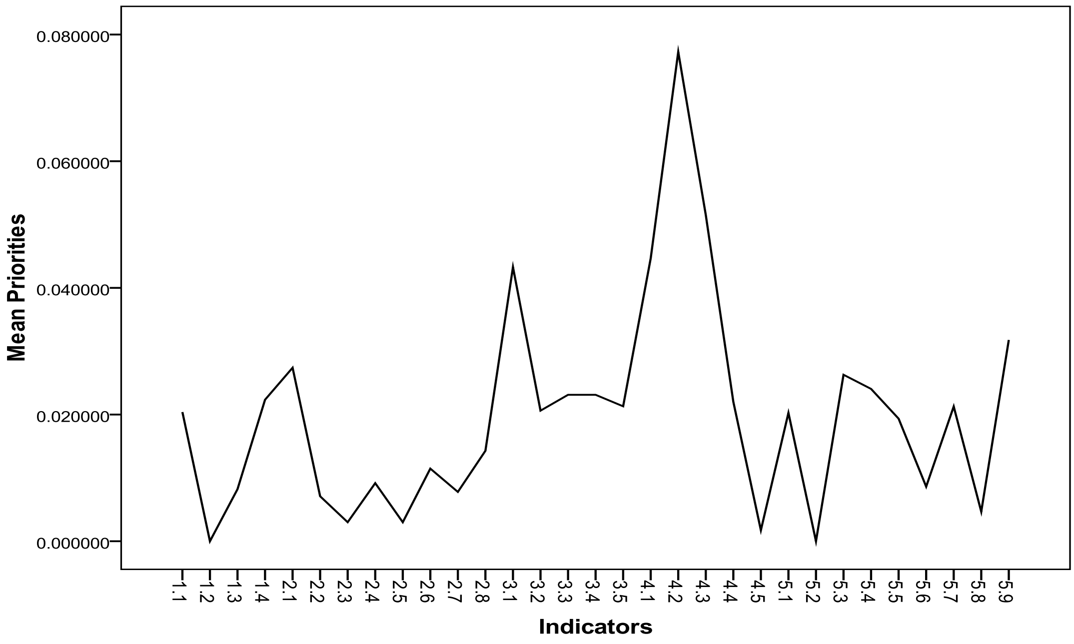

Figure 11: Priority of indicators for time step unweighted 2030

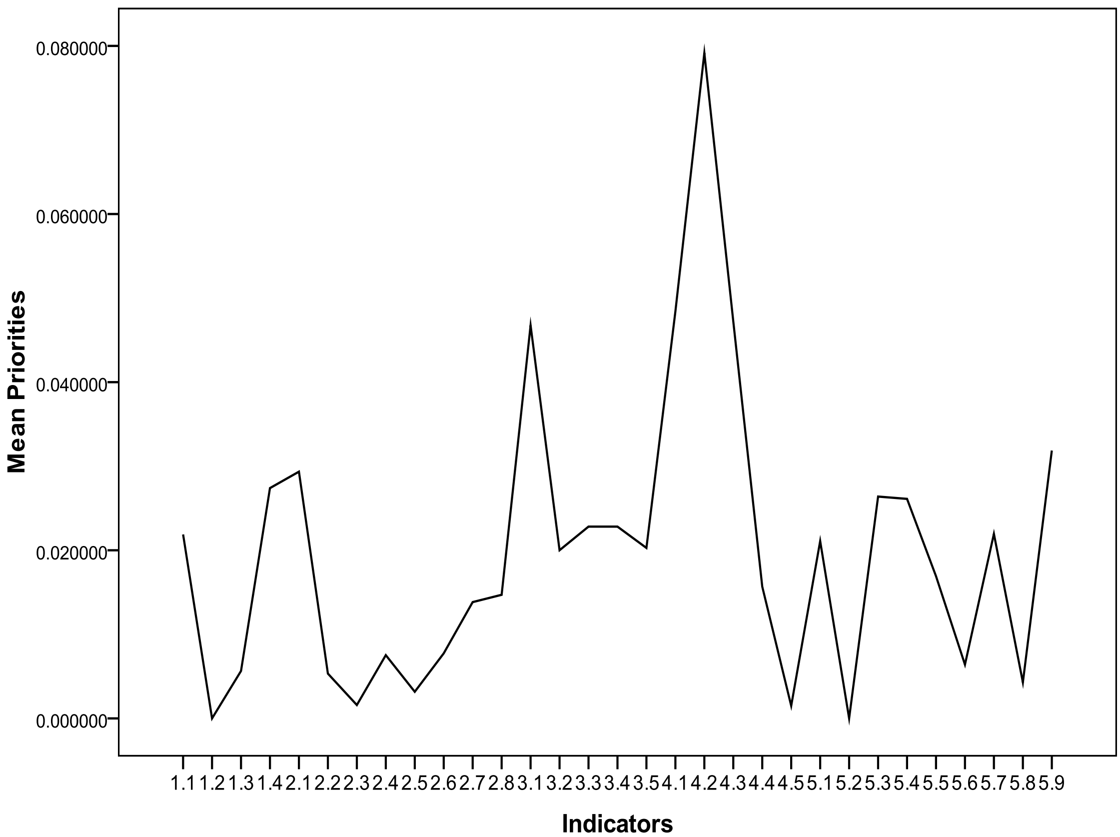

Figure 12: Priority of indicators for time step weighted 2030

Fig. 13 compares the overall priorities of the weighted and unweighted indicators for the time step 2020 and 2030. With some exceptions, the trends of priorities are similar, for instance in all cases the priorities were fluctuating but had a peak in the indicator biodiversity loss. The values of the weighted model at time step 2020 and 2030 showed relatively higher priorities than the values of the unweighted model in 2020 and 2030 (Figure 13)

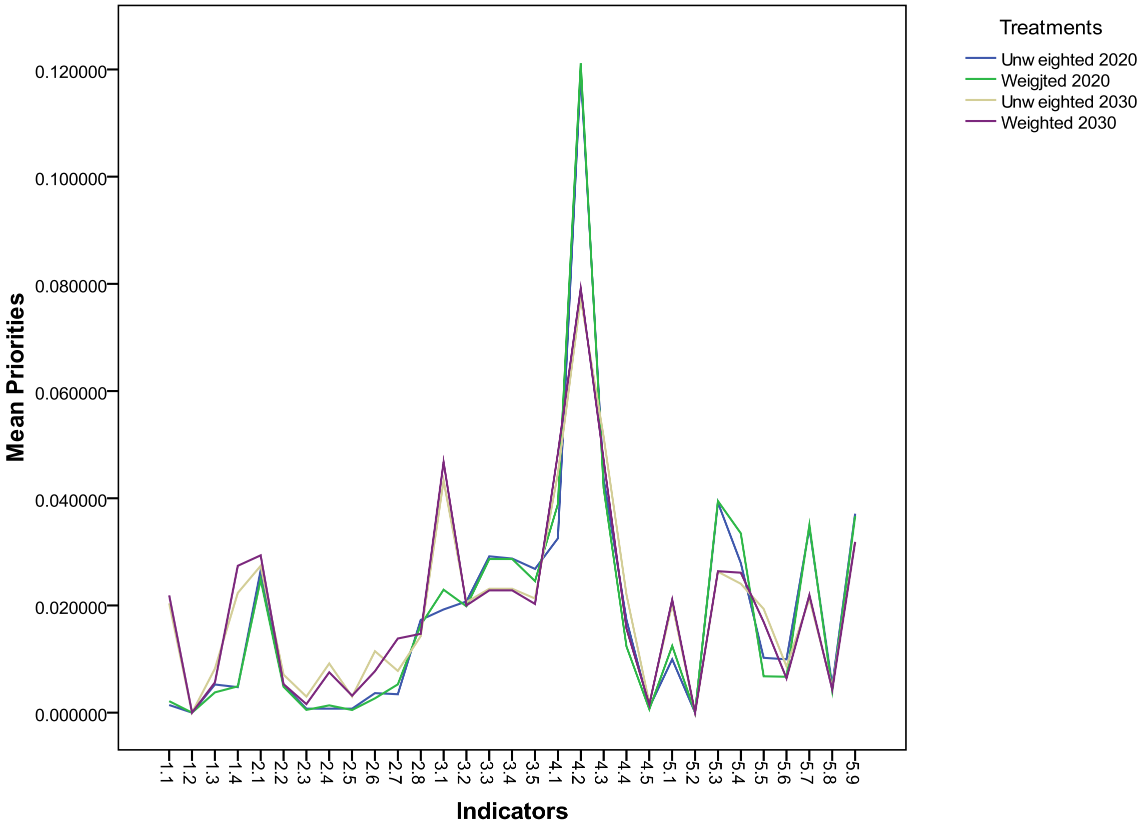

Figure 13:Overall priorities for 2020-2030 weighted and un weighted indicators

4.3 Performance of the management strategies with regard to the indicators

The ranking for each management alternative according to each of the thirty one indicators is shown in Figure 14 and 15. The ecological management strategy scored the highest rank for the indicators: reduction of wildlife disease, conservation of threatened and endemic species. This management alternative contributes to the enhancement of the individual and collective ecological functioning that will improve plant and animal health and increase overall biodiversity (CCDE, 2002). The grazing and settlement management alternative scored best on the indicators reducing of human population, population of domestic animals and domestic over grazing. On the other hand tourism development and management alternative scored best under the wildlife disease monitoring and prevention of hybridization. However, the outreach alternative did not score best for any of the indicators, as this management alternative aims more on stakeholder support (PADPA, 2009) (Figures 14 and 15).

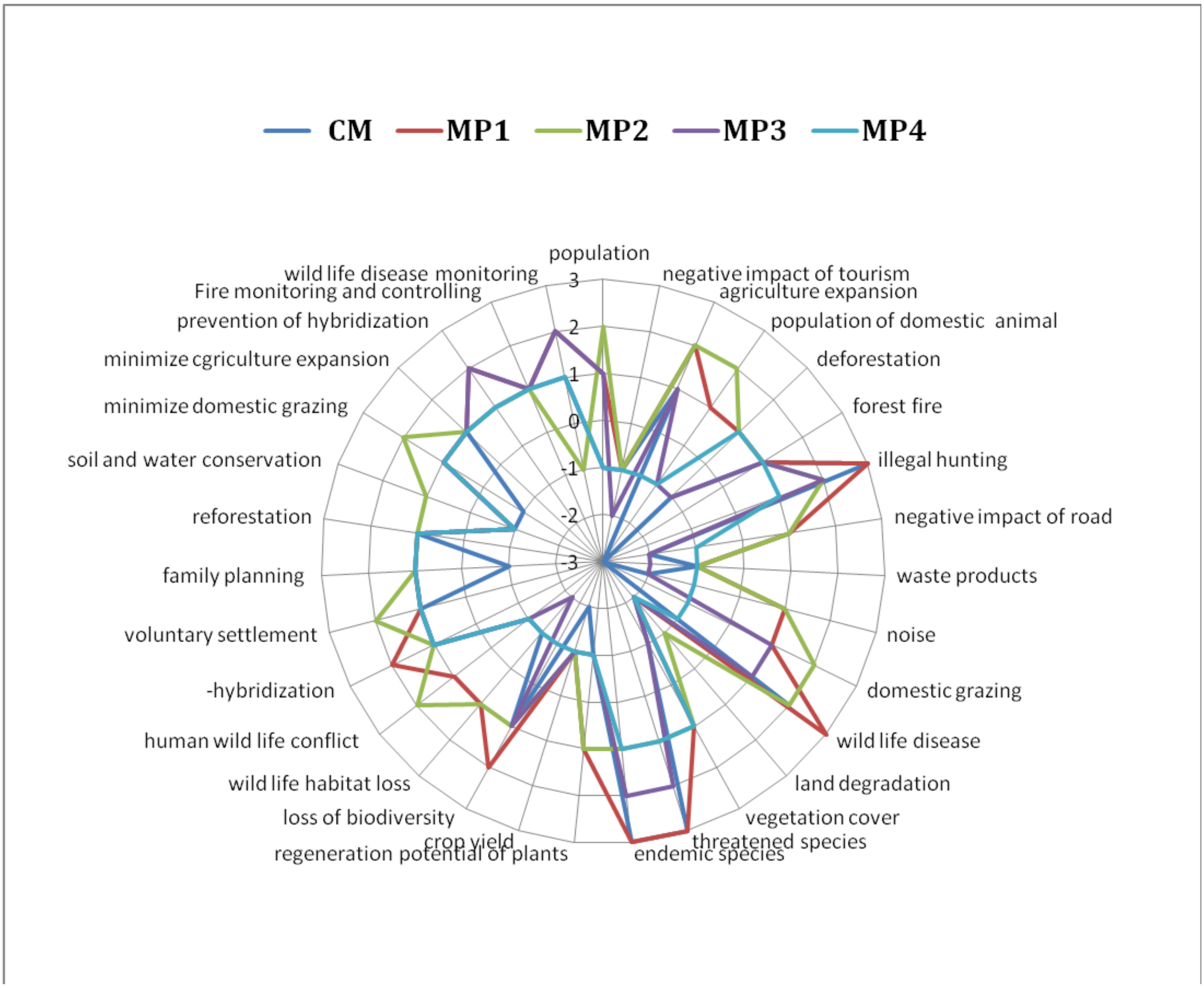

Figure 14: Ranking of alternatives based on indicators for time step 2020

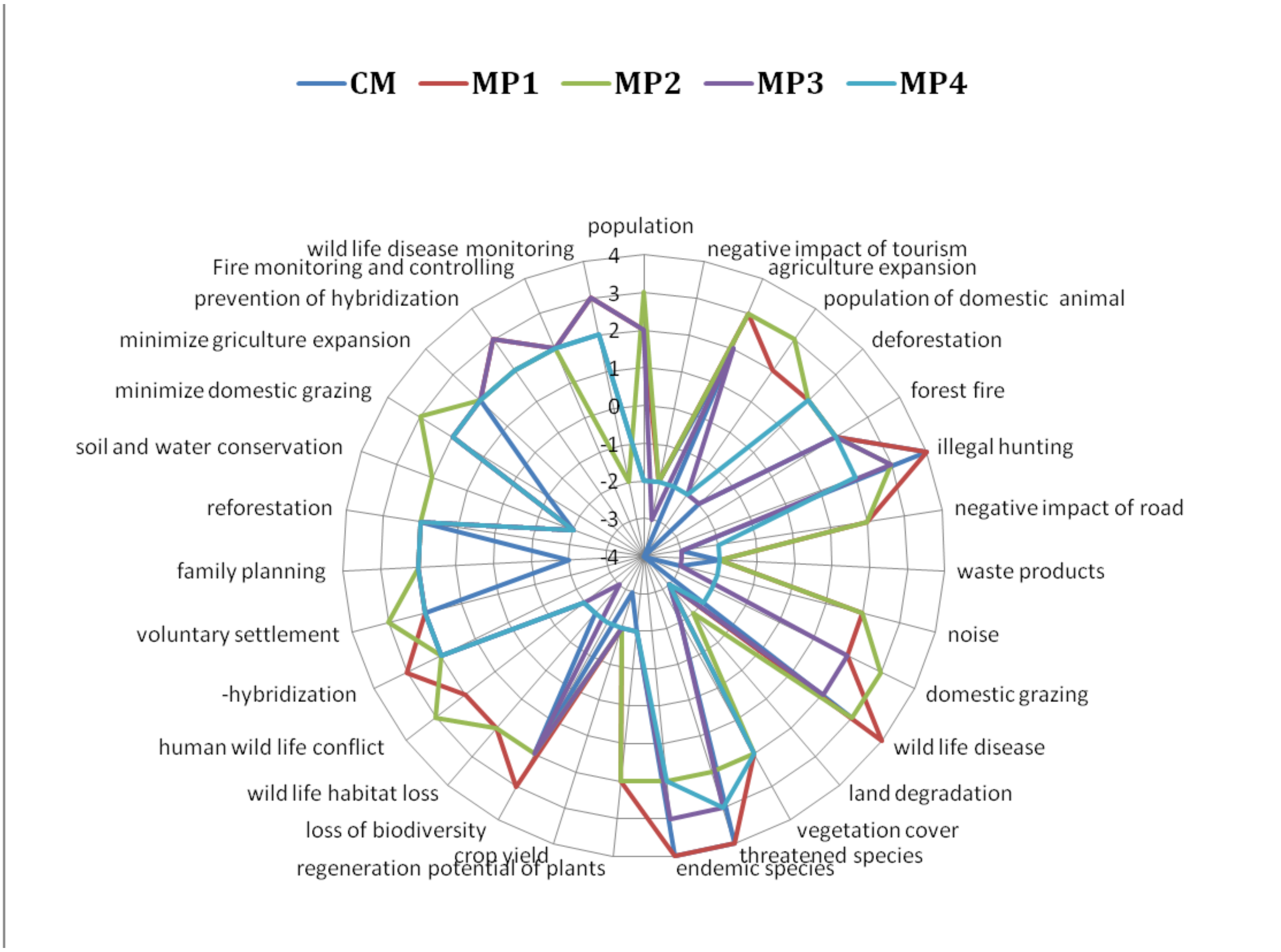

Figure 15: Ranking of alternatives based on indicators for time step 2030

4.4 Preferences and ranking of the alternatives the time step 2020 with equally weighted and weighted indicators

Based on the estimations for the performance of the management strategies for each indicator the overall priorities for each strategy were calculated using both the unweighted and weighted indicators for time step 2020. The most preferable alternative was the ecological management strategy with a preference value of 0.291, and 0.288 for the unweighted and weighted indicators respectively (Table 6 and Table 7). The Ecological Management Strategy is being developed as best-practice management, followed by Grazing and settlement (0.234, 0.232). The Current management was ranked at third position with the unweighted model (preferences of 0.17) but was on fourth position with the weighted indicators (0.168), the least preferable option was the Outreach programme (0.136, 0.136) (Table 6 and Table 7).

Table 6 : Ranking of alternatives for time step 2020 with unweighted indicators

Name	Ideal	Normal	Ranking
Current management	0.583036	0.170101	3
Ecological management	1	0.291751	1
Grazing and settlement	0.803625	0.234458	2
Tourism management and development	0.57437	0.167573	4
Outreach programme	0.46655	0.136116	5

Table 7: Ranking of alternatives for time step 2020 with weighted indicators

Name	Ideal	Normal	Ranking
Current management	0.584186	0.168123	4
Ecological management	1	0.28779	1
Grazing and settlement	0.806389	0.232071	2
Tourism management and development	0.610581	0.175719	3
Outreach program	0.473594	0.136296	5

4.5 Preferences and ranking of the alternatives for the time step 2030 with unweighted and weighted indicators

By comparing the ranking of management alternatives between unweighted and weighted indicators for the time step 2030, the ranking was similar for both. The highest preferred alternative was ecological management (0.289, 0.286), followed by grazing and settlement (0.271, 0.271), tourism management and development (0.153, 0.156) current management (0.150, 0.150) and the least preferable option was the outreach alternative (0.134, 0.135) for both unweighted and weighted indicators respectively (Table 8 and 9).

Table 8: Ranking of alternatives for time step 2030 with unweighted indicators.

Name	Ideal	Normal	Ranking
Current management	0.5207	0.150498	4
Ecological management	1	0.28903	1
Grazing and settlement	0.940044	0.2717	2
Tourism management and development	0.532104	0.153794	3
Outreach program	0.467006	0.134978	5

Table 9: Ranking of alternatives for time step 2030 with weighted indicators

Name	Ideal	Normal	Ranking
Current management	0.525641	0.150344	4
Ecological management	1	0.28602	1
Grazing and settlement	0.949831	0.27167	2
Tourism management and development	0.545982	0.156162	3
Outreach program	0.474811	0.135805	5

4.6 Super matrix of unweighted indicators for the time period 2020.

Besides the current management alternative, four other alternatives were evaluated. The performance of each strategy was compared for each indicator for both time steps and for both models (weighted and unweighted). Table 10 . indiacted the super matrix of unweighted indicators for the time period 2020. In this matrix we can find the original values of the pair wise comparisions which can give an impression on the process of calculating the overall priorities for the management alternatives. For instance, the preference value of the alternatives with regard to indicator biodiversity loss show that MP1 is best performing by scoring the highest (0.355); MP2, MP3, and CMP (0.194) are equally good, and MP4 (0.069) is the least performing. This implies that among the alternatives MP1 is the best to come over the problem of biodiversity loss. On the other hand, MP2 strategy has scored the highest preference (0.386) for the management of the problems of population in the park followed by MP1 and CMP (0.225) where as MP3 and MP4 (0.081) were the least preferable option.

Table 10: Unweighted super matrix of the pressure at time step 2020

	CMP	MP1	MP2	MP3	MP4	1.1	1.2	1.3	1.4	4.1	4.2	4.3	4.4	4.5	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	3.1	3.2	3.3	3.4	3.
CMP	0.000	0.000	0.000	0.000	0.000	0.225	0.219	0.164	0.050	0.111	0.191	0.125	0.095	0.166	0.090	0.200	0.297	0.080	0.222	0.080	0.046	0.218	0.166	0.076	0.200	0.142	0.069	0.200	0.142	0.200	0.164	0.166	0.090	0.313	0.314	0.111
MP1	0.000	0.000	0.000	0.000	0.000	0.225	0.239	0.303	0.283	0.222	0.355	0.317	0.278	0.333	0.272	0.200	0.297	0.350	0.222	0.350	0.232	0.379	0.166	0.230	0.200	0.142	0.191	0.200	0.285	0.200	0.303	0.166	0.272	0.313	0.314	0.333
MP2	0.000	0.000	0.000	0.000	0.000	0.386	0.219	0.303	0.436	0.222	0.191	0.346	0.430	0.166	0.272	0.200	0.157	0.350	0.222	0.350	0.391	0.218	0.333	0.230	0.200	0.428	0.355	0.200	0.142	0.200	0.064	0.333	0.272	0.098	0.099	0.333
MP3	0.000	0.000	0.000	0.000	0.000	0.081	0.101	0.164	0.114	0.222	0.191	0.073	0.098	0.166	0.090	0.200	0.157	0.080	0.111	0.080	0.232	0.126	0.166	0.230	0.200	0.142	0.191	0.200	0.285	0.200	0.303	0.166	0.090	0.176	0.159	0.111
MP4	0.000	0.000	0.000	0.000	0.000	0.081	0.219	0.064	0.114	0.222	0.069	0.133	0.098	0.166	0.272	0.200	0.088	0.138	0.222	0.138	0.096	0.056	0.166	0.230	0.200	0.142	0.191	0.200	0.142	0.200	0.164	0.166	0.272	0.098	0.115	0.111
1.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.2	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.3	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.4	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
4.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	1.000	0.500	1.000	0.000	0.000	1.000	1.000	0.500
4.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.500	0.000	0.333	0.500	0.000	0.500	0.000	0.000	1.000	0.000	0.000	0.500
4.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.333	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.333	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.1	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.833	0.000	0.000	0.000	0.000	0.142	0.000	1.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.2	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.3	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.4	0.000	0.000	0.000	0.000	0.000	0.166	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.5	0.000	0.000	0.000	0.000	0.000	0.177	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.6	0.000	0.000	0.000	0.000	0.000	0.166	0.333	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000
5.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.333	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.190	0.000	0.500	0.000	0.000	0.200	0.000	0.000	0.000	0.500	0.000	0.200	0.500	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000
3.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.285	0.500	0.000	0.000	0.500	0.200	0.500	0.000	0.000	0.000	0.000	0.200	0.000	0.500	0.000	0.500	0.000	0.000	0.000	0.000	0.000
3.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.500	0.000	0.000	0.500	0.200	0.500	0.000	0.000	0.000	0.000	0.200	0.000	0.500	0.000	0.500	0.000	0.000	0.000	0.000	0.000
3.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.190	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.500	0.500	0.200	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000

1.1 Population
1.2 Agriculture expansion
1.3 Tourism
1.4 Population of domestic animal
2.1 Deforestation
2.2 Forest fire
2.3 Illegal hunting
2.4 Negative impact of road
2.5 Production of waste
2.6 Noise disturbance
2.8 Wild life disease
2.7 Domestic grazing
2.4 Negative impact of road
3.1 Land degradation
3.2 Vegetation cover
3.3 Threatened species
3.4 Endemic species
3.5 Regeneration potential of plants
4.1 Crop yield
4.2 Loss of biodiversity
4.3 Wild life habitat loss
4.4 Human wild life conflict
4.5 Hybridization
5.1 Voluntary settlement
5.2 Family planning
5.3 Reforestation
5.4 Soil and water conservation
5.5 Minimize domestic grazing
5.6 agriculture expansion
5.7 Prevention of hybridization
5.8 Fire monitoring
5.9 Wild life disease monitoring

4.7 Over all priorities for all five management alternatives

The main finding from the analysis of the Driving force, Pressure, State, Impact and Response (DPSIR) model with the Analytical Network Process (ANP) has identified that the current management alternative is far to be sustainable (Keiner n.d), when compared with the other four management alternatives. The ANP results showed that the best ranking was achieved by the ecological management strategy (0.288) followed by the grazing and settlement management (0.252), Tourism management and development (0.163) the current management (0.159) and the outreach management were the least preferable options (0.135) (Table 11).

Table 11: All over scoring of alternatives for time 2020 and 2030 for prior and equally weighted indicators

	CMP	MP1	MP2	MP3	MP4
Un weighted 2020	0.170101	0.291751	0.234458	0.167573	0.136116
Weighted 2020	0.168123	0.28779	0.232071	0.175719	0.136296
Un weighted 2030	0.150498	0.28903	0.2717	0.153794	0.134978
Weighted 2030	0.150344	0.28602	0.27167	0.156162	0.135805
Average	**0.1597665**	**0.288648**	**0.252475**	**0.163312**	**0.135799**

The overall priorities for the five managemenet alternatives with respect to both time steps are shown in Figure 16. The figure illustrates that ecological management alternative (MP1) can gain the highest preference values in all time steps. On the other hand MP2 (Grazing and settlement management alternative) starts with a preference value of 0.232 and 0.2345(un weighted and weighted 2020) to 0.2717 (unweighted and weighted 2030). The preferences for tourism management and development (MP3) and Current management Programmes (CMP) showed a slightly reduction over time, but there was no significant change for Outreach programmes (MP4).

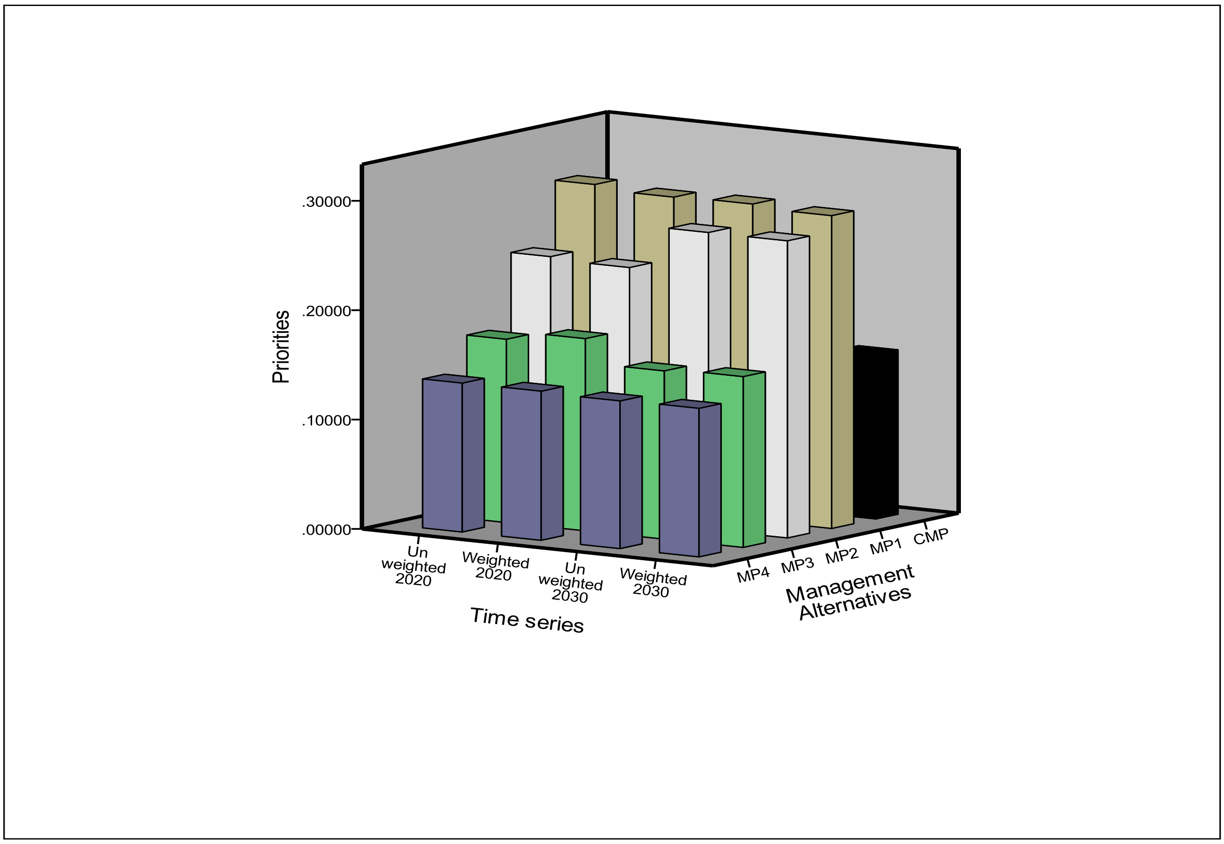

Figure 16: Overall priorities of the alternatives

The results from this research analysis show that the combined use of the ANP and the DPSIR model is efficient in representing the real problem situation of the SMNP. It offers an enrichment of a simply state-based view and a figurative understanding of a multi-dimensional problem. The ANP-DPSIR model succeeds in representing the complexity of environmental changes by integrating information about interdependencies through the ANP and resolves the limitations of the DPSIR framework, which can only suggest linear unidirectional causal chains, while oversimplifying the linkages and the structures of the real situations (Toppen and Prastacos, 2004)

The DPSIR approach was found to be efficient for the analysis of the environmental aspect of the problem and socioeconomic interaction (Canter, 1990; Glasson, *et al*., 2005; The´rivel *et al*., 1992). This assumption perfectly reflects the final ranking of the alternatives of environmental assessment where the preferred alternative was the ecological management strategy.

The expected and actual performance of the ecological management alternative according to driver, pressures, state, impacts and responses framework of the indicators showed that the performance of this strategy was best for both time steps 2020 and 2030. This alternative would be the most promising to overcome the most important problems related to biodiversity conservation, domestic animal population and human population settlement in the park.

According to ANP method, the obtained results reveals that the indicator related to biodiversity was the most interconnected element in the network and it has been influenced by many of the indicators directly or indirectly. Strong influences were observed from the most influential indicators population and population of domestic animals. The DPSIR-based conceptual framework, which has been adopted to describe the overall effects of anthropogenic factors and the environment, seems highly capable of handling the complex socioeconomic and environmental factors of SMNP. However, this framework scheme is far from identifying all possible interactions among variables, because anthropogenic and natural systems are extremely complex, and can be hardly represented by indicators. Moreover, the categorization of indicators is a subjective procedure that has not been codified yet, because it is always a matter of perspectives.

The indicators selected to represent the environmental variables may differ from other methodologies and the DPSIR framework has demonstrated biases in considering different perspectives and concerns of the several stakeholders and in integrating the social and economic aspects (Svarstad *et al.*, 2008). In addition, while addressing many of the problems associated with earlier frameworks, DPSIR has been criticized for several shortcomings (Rekolainen *et al*. 2003). A set of stable indicators that serve as a basis for analysis may not take into account the changing dynamics of the system in question. Also, the framework cannot capture trends except by repeating the study of the same indicators at regular intervals as performed for instance in this study for time step 2020 and 2030. The other drawback is that it does not specifically illustrate clear cause–effect relationships for environmental problems, it has always subjective elements. In this context this study had also some external limitations which include; availability of reliable and sufficient data for the development and application of suitable indicators.

5.0 CONCLUSION AND RECOMMENDATION

The whole decision analysis framework for evaluating management alternatives is a great deal of theoretical and methodological techniques. It was necessary to develop an integrated and dynamic model which combines the innovative potentials of the Driving force, Pressure, State, Impact and Response (DPSIR) framework while measuring performance of management strategies with the Analytic Network Process (ANP). It was possible to develop simple indicator sets using existing data and provide very informative results. The output of this study can greatly assist SMNP management authorities to implement an effective monitoring for conservation and sustainable management. The insights in the decision analysis allow gaining a deeper understanding which provides managers with a valuable platform for further exploration of other alternative management strategies. It is recommended that, the presented local set of indicators could be improved. It would be important to increase the required knowledge for indicator development, and more specific information about current situation of the park ecosystem functions and social structure of local communities. In addition innovative ways of improving the efficiency of management operations are needed. Based on the insights gained and the identified knowledge gaps future follow up studies are advisable too.

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APPENDICES

Appendix 1: The cause and effect relationship of indicators

→ 1.3 (when population size increases there is a need to extend farm land)

→ 1.4 (when population size increases the population of domestic animals increase also)

→ 2.1 (when population size increases there is a need to more fire wood and contraction wood, deforestation)
1.1 →2.2 (when population size increases more fire will start in the forest to demand wood and the land)
1.1 →2.3 (when population increases illegal hunting will increase to demand the meat and extra income)
1.1 →2.4 (when population increases there is a need for more road infrastructure)
1.1 →2.5 (when population increases waste products on the park will increase)
1.1 →2.6 (when population increases noise disturbance will increase)
→ 2.4 (when number of tourists increases there is a need to more road infrastructure)
1.1 →2.5 (when number of tourists waste products on the park will increase)
1.2 →2.6 (when number of tourists increases noise will increase on in the park)
→2.1 (to expand farmland deforestation will takes place)
1.3 → 2.2 (to expand farmland fire is needed to clear the land)
1.4→ 2.6 (when number of domestic animals increase noise in the park will increase)
1.4 → 2.7 (when number of domestic animals increase domestic grazing will increase)
1.4→ 2.8 (when No of domestic animals increase a chance of wildlife disease transfer due to habitat sharing)
2.2 → 2.1 (fire causes deforestation)
2.4 → 2.1 (road construction can cause deforestation to make short cuts)
2.4 → 2.6 (noise disturbs wild life habitat)
2.1 → 3.1 (deforestation causes land degradation / erosion)
2.1 → 3.2 (deforestation causes in reducing vegetation cover)
2.1 → 3.5 (deforestation can reduce regeneration potential of plants)
2.2 → 3.1 (forest fire can cause land degradation)
2.2 → 3.2 (forest fire reduces vegetation cover)
2.2 → 3.3 (forest fire can affect threatened species)
2.2→ 3.4 (forest fire affect endemic species)
2.2 → 3.5 (forest fire reduces regeneration potential of most plants)
2.3 → 3.3 (illegal hunting can affect threatened species)
2.3 → 3.4 (illegal hunting can affect endemic species)
2.4 → 3.1 (roads constriction can cause erosion (land degradation)
2.4 → 3.2 (roads constriction can cause deforestation)
2.6 → 3.3 (noise affects threatened species by disturbing them and their habitat)
2.6 → 3.4 (noise affects endemic species by disturbing them and their habitat)
2.7 → 3.1 (domestic overgrazing can cause land degradation)
2.7 → 3.2 (domestic overgrazing can affect vegetation cover)
2.7 → 3.3 (domestic overgrazing affects threatened species, sharing of fodder and habitat)
2.7 → 3.4 (domestic overgrazing affects endemic species , sharing of fodder and habitat)

2.7 → 3.5 (domestic overgrazing affects regeneration potential of plants)
2.8 → 3.3 (wildlife disease affects threatened species)
2.8 → 3.4 (wildlife disease affects endemic species)
3.1→ 4.1 (degraded land can cause to low crop productivity)
3.2 → 4.3 (a good vegetation cover is safe to wildlife habitat)
3.3 → 4.2 (loss threatened species means loss of biodiversity)
3.4 → 4.2 (loss of endemic species means loss of biodiversity)
3.5→ 4.2 (a good regeneration potential of plants can keep biodiversity)
3.5 → 4.3 (poor regeneration potential of plants can cause habitat loss)
4.3 → 4.2 (habitat loss can cause biodiversity loss)
4.3 → 4.4 (when wild animals lose their habitat they move to crop lands, human wildlife conflict)
4.5 → 4.2 (hybridization can cause animal biodiversity loss)
4.1→ 5.4 (crop yield can be improved through soil and water conservation)
4.2 → 5.3 (biodiversity can be sustained through reforestation)
4.2 → 5.7 (biodiversity can sustain through preventing hybridization)
4.2 → 5.9 (biodiversity can sustain through avoiding wildlife disease)
4.3 → 5.1 (wild life habitat destruction can be reduced through voluntary settlement)
4.3 → 5.3 (wildlife habitat destruction can reduced by reforestation)
4.3 → 5.5 (wild life habitat destruction can be minimized through avoiding domestic grazing)
4.3 → 5.6 (wild life habitat destruction can be minimized through avoiding agriculture expansion)
4.3 → 5.8 (maintain wild life habitat by avoiding forest fire)
4.4 → 5.1 (human wild life conflict can be avoided by voluntary settlement)
4.4 → 5.5 (human wild life conflict can be reduced by avoiding domestic grazing)
4.4 → 5.6 (human wild life conflict can be reduced by avoiding farm expansion)
4.5 → 4.2 (hybridization can cause biodiversity loss)
4.5 → 5.5 (hybridization can be avoided by stopping domestic grazing)
4.5 → 5.7 (hybridization can be avoided by implementing hybridization prevention programme)
5.1 → 1.1 (voluntary settlement of people helps to reduce the population size in the park)
5.1 → 1.3 (voluntary settlement can reduce further agricultural land expansion)
5.1 → 1.4 (when population reduce through voluntary settlement number of domestic grazers also decrease)
5.1 → 2.1 (voluntary settlement can reduces human pressure on deforestation)
5.1 → 2.2 (voluntary settlement can reduces forest fire started by people)
5.1 → 2.3 (voluntary settlement can reduce illegal hunting pressure)
5.1 → 2.4 (voluntary settlement can reduce impacts of road)
5.1 → 2.5 (voluntary settlement can reduce waste (landfill) on the area)
5.1 → 2.6 (voluntary settlement can reduce noise disturbance)
5.1 → 2.7 (voluntary settlement can reduce domestic grazing)
5.1 → 4.3 (voluntary settlement of people can reduce further habitat destruction by people)
5.1 → 4.4 (voluntary settlement of people reduce human wild life conflict)
5.2 → 1.1 (family planning helps to reduce the population size in the future)
5.4 → 3.5 (soil and water conservation can improve the regeneration potential of plants)
5.4 → 3.1 (soil and water conservation can rehabilitate degraded land)
5.6 → 1.3 (minimize agriculture expansion can reduce the expansion of new farm land)
5.6 → 2.1 (minimize agriculture expansion can reduce furtherer deforestation)

5.5 → 1.4 (minimizing domestic grazing reduce population of domestic grazers)
5.5 → 2.6 (minimizing domestic grazing reduce noise disturbance on wildlife habitat)
5.3 → 2.1 (reforestation can help to replace loss due to deforestation)
5.8 → 2.2 (fire controlling and prevention avoids lose due to fire)
5.5 → 2.7 (minimizing domestic grazing can avoid over grazing)
5.5 →3. 1 (minimizing domestic grazing can reduce land degradation)
5.6 → 3.1 (minimizing farm land expansion can help to reduce land degradation)
5.3 → 3.2 (reforestation increases vegetation cover)
5.5 → 3.2 (minimizing domestic grazing can improve the vegetation cover of the area)
5.5 → 3.3 (minimizing domestic grazing reduces computation for fodder with threatened species)
5.5 → 3.4 (minimizing domestic grazing reduces computation for fodder with endemic species)
5.6 → 3.2 (avoiding further agriculture expansion can keep the vegetation cover)
5.8 → 3.2 (avoiding and controlling fire can help to increase vegetation cover)
5.7 → 3.3 (prevention of hybridization keep the biodiversity of threatened species)
5.9 → 2.8 (wild life disease monitoring can reduce wild life disease)
5.9 → 3.3 (wild life disease prevention can keep the biodiversity of threatened species)
5 7 → 3.4 (prevention of hybridization keep the biodiversity of endemic species)
5.9 → 3.4 (wild life disease prevention can keep the biodiversity endemic species)
5 3. → 3.5 (reforestation can increase the regeneration potential of plants)
5. 5 → 3.5 (minimizing domestic grazing can improve the regeneration potential of plants)
5.8 → 3.5 (avoiding and controlling fire can improve the regeneration potential of most plants)
5.4 → 4.1 (soil and water conservation can improve crop yield)
5.3 → 4.2 (planting of endogenous (reforestation) trees can prevent loss of biodiversity)
5.7 → 4.2 (preventing hybridization and avoiding of genetic mixing can keep biodiversity of wildlife)
5.9 → 4.2 (preventing wild life disease can keep the wildlife biodiversity from loss)
5.1 → 4.3 (voluntary settlement of people can reduce extra wild life habitat destruction)
5.3 → 4.3 (Reforestation can help to rehabilitation of degraded habitat)
5.5 → 4.3 (minimizing domestic grazing will reduce further wildlife habitat destruction)
5.6 → 4.3 (decreasing of agriculture expansion can minimize destruction of further wild life habitat)
5.8 → 4.2 (fire monitoring and controlling can keep biodiversity from loss)
5.8 → 4.3 (preventing of fire can help to avoid habitat loss)
5.1 → 4.3 (voluntary settlement can reduce the extent of human wild life conflict)
5.5 → 4.4 (minimizing of domestic grazing can reduce the extent of human wild life conflict)
5.6 → 4.4 (minimizing of further expansion of farm land can reduce the extent of human wild life conflict)
5.5 → 4.5 (minimizing domestic grazing can reduce the probability of hybridization by reducing contact)
5.5 → 5.9 (minimizing domestic grazing helps to reduce the wild life disease by reducing contact of domestic and wild animals)

Appendix 2: Scoring of indicators for each management alternatives

	2020					2030					2020										2030									
indicators	cmp	MP1	MP2	MP3	MP4	CM	MP1	MP2	MP3	MP4	cm/mp1	cm/mp2	cm/mp3	cm/mp4	mp1/mp2	mp1/mp3	mp1/mp4	mp2/mp3	mp2/mp4	mp3/mp4	CM/MP1	CM/MP2	CM/MP3	CM/MP4	MP1/MP2	MP1/MP3	MP1/MP4	MP2/MP3	MP2/MP4	MP§/MP4
population	-1	1	2	1	-1	-2	2	3	2	-2	-2	-3	-2	0	-1	0	2	1	3	4	-4	-5	-4	0	-1	0	4	1	5	4
negative impact of tourism	-1	-1	-1	-2	-1	-2	-2	-2	-3	-2	0	0	1	0	0	1	0	1	0	-1	0	0	1	0	0	1	0	1	0	-1
agriculture expansion	1	2	2	1	-1	2	3	3	2	-2	-1	-1	0	2	0	1	3	1	3	4	-1	-1	0	4	0	1	5	1	5	4
population of domestic animal	-3	1	2	-1	-1	-4	2	3	-2	-2	-4	-5	-2	-2	-1	2	2	3	3	0	-6	-7	-2	-2	-1	4	4	5	5	0
deforestation	-1	1	1	-1	1	-2	2	2	-2	2	-2	-2	0	-2	0	2	0	2	0	-4	-4	-4	0	-4	0	4	0	4	0	-4
forest fire	1	1	1	1	1	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
illegal hunting	3	3	2	2	1	4	4	3	3	2	0	1	1	2	1	1	2	0	1	1	0	1	1	2	1	1	2	0	1	1
negative impact of road	-2	1	1	-2	-1	-3	2	2	-3	-2	-3	-3	0	-1	0	3	2	3	2	-1	-5	-5	0	-1	0	5	4	5	4	-1
waste products	-1	-1	-1	-2	-1	-2	-2	-2	-3	-2	0	0	1	0	0	1	0	1	0	-1	0	0	1	0	0	1	0	1	0	-1
noise	-2	1	1	-2	-1	-3	2	2	-3	-2	-3	-3	0	-1	0	3	2	3	2	-1	-5	-5	0	-1	0	5	4	5	4	-1
domestic grazing	-3	1	2	1	-1	-4	2	3	2	-2	-4	-5	-4	-2	-1	0	2	1	3	4	-6	-7	-6	-2	-1	0	4	1	5	4
wild life disease	2	3	2	1	-1	3	4	3	2	-2	-1	0	1	3	1	2	4	1	3	4	-1	0	1	5	1	2	6	1	5	4
land degradation	-2	-2	-1	-2	-2	-3	-3	-2	-3	-3	0	-1	0	0	-1	0	0	1	1	0	0	-1	0	0	-1	0	0	1	1	0
vegetation cover	-1	1	1	-1	1	-2	2	2	-2	2	-2	-2	0	-2	0	2	0	2	0	-4	-4	-4	0	-4	0	4	0	4	0	-4
threatened species	3	3	1	2	1	4	4	2	3	3	0	2	1	2	2	1	2	-1	0	0	0	2	1	1	2	1	1	-1	-1	0
endemic species	3	3	1	2	1	4	4	2	3	2	0	2	1	2	2	1	2	-1	0	1	0	2	1	2	2	1	2	-1	0	1
regeneration potential of plants	-1	1	1	-1	-1	-2	2	2	-2	-2	-2	-2	0	0	0	2	2	2	2	0	-4	-4	0	0	0	4	4	4	4	0

crop yield	-2	-1	-1	-1	-1	-3	-2	-2	-2	-2	-1	-1	-1	-1	0	0	0	0	0	0	-1	-1	-1	-1	0	0	0	0	0	0
loss of biodiversity	1	2	1	1	-1	2	3	2	2	-2	-1	0	0	2	1	1	3	0	2	4	-1	0	0	4	1	1	5	0	4	4
wild life habitat loss	-1	1	1	-2	-1	-2	2	2	-3	-2	-2	-2	1	0	0	3	2	3	2	-1	-4	-4	1	0	0	5	4	5	4	-1
human wild life conflict	-1	1	2	-1	-1	-2	2	3	-2	-2	-2	-3	0	0	-1	2	2	3	3	0	-4	-5	0	0	-1	4	4	5	5	0
-hybridization	1	2	1	1	1	2	3	2	2	2	-1	0	0	0	1	1	1	0	0	0	-1	0	0	0	1	1	1	0	0	0
voluntary settlement	1	1	2	1	1	2	2	3	2	2	0	-1	0	0	-1	0	0	1	1	0	0	-1	0	0	-1	0	0	1	1	0
family planning	-1	1	1	1	1	-2	2	2	2	2	-2	-2	-2	-2	0	0	0	0	0	0	-4	-4	-4	-4	0	0	0	0	0	0
reforestation	1	1	1	1	1	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
soil and water conservation	-1	-1	1	-1	-1	-2	-2	2	-2	-2	0	-2	0	0	-2	0	0	2	2	0	0	-4	0	0	-4	0	0	4	4	0
minimize domestic grazing	-1	1	2	1	1	-1	2	3	2	2	-2	-3	-2	-2	-1	0	0	1	1	0	-3	-4	-3	-3	-1	0	0	1	1	0
minimize agriculture expansion	1	1	1	1	1	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
prevention of hybridization	1	2	1	2	1	2	3	2	3	2	-1	0	-1	0	1	0	1	-1	0	1	-1	0	-1	0	1	0	1	-1	0	1
Fire monitoring and controlling	1	1	1	1	1	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
wild life disease monitoring strategy	1	2	-1	2	1	2	3	-2	3	2	-1	2	-1	0	3	0	1	-3	-2	1	-1	4	-1	0	5	0	1	-5	-4	1

Appendix 3: weighted super matrix of the pressure at time step 2020

	CMP	MP1	MP2	MP3	MP4	1.1	1.2	1.3	1.4	4.1	4.2	4.3	4.4	4.5	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	3.1	3.2	3.3	3.4	3.5
CMP	0.000	0.000	0.000	0.000	0.000	0.026	0.111	0.080	0.025	0.055	0.093	0.041	0.049	0.055	0.044	0.066	0.148	0.026	0.111	0.040	0.022	0.107	0.041	0.038	0.050	0.047	0.011	0.040	0.047	0.050	0.041	0.083	0.044	0.157	0.156	0.055
MP1	0.000	0.000	0.000	0.000	0.000	0.073	0.111	0.149	0.141	0.111	0.175	0.113	0.137	0.111	0.133	0.066	0.148	0.116	0.111	0.175	0.112	0.186	0.041	0.115	0.050	0.047	0.031	0.040	0.095	0.050	0.075	0.083	0.133	0.157	0.156	0.166
MP2	0.000	0.000	0.000	0.000	0.000	0.126	0.111	0.149	0.218	0.111	0.093	0.113	0.215	0.055	0.133	0.066	0.078	0.116	0.111	0.175	0.191	0.107	0.083	0.115	0.050	0.142	0.059	0.040	0.047	0.050	0.016	0.166	0.133	0.000	0.049	0.166
MP3	0.000	0.000	0.000	0.000	0.000	0.082	0.055	0.091	0.057	0.111	0.106	0.024	0.049	0.055	0.040	0.066	0.078	0.026	0.055	0.000	0.129	0.000	0.041	0.115	0.050	0.047	0.031	0.045	0.095	0.050	0.075	0.083	0.040	0.077	0.088	0.055
MP4	0.000	0.000	0.000	0.000	0.000	0.024	0.111	0.029	0.057	0.111	0.031	0.041	0.045	0.055	0.149	0.066	0.044	0.046	0.111	0.069	0.043	0.025	0.041	0.115	0.050	0.047	0.031	0.040	0.047	0.050	0.041	0.083	0.149	0.057	0.049	0.055
1.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.2	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.3	0.000	0.000	0.000	0.000	0.000	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.4	0.000	0.000	0.000	0.000	0.000	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000
4.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.222	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.333	0.008	0.250	0.000	0.000	0.500	0.500	0.250
4.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.120	0.000	0.125	0.000	0.068	0.100	0.000	0.166	0.000	0.000	0.500	0.000	0.000	0.250
4.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.043	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.1	0.000	0.000	0.000	0.000	0.000	0.094	0.000	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.166	0.000	0.000	0.000	0.000	0.044	0.000	0.250	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.2	0.000	0.000	0.000	0.000	0.000	0.061	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000	0.000
2.3	0.000	0.000	0.000	0.000	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.6	0.000	0.000	0.000	0.000	0.000	0.039	0.155	0.000	0.119	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.030	0.000	0.000	0.000	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.312	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.068	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000
5.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.099	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.065	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1.1 Population
1.2 Agriculture expansion
1.3 Tourism
1.4 Population of domestic animal
2.1 Deforestation
2.2 Forest fire
2.3 Illegal hunting
2.4 Negative impact of road
2.5 Production of waste
2.6 Noise disturbance
2.8 Wild life disease
2.7 Domestic grazing
2.4 Negative impact of road
3.1 Land degradation
3.2 Vegetation cover
3.3 Threatened species
3.4 Endemic species
3.5 Regeneration potential of plants
4.1 Crop yield
4.2 Loss of biodiversity
4.3 Wild life habitat loss
4.4 Human wild life conflict
4.5 Hybridization

5.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.125	0.083	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.042	0.000	0.166	0.000	0.000	0.087	0.000	0.000	0.000	0.000	0.222	0.025	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.047	0.000	0.166	0.000	0.000	0.116	0.000	0.000	0.000	0.125	0.000	0.032	0.100	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000
3.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.095	0.250	0.000	0.250	0.250	0.098	0.250	0.000	0.000	0.000	0.000	0.037	0.000	0.166	0.000	0.125	0.000	0.000	0.000	0.000	0.000

5.1 Voluntary settlement
5.2 Family planning
5.3 Reforestation
5.4 Soil and water conservation
5.5 Minimize domestic grazing
5.6 agriculture expansion
5.7 Prevention of hybridization
5.8 Fire monitoring
5.9 Wild life disease monitoring

Appendix 4: Unweightd super matrix of the pressure at time step 2030

	CMP	MP1	MP2	MP3	MP4	1.1	1.2	1.3	1.4	4.1	4.2	4.3	4.4	4.5	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	3.1	3.2	3.3	3.4	3..5
CMP	0.000	0.000	0.000	0.000	0.000	0.199	0.222	0.112	0.038	0.111	0.198	0.085	0.318	0.333	0.294	0.200	0.297	0.392	0.222	0.392	0.247	0.382	0.166	0.238	0.200	0.111	0.195	0.200	0.285	0.200	0.308	0.166	0.294	0.297	0.313	0.384
MP2	0.000	0.000	0.000	0.000	0.000	0.362	0.222	0.298	0.472	0.222	0.198	0.387	0.470	0.166	0.294	0.200	0.157	0.392	0.222	0.392	0.406	0.223	0.333	0.238	0.200	0.555	0.358	0.200	0.142	0.200	0.042	0.333	0.294	0.088	0.098	0.385
MP3	0.000	0.000	0.000	0.000	0.000	0.190	0.111	0.156	0.082	0.222	0.198	0.053	0.070	0.166	0.058	0.200	0.157	0.058	0.111	0.058	0.247	0.132	0.166	0.238	0.200	0.111	0.195	0.200	0.285	0.200	0.308	0.166	0.058	0.157	0.176	0.072
MP4	0.000	0.000	0.000	0.000	0.000	0.046	0.222	0.061	0.082	0.222	0.044	0.085	0.073	0.167	0.294	0.200	0.088	0.097	0.222	0.097	0.065	0.038	0.166	0.238	0.200	0.111	0.195	0.200	0.142	0.200	0.170	0.166	0.294	0.157	0.098	0.076
1.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.333	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.3	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.4	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	0.333	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
4.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.500	1.000	0.000	0.000	1.000	1.000	0.500
4.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.500	0.000	0.333	0.500	0.000	0.500	0.000	0.000	1.000	0.000	0.000	0.500
4.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.333	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.1	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.142	0.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.2	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
2.3	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.4	0.000	0.000	0.000	0.000	0.000	0.166	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.5	0.000	0.000	0.000	0.000	0.000	0.166	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.6	0.000	0.000	0.000	0.000	0.000	0.166	0.333	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000
5.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.297	0.333	0.000	0.000	0.000	1.000	1.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1.1 Population
1.2 Agriculture expansion
1.3 Tourism
1.4 Population of domestic animal
2.1 Deforestation
2.2 Forest fire
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3.3 Threatened species
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3.5 Regeneration potential of plants
4.1 Crop yield
4.2 Loss of biodiversity
4.3 Wild life habitat loss
4.4 Human wild life conflict

5.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*4.5 Hybridization*
5.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.197	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.1 Voluntary settlement*
5.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.00000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.2 Family planning*
5.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.168	0.333	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	*5.3 Reforestation*
5.6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.168	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.4 Soil and water conservation*
5.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.5 Minimize domestic grazing*
5.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.168	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.6 agriculture expansion*
5.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.7 Prevention of hybridization*
3.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.333	0.200	0.000	0.500	0.000	0.000	0.200	0.000	0.000	0.000	0.00	0.500	0.200	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.8 Fire monitoring*
3.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.200	0.000	0.500	0.000	0.000	0.200	0.000	0.000	0.000	0.500	0.000	0.200	0.500	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	*5.9 Wild life disease monitoring*
3.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.500	0.000	0.000	0.500	0.200	0.500	0.000	0.000	0.000	0.000	0.200	0.000	0.500	0.000	0.500	0.000	0.000	0.000	0.000	0.000	

Appendix 5: Weighted super matrix of the pressure at time step 2030

	CMP	MP1	MP2	MP3	MP4	1.1	1.2	1.3	1.4	4.1	4.2	4.3	4.4	4.5	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	3.1	3.2	3.3	3.4	3.5
CMP	0.000	0.000	0.000	0.000	0.000	0.066	0.111	0.037	0.012	0.037	0.099	0.025	0.023	0.055	0.029	0.100	0.074	0.014	0.222	0.019	0.009	0.055	0.041	0.023	0.050	0.027	0.009	0.066	0.071	0.050	0.034	0.083	0.021	0.148	0.156	0.038
MP1	0.000	0.000	0.000	0.000	0.000	0.065	0.111	0.123	0.107	0.074	0.180	0.129	0.106	0.111	0.147	0.100	0.074	0.098	0.222	0.130	0.061	0.095	0.041	0.119	0.050	0.027	0.032	0.066	0.142	0.050	0.061	0.083	0.147	0.148	0.156	0.192
MP2	0.000	0.000	0.000	0.000	0.000	0.120	0.111	0.099	0.157	0.077	0.099	0.129	0.156	0.055	0.147	0.100	0.039	0.098	0.222	0.130	0.100	0.055	0.083	0.119	0.050	0.138	0.059	0.066	0.071	0.050	0.008	0.166	0.147	0.044	0.049	0.192
MP3	0.000	0.000	0.000	0.000	0.000	0.063	0.055	0.052	0.027	0.074	0.099	0.017	0.023	0.055	0.029	0.100	0.039	0.01474	0.111	0.019	0.061	0.033	0.041	0.119	0.050	0.027	0.032	0.066	0.142	0.050	0.061	0.083	0.029	0.078	0.088	0.038
MP4	0.000	0.000	0.000	0.000	0.000	0.015	0.111	0.020	0.027	0.074	0.022	0.02	0.023	0.055	0.147	0.100	0.022	0.024	0.222	0.032	0.016	0.009	0.041	0.119	0.050	0.027	0.032	0.066	0.074	0.050	0.034	0.083	0.147	0.078	0.049	0.038
1.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000	0.100	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.3	0.000	0.000	0.000	0.000	0.000	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.4	0.000	0.000	0.000	0.000	0.000	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.250	0.100	0.000	0.000	0.000	0.1667	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000
4.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.222	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.083	0.200	0.000	0.000	0.500	0.500	0.250
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.000	0.125	0.000	0.068	0.16667	0.000	0.166	0.000	0.000	0.500	0.000	0.000	0.250	
4.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.043	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.1	0.000	0.000	0.000	0.000	0.000	0.084	0.000	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.000	0.00	0.000	0.000	0.046	0.000	0.250	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.2	0.000	0.000	0.000	0.000	0.000	0.041	0.000	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000	0.000
2.3	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.4	0.000	0.000	0.000	0.000	0.000	0.062	0.246	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.5	0.000	0.000	0.000	0.000	0.000	0.069	0.097	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.6	0.000	0.000	0.000	0.000	0.000	0.046	0.155	0.000	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.000	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.179	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.098	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.000

1.1 Population
1.2 Agriculture expansion
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5.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.099	0.166	0.000	0.000	0.000	0.250	0.250	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.2 Family planning*
5.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.3 Reforestation*
5.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.065	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.4 Soil and water conservation*
5.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.5 Minimize domestic grazing*
5.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.083	0.083	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.000	*5.6 agriculture expansion*
5.6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.083	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.7 Prevention of hybridization*
5.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.8 Fire monitoring*
5.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*5.9 Wild life disease monitoring*
5.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.2500	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	