Sustainable Forest Management for Implementers

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Introduction

After more than 40 years of practical forest management and coming to the end of my service, I came to the decision to write a book which incorporates all my experience and knowledge I have gained over all these years. This book is especially focused on the development aid sector, or better called international co-operation, in which I worked all together 15 years but over a time span of more than 30 years.

In many of these countries the forestry sector is characterized by a lack of knowledge and skills, especially when it comes to technically subjects, to the implementation of planned activities inside the forest. This applies not only for professional staff of these countries but alarmingly even to the so called "Forestry Experts" which are working for all these international development agencies and NGOs. Many of these experts have joined these agencies directly after completion of their studies or PHDs and have never worked in a Forestry Department or company in their homelands, have never gained any practical experience. This results very often in halfhearted and precarious decisions and actions, especially when it comes to practical implementation in the field. This situation occurred in most of the development aid projects I worked with. Sometimes the projects ceased before the actual implementation even commenced.

Another problem I experienced that there is not much exchange of experiences, or, to say it in other words: "Each project tries to invent the wheel again".

In many of these countries the responsible Forestry Departments are badly organized and financed. So, politicians often think that by outsourcing the forest management to companies or contractors through issuing of licenses these problems can be solved. This could be a good choice if these companies have employed well trained and educated staff, which is mostly not the case. Furthermore the respective Forestry Department has to be in the position to control and monitor these license holders closely, which can be implemented only with trained staff again.

As representatives of their Governments, Forestry Departments can never give up the responsibility for their forests. They are fully responsible towards the public! Outsourcing of responsibilities is not always a good solution!

In this regard, I have written a chapter showing a possible organization of a Forestry Department including an example for a job description for a respective work flow.

Sometimes politicians are starting their political campaign with the promise to stop cutting trees and forestry at all and to put all forests under protection. They forget that timber cannot be beaten for all kind of use by any other material in terms of positive energy balance and carbon fixation. Thus, a sustainable forest management providing timber for all kind of use and at all times has to be considered the optimal solution for following generations.

This book is supposed to give guidance to all staff involved in all the fields of Sustainable Forest Management with an emphasis on forest operations and implementation of activities inside the forest. The language, procedures and methodologies are kept as simple as possible to serve for all staff involved. It does not claim to be based on scientific studies but on practical knowledge and experience.

At the end we will be valuated and have to evaluate our own performance not by how many publications or guidelines we have written but by the fact what has changed inside the forest, what has been really implemented and to which extend the forest has improved.

Walter Benneckendorf

I. Management Planning Guidelines Overview

Glossary

a.m.	above mentioned
DBH	Diameter in Breast Height
e.g.	Example given
FIS	Forest Information System
FO.	Forest Officer
FSC	Forest Stewardship Council
FW	Forest Worker
GIS	Global Information System
Ha/ha	Hectare
Mgt.	Management
PEFC	Programme for the Endorsement of Forest Certification Schemes
PCT	Potential Crop Tree

1 Management Planning and Mgt. Goal

The first step in Management Planning is the formulation of the management goal, asking the question: what do we want from our forest, to what functions it should serve? This Mgt. Goal has to match, of course always with the respective regulatory requirements (Forest Laws) of the respective country.

As an example the following formulation could serve:

The Mgt. Goal is the sustainable production of high value timber from mixed, autochthonous species stands. This requires sometimes a change of present species composition, primarily from monoculture stands, into multi-storied mixed deciduous stands, which are well in line with mitigating the impacts of- and adapting to the ongoing climate change. Additionally, the production of high value timber has to be considered a pre-condition for the improvement of the country's forestry sector, the generation of income and new jobs and finally even the increase of biodiversity. Additionally, the production of non-timber products has to be encouraged.

The management comprises all forest functions as production, protection, welfare and recreation and education.

For the purpose of safeguarding the sustainability and after fulfilling the respective requirements, the certification of the forests by an internationally recognized institution (FSC, PEFC) is highly recommended.

A more detailed information can be found under the chapter "Silviculture". There an example is given for a "Long Term Ecological Forest Development".

2 Zoning to Forest Functions

As a policy advice for a forest administration the development and application of a sustainable forest management system is recommended, based on integrated multiple-use management planning which incorporates timber production, soil conservation, non-forest produces, community needs and conservation of flora and fauna. Refer to **"Guidelines for Zoning according to Forest Functions".**

3 Opening-Up Systems

3.1 Basic Road Network

For ecological reasons forest road densities should be kept to a minimum. However, a prerequisite for efficient forest management is an adequately established road network which facilitates the use of appropriate technologies for silviculture, tending, harvesting operations, protection and even recreation. In some remote areas, forest roads even may play an important role in rural development. This Basic Road Network gives access to the forest for implementation of the forest inventory and forest protection. Refer to **"Guidelines for Forest Road Construction, chapter 3.7".**

3.2 Opening-Up Road Network

For harvesting operations an Opening-Up Road Network, consisting of Feeder Roads and Skid trails have to be added on a later stage. Refer to chapter **"Guidelines for Forest Road Construction and Harvesting Guidelines, chapter 3.8 and Harvesting Guidelines".**

4 Inventory and Forest Record Book

There are many designs and different inventories. First of all one has to clarify for what purpose this inventory should serve and what data it should produce. At the end, when it comes to sustainable forest management, to activities inside the forest, a management inventory, where data as species, age classes, crown closure, etc. have to be collected and documented in a **Forest Record Book**. Refer to **"Guidelines for Forest Inventory and Forest Record Book".**

5 Silvicultural Guidelines

5.1 Stand Establishment

Here we have to refer to the a.m. Mgt. Goal. To keep broad leaf and mixed stands, one can depend on natural regeneration. To increase the number of those stands, planting or sowing with appropriate species should commence as soon as possible. Most of the gaps inside the forest, except for ecological and recreational reasons, should be treated accordingly. Sometimes, these areas have to be protected by fencing against roaming livestock and wildlife.
Refer to **"Guidelines for Stand Establishment".**

5.2. Tending operations

5.2.1 Pre-commercial Thinning Operations

These are thinnings where no commercial timber can be produced (DBH < 10 cm). Maintenance of young stands might become necessary, even the timber cannot be used.
Refer to **"Thinning Operations and Pruning".**

5.2.2 Thinning Operations

Thinnings have to be carried out to regulate tree distribution, directing the growth to PCT's, eliminate bad quality and weak trees and last but not least stabilizing the stands. The activities differ according to tree species and age classes by harvesting techniques and intensity. Before these activities can commence, the opening-up road network has to be established. For the actual operations refer to **"Thinning Operations and Pruning"**

5.3 Harvesting Operations
Refer to **"Harvesting Guidelines".**

6 Economics
Despite serving for all the other forest functions, forestry aims to make a profit. This is the point where a lot of environmentalists start to complain - and there are good reasons for since in many countries the forestry sector was or still is characterized by corruption and a bad, not sustainable management. It was very often a mere exploitation not taking biodiversity and sustainability into account. Refer to **"Economics"**

7 Forest Protection
Since in each country fauna and flora is different, guidelines for forest protection have to be developed separately incorporating the respective national biodiversity regulations and laws. The following can serve only as an example. Refer to **"Forest Protection Guidelines".**

7.1 Forest Fire Management
Most of wildland fires are man- made. Therefore, the conclusion to emphasis on forest fire prevention becomes obvious. Refer to **"Forest Fire Fighting Guidelines".**

8 Recreation
On most of the countries the access of citizens to the forest is regulated by the respective Forest Law. All people should have the right to enter the forest for recreational purposes. Therefore all attractive sceneries, e.g. springs, waterfalls, nice views, lakes, etc., should be made public for the citizens. Refer to **"Recreation Guidelines"**

9 Education

9.1 Forestry Sector
In most of the developing countries presently Forest Officers (FO) with practical management experience and Qualified Forest Workers (FW) are lacking. The foundation of a "Forestry Training Center" in these countries is highly recommended. Refer to **"Education Guidelines for the Forestry Sector".**

9.2 Citizens and School Students
A forest administration has the duty to inform its citizens about their environment, forest functions, problems in the forest and restrictions. The main goal is creating awareness and sensitization for environmental issues. Refer to **"Education Guidelines for Citizens and School Students".**

10 Pasture Management
Opposite to the number of wildlife, the number of livestock in many countries, roaming through the forest is much too high. This leads to excessive browsing on natural regeneration. Without controlling this roaming livestock, a sustainable forest management is not feasible.
Refer to **"Guidelines for Pasture Management".**

11 Ergonomics and Work Safety
Work in the forestry sector is besides mining and oil drilling the most dangerous operation worldwide. To prevent accidents and to keep forest workers healthy, refer to "**Guidelines for Ergonomics and Work Safety**".

12 Set-Up and Duties of Forestry Departments
There are many different names used, e.g. Forestry Department, Forest Department, Forestry Authority or Forest Agency, for an administration with the task to manage a country's forests. Whatever it is named, these administrations are fully responsible to their governments and the public for the sustainable management of their forests. Refer to "**Set-Up of Forestry Departments and Staff".**

Management Planning for Implementers

To carry out a sustainable management in your forests, just follow the steps of this Management Planning Guidelines in succession. At a later stage all activities should be documented in a Forest Information System (FIS) based on a GIS program.

II. Forest Zoning

Glossary

FD. . . . . Forest Department
FDis . . . . . Forest District
FMP . . . . . Forest Management Plan
FSC . . . . . Forest Stewardship Council
FPIC . . . . . Free, Prior Informed Consent
GIS . . . . . Global Information System
Ha/ha . . . . . Hectare
HCV . . . . . High Conservation Value
HCVF . . . . . High Conservation Value Forest
MCPFE . . . . . Ministerial Conference of Protection of Forest in Europe
Mgt.. . . . . Management
M.R. . . . . Management Regime
NTFP . . . . . Non Timber Forest Products
PD. . . . . Production
PT. . . . . Protection
R. . . . . Recreation
SE. . . . . Socio-Economic
W . . . . . Welfare

This chapter is derived primarily from all the publications listed under 7. References

1. Purpose and Definitions

Forest zoning is one of the first steps in management planning. It assures the delineation of forest land according to its functions. It generates quantitative (ha) and qualitative (protection, production etc.) results which are the basis for following management planning and management options.

1.1 Definition Zoning:

Zoning refers to a landscape approach in which the overarching forest functions are defined and priorities for forest complexes are outlined. Forest categorization is a bottom up process in which individual stands or larger units are classified according to specific values and functions which are intrinsic (biodiversity and soil protection) and extrinsic (cultural and economic) in its nature. All forest can and should serve more than one functions in order to provide the best possible provision of all functions over the country.

1.2 Objective and Scope of the Directive

The objective of this zoning directive is to guide and regulate the quality and intensity of human interaction (i.e. forest use and extractive action) with forest. It applies for all kind of forest land (public and private). Forest land can be set aside permanently or temporarily for specific purposes, e.g. for protection, production, hunting or recreation, following the zoning classification and according rules and regulations listed below.

2. Forest Functions

2.1 Protective Functions

Protective forest functions can be separated according to the “Ministerial Conference on the Protection of Forest in Europe” (MCPFE) criteria and indicators or to the “High Conservation Values (HCV) issued by FSC and the HCV Resource network (HCVF). Both systems are possible, but HCVF has some advantages since it provides a practical method/toolkit which defines and determines high conservation values. They alongside with their respective sub-units are individually developed so that each HCV contains following elements:

- Introduction of each HCV. This includes a general discussion, with examples of what is intended to be included (and excluded) within each HCV. It also identifies the elements that a HCV consists of and explains the importance of each element;
- A rationale is given for each element, which provided the requirements that have to be taken to define each element at the national or regional level;
- Guidance on the preliminary and full assessment required for each element, in order to facilitate the HCVF identification process. The preliminary assessment acts as a coarse filter, to rapidly exclude forests that clearly do not contain a particular value and save time and expenses involved in a detailed analysis. This preliminary assessment is clear and simple and does not require the use of complex data or highly technical information, preventing the process from being an unnecessary burden on forest managers.
- Guidance on how to define the HCV for each element. Defining HCVs requires two steps:
  - The first step is to compile the information necessary to identify important values within the country or region.
  - The second step is to set the threshold levels for each value. On the basis of the above, a value asserts itself as a High Conservation Value;
- A manual-toolkit should provide the guidelines on how to develop a specific, more detailed and clear interpretation with specific reference to the social, economic, and environmental conditions of the respective country. Additionally it can serve as an example for national forest managers, working in areas which have not yet been identified nor approved, on how to interpret the global definitions and apply them to their local environment. Finally the manual-toolkit should provide a detailed explanation and methodology for the definition of the six HCV types defined by the FSC, and provides recommendations in regards to the required management and monitoring methods for each HCV type. For the time being the generic toolkits and guidance of FSC and the HCV resource network are considered to be an acceptable base to work on.

2.3 Productive Function

Productive Function refers to the economic and sustainable production of the raw material “wood”. Productive Forests are forest areas in which a sustainable harvest based on an allowable cut defined in the Mgt. Plan is reasonably possible without jeopardizing the protective and socio-economic functions of the forest ecosystem.

This means in practice, that harvesting is principally possible to the extent defined by the increment and production potential of the forest. Yet the harvesting has to be done within the framework of an approved Mgt. Plan and a necessary documentation is required. This applies for timber, firewood as well as for non-timber forest products (NTFPs).

2.4 Socio-economic Function

The terminology shows that the third category focuses on the socio-economic function and the services that forests provide to the society. Unlike the remunerated products of productive forests the socio-economic functions of forests are often consider to be commons and as such to be provided for free to the users. This applies especially for recreation and tourism, but also for provision of fodder and food if it is consumed by

local animals or collectors. In addition the provision of firewood at nominal rates can be considered to be a social function although the economics of this should be discussed separately from the functional categorization of forests. In any case the envisaged discussion will have to define if carbon sequestration is a part of the productive function as the accumulated carbon may be an environmental service that is provided to the global and country society for free or whether this will be remunerated.

Detail criteria have to be worked out in joint discussions with a working group. Already existing local categories of green zone forests and recreation forests should be integrated in the socio-economic forests with specific management restrictions in urban or rural context as far as necessary.

2.5 Multiple Forest Function Scheme

For every function area, the 3 forest functions, production (PD), protection (PT) or socio-economic (SE) must be evaluated and justified. The SE function is further divided in welfare (W) and recreational (R) functions. One of the 3 functions must be defined as the lead function. The function of highest public interest shall become the lead function. A preliminary assessment may be given from the existing categorization of existing management plans. This category however will have to be crosschecked at latest in the process of the next management planning exercise. In this way a vacuum on the functional classification is avoided.

The productive function is not subject to a multilevel evaluation and shall be the lead function if none of the other 2 functions (PT, SE) is set. In other words, if a forest area is not entitled to protection- or socio-economic function, it belongs automatically to the production function.

The avoidance or reduction of dangers to life, the importance of forest functions for the national economy and the frequency of visitors can serve as criteria for the public interest. In the case of forests with an object protection function, the economic value is a fictitious value that is derived from saving expenses for protective constructions.

The value shall be represented numerically and express the degree of public interest in the respective forest function. One of the following grades shall express the value of the protective, welfare and recreational functions:

Table 1: Degree of Public Interest

Value	Importance	Degree of public interest
0	none	No specific public interest
1	low	Public interest
2	medium	Increased public interest
3	high	Special public interest

If two or even all three functions are assigned the highest value (3), the following order shall apply for determining the lead function: protective function comes before socio-economic function and productive function. In such a case, the lead function of this function area will be the protective function. Functions even with lower importance may result in limitations of the lead function (e.g. a protection function importance 1 in a forest area with lead function production can restrict certain operations or is requiring the prior communication with *or* permission from the supervision authority). This has to be reflected during the Mgt. planning process and in the respective Mgt. Plan. This can apply for any measure as harvesting, hunting, extraction of NTFP products, application of insecticides, forest road construction, etc.

The evaluation of the individual functions (PT, W, R) within one functional area is carried out by assigning a three-digit value number where the digits have the following meaning (see table 2).

For the new assessment a guideline for the definition of public interest in various aspects will have to be elaborated to avoid ambiguity (refer to *MCPFE and HCV criteria and indicators)*.

3. Management Regimes (M.R.)

3.1. The ubiquitously valid principle of Sustainable Forest Management (SFM)

Definition SFM adopted by the MCPFE:
The stewardship and use of forests and forest lands in a way and at a rate that maintains their biodiversity, productivity, regeneration capacity, vitality and

Table 2: Examples of Value Numbers

Value Number (e.g.)	Lead function	Protective function (PT) – hundred's place	Welfare function (W) – ten's place	Recreational function (E) – unit's place
321	PT	3 = special public interest = high importance	2 = increased public interest = medium importance	1 = public interest = low importance
121	P (Production, because none of the other 3 functions has the value 3)	1	2	1

their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national and global levels, and that does not cause damage to other ecosystems.

SFM should be the general rule for all Forestry on all forest land, defined in guidelines still and based on international standards, e.g. below.

3.2. Management Regime principles, rules, limitations and prohibitions with Protection Function as lead function

HCV – 1: Species diversity

Concentration of biological diversity including endemic species, and rare, threatened or endangered species, which are significant at global, regional or national levels.

Recognizing significant values in practical terms:

Significant values are those recognized as being either unique, or outstanding relative to other examples in the same region, because of their size, number, frequency, quality, density or socio-economic importance, on the basis of existing priority frameworks, data or maps, or through field studies and consultations undertaken during the HCV assessment.

Endemic species are those which are only found within a restricted geographical region, which may range from a unique site or a geographical feature (such as an island, a mountain range or river basin), to a political boundary such as a province or country. Endemic and range-restricted species are particularly vulnerable to threats as they have a limited distribution and may have smaller populations than widespread species. Endemism only generally triggers HCV status if the population is also nationally significant. The scale of endemism (e.g. national and regional) needs to be agreed.

Note that for HCV 1, 2, and 3, the values need to be significant at a national or regional scale (or higher).

HCV – 1a: Protected areas

- Strictly protected areas for the purpose of scientific research
- Strictly protected wildlife areas
- Recommended 300 m wide protective forest strips around strict protected areas (Nature Reserves, National Parks);

HCV – 1b: Endangered species and species under threat

- Endangered species of flora and fauna
- Related biotopes and habitats
- Nature monuments
- Over-mature trees;
- Virgin or slightly modified forests;
- High productivity, sample and reference (genetic reservation) value, slightly modified or virgin forests;
- Places of permanent sample areas in the forests for eco-monitoring;

HCV – 1c: Endemic species

- Species listed in the IUCN Red List as vulnerable, endangered or critical endangered.
- Endemic means species that are endemic to the respective eco-region.

HCV – 1d: Important temporary concentrations

- Sites that are used seasonally or temporally by major concentrations of species for feeding, breeding or shelter and refuge from adverse climatic events.
- Migratory sites, migratory corridors and wintering sites

HCV – 2: Landscape-level ecosystems and mosaics

Large landscape-level ecosystems and ecosystem mosaics that are significant at global, regional or national levels and that contain viable populations of the great majority of the naturally occurring species in natural patterns of distribution and abundance.

A literal and scientific interpretation of the HCV 2 definition recognizes that the great majority of species are organisms such as insects, plants and fungi, some of which would be viable within even fairly small areas. It must be recognized that conservation efforts often have a bias towards larger, more charismatic species, particularly mammals and birds – in part because they are more studied.

HCV 2 was designed to give some explicit protection to large and adequately-intact forests (valuable for their own sake since they are in a steady decline), and also for the sake of the species that require very large areas of natural forest to maintain themselves. The intent is that large landscapes need to be protected for their own intrinsic value and for viable populations of the species that depend on them.

The following would qualify as HCV 2:

- Large areas (e.g. could be greater than 50,000 ha, but this is not a rule) that are relatively far from human settlement, roads or other access. Especially if they are among the largest of such areas in a particular country or region.
- Smaller areas that provide key landscape functions such as connectivity and buffering (e.g. protected area buffer zone or a corridor linking protected areas or high quality habitat together). These smaller areas are only considered HCV 2 if they have a role in maintaining larger areas in the wider landscape.

- Large areas which are more natural and intact than most other such areas.

HCV – 3: Ecosystems and habitats

Rare, threatened, or endangered ecosystems, habitats or refuges.

The following would qualify as HCV 3:

Ecosystems that are:

- Naturally rare because they depend on highly localized soil types, locations, hydrology or other climatic or physical features, such as some types of limestone karst forests, inselbergs, mountain forest, or riverine forests in arid zones.
- Anthropogenic ally rare, because the extent of the ecosystem has been greatly reduced by human activities compared to their historic extent, such as natural seasonally flooded grasslands on rich soils, or fragments of primary forests in regions where almost all primary forests have been eliminated.
- Threatened or endangered (e.g. rapidly declining) due to current or proposed operations.
- Classified as threatened in national or international systems (such as the IUCN Red List of Ecosystems).

HCV – 4: Ecosystem services

Basic ecosystem services in critical situations including protection of water catchments and control of erosion of vulnerable soils and slopes.

Ecosystem services are the benefits people obtain from ecosystems, including provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; cultural services such as recreational, spiritual, religious and other nonmaterial benefits; and supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits. Such basic services become HCV 4 in critical situations:

Critical situations

An ecosystem service is critical where a disruption of that service poses a threat of severe, catastrophic or cumulative negative impacts on the welfare, health or survival of local communities, on the functioning of important infrastructure (roads, dams, reservoirs, hydroelectric schemes, irrigation systems, buildings, etc.), or on other HCVs.

