Biodiversity for Busy Managers
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BIODIVERSITY IN PLANTATION LANDSCAPES

A Practical Resource Guide for Managers and Practitioners in Oil Palm Plantations

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About Wild Asia

Wild Asia works with businesses to improve social and environmental practices to meet and exceed global standards. We aim to inspire change from within the industry through partnerships with businesses which have an impact on the environment, wildlife, people and communities. We advise, train and innovate new approaches to support this mission.

Wild Asia has a wide experience in dealing with the complexities and challenges of promoting sustainability in the region, and expertise in the forestry, tourism and agriculture sectors.

Wild Asia is legally chartered as a Malaysian company (Reg. No: 634446-W) and operates as a "social enterprise", a business that works for social or environmental missions rather than maximising shareholder returns.

About MPOWCF

Since its inception in 2006, the Malaysian Palm Oil Wildlife Conservation Fund (MPOWCF) has initiated a number of wildlife and biodiversity conservation programmes examining highly pertinent issues faced by the industry: from orang utan and elephant conservation to the country's first Wildlife Rescue Centre. These initiatives send a strong message to stakeholders that the Malaysian palm oil industry is indeed committed in its actions to the conservation of the environment and wildlife in Malaysia while at the same time managing the industry's activities sustainably.

About Biodiversity for Busy Managers

Biodiversity for Busy Managers is an initiative by the Malaysian Palm Oil Council and Wild Asia to develop useful and practical resources for those on the front line of land development. The idea is to inspire, share and guide managers and planners about the key biodiversity issues that apply to land development, and to look at opportunities for inspiring change.

Initiated in 2010, **Biodiversity for Busy Managers** aims to develop and provide resources in multiple formats. In addition to *Biodiversity in Plantation Landscapes*, other resources that have been developed include:

- A **web-based** resource center and interactive forum;
- **Training courses** delivered during field-based workshops;
- A series of topic-based **Insight Guides**.

For more information see http://oilpalm.wildasia.org

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Introduction

Why this book?

Biodiversity in Plantation Landscapes is part of the *Biodiversity for Busy Managers* (B4BM) initiative by the Malaysian Palm Oil Council and Wild Asia. It aims to make the relatively recent industry-wide emphasis on biodiversity accessible and practical for those 'on the ground'.

Although biodiversity is much talked about, mostly in relation to the Roundtable for Sustainable Palm Oil Principles and Criteria (RSPO P & C) and High Conservation Value (HCV) assessments, there has not always been a clear presentation of key concepts, or guidance on how to apply them practically in estate management.

Biodiversity in Plantation Landscapes:

- Makes environmental/biodiversity issues easily understandable
- Focuses on the biodiversity issues of relevance to the oil palm plantation industry
- Offers solutions, tools and examples to enable plantation managers to protect and enhance biodiversity.

The publication of this book follows a number of B4BM workshops in various areas of both East and West Malaysia, in which much of the content was presented. This provided valuable opportunities to 'field test', refine and modify the material through a process of dialogue with planters.

Plate 1. **Planters at a B4BM workshop in Miri, Sarawak.** *WA.*

In addition to *Biodiversity in Plantation Landscapes*, the B4BM project includes a series of Insight Guides, which provide more details on particular topics of relevance to planters, and an ongoing online dialogue via the Wild Asia website, at http://oilpalm.wildasia.org/.

Who is it for?

Biodiversity in Plantation Landscapes is primarily for oil palm plantation managers and assistant managers working in Malaysia. It will also benefit anyone working in plantation field operations, such as research officers, senior managers, plantation cadets, and small-holding plantation owners. Government departments and non-government organisations working with the plantation industry will also find the contents useful.

Although the Guide has been written with the Malaysian oil palm plantation industry in mind, many of the principles and methods, as well as the background information on biodiversity, are applicable to oil palm plantation operations outside Malaysia, as well as to the management of other tree plantations, such as rubber, acacia, albizia, etc.

How should it be used?

Potential readers of *Biodiversity in Plantation Landscapes* may pick it up for any of several reasons:

"What are the biodiversity-related issues affecting and being affected by the industry?"

start with Chapter 1

"I want to know how to address a particular issue or problem."

start with Chapter 2

"I need ideas on how to implement and monitor management actions."

start with Chapter 3

"I'd like to know what's already being done to address biodiversity in plantations."

start with Chapter 4

"What research has been carried out on biodiversity in plantations, and how does this apply to management?"

start with Chapter 5

1. Biodiversity in Context

Biodiversity – the variety of life on this planet - is essential for life. Globally, biodiversity is threatened by a number of human activities which affect the ability of ecosystems to provide the services on which life depends.

Plate 2. **Remnant riverine forest bordering a plantation in Johor.** *WA/Lim Kim Chye.*

1.1. What is biodiversity?

"Biodiversity" has become a 'buzzword' over the past few years, in the media and industry, including the palm oil industry. Many people use the word as if it is interchangeable with "wildlife" or "species", but biodiversity is a much broader term than this. So what is biodiversity?

A good working definition is:

> ***"Biological diversity (or biodiversity) is the variety of life on the planet. This includes the diversity within species, between species and of ecosystems."***

a. Diversity within species (genetic diversity) - the genetic make-up of individual organisms and populations

b. Diversity between species (organismal diversity)

c. Diversity of ecosystems (ecological diversity) - very large-scale differences such as those across ecosystems and landscapes (both natural and man-made).

It can thus be seen that biodiversity varies in *scale*. Biodiversity also varies with *time*. For example, an ecosystem may vary in biodiversity at different seasons, high and low tide, day and night, etc.

1.2. Why is biodiversity important?

Biodiversity is essential for the sustenance of life on the planet

Healthy biodiversity enables ecosystems to function effectively, which in turn ensures that they provide key services which affect human livelihood. We are often unaware of these services and the ways in which they provide stability and security to our existence until they are damaged or destroyed. Calamities as diverse as air pollution ("haze"), flooding and pandemic/epidemic diseases are all linked to the destruction of biodiversity.

Biodiversity supplies us with many essential goods and services

Biodiversity provides us with many essential goods – from food and water to basic construction materials to fuel and medicines – and contributes significantly to national economies and employment. In addition, ecosystems provide, at no extra cost, essential services such as nutrient cycling, air and water purification, flood and drought mitigation and soil formation.

1.3. What are ecosystem services?

As life becomes increasingly technologically - driven, it is easy to forget how dependent we are on our environment (literally, "that which surrounds us"). In recent years, scientists have sought to identify and describe the aspects of Earth upon which human (and all) life depends. These are known as 'ecosystem services' – "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily, 1997); in other words, "the set of ecosystem functions that are useful to humans" (Kremen, 2005). The most basic of these is the regeneration of the air we breathe and the supply and distribution of water we drink, but there are many others. The following is merely a summary of the principal ecosystem services on which we depend.

- **Provisioning.** The products obtained from ecosystems, including food, clean water, timber, biochemicals, medicines, etc.

- **Regulating.** Benefits from ecosystem processes, such as pollination, regulation of climate, floods and tsunamis, pests, etc.

- **Cultural.** Non-material benefits from ecosystems; for example, education, religious and cultural, enjoyment, recreation and leisure, tourism, etc.

- **Supporting.** Those which underpin other ecosystem services: soil formation, nutrient cycling, oxygen production, provision of habitat, primary production, etc.

Healthy ecosystems are sometimes more valuable in their natural state than when developed for economic purposes.

Although it is extremely difficult to attach a 'market value' to ecosystem services, it is increasingly recognised that the value of ecosystem services sometimes outweighs that of economic use.[1] Therefore, protecting ecosystem services should be one of the most important responsibilities of politicians, resource managers, and society in general.

1.4. What are the economics of preserving (or losing) biodiversity?

Traditional measures of economic value fail to take into account the considerable worth which non-tradable products and services provide to national economies. Although the value of many non-consumptive uses, such as recreation, is widely recognised, these are not usually assigned monetary value. Furthermore, the costs of biodiversity destruction are also rarely assigned an economic value, and are not normally borne by the people responsible for it, but by low-income communities who depend on it, and future generations.