The concept of critical situations relates to:

- Cases where loss of or major damage to an ecosystem service would cause serious prejudice or suffering to recipients of the service either immediately or periodically (e.g. regulation of water provision during critical drought periods), or
- Cases where there are no viable, readily available or affordable alternatives (e.g. pumps and wells) that can be relied on if the service fails.
- It may be useful to think about HCV 4 as supporting and regulating services in critical situations. Provisioning and cultural ecosystem services overlap more directly with HCV 5 and 6 which are treated in more detail in later sections.

The following situations may indicate the presence of a likely HCV 4:

- Remote and/or poor rural areas where people rely directly on natural resources to supply most of their needs, including water
- Upstream of extensive or important wetlands, fish nurseries and spawning grounds, or sensitive coastal ecosystems (e.g. mangrove forests, coral reefs etc.)
- Upstream of important municipal water sources
- Steep or mountainous areas, or areas of high rainfall, where the risk of catastrophic erosion is high.
- Where there is naturally low soil fertility, especially on sandy, peaty or fragile soils, where land clearance, drainage, use of heavy machinery or other intensive land use might affect soil structure and fertility.
- Arid or dryland areas particularly susceptible to erosion and desertification.

HCV 4, 5, and 6 are significant to the communities that rely on them

– so they are not relative to any scale but absolute in their irreplaceability to that community.

- Noise protection forests
- Climate protection
  - Air quality and purity
  - Micro forest climate
  - Protection against winds, and the regulation of humidity, rainfall and other climatic elements.

HCV – 4a: Forests important to water courses

- Managing extreme flow events, including vegetated riparian buffer zones or intact floodplains
- Maintaining downstream flow regimes
- Maintaining water quality characteristics
- Provision of clean water, for example where local communities depend on natural rivers and springs for drinking water, or where natural ecosystems play an important role in stabilizing steep slopes. These two values frequently occur together and the area which provides the critical services (water provision and erosion control) may overlap partially or completely.
- Water protection
  - Ground water formation and recharge zones
  - Water quality
  - Water shed
  - Recommended 200 m protecting strips along the rivers, forest strips existing around lakes, water reservoirs and water bodies
  - Forest strips protecting spawning areas with special protective value, along the rivers;

- Forest districts, existing around wetlands, river hears, spring hears and glaciers;
- Forest strips contributing to prevention of formation of mudflows; river bank-protecting strips for prevention of mudflows;
- Floodplain forests;
- Forest strips around existing mineral and thermal waters of healing qualities.

Recommended regulations on Water Protecting Strip:

- 1. Length up to 25 km – 10 meters.
- 2. Length up to 50 km – 20 meters.
- 3 Length up to 75 km – 30 meters.
- 4. Length over 75 km – 50 meters.

HCV – 4b: Forests important for erosion control

- Protection of vulnerable soils, aquifers and fisheries
- Erosion risks
  - Soil sensitivity
  - Rock formation
  - Geological formations
  - Grasslands providing buffering against flooding or desertification
  - *Steepness, no harvesting operations above 35° slope*
  - *Forest strips existing around avalanche formation and downstream;*
  - *Anti-erosion forest strips of particular importance;*
  - *Protecting forest strips against landslides;*
  - *Forest district, existing around landslides, rock fall- and exposed areas;*
  - *Recommended 300 m protecting strips of subalpine forests;*
  - *Recommended 50 m protecting strips of forest edges;*
  - *Recommended 100 m protecting forest strips existing on limestone and cave formations and around them; protecting strips of forests, existing around natural hollows;*
  - *Forests, represented on the cliffs, cliff projections and rock piles;*
  - *Forest areas on the grounds sensible towards the impact of wind and water;*
  - *Forest districts, existing around deep ravines, canyons, precipices;*
  - *Forest districts, existing around rehabilitated or abandoned quarries;*
  - *Protective forest strips existing around snowdrifts and windy areas;*
  - *Forest strips intruded into areas without forest cover;*
  - Forest areas up to 100 ha represented on bare areas;
  - Forest areas existing around travertine and beginnings of natural springs;
  - Forest areas existing on inversion slopes.

HCV – 4c: Forests presenting important fire barriers

- Forests, wetlands and other ecosystems which provide a protective barrier against destructive fires that could threaten communities, infrastructure or other HCVs.
- Fire prevention and protection
- Forest areas with anti-fire purpose;
- Forest areas existing around burnt areas.

HCV – 5: Community needs

Sites and resources fundamental for satisfying the basic needs of local communities or indigenous peoples (for example for livelihoods, health, nutrition, water), identified through engagement with these communities or indigenous peoples.

It is important to ensure that HCV 5 resources are not abruptly restricted without a transition plan with suitable alternatives identified using participative methods, and ideally with a full Free, Prior Informed Consent (FPIC) process.

The following indicate a high likelihood of HCV 5 in the area:

- Access to health centers or hospitals is difficult,
- Most houses are built from, and household tools made from, locally available traditional / natural materials,
- There is little or no water and electricity infrastructure
- People have a low capacity to accumulate wealth (living “day to day”)
- Farming and livestock raising are done on a small or subsistence scale
- Indigenous hunter-gatherers are present
- There is presence of permanent or nomadic pastoralists
- Hunting and/or fishing is an important source of protein and income
- A wild food resource constitutes a significant part of the diet, either throughout the year or only during critical seasons

The following can qualify as HCV 5:

- Water sources necessary for drinking water and sanitation
- Items which are bartered in exchange for other essential goods, or sold for cash which is then used to buy essentials including medicine or clothes, or to pay for school fees.
- Areas for collection of non-wood forest resources;
- Areas for collection of wild fruit and berries by local community;
- Areas for collection of leaf vegetables, plants for pickling, seasoning-flavoring- dressing plants and edible mushrooms;
- Forest areas with high concentration of the best honey plants;
- Forest areas for nesting of Georgian endemic bees;

- Traditional tree-based bee-keeping forests;
  - Pollination services, for example exclusive pollination of subsistence crops provided by native bees where the pollinators are dependent on the presence of suitable forest habitat and do not survive in purely agricultural landscapes.
- Forest areas rich of medicinal herbs;
- Fishing areas;
- Forests with wild plants, used in production of traditional garments, household items, decoration of living environment;
- Forests with plants containing coloring and astringent (tannin-based) matters;
- Forest areas represented by plants for baskets, wicker-work, tying up, fencing, making pillows, mats, brooms;
- Forests important for the use of wood resources:
  - Forest areas intended for special fire-wood use for the part of the village community which doesn't have any other means of alternative heating;
  - Forest areas intended for reserve fire-wood use, where use of resources shall be permitted if, in extreme situation, local community doesn't have other energy resources;
  - Forest areas to be used for utilization of timber and fire-wood for agricultural and ritual purposes, for constructing roves, including coppiced forest stands.
  - Forest areas intended for obtaining timber for the purpose of construction of houses or other personal use.
- Forests with recreational, climate regulating, sanitary-hygienic and other properties having particular value for population;
- Forests of significance for balneology(forests existing around resort areas of various kinds);
- Forest strips, existing around holiday homes, children's camps and medicinal and recreational establishments;
- Forest strips existing around tourist tracks of national and regional importance;
- Forests existing around suburban areas, summer cottages and settlements;
- Green zone forests.
- *Forest areas located around special purpose objects:*
  - Protective forest areas existing around communication facilities;
  - Protective forest areas existing around railroads and motor roads;
  - Protective forest areas existing around water head-facilities;
  - Protective forest areas existing around hydronods and canals;
  - Protective forest areas existing around pipelines;
  - Protective forest zones of power transmission communications;
  - Protective forest strips existing around cableways and skiing routes;
  - Cattle routes and forest strips existing around them.

HCV – 6: Cultural values

Sites, resources, habitats and landscapes of global or national cultural, archaeological or historical significance, and/or of critical cultural, ecological, economic or religious/sacred importance for the traditional cultures of local communities or indigenous peoples, identified through engagement with these local communities or indigenous peoples.

HCV 6 Indicators:

- UNESCO World Heritage sites
- Museums, heritage lists, national data sets, authorities and any organizations which specialize in particular geographic areas or cultures
- National directives concerning archaeological sites and resources
- Consultation with anthropologists, historians, archaeologists, museums and databases for identification of "sites of global or national significance".

The following would qualify as HCV 6:

- Sites recognized as having high cultural value within national policy and legislation.
- Sites with official designation by national government and/or an international agency like UNESCO.
- Sites with recognized and important historical or cultural values, even if they remain unprotected by legislation.
- Religious or sacred sites, burial grounds or sites at which traditional ceremonies take place that have importance to local or indigenous people.
- Plant or animal resources with totemic values or used in traditional ceremonies.
- Quiet locations and reproduction areas of game-reserves and recommended 100 m protective forest zones existing around them;
- Shrine forests, sacred and ritual places, old graveyards, tombs and remnants of towns, destroyed or abandoned villages, and forest strips located around the paths leading to ritual places; stations of ancient people, battlefields; places of archeological value, forest stands existing around historical- cultural and archeological monuments; forests located around leisure and feasting places around the springs and their sources; places of religious purpose (places where sacred trees grow, spiritual places, springs with sacred water, sacred stones, hills of honor, places of sacrifice, myth-related places);

3.3 Management Regime principles, rules, limitations and prohibitions with Production Function as lead Function

Sustainable forest management has to follow international standards set in the respective guidelines listed below (refer to "Improved Pan-European Indicators for Sustainable Forest Management"). Adherence to set standards should become compulsory for everybody involved in any forest operations.

1. Manageent Planning and Management Goals
2. Zoning to Forest Functions
3. Opening-Up Systems
   3.1 Basic Road Network
   3.2 Opening-Up Road Network
4. Inventory and Forest Record Book
5. Silvicultural Guidelines
   Forest seed plantations, seed areas and places of concentration of mother trees;
   Experimental, sample or model areas for forestry activities;
   Geographical and experimental forest plantation areas;
   5.1 Stand Establishment
      Guidelines for Stand establishment
      Forest-gardens and forest areas allocated for designed forest-gardens.
   5.2 Tending operations
      5.2.1 Pre-commercial Thinning Operations
      5.2.2 Thinning Operations
   5.3 Harvesting Operations
6. Protection
   6.1 Forest Fire Management
7. Recreation
8. Education
   8.1 Forestry Sector
   8.2 Citizens and School Students
9. Wildlife Management
10. Livestock / Pasture Management
11. Ergonomics and Work Safety in Forestry
12. Monitoring & Evaluation

3.4 Management Regime principles, rules, limitations and prohibitions with Socio-Economic Functions as lead Function

Definition of areas with social rights and needs during the zoning process:

E.g. for firewood production, NTFPs as Christmas trees, mushrooms and truffles, fruits, game products, snails, ornamental plants, honey, cork, medicinal or colorant products, seeds of forest tree species and fodder and grazing for livestock. (Refer to Guidelines for Pasture Management and HCV-5)

4. Identification

4.1 Strategic ('Top Down') Identification of Forest Functions

4.1.1 By Law or Directive or through otherwise existing rights

Using the precautionary approach:

The Precautionary Approach means that when there is a threat of severe or irreversible damage to the environment or a threat to human welfare, responsible parties (Governments, Ministries, FDs) need to take explicit and effective measures to prevent the damage and risks, even when the scientific information is incomplete or inconclusive, and when the vulnerability and sensitivity of values are uncertain.

- Forest Code (Law) of the respective country
- Environmental Protection Law of the respective country
- Soil Protection Law of the respective country.
- Water Protection Law of the respective country
- National Biodiversity Strategies
- Respective Management Guidelines
- Corresponding edicts

This top-down / strategic identification is usually carried out by GIS-referenced mapping, should be registered and made available to the public in an online 'Forest Portal". The identification process of HCVFs should be implemented by the Inventory Unit of respective FD during the Management Planning process for all forest land.

4.1.2 Forest Areas

The manual – toolkit for HCVFs is designed to be used in any landscape or forested area including private or institutional ownership or management, church- and municipality forests, areas under license and other areas.

The first thing to do is select a forest area that is being managed, and then, secondly, via the utilization of this manual evaluate the threshold value presence of the HCVs. The third task is to delineate a management regime required which will enable the maintenance and improvement of the identified HCVs. The last step is the implementation and adherence to the HCV monitoring protection program.

In order to summarize the process for establishing HCVF presence consists of four straightforward steps:

4.1.3 Identification of HCVF:

The lead assessor or manager needs to collect enough information to make a preliminary judgement on the likely HCVs to be found and the likely impact of operations – this will guide decisions on assessment team composition and data gaps to be addressed, and the scale of consultation required for the assess-

ment. The initial data gathering should aim to cover the following:

a. Location and size of the project area (e.g. management unit, concession, plantation).
b. Land use and land cover classification
c. Land tenure and ownership
d. Landscape context, including land and resource use – both small scale or industrial
e. scale (e.g. settlements, forestry, agriculture, infrastructure) surrounding the project area
f. Presence and status of a regional land and resource use plan
g. Presence and condition of protected areas in the landscape.
h. Distribution and connectivity of ecosystems across the landscape and barriers affecting
i. movement into and out of the assessment area
j. Soils and geology
k. Watershed maps and criticality of area for maintaining water supply and quality.

Decide if the forest under management contains some HCVs. It is worth noting that valuable information for practitioners in the identification of HCVF value presence is included in this manual. Any type of forest, high or coppice, natural or artificial, can be potentially considered as a HCVF. An example of a HCV is: Plantations of introduced conifers set up for the purpose of wood supply for wood pulp industry can become high conservation value forests if their recreational or other sociological values become primary ones. Similarly, cultivated forest areas or low degraded forests, which preserve soil from washing out and erosion, can also be considered as a HCVF. HCV are those structural elements and functions of forests (rare, endemic and relic species; endangered plants, animals and fungi; endangered habitats and ecosystems; upper vegetation belt etc.) whose values deserve special concern in order these values to be permanently conserved and improved.

4.1.4 Consultation:

Stakeholder consultation is valuable to:

1. Help the assessor evaluate whether a certain value is present.
2. Help the manager (or consultant) design a proper management regime for maintaining the value.
3. Inform local stakeholders that a value is present and that certain measures may be necessary to maintain that value, e.g. set-asides or no-hunting zones.
4. Identify stakeholders, who will be directly affected by or bear the cost of a potential activity (e.g. forestry, agriculture, etc.)
5. Common examples include:
   a. Local communities who use ecosystem products or services
   b. Organisations and institutions that represent these communities (above)
   c. Those whose legitimate commercial use of the natural resources will be altered by development activities
   d. Environmental and social organisations, academics and researchers that represent the wider public and/or have an interest in the way the ecosystems are managed
   e. Government bodies will always need to be kept informed of discussions even if they are not directly affected

According to the FSC criteria 9.2, the identification and management of HCVF needs to be conducted in agreement with all vested parties. The consultation process is useful for any forest owner, since they can count on stakeholders' wide knowledge and experience which will ensure better informed decisions on HCVF identification and the subsequent management.

4.1.5 Management of HCVF:

The most frequent question regards the management technique which needs to be applied in order protect the HCVF. The answer to this question is not unilateral as it much depends on which HCV element is present. It must be taken into consideration that forests and the values that they each contain are unique and very unpredictable. In light of this it is important to evaluate each case singularly bearing in mind their specific area characteristics as it is impossible to provide general management principles for each and every forest environment. As a result of this, this manual includes essential generalized management recommendations which can assist practitioners on managing HCVFs adequately. This also signifies that Forest Departments / forest companies are expected to employ the forest management regimes that will maintain each identified HCV, by taking into consideration local conditions, resources and existing knowledge.

4.1.6 Monitoring

(s. Chapter III)

4.2. Identified by rule of law, to be applied on all forest land, and to be locally specified (registered ('Bottom-Up') in the FMP or corresponding documents)

4.2.1 By Ubiquitously Applying Rules in order to regulate human forest use, interference, extraction of forest products under specific geographical/natural conditions:

All human forest use has to follow rules and regulations under the respective Forest Management Plans, where zoning and management standards are incorporated, for each Forest District, compartment and sub-compartment, the smallest management entity.

These rules come into force from the day of approval and publication of this directive. An additional specific mapping, registration and publication (on the Forest Portal) of those forest areas which fall under these rules have to be implemented particularly through decadal Forest Management Plans. The establishment or any change of the zoning (i.e. change of lead to secondary function) has to be in accordance with the principle of SFM and HCV criteria. Their establishment and any corrections have to be approved by the Inventory Unit of respective Forest Department and the Forest District Offices, or the environmental protection authority, as far as zoning of the protection function is involved. For each sub-compartment all activities, e.g. allowable cut, harvesting system, protected areas (according to HCV), set timeframe for uses, obligations and restrictions, are clearly defined in these FMPs.

Examples:

1. Forest-Area Slopes > 35°
   Defined in the respective guidelines and FMPs.

2. Forest Space (forest lots or forest extensions) near springs, creeks, rivers (running waters), ponds and lakes and standing freshwaters
   Defined in the respective guidelines and FMPs.

3. Forest Space above and near natural monuments, geological specific formations such as caves, karst, at and near areas of specific biodiversity value (for reproduction, rest, and/or nourishment of endangered wildlife incl. plants)
   Defined in the respective guidelines and FMPs.

4. Forest Spaces whose removal, destruction or management may cause dangerous impact and hazard to human populations or objects
   Defined in the respective guidelines and FMPs.

5. Traditional hunting rights
   Defined in the respective guidelines and FMPs.

6. Others

5. Implementation and Control

5.1 Implementation

Implementation, enforcement and supervision is to be guaranteed by the local forest authority (FDis) according to rule of law, ensuring identification of functions in FMPs and their registration in the data-base (incl. Forest Portal Publication, GIS).

5.1.1 by law and GIS-based 'Strategic (Top-Down) Identification'

Management according to the existing Forest Code (Law) of the respective country, its degrees and regulations, including even this zoning directive.

5.1.2 by GIS-based identification of areas subject to rules (e.g. > 35° rule)

All information which can be identified via GIS has to be registered in the respective data-base and on maps for the entire country, region and Forest District.

5.1.3 through in-situ identification and mapping via Forest Management Planning or corresponding plans

All this GIS information together with ground surveillance data (Inventory) are the basis for the FMP which has to be developed for each sub-compartment and where all protected areas, nature monuments, restriction etc. are described and localized in a map.

5.2 Enforcement, Supervision and Control

5.2.1 During Forest and Forest Use Surveillance

Permanent monitoring and control by FD staff on all levels and reflection of findings in the next FMP.

5.2.2 Integrated part of Forest Management Planning

Monitoring HCVF: This is the essential part of any SFM system since it enables the FD / forest companies and forest owners to evaluate if the forest management goals are met and whether the applied system needs to be amended. As the HCVF element can be affected by the forest management applied, it is essential that it be constantly be monitored with special attention in order to identify any changes. Once more, it is not possible to provide detailed generalized instructions on how to monitoring each HCV, but within this toolkit, essential principles are provided to aid practitioners on how to implement a monitoring program.

5.2.3 During Forestry Operations

Assuring of any kind of operation according to approved FMP following SFM principles by FD staff on all levels according their respective job descriptions.

6. Zoning for Implementers

To get an overview about all the regulations mentioned above just follow the few steps listed below and zone your forest accordingly:

Zone 1: Protection forest (no or restricted management, refer to HCV-classes I-VI)

1.1 Steepness
Above 35° slope (70%)
1.2 Endangered species of flora and fauna
Related habitats
1.3 Erosion risks
Soil sensitivity
Rock formation
1.4 Water protection
Ground water formation
Water quality
Water shed
1.5 Noise protection
1.6 Climate protection
Air quality and purity
Micro forest climate
1.7 Nature protection
Habitats, biodiversity

Zone 2: Production forest

All other forest land which does not fit to the zones 1 and 4 can be considered Production Forest.

Zone 2.1: Close to nature forest management
Zone 2.2: Plantation forests, mixed plantations and forests considered to be converted into natural forest management.

Zone 3: Forests for community needs, welfare and recreation

3.1: Recreation forest

- Easily accessible (vehicle, hiking trail)
- Beautiful scenery and views
- Parking areas
- Recreational facilities (refer to related guidelines)
- Sports
- Recreation forests can be used commercially as long it still serves it purpose!

3.2 Education Forest

- Educational trails (refer to related guidelines)
- Forest Camps

All boundaries should be shown in a Mgt. Map, scale 1:25000 (min. 1:50000). A detailed zoning will be achieved during the final tree marking or planting operation, where the entire area will be assessed and all rare species of fauna and flora can be found and finally protected.
If necessary, for each sub-compartment a special Mgt.-Plan can be produced in which all necessary regulations for the protection and functions of a HCV can be described in detail.

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Forest Road Construction Planning in Hanui Province, China (Foto: P. Hess)

III. Opening-Up Systems

Guidelines for Forest Road Construction

Glossary

Camber	The gradient from the center of the road to the shoulders
FDis	Forest District
ft	Feet
GIS	Geographic Information System
GPS	Global Positioning System
GSS	Ground Skidding System
h	Hour
ha	Hectare
hp	Horsepower
km	Kilometer
LDCCS	Long distance cable crane system
m	Meter
Mgt.	Management
MOH	Machine Operating Hour
m^3	Cubic Meter
Right-of-way	Total width of the cleared corridor for the road construction

1. Introduction

For ecological reasons road densities should be kept to a minimum. However, a prerequisite for efficient forest management is an adequately established road network which facilitates the use of appropriate technologies for silviculture, tending and harvesting operations. In some remote areas, forest roads even may play an important role in rural development.

In many countries, forests in mountainous terrain are characterized by a very low density or a complete absence of forest roads.

In steep terrain with difficult topographic and soil conditions and especially in areas with high intensity rainfall, careful planning, surveying and construction of forest roads needs to be exercised. Established technical road specifications such as maximum gradients, road widths and drainage structures should be adhered to strictly. Full compliance to such standards and constructions methods is not possible in some countries since forest engineers, who can design, oversee and monitor forest road engineering activities are lacking.

Badly located and poorly constructed and maintained roads and skid trails lead to landslides, siltation, and local flooding thus greatly degrading the environment. Severe erosion can be avoided alone by preventing road construction in steep terrain with ground slopes above 50%.

Up to 90 % (this figure refers for Tropical Moist Forests only) of erosion in managed forests originates from the construction of roads and skid trails. (Hodgson, 1986)

24 % of the total erosion caused by logging roads could be prevented by conventional engineering methods (Mc Cashion and Rice, 1983).

These guidelines are intended to provide practical guidance to personnel involved in forest road construction. They describe the particular road classifications and the according standards, the planning procedure and finally the actual road construction.

2. Road Classification and Standards

2.1 Structural Parts of a Road

Forest roads, like major hard-surfaced highways, are engineering structures. All consist of two parts: the subgrade and the pavement, which is subdivided into the subbase-, base- and surface-layer. Some terms commonly used for various parts of the structure are shown in figure 1.

2.2 Road Classification

Generally, four types of forest roads can be classified:

Main Roads

Generally, main logging roads with the intention of integrating them into the public road network are planned and designed for facilitating the overall access to and through forest areas. They are the main artery of the road network, surfaced and designed for high travel speed and to absorb heavy traffic density. They are usually constructed as two-lane roads with a bearing capacity corresponding to two logging trucks, one loaded and one light to meet without reducing speed.

Main roads also serve for long-distance timber transport. They are part of the Basic Road Network and, hence, should be maintained permanently.

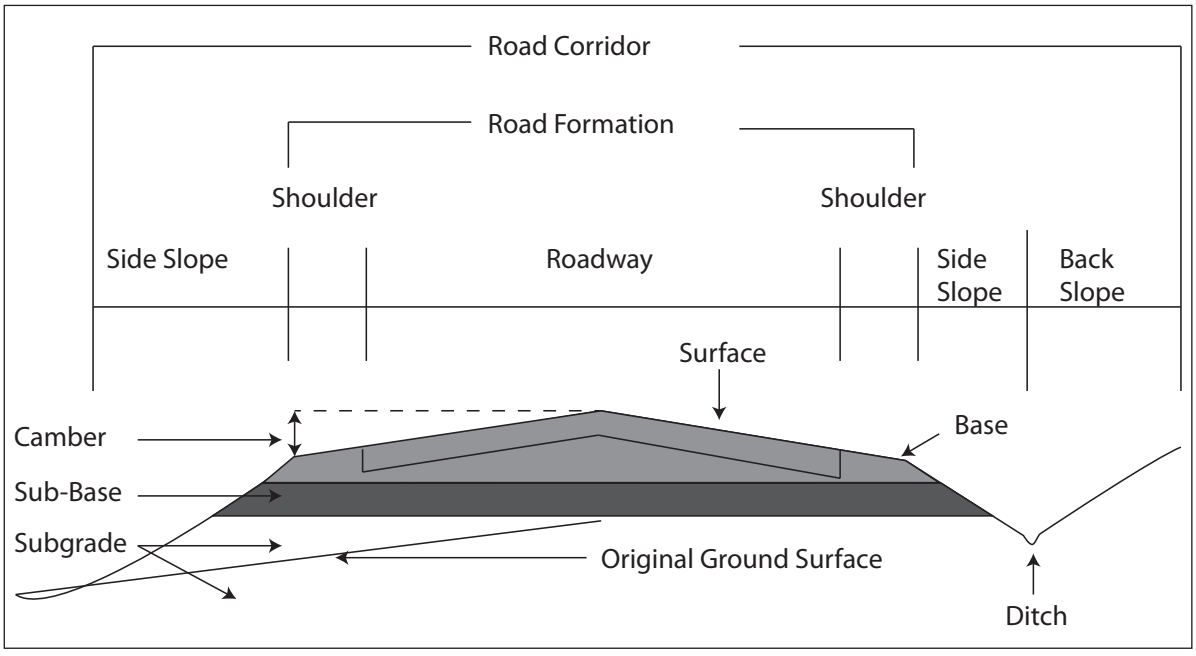

Figure 1 Typical Road Cross Section (Source: FAO, 1977)

Secondary Roads

Secondary roads are narrower than main roads. Vehicles can meet but loaded traffic has right of way and light vehicles must stop to allow loaded trucks to pass. They are one-lane roads, surfaced and connecting the feeder roads to the main road. They serve for timber extraction, general access, tending and forest protection purposes and are therefore part of the Basic Road Network. They should be maintained permanently.

Feeder Roads

Feeder roads are un-surfaced and built for temporary use only. They form the extremity of the entire Forest Road Network and are considered as part of the Opening -Up Network. The width of a feeder road is one lane with a sufficient number of meeting points to facilitate safe passing of loaded traffic.

Skid Trails

Unlike air-borne yarding systems, ground extraction relies on skid trails. The procedure for their planning, survey and construction is the same as for roads.

Their density varies according to the respective road density and logging equipment used. The distance between two skid trails has to be limited to 100 m, in extreme situations max. 200 m.

2.3 Road Standards

(see Table 1)

3. Planning

In general, all already existing roads should be integrated into the particular road networks to minimize the loss of forest land and erosion. Only in a few cases, where the road alignments are too steep and cannot be maintained economically, the construction

Table 1: Road Standards (* = adverse gradient for loaded truck (As far as possible never exceed 8% slope)

	Road Classes			
	Main Road	**Sec. Road**	**Feed. Road**	**Skid trail**
Lanes	Dual lane	Single lane	Single lane	-
Truck loads per day	> 50	up to 50	up to 6	-
Designed speed (km/h)	50 - 60	25 - 40	15 - 25	-
Width of road corridor (m)	20 - 25	15 - 20	12 - 15	8 - 12
Tot. width of road formation (m)	9 - 12	8 - 10	6 - 8	4 - 5
Width of road way (m)	7 - 10	6 - 8	5 - 6	4 - 5
Width of road shoulders (m)	2 x 1 = 2	2 x 1 = 2	2 x 0.5 = 1	-
Min. radius of curvature (m)	50	30	20	-
Curve widening (m)	0.5	0.5	1	-
Super elevation (ratio)	1 : 10	1 : 12	1 : 15	-
Max. gradient (%)	6 (8)*	8 (10)*	10 (12)*	27 (18)*
Min. gradient (%)	2	2	2	2
Road camber - from center to the ditches % - to the hill-side only %	2 - 6	2 - 6	2 - 6	5
Embankments (height to width) - hill-side - valley-side - rocky terrain	1 : 1 1 : 2 1 : 0.2 - 0.5	1 : 1 1 : 2 1 : 0.2 - 0.5	1 : 1 1 : 2 1 : 0.2 - 0.5	1 : 0.5 1 : 1 1 : 0.2 - 0.5
Drainage - culverts - min. diameter (cm)	concrete 40	concrete 40	concrete 40	Surface cross drain
Wooden bridges - min. width (m)	4	4	4	-
Stabilization - sub-base (0/150) m^3/ 1 m of road - base (0/50) m^3/ 1 m of road - surface (0/30) m^3/ 1 m of road	1.0 - 4.0 0.6 - 2.0 0.6 - 1.0	0.5 - 2.0 0.3 - 1.0 0.3 - 0.5	-	
- Species	Pine, Norway Spruce, Larch, tropical hardwoods			
- Span (m)	10	11	12	13	14	15	16	17
- Bridge capacity (t)	Min. Diameter (cm)							
Truck with 3 axles cross-weight 32 t	59	63	67	71	75	79	83	86
Truck with 4 axles cross-weight 40 t	61	65	69	71	75	79	83	87
Truck with 2 axles cross-weight 43.5 t	65	68	71	75	78	84	86	90
Truck with 5 axles cross-weight 51 t	63	67	71	75	79	84	86	90

of a new road, or parts of it, can be considered more appropriate.

Planning of road networks comprises the following steps in succession:

- Timing
- Calculation of the optimal road density
- Forest Road Inventory
- Preparation of road maps
- Preparation of the Forest Road Record Book
- Determination of road and skid trail densities
- Determination of the Basic Road Network
- Determination of the Opening-Up Network
- Road Survey

3.1 Timing

Efficient logging operations as well as carrying out of inventories and silvicultural treatments require exact and proper planning and time scheduling. Road construction should be carried out well in advance (1 - 2 years) before logging or any other operations start. At least 6 months are required to give the subbase sufficient time to settle and the road surface to dry. Costs can be reduced by 15 - 20 %, when road construction is carried out during the dry months. Furthermore, planning of the road network ahead of logging operations can lower the road density by up to 11 % and steep grades by up to 73 % as compared to normal ad hoc construction methods (Satterlund, 1972). Especially the steep gradient sections of a road cause most of the wear and tear of haulage vehicles and produce delays in haulage time.

3.2 Calculation of the Optimal Road Density

The calculation of the arithmetic optimal road density for a particular License Area or FDis is an important step in planning the forest road network. The results, calculated on financial conditions only, show beside the optimal (theoretical) road density and the total transportation costs per m^3, the highest profit respectively the lowest loss for the entire harvesting operation in a certain time frame (depreciation of the road network) and for a certain area (License Area).

With the help of appropriate computer software (e.g. Excel) this calculation can be done easily.

The software is available with the author.

The next step then is to study alternatives within the range of the optimal road density.

(s. Table 2)

The table shows clearly that the lowest total transportation costs (TTC) per year and ha correspond with a road density of 5 m/ha. Therefore this density can be considered optimal.

The calculation is based on an AAC of 1 m^3/ha/a, interest rates of 8% and a depreciation time of 40 years. For further assumptions see appendix 1.

Table 2: Arithmetic optimal road density and total transportation costs for Deramakot Forest Reserve, Malaysia

RD (m/ha)	IC ($/ha/a)	MC ($/ha/a)	YC ($/ha/a)	AC ($/ha/a)	Yd ($/ha/a)	TTC ($/ha/a)
1	4.19	9.73	350.40	0.93	0.10	365.35
2	8.39	19.46	175.20	0.46	0.20	203.71
3	12.58	29.19	116.67	1.64	0.30	160.38
4	16.77	38.92	87.50	1.23	0.40	144.82
5	20.97	48.65	70.00	0.99	0.50	141.11
6	25.16	58.38	58.33	0.82	0.60	143.29
7	29.35	68.11	50.00	0.70	0.70	148.86
8	33.54	77.84	43.75	0.62	0.80	156.55
9	37.74	87.57	38.89	0.55	0.90	165.65
10	41.93	97.30	35.00	0.49	1.00	175.72
15	62.90	145.95	23.33	0.33	1.50	234.01
20	83.86	194.60	17.50	0.27	2.00	298.23
25	104.83	243.25	14.00	0.20	2.50	364.78
30	125.79	291.90	11.67	0.16	3.00	432.52

RD = road density (m/ha)
IC = investment costs ($/ha/a)
MC = maintenance costs for roads ($/ha/a)
YC = distance depending yarding costs ($/ha/a)
AC = additional costs ($/ha/a)
Yd = yield losses due to road construction ($/ha/a)
TTC = total transportation costs

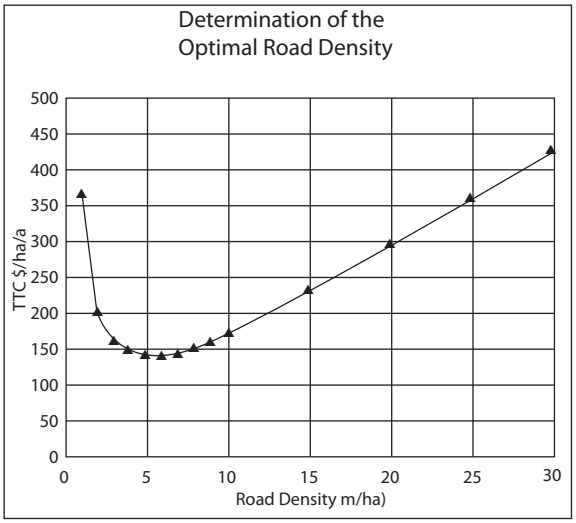

Figure 2: Determination of the Optimal Road Density

3.3 Forest Road Inventory

One of the first steps in the preparation of the Management Plan for a particular License Area or FDis is the road inventory. The purpose is to obtain a complete overview of the existing road network, its condition, the operation area and coupe boundaries, as well as the drainage structures. Before the field work commences, existing information like already existing road maps, reports, logging plans, aerial photos, satellite images etc. should be screened first.

The actual road survey is carried out with a GPS (Global Positioning System), while driving with an off-road vehicle on all accessible roads. (for GPS information see producer's manual).

At the same time other features i.e. road classification, name, location, road condition and the road length can be assessed using the "Forest Road Network Form" (Appendix 2). If a GPS is not available, the "Road Survey Form" can be used. (Appendix 3). Usually the existing road network becomes part of the Basic Road Network.

After tracking with the GPS is completed, the collected data are processed on a PC, transferred to a GIS (Geographic Information System) and edited (e.g. corrections, description of way-points etc.), before a first edition of a "Road Map" is produced with a GIS-plotter.

3.4 Road Maps

The road map is produced at a scale of 1:50,000. It comprises the entire FDis area and shows the following features:

- FDis area
- Main roads (tracked with GPS or planned)
- Secondary roads (tracked with GPS or planned)
- Feeder roads (tracked with GPS or planned)
- Impracticable roads 8digitized from aerial photos)
- Road numbers
- Road junction numbers
- Road length
- All Water courses
- Compartment boundaries

Table 3: Road, skid trail and cable corridor densities according to extraction system.

Inclination %	Harvesting System	Required Road Densities			
		Classification	**Density m/ha**	**Distances between roads/trails m**	**Average forwarding distance m**
0 – 30 (skid trails, not formed)	Motor manually / Tractor	Sec. Road Feeder Road Skid trail	3 8 500	3300 1250 20	825 313 5
30 – 55 (skid trails formed)	Motor manually / Tractor	Sec. Road Feeder Road Skid trail	3 8 100	3300 1250 100	825 313 25
55 – 70 (cable corridors)	Motor manually / cable crane	Sec. Road Cable Corrid.	3 100	3300 100	825 25
55 – 70 (Log lines)	Motor manually / hand work	Sec. Road Feeder Road Skid trail	3 8 500	3300 1250 20	825 313 5
55 – 70	Motor manually / Helicopter	Sec. Road	3	3300	825
> 70	Protection Forest	Sec. Road	3	0	0