A global initiative to draw attention to the global economic benefits of biodiversity and to highlight the growing costs of biodiversity loss and ecosystem degradation, The Economics of Ecosystems and Biodiversity (TEEB) study, has published many examples of economic costs and benefits of conserving or destroying different aspects of biodiversity.[2]

1 For some examples, see Box 2.2 in Ecosystems and Human Well-being: Biodiversity Synthesis, downloadable at http://www.maweb.org/documents/document.354.aspx.pdf

2 http://www.teebweb.org/Home/tabid/924/Default.aspx

1.5. What is happening to biodiversity globally?

Before looking at the situation with regard to the palm oil industry, it is useful to gain a broad perspective by looking at the state of biodiversity and ecosystem services worldwide. The Millennium Ecosystem Assessment (MA) was called for by the United Nations Secretary-General Kofi Annan in 2000. Initiated in 2001, the objective of the MA was to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being.

The MA is the most comprehensive survey ever carried out into the state of the planet. It was drawn up by researchers from 95 nations over four years from 2001 to 2005. The following are some of its key findings.[3]

Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth.

Plate 3. **Millennium Ecosystem Assessment**
http://www.maweb.org/en/GraphicResources.aspx.

Table 1. **Summary of human impacts on ecosystems in the last 50-60 years**

Ecosystem component	Human impact in the last 50-60 years
Terrestrial natural habitats	More land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850. By 2000, cultivated systems covered 25% of Earth's terrestrial surface.
Coral reefs	20% of the world's coral reefs have been lost and a further 20% degraded in the last several decades.
Mangroves	35% of mangrove area has been lost in the last several decades.
Freshwater	The amount of water in reservoirs has quadrupled since 1960. Withdrawals from rivers and lakes doubled 1960 – 2000. Five to possibly 25% of global freshwater use exceeds long-term accessible supplies. Fifteen to 35% of irrigation withdrawals exceed supply rates and are therefore unsustainable.
Ecosystems	Five to 10% of the area of five biomes[4] was converted between 1950 and 1990. More than two thirds of the area of two biomes and more than half of the area of four others had been converted by 1990.
Biogeochemical cycles	Since 1960, of the amount of biologically available nitrogen in terrestrial ecosystems doubled, and that of phosphorus tripled. More than 50% of all synthetic nitrogen fertiliser ever used has been used since 1985, and 60% of the increase in atmospheric CO_2 concentration since 1750 has taken place since 1959.
Ecosystem services	Approximately 60% (15 out of 24) of the ecosystem services evaluated in the MA are being degraded or used unsustainably. The degradation of ecosystem services often causes significant harm to human well-being and represents a loss of a natural asset or wealth of a country.
Species diversity	The distribution of species on Earth is becoming more homogenous (there are fewer species, and these occupy larger areas). The population size or range (or both) of the majority of species across a range of taxonomic groups is declining. Humans have increased the species extinction rate by as much as 1,000 times over background rates typical over the planet's history. Ten to 30% of mammal, bird, and amphibian species are currently threatened with extinction.
CO_2 emissions	Atmospheric concentration of carbon dioxide has increased by 19% since 1959.
Climate change	Climate change in the past century has already had a measurable impact on ecosystems. Global average sea level has risen 0.1-0.2 meter in the last 100 years.

3 All the information in this section is taken from the Millennium Ecosystem Assessment website: http://www.maweb.org
4 See 8.2 Glossary of Terms

1.6. What is affecting biodiversity most?

1.6.1. Change in land-use

Change in land-use or habitat destruction, defined as when a natural habitat, such as a forest or wetland, is altered so dramatically that it no longer supports more than a fraction of its original processes and species, is considered the most important driver of species extinction worldwide (Sodhi & Ehrlich, 2010).

Globally, agriculture and other large land developments, such as mining, clear-cut logging, trawling, and urban sprawl, are known to destroy or severely degrade habitats. In developing nations, where most habitat loss is now occurring, the drivers of environmental change have shifted fundamentally in recent decades. Instead of being caused mostly by small-scale farmers and rural residents, habitat loss, especially in the tropics, is now substantially driven by globalisation, promoting intensive agriculture and other industrial activities.

1.6.2. Fragmentation and isolation

Few habitats are destroyed entirely. Very often, habitats are reduced in extent and simultaneously fragmented, leaving small pieces of original habitat persisting like islands in a sea of degraded land. Fragmentation disrupts extensive natural habitats into increasingly isolated 'patches' of remnant vegetation.

1.6.3. Habitat change

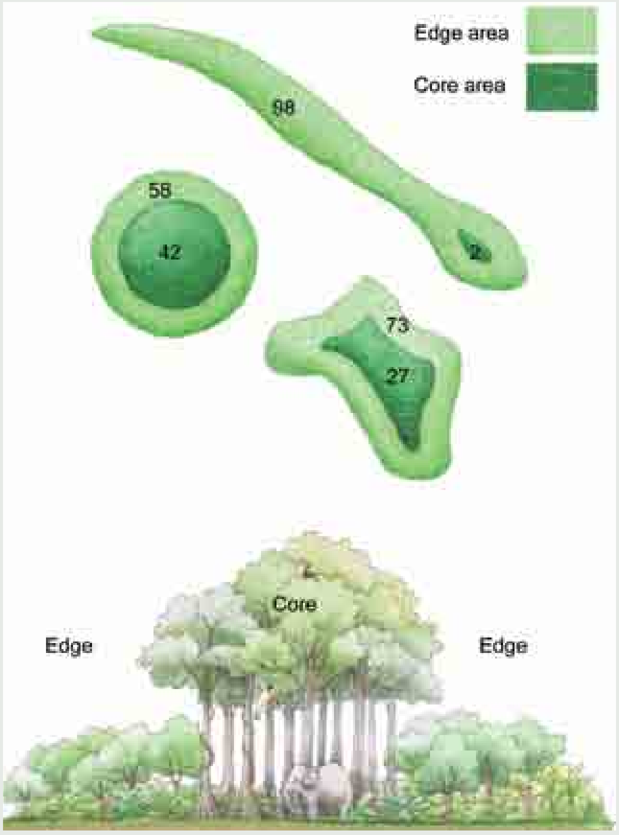
Habitat change or landscape change can be differentiated from habitat destruction in that it occurs gradually and in piecemeal fashion, rather than as a result of a sudden dramatic alteration, and results in largely degraded habitats rather than completely altered ones.

Landscape change is a dynamic process. Characteristic changes along a time trajectory include: (i) a decline in the total area of the fragments; (ii) a decrease in the size of many fragments (large tracts become scarce, small fragments predominate); (iii) increased isolation of fragments from other similar habitat; and (iv) shapes of fragments are increasingly dominated by straight edges compared with the boundaries of natural features such as rivers. For small fragments and linear features such as roadside vegetation and riparian strips, the ratio of perimeter length to area is high, resulting in a large proportion of edge habitat.

Habitat change can have a profound impact on the biophysical characteristics of a landscape, affecting its hydrology (drainage patterns and water flows, groundwater availability), microclimate, soil fertility, erosion and sedimentation patterns, presence of invasive species, reduction of core habitat and a resultant loss in species diversity.

Box 1. **How do habitat shape and area affect biodiversity?**

Figure 1. **Fragment shape has a critical influence on the relative amounts of core and edge habitat. (Source: Managing Biodiversity in the Landscape, NRE 2009a.)**



Unmodified, natural landscapes consist of large areas of 'core habitat' and relatively small areas of 'edge habitats' where one habitat type meets another. These large, relatively uniform core areas provide ample space for species populations to sustain themselves.

As areas of natural habitat are cleared or modified for other land-use, there are three major impacts on biodiversity.

Habitat fragmentation: Clearance of an area of natural habitat creates a barrier which many species are loth to cross. As a landscape is developed for agriculture or infrastructure, areas of natural habitat are broken up into a patchwork of smaller areas, each separated from others by varying distances. This fragmentation isolates subpopulations of species, restricting gene-flow and opportunities for pollination, breeding, and feeding. Even though, overall, there may be substantial natural habitat still left, each of the several areas may be too small to sustain more than a fraction of the original biodiversity. Relict populations of many species may remain in some patches, but if there are insufficient resources to sustain them, they will die out eventually.

Edge effect: As large areas of habitat are broken into many smaller ones, the ratio of edge habitat to core habitat increases. Edge habitat differs from core habitat in many ways, such as levels of light, temperature and humidity, susceptibility to wind disturbance and hunting pressure, etc. Open country pioneer species also increase competition for these areas, often displacing the original inhabitants. For these reasons, many species which naturally occur in core habitat are unable to survive at the edges. The shape of the habitat fragment is therefore an important factor in determining its biodiversity value.

Ecosystem weakening: Natural ecosystems are extremely resilient, able to withstand or recover from catastrophic natural events such as fire, flood and drought. However, as natural ecosystems become degraded or diminished in size, their ability to provide ecosystem services such as flood mitigation, water catchment, storm damage prevention, climate regulation and others also decreases. This was dramatically demonstrated during the 2004 South-east Asian tsunami. Areas with healthy coastal mangrove ecosystems were much less badly affected than those where the mangrove forests had been removed or degraded. Degraded natural ecosystems are more fragile and less resilient than healthy ones.

1.6.4. **Invasive species**

An invasive species is one that arrives (often with human assistance) in a habitat it had not previously occupied, then establishes a population and spreads autonomously. Species invasions are one of the main conservation threats today and have caused many species extinctions. The great majority of such invasions are by species introduced from elsewhere, although some regionally native species have become invasive in newly occupied habitats.

1.6.5. Over-exploitation

Human exploitation of biological commodities involves resource extraction from the land, freshwater bodies or oceans, so that wild animals, plants or their products are used for a wide variety of purposes, ranging from food to fuel, shelter, fibre, construction materials, household and garden items, pets, medicines, and cosmetics.

Over-exploitation of natural resources occurs when a resource is harvested faster and more extensively than its ability to repopulate to original levels. Some examples in South-east Asia are unsustainable logging in tropical forests, overfishing in marine and freshwater ecosystems, and uncontrolled hunting of many wildlife species. Illegal wildlife trade is one obvious and serious form of over-exploitation.

1.6.6. Pollution

Human activities can pollute both on a local and global scale and may affect water - with sewage, fertilisers, toxic chemicals and oil; soil - with pesticides, wastes, and toxic chemicals (which may be washed into water); and air - with smoke and gases such as sulphur dioxide.

Fossil fuels release carbon dioxide, sulphur dioxide and nitrogen oxides, all of which have polluting effects. Carbon dioxide is one of the gases which contributes most towards the 'greenhouse effect'. This occurs as heat from the sun which is reflected off the earth's surface is trapped by a layer of "greenhouse gases" within the earth's atmosphere, gradually increasing its overall temperature.

Sulphur dioxide and nitrogen oxides in the atmosphere cause acid rain, the effects of which can be far-reaching, as it can fall thousands of miles away. Acid rain can damage trees and plants directly and also washes into rivers and lakes, where increased acidity may kill flora and fauna. It also damages stonework and metalwork on buildings.

Fertilisers are a potent source of pollution, as the nutrients not absorbed into the soil or taken up by the plants may be washed into rivers and lakes, where they encourage the growth of bacteria and algae, causing eutrophication. As the bacteria increase, they use more and more oxygen from the water, causing aquatic plants, fish and other aquatic organisms to die.

1.6.7. Climate change

One of the reasons Earth is habitable is that concentrations of various atmospheric gases (e.g. carbon dioxide, methane, nitrous oxide, chlorofluorocarbons; also called greenhouse gasses) are such that some of the radiant heat received from the sun is trapped, rendering it a considerably warmer planet than it otherwise would be. However, the effect of increasing the amounts of these gases in the atmosphere is to increase the amount of radiant heat trapped, which increases the planet's temperature, leading to climate change.

2. Impacts on Biodiversity in Oil Palm Plantations

To understand how a plantation is affecting biodiversity, it is necessary to see it in the context of the whole ecosystem or landscape.

It is necessary to know:

i. WHAT negative impacts on biodiversity may occur; or are occurring, and how these can be avoided or offset.

ii. WHEN in the life of a plantation impacts are most likely to occur.

Plate 4. **Plantations are often part of a mosaic of land-uses in a landscape.** *Dave Bakewell.*

2.1. The need for a landscape-level perspective

A plantation does not exist as an isolated island of development, but sits within the wider context of the landscape, where there is often a complex pattern of land-use. This may include other plantations or agricultural crops, settlements and associated infrastructure, as well as a variety of natural habitats. It is the magnitude of loss of natural terrestrial areas, the forests, wetlands and natural waterways, within the landscape as a whole that underlies the scale and nature of the impacts, both on organismal biodiversity (e.g. species richness) and ecosystem services (e.g. rainfall in water catchments).

Although it is difficult for individual plantations to address landscape-level impacts, plantations can and should use landscape-level considerations to plan the development within their boundaries. For example, assessing the significance of patches of natural habitat within the plantation should include how these patches relate to the presence or absence of other natural areas within the landscape beyond the plantation boundaries.

This chapter looks at several key aspects necessary for effectively managing impacts on biodiversity in plantations.

i. *Section 2.2 (Concerns and solutions)* gives short summaries of impacts, how to know if they are occurring and HOW these impacts can be avoided, mitigated or offset. In some cases, these impacts are generic to several forms of land-clearing and development, but are included here as a guide to what may be occurring in oil palm plantations.

ii. *Section 2.3* gives an overview of typical activities carried out at each development phase and a summary of WHEN various impacts are most likely to occur during the life cycle of the plantation.

2.2. Concerns and solutions

2.2.1. Loss of critical natural habitats

UNDERSTANDING THE CONCERNS

Plantations should be developed to avoid or minimise destruction of natural habitats - land and water areas where the biological communities are formed largely by native plant and animal species, and where human activities have not essentially modified the area's primary ecological functions (IFC, 2006; IFC, 2007). See also Appendix 1.

IDEAS FOR SOLUTIONS

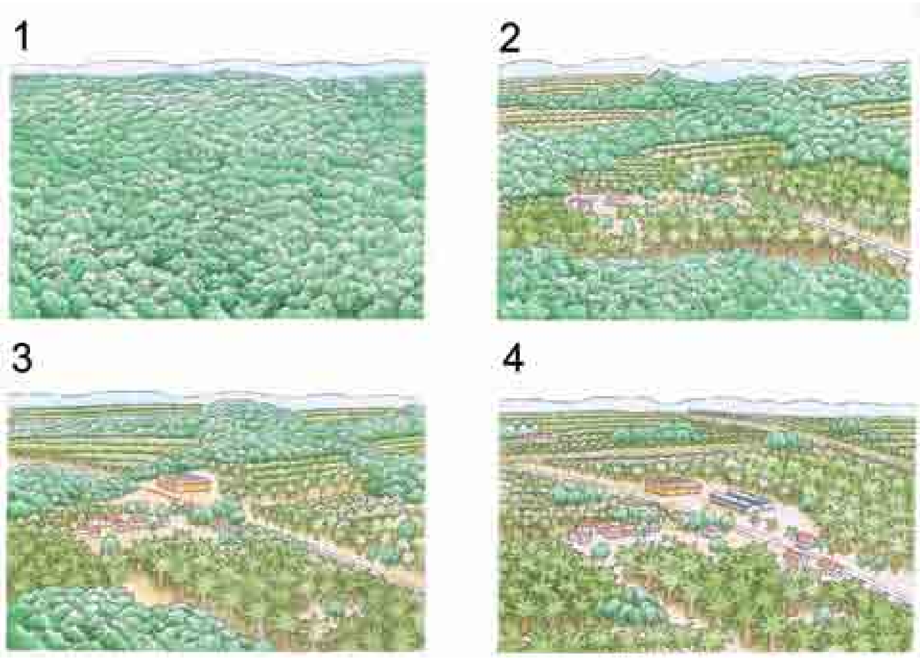
What?	How?
1. Identify, categorise, and delineate natural and modified habitat types and ascertain biodiversity values of national and regional importance before converting land to a plantation.	Survey the project area with the help of local or international experts. It will be useful to refer to regional, national, local conservation plans. Refer to National toolkits on High Conservation Values or other guidance documents.[1] Encouraging wider consultation at this early stage is good practice.
2. Avoid converting any areas which contain critical habitat, including known sites for rare, threatened or endangered species, or important wildlife breeding, feeding or staging areas.	Adjust plantation development plans to protect areas of proven high biodiversity values.
3. Be aware of the presence of rare, threatened or endangered species in the areas already used for plantation crop and consider them during management processes (land development or operations).	
4. Minimise disturbance of surrounding natural areas and any natural waterways within the site.	For new developments or replantings, demarcate buffer zones along natural waterways (at least follow national or local regulations) and beside HCV areas.

2.2.2. Forest fragmentation

UNDERSTANDING THE CONCERNS

Forest fragmentation is a process that occurs at landscape-level, and had almost certainly begun before the development of the current plantation operations. The process started when land was first cleared for infrastructure and agriculture, concentrating on the most fertile areas for the crop. Prior to this, the area may have been logged. As the process continues, what typically remains of the original natural habitat are increasingly isolated 'islands' which may be (a) legally protected through some form of gazettement (e.g., wildlife sanctuary or water catchment) or (b) not suitable for development (e.g., steep land, infertile soils, swampy areas). The negative effects of fragmentation on biodiversity become more serious over time, leaving many small pockets of natural habitat almost devoid of much of their original fauna and flora.

Figure 2. **The process of forest fragmentation.**



Source: Managing Biodiversity in the Landscape, NRE 2009a

1 The High Conservation Value Forest (HCVF) Toolkit for Malaysia can be downloaded from http://www.hcvnetwork.org/resources

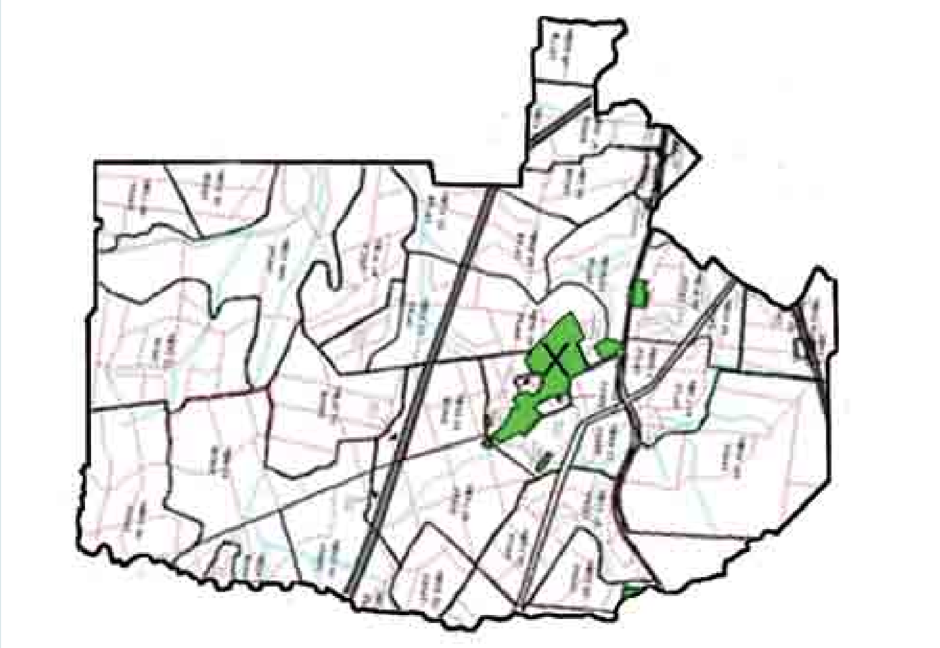


Figure 3. **It is difficult to know the value of forest fragment X for biodiversity using a map which only shows the boundaries of the plantation.** ➔

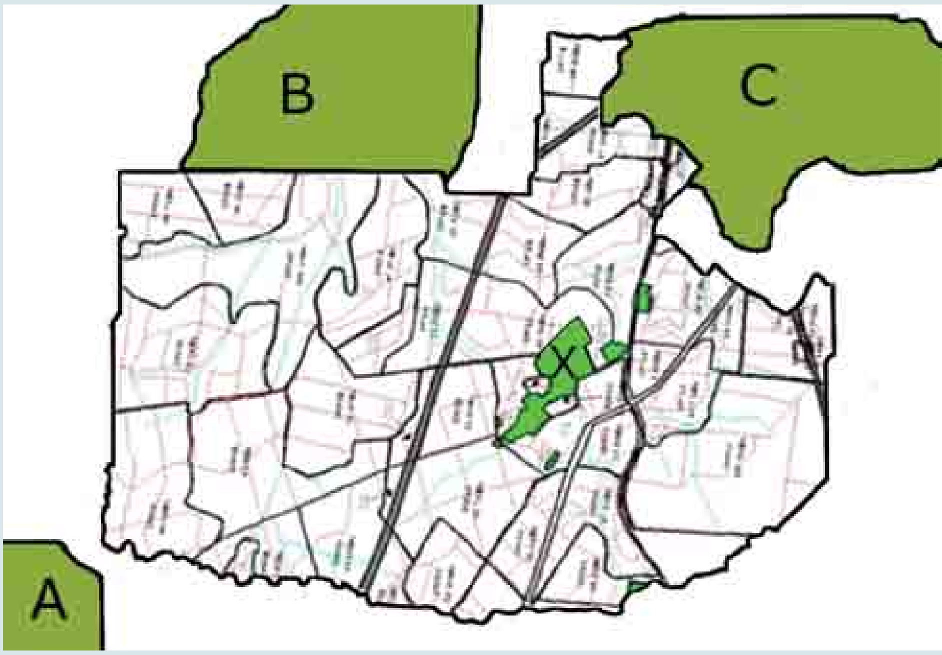
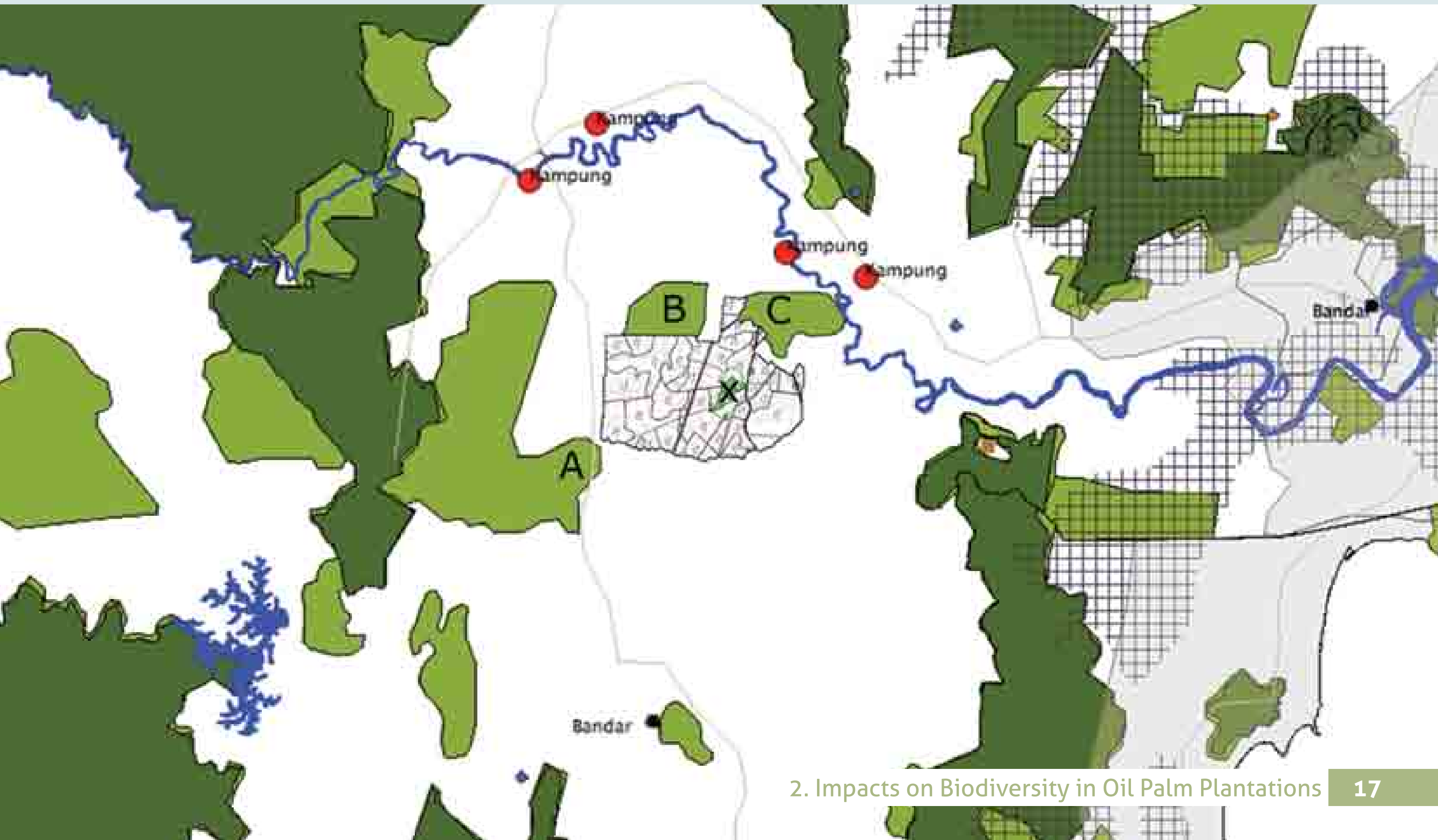


Figure 4. **Viewing the plantation within the context of what lies beyond its boundaries gives a much clearer understanding of the value of forest fragment X, Using this map as a guide, plans might be made to reconnect X to forest areas B or C via natural corridors to increase its biodiversity value.** ➔

Figure 5. **Seeing the estate in relation to the wider landscape changes the picture again. On the basis of this map, it might be decided that forest fragment X could form part of a natural corridor to reconnect B and C to A.**

Seeing the plantation in the context of the whole landscape is vital to understand its ecological importance. 🡓



IDEAS FOR SOLUTIONS

What?	How?
1. Identify main values of existing fragments and set management goals accordingly.	With the help of knowledgeable resource people, the first step will focus on the identification of natural forest fragments within or adjacent to the plantation. Where natural corridors can be identified, management options may be to conserve what is already there, or in some cases, rehabilitate.
2. Study satellite images and land-use maps showing land-use in the wider landscape to understand where fragments would benefit from being reconnected to each other or to larger Protected Areas beyond the estate boundaries.	Fragments could be reconnected by establishing natural corridors of native vegetation along river banks or roads, or building wildlife bridges over barriers such as deep drains (see Plate 20). Many natural corridors can also function as buffer zones, helping to protect water resources and reduce topsoil loss.
3. Discover any already established migration routes for large mammals, such as elephants, which cross estate land. In the long run it may be more cost-effective to preserve these routes in their natural states.	Consultation with knowledgeable experts here is very useful. These inputs can provide the basis for management decisions, which may be to protect existing wildlife corridors or to encourage adjacent plantations to accommodate these wildlife corridors.
4. Protect fragments and corridors of native forest within and around plantations. Riverside buffers and remnants on steep slopes should be a priority.	These "unplantable" areas should be designated and included in plantation maps. Signboards, boundary markings and other management actions help establish these conservation areas.

Several case studies where these principles are applied are included in Chapter 4.

Plate 5. **Cables strung between trees on either side of drains provide a means for primates to cross from one forest fragment to another.** *Dave Bakewell.*

Plate 6. **Connectivity of natural habitat is possible in a developed agricultural landscape.** *WWF-Malaysia.*

2.2.3. Over-exploitation of natural resources

UNDERSTANDING THE CONCERNS

Not all hunting, fishing or collection of natural resources has a negative impact on species or biodiversity as a whole. If removal of natural resources is kept within sustainable levels, it should not have a long-term detrimental impact on populations of the species in question. In fact, where habitats are managed for hunting or fishing, populations of game and other species may actually benefit.

However, if the harvest rate exceeds the ability of the resource to repopulate, this will hasten local extinction of particular species or a general decline in biodiversity.

Examples of over-exploitation are the widespread use of snares to catch wildlife, which impacts a wide spectrum of species, or the use of poison to catch fish, which impacts the water quality as a whole, as well as decimating fish populations indiscriminately.

Plantations facilitate access to natural areas by improving the road networks, and often increase human populations adjacent to natural areas. Plantation workers themselves may harvest species for food, trade or medicine, or others may use the plantation infrastructure to get into previously inaccessible natural areas. This is an issue if the target species is endangered or protected.

IDEAS FOR SOLUTIONS

Some steps that plantations can implement to control natural resource harvesting include:

What?	How?
1. Assess which species may be under threat.	Conduct surveys amongst workers and local community to understand what species are being sought and for what purpose.
2. Assess trends in populations of local wildlife species and stands of valued forest products.	Conduct censuses of certain species known to occur within the site and monitor their numbers over time. In addition, for recording purposes, maintain a list of any species that have had to be relocated from the site for safety purposes (e.g. crocodiles, snakes, etc.)
3. Assess whether harvesting is at sustainable or unsustainable levels.	Consider: • Does it contravene national laws? • Does it concern rare, threatened or endangered species? • Are harvests/populations of the species increasing, stable or declining? • Are harvesting levels limited by consumption needs or profit-driven?
4. Draw up a management plan based upon this assessment.	
5. Operationalise management steps.	Train security personnel to ensure that the plan is implemented and enforced. Inform and liaise with relevant government agencies on matters which contravene national wildlife laws. Consider seeking the help of organisations which specialise in the control of illegal wildlife trade (e.g. TRAFFIC[2], Wildlife Conservation Society[3]).

2 http://www.traffic.org/southeast-asia/
3 http://www.wcs.org/where-we-work/asia/malaysia.aspx

Box 2. **Is your IPM going to pot?**

The Barn Owl (*Tyto alba*) has been a key aspect of Integrated Pest Management (IPM) in oil palm plantations in West Malaysia since the 1980s. Plantations now routinely invest in nestboxes and regular surveys to ascertain the birds' breeding success. However, these efforts are being undermined by a clandestine trade in owl meat - owls caught in Malaysia smuggled to China as a food delicacy.

The trade was exposed recently by enforcement staff of the Department of National Parks and Wildlife (PERHILITAN) in Peninsular Malaysia, in Johor and Pahang in November 2008 and January 2009. They made raids in which over 1,000 owls, most of them Barn Owls, were seized[4].

Plate 7. **Part of a PERHILITAN seizure of owl carcases.** *Chris Shepherd.*

4 Bakewell *et al.* 2011

2.2.4. Summary of impacts on natural resources

Table 2. **Summary of potential natural resource impacts, suggestions for reducing environmental risks, and monitoring**

The Concern	The Solution	Effectiveness Indicators
1. Loss of natural habitats.	Conduct biodiversity assessments prior to land development and ensure that all natural and critical habitats are identified, delineated and safeguarded (see Appendix 1).	Areas identified to be preserved are protected and the information is integrated into development plans.
2. Available natural habitats impacted by development (land-use change).	Create buffers of suitable size around all sensitive areas to reduce disturbance by development.	Buffers are maintained and minimal encroachment evident from field inspection. See Appendix 4.
	Provide measures to reduce onsite and offsite impacts from soil erosion and pollution, especially of waterways.	See section 2.2.7 on soil erosion.
3. Fragmentation of habitats.	Ensure biodiversity assessments highlight potential areas outside and within the property that may be fragmented.	Maps showing land-use are available.
	Reconnect fragments.	Projects initiated and area maintained under natural cover is monitored (to show changes over time).
4. Natural resource harvesting.	Improve security patrols and reduce opportunities for wildlife trade across plantation boundaries.	Records of security enforcement and activities.
	Improve understanding and awareness of target species that deserve protection, particularly amongst workers and surrounding local communities.	Records of awareness-raising activities.
	Initiate studies to better understand status of populations of target species and levels of hunting/resource extraction.	Results of surveys showing trends over time.
	Conduct assessments to understand the types of pressures on forest resources within (and adjacent to) plantation boundary.	Assessments available and specific mitigation plans developed (where necessary).

2.2.5. Stresses on water resources (availability and quality)

UNDERSTANDING THE CONCERNS

Water is used in plantations for irrigation in the nursery, fruit-processing in the mill and domestic consumption. Water flow may be accelerated through a network of field drains; water may be dammed in peat or coastal plains to control its levels in the fields. Good water management means that crop production is optimised, while the quantity and quality of water resources is conserved and maintained.

Some of the ways in which plantations can impact water quality and availability include:

- Diversion or excessive use affecting downstream users (communities or other forms of agriculture);
- Increased surface water runoff from plantations increasing the risk of flooding downstream;
- Increased soil erosion affecting downstream water availability (reduces stream capacity) and quality (physical and chemical);
- Plantation activities releasing hazardous or polluting wastes into the environment e.g., from landfills, workshops, etc (see section 2.2.9) leading to eutrophication; and
- Blockages or other structures (e.g., undersized culverts) affecting drainage flow.

IDEAS FOR SOLUTIONS

What?	How?
1. In the planning stage, it is important that the volume of water required for the mill and nursery or other known uses is determined.	This can be an estimate, or based on records of use.
2. Sites for water intake should be selected based on an assessment of the overall water availability and also potential impacts on downstream users.	
3. A water conservation plan should be developed to ensure efficient use of the resource. This is useful whether or not the source of water is the mains or local supply, as saving water will reduce the resources (and cost) for treating the water.	This should be established as one of the goals of an environmental management system.
4. Water use in general, for mills or domestic uses, should always be measured.	
5. Implement good field practices which reduce surface runoff, divert surface runoff into vegetation and maximise utilisation of rainwater.	• In steep areas, plant along the contours to 'break up' the slopes to reduce the volume and speed of run-off. • Train workers not to wash chemicals/pesticide containers, clothes or pollutant material in nearby rivers/streams. • Construct silt-pits or sedimentation traps to reduce flow of silt-laden water into waterways. • Direct all silt-laden runoff (especially from roads and bridges) into terraces, fields, or areas with vegetation to avoid direct runoff into waterways. • Maintain border vegetation along canals and drainage systems, as well as natural waterways. • Allow soft-grasses in natural depressions where run-off water collects. This will minimise soil erosion by the water. More of the excess water can be retained by the grass, allowing it a longer time to infiltrate the soil. • During land clearing, the disposal of the vegetation debris into waterways should be prevented, as this reduces the water flow and will have an impact on the overall water quality. • All organic waste, such as fronds or trunks, should be retained in the fields and allowed to degrade naturally. This common practice can reduce surface water flows and soil erosion.
6. Monitoring of water quality should not be restricted to chemical tests and laboratory reports. By all means ensure that regular water quality testing is done, especially where required by law (e.g., drinking water supplies, environmental impact monitoring), but regular surveillance or field audits can also identify and control known sources of pollution or impacts.	• Visually inspect water quality, especially around domestic areas, those areas affected by mill outflows, workshop and washing bays and other potentially polluting facilities. • Water quality testing should include basics such as COD, BOD, pH, suspended solids, etc. • Note mineral oil spillages or other pollution sources from generators, vehicles, fuel stores or scheduled waste stores. • Look for blocked or polluted drains or waterways around lines sites. • Identify areas in the fields where silt traps or diversion drains are necessary. • Identify problems with undersized culverts by examining the erosion patterns around the outlets.

Summary of impacts on water resources (availability & quality)

Table 3. **Summary of potential impacts on water resources, suggestions for reducing environmental risks, and monitoring**

Stress on water resources		
The Concern	***The Solution***	***Effectiveness Indicators***
1. Decrease in water availability.	Conduct a water availability assessment to determine locations of water intake points for plantation activities (e.g., nursery, mill, domestic supply).	Assessment is available.
	Develop water use reduction plans for key plantation activities.	Continuous monitoring of water use by work area for both plantation and mill.
2. Decline in ground water quality.	Eliminate or minimise likely groundwater pollution sources (e.g., dumpsites, etc).	Continuous monitoring of all groundwater pollution sources.
3. Decline in surface water quality.	Divert or reduce surface water run-offs to minimise impact on natural waterways.	Records of field inspections are available.
	Maintain vegetation along all waterways, natural depressions and field drains to reduce direct impacts.	Projects initiated and area maintained under natural cover is monitored (to show changes over time).
	Eliminate or minimise likely water pollution sources (e.g., oil contamination, etc).	Continuous monitoring of all water pollution sources. Records of field inspections and water quality monitoring are available.

2.2.6. Eutrophication of aquatic environments

UNDERSTANDING THE CONCERNS

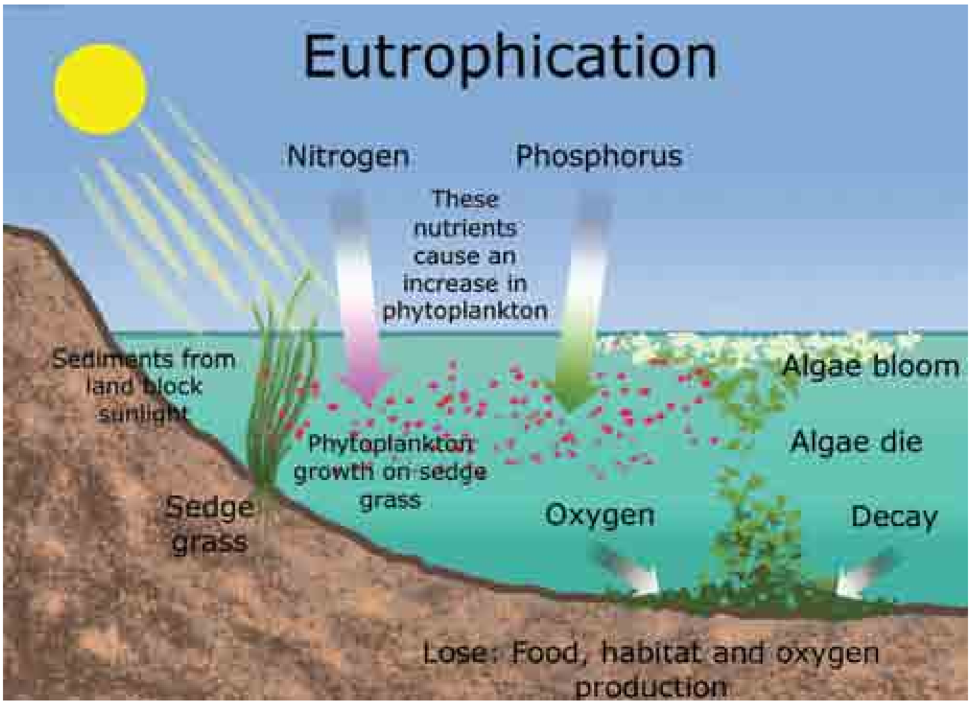
Eutrophication is the addition of natural or artificial nutrients, for example nitrate or phosphate, into natural water bodies, resulting in an increase in algae. This has the effect of reducing oxygen availability in the water or promoting excessive plant growth and decay, favouring simple algae over other more complicated plants, causing a severe reduction in water quality. Enhanced growth of aquatic vegetation and algal blooms disrupts normal functioning of the ecosystem, causing a variety of problems, such as a lack of oxygen for fish and other aquatic fauna. The water becomes cloudy, typically a shade of green, yellow, brown or red. Eutrophication also decreases the value of rivers, lakes, and estuaries for recreation, fishing, hunting and aesthetic enjoyment. Health problems can occur where eutrophic conditions interfere with drinking water treatment.

See Figure 6 for an illustration of this process.[5]

In plantations, untreated sewage effluent, surface water run-off carrying fertilisers, or greywater from domestic use are all potential causes of eutrophication. The use of fertilisers in plantations is addressed in this section, and domestic wastewater (sewage and greywater) in section 2.2.9.

5 See Chapter 1 of Bartram *et al*. 1999

Figure 6. **Illustration of the effects and causes of eutrophication.**



Source: Adapted by Dave Bakewell from http://lincoln.ne.gov/city/pworks/watrshed/educate/fertiliz/index.htm

Fertilisers are usually applied as inorganic chemicals, although some may be compost or organic. Between 900[6] and 1,500 kg/year of fertilizers (nitrate, phosphate and potassium) are applied per hectare in Malaysia[7]. There are two potential environmental impacts of excessive fertiliser use: risk to aquatic environments through eutrophication, and release of greenhouse gasses (see section 2.2.10). The greatest risk of runoff and leaching of fertilizers is during heavy rain. Increased use of organic fertiliser could improve the soil structure and soil infiltration.

IDEAS FOR SOLUTIONS

What?	How?
1. Determine fertiliser inputs required.	Conduct both leaf and soil sampling to optimise the amounts applied. As a guide, the EU suggests that fertiliser applications should create a nitrogen surplus below 5kg/ha/yr[8].
2. Apply organic matter, such as compost, to replace inorganic fertilisers to practical extent.	A reputable agronomist should be consulted on changes to fertiliser application necessary.
3. Establish buffer zones, strips or other "no treatment" areas of natural grasses or vegetation along water sources, rivers, streams, ponds, lakes and ditches to act as filters to catch runoff from the land.	Buffer zones should follow at least national or local guidelines (see Appendix 4). On a practical level, the size depends on a number of factors such as availability of land, terrain and existing vegetation.
4. Fertilisers should be protected from rain and direct sun when stored, and should be placed off the ground to avoid soil contamination. Any runoff or drainage from storage areas should be directed into fields and away from natural waterways.	Follow guidelines for storage and handling such as those established by GIFAP (International Group of National Associations of Manufacturers of Agrochemical Products).
5. Maintain records of fertiliser application.	Continuous monitoring and records maintained.

6 http://data.worldbank.org/indicator/AG.CON.FERT.ZS
7 anonymous source; based on actual amounts in a plantation in Sarawak, Malaysia in 2009

Summary of impacts on water resources (eutrophication)

Table 4. **Summary of potential impacts on water resources, suggestions for reducing environmental risks, and monitoring**

Eutrophication of aquatic environments		
The Concern	***The Solution***	***Effectiveness Indicators***
1. Increased nutrient-load of waterways from fertiliser runoff.	Improve efficiency of fertiliser application to reduce the amounts applied (i.e., better estimation of fertiliser needs by soil/leaf sampling) and reduce runoff (i.e. control of timing of application).	Agronomic reports from a reputable agronomist as the basis for fertiliser application.
	Increase the volume of organic fertilisers applied to fields.	Records of inorganic and organic fertiliser use showing trends.
	Ensure surface water runoff diversions run back into fields or natural vegetation to prevent nutrient-rich waters from entering natural waterways.	Records of field inspections are available.
	Allow natural grasses or vegetation along all natural waterways and depressions to increase filtration of nutrient-rich water.	Records of field inspections are available.
2. Increased nutrient-load of waterways from wastewater (see section 2.2.9 d).	Control flow of wastewater into natural waterways through improved wastewater containment measures. Field inspections to check for tell-tale signs of high-organic load (e.g. algal growth).	Records of field inspections are available.
	Improve wastewater treatment. Examples include changes to design of septic tanks or innovating new ways of addressing waste water (e.g. use of constructed wetlands or engineering solutions to improve aeration of waste water).	Records of visual field inspections and regular water quality monitoring (usually focused on BOD and *E. coli* readings) are available.

2.2.7. Soil erosion and loss of productive capacity

UNDERSTANDING THE CONCERNS

Soil erosion and the general degradation of soils is an issue all planters should be familiar with. In a plantation environment, "accelerated" soil erosion by water or wind may affect both agricultural areas and the natural environment, and is one of the most widespread of today's environmental problems. It has impacts both at the place where the soil is detached from and wherever the eroded soil ends up. Apart from soil erosion, other causes of soil degradation are soil compaction, low organic matter content, loss of soil structure, poor internal drainage, salinization, and soil acidity problems.

The factors that influence soil erosion are:

1. Rainfall and runoff;
2. Soil erodibility;
3. Slope, gradient & length; and
4. Vegetation cover.

Rainfall and runoff factors must be considered in assessing a water erosion problem. Soil movement by rainfall (raindrop splash) is usually greatest and most noticeable during high-intensity thunderstorms. Runoff occurs whenever there is excess water on a slope that cannot infiltrate the soil. The amount of runoff is increased if infiltration is reduced due to soil compaction. Runoff from agricultural land may be greatest during early land development and replanting when the vegetative cover is reduced.

Soil erodibility is an estimate of the tendency of soil to erode, based on its physical characteristics. Generally, soils with higher infiltration, higher organic matter and improved structure have a greater resistance to erosion. Sand, sandy loam and loam-textured soils tend to be less erodible than silt, very fine sand and certain clay-textured soils. Earthworks and activities which lower soil organic matter cause poor soil structure and result in soil compaction, which increases erodibility.

Naturally, the steeper the **slope**, the greater the erosion. Soil erosion also increases with slope length, due to the faster water flow, which increases its erosive power. Consolidation of small fields into larger ones often results in longer slopes with increased erosion potential.

In general, the soil erosion potential is increased if it has no or very little cover, whether of vegetation or mulch. The cover protects the soil from rain splash, which detaches the soil particles and allows them to be carried away, and slows down the surface water flow (reducing its erosive power) and allows more water to infiltrate the soil.

Some of the known impacts of soil erosion include[8]:

Onsite Effects

- Loss of top soil.
- Crop growth and yield are directly affected through the loss of natural nutrients and applied fertilisers with the soil.
- Seeds and plants can be disturbed or completely removed from the eroded site.
- Pesticides and nutrients may also be carried off the site with the eroded soil.
- Soil quality, structure, stability and texture can be affected by the loss of topsoil. Textural changes can in turn affect the water-holding capacity of the soil, making it more susceptible to extreme conditions such as drought.

Offsite Effects

- Eroded soil deposited down slope can inhibit or delay the emergence of seeds, bury small seedlings and necessitate replanting in the affected areas.
- Sediment can be deposited on down slope properties and cause road damage.
- Sediment which reaches streams or watercourses can accelerate bank erosion, clog drainage ditches and stream channels, silt up reservoirs, smother fish spawning grounds, reduce downstream water quality and increase the risk of flooding.
- Pesticides and fertilisers, frequently transported along with the eroding soil, can contaminate or pollute downstream water sources and recreational areas.

8 http://www.omafra.gov.on.ca/english/engineer/facts/87-040.htm and IFC, 2007

IDEAS FOR SOLUTIONS

What?	How?
1. Protect sensitive areas.	Plan developments to avoid highly erodible soils
	In steep areas, plant along contours.
2. Minimise erosion.	Manage the total area of land development and replanting to reduce the areas devoid of vegetation at any one time.
	Use stone barriers, vegetative cross-slope barriers (including frond piles), terraces, or drainage and diversion canals.
	Direct all silt-laden runoff (especially from roads and bridges) into terraces, fields, or areas with vegetation to avoid direct entry into waterways.
	Use plant cover (e.g. cover crops) or intercrops and shelterbelts to reduce erosion from wind and heavy rains.
	Allow soft-grasses in natural depressions where run-off water collects. This minimises soil erosion from these. This allows the water more time to infiltrate the soil and slows the water speed, which reduces its erosive power.
3. Reduce soil compaction.	Control the use of heavy machinery (note: cattle also cause significant soil compaction).
4. Protect soil quality.	Increase the soil organic matter by applying organic matter such as crop residues, compost and manure to protect the soil physically from sun and rain, and to feed soil biota. This has a direct impact on soil fertility and reduces surface runoff.

Source: Adapted from IFC, 2007b

Summary of impacts of soil erosion

Table 5. **Summary of impacts on soil and productive capacity, suggestions for reducing environmental risks, and monitoring**

Soil erosion and loss of productive capacity		
The Concern	***The Solution***	***Effectiveness Indicators***
1. Soil erosion from exposure to water (rain and runoff).	Better planning prior to earthworks to avoid developing on areas of high erodibility or steep and long slopes.	Soil assessment and erosion risk assessment available, with results reflected in development plans.
	Implement best management practices to protect soils (e.g., terraces along contours, planting cover crops, or runoff diversions to reduce flow speed over exposed fields).	Field inspection to identify problematic areas in development areas and to visually inspect waterways.
	Plan and control use of heavy machinery during earthworks and operational phases of plantation development to reduce soil compaction.	Maps or other planning documents, and records of training and supervision of earthwork contractors to ensure plans are followed are available.
		Field operations limit or reduce impacts (e.g. correct tyre pressures, dedicated paths) of heavy machinery in fields.
2. Silt-laden runoff into natural waterways.	Integrate silt pits, diversion canals or other measures to divert silt laden runoff away from waterways.	Field inspection to identify problematic areas in land development areas and to visually inspect waterways.

2.2.8. **Pesticides use**

UNDERSTANDING THE CONCERNS

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest. A pesticide may be a chemical substance, biological agent (such as a virus or bacterium), antimicrobial, disinfectant or device used against any pest. Pests include insects, plant pathogens, weeds, molluscs, birds, mammals, fish, nematodes (roundworms), and microbes that destroy property, spread disease or are a vector for disease or cause a nuisance. The term 'pesticides' also includes, for example, herbicides, insecticides, and fungicides.

In plantations, pesticides are used in the nursery (insecticides and weedicides), during immature and mature plantings (e.g. weedicides for the control of woody growth) and to control pest outbreaks such as bagworm caterpillars (insecticides) or rats (rodenticides). The most common mode of application is knapsack sprayers; aerial application is uncommon, and there is some use of motorised power sprayers.

Although there are benefits to the use of pesticides, there are also drawbacks, such as toxicity to humans and other animals. Potential environmental impacts are illustrated through reviewing global uses of pesticides. These serve as guides for evaluating plantation uses of pesticides. Some impacts of pesticide use include[9]:

- *Contamination of non-target species.* Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, including non-target species, air, water, bottom sediments, and food. The amount of pesticide that migrates from the intended application area is influenced by the particular chemical's properties: its propensity for binding to soil, vapour pressure, water solubility, and resistance to break-down over time.

- *Air pollution.* Pesticide drift occurs when the pesticide gets suspended in the air as particles and is carried by wind to other areas, contaminating them. Pesticides applied to crops can volatilise and be blown by wind to nearby areas, potentially posing a threat to wildlife.

- *Water Pollution.* In the United States, pesticides were found to pollute every stream and over 90% of wells sampled in a study by the US Geological Survey (Gilliom et al., 2006). There are several major routes through which a pesticide reaches water:

    - it may drift outside of the intended area when sprayed;

    - it may percolate, or leach, through the soil;

    - it may be carried to water as runoff or by eroding soil;

    - it may be spilled accidentally or through neglect.

9 http://en.wikipedia.org/wiki/Environmental_effects_of_pesticides

Factors that affect a pesticide's ability to contaminate water include its water solubility, distance from the application site to a body of water, weather, soil type, presence of a growing crop, and the method used to apply the chemical.

- *Soil contamination.* Some of the chemicals used in pesticides are persistent soil contaminants, whose impact may endure for decades and adversely affect soil conservation.

- *Direct poisoning of wildlife.* Animals may be poisoned by pesticide residues that remain on food after spraying, for example when wild animals enter sprayed fields or nearby areas shortly after spraying.

- *Indirect poisoning of wildlife.* Poisoning from pesticides can travel up the food chain (e.g. birds can be harmed eating insects and worms that have consumed pesticides). Some pesticides can bioaccumulate, or build up to toxic levels in the bodies of organisms that consume them over time, a phenomenon that seriously impacts species high on the food chain.

  Throughout Europe, reductions in bird populations have been found to be associated with the times and areas in which pesticides are used. In another example, some fungicides used in peanut farming are only slightly toxic to birds and mammals, but may kill off earthworms, which can in turn reduce populations of the birds and mammals that feed on them.

  The herbicide, paraquat, when sprayed on bird eggs, causes growth abnormalities in embryos and reduces the number of chicks that hatch, but most herbicides do not directly cause much harm to birds. Herbicides may endanger bird populations by reducing their habitat.

  Fish and other aquatic biota may be harmed by pesticide-contaminated water. Pesticide surface runoff into rivers and streams can be lethal to aquatic life, sometimes killing all the fish in a stream.

  Insecticides are more toxic to aquatic life than herbicides and fungicides.

IDEAS FOR SOLUTIONS

What?		How?
1.	Selection of pesticides for use in plantations should be evaluated for toxicity to humans and the environment, as well as effectiveness and cost.	Build a database of commonly used pesticides and extract relevant information about the product from the product's Material Safety Data Sheets (MSDS), websites and databases published by International bodies (e.g., World Health Organisation or Stockholm Convention) (see Table 6).
2.	Avoid spraying banks of natural waterways regardless of size.	
3.	Reduce likelihood of chemicals from spraying spreading to other areas.	Create natural buffers (allow natural vegetation to establish or establish tree cover) between plantations and neighbouring land, and between fields and settlement areas.
4.	Adopt long-term goals for the reduction or elimination of pesticide use.	Increased usage of Integrated pest Management (IPM). See Box 3.

Table 6. **Example of a simple database of commonly used pesticides**

Common chemicals used on estates			Hazards			Notes
Type	Trade Name	Active Ing	Man	Water	Environment	
Herbicide	Ally 20DF	Metsulforon-methyl 20%	Irritant			Eyes, nose, throat, skin irritation
Herbicide	Basta 15	Glufosinate-ammonium	Harmful	Pollutant		Hamful in contact with skin and if ingested; serious eye damage
Herbicide	Nufarm 2,4-Amine	2,4-D dimethylamine 48%	Toxic	Pollutant		Eye, skin irritation; harmful if swallowed or inhaled
Herbicide	Glyphosate 41%	Glyphosate Isopropylamine salt (41%)	Harmful			Eye, skin irritation; harmful if swallowed or inhaled
Herbicide	Garlon 250	Triclopyr butoxyethyl ester (32.1%)	Irritant	Harmful		Skin irritation; skin sensitization; harmful to aquatic organisms
Herbicide	Starane 200	Fluroxypyr 1-methylheptyl ester	Irritant			Slight eye irritation
Rodenticide	Storm Block Bait (0.005%)	Flocoumafen 0.005%	Very toxic	Toxic	Dangerous	Very toxic if inhaled, or contact with skin; very toxic to aquatic organisms
Insecticide	Decis	Deltamethrin 2.8%	Harmful	Toxic		Harmful if ingested (e.g. lung damage); skin irritation, serious eye damage; toxic to aquatic organisms
Fungicide	Thiram		Harmful	Toxic		Eye, skin irritation; harmful when in contact with skin or ingested; chronic exposure-toxic to urinary system, blood and liver; toxic to fish; releases toxic fumes when heated; neuro-toxic to animals

Box 3. **Integrated Pest Management**

Integrated Pest Management (IPM) is an ecological approach with the main goal of significantly reducing or eliminating the use of pesticides while at the same time managing pest populations at an acceptable level. It has three stages: prevention, observation and intervention.

An IPM system is designed around six basic components[11]:

PREVENTION

1. **Acceptable pest levels:** The emphasis is on control, not eradication. Attempting to wipe out an entire pest population can be costly, environmentally unsafe, and is frequently unachievable. IPM programmes first work to establish acceptable pest levels, called action thresholds, and apply controls if those thresholds are crossed. These thresholds are pest and site specific, meaning that what may be acceptable at one site may be unacceptable at another. This stops the pest gaining resistance to chemicals produced by the plant or applied to the crops. If many of the pests are killed then those that have resistance to the chemical will rapidly reproduce forming a resistant population. Not killing all the pests will leave some unresistant ones to dilute any resistant genes that appear.

2. **Preventive cultural practices:** Selecting crop varieties best for local conditions, and maintaining healthy crops is the first line of defence, together with plant quarantine and 'cultural techniques' such as crop sanitation (e.g. removal of diseased plants to prevent spread of infection).

OBSERVATION

3. **Monitoring:** Regular observation is the cornerstone of IPM. Observation is broken into two steps:

   i. Inspection. Visual inspection, insect and spore traps, and other measurement methods and monitoring tools are used to monitor pest levels.

   ii. Identification. Accurate pest identification is critical to successful IPM.

Record-keeping is essential, as is a thorough knowledge of the behaviour and reproductive cycles of target pests. Since insects are cold-blooded, their physical development is dependent on the temperature of their environment. Many insects have had their development cycles modeled in terms of degree days. Monitoring the degree days, or other relevant indicators, of an environment is essential to determine when the optimal time for a specific insect's outbreak is.

INTERVENTION

4. **Mechanical controls:** Should a pest reach an unacceptable level, mechanical methods are the first options to consider. They include simple hand-picking, erecting insect barriers, using traps, vacuuming and tillage to disrupt breeding.

5. **Biological controls:** Natural biological processes and materials can provide control, with minimal environmental impact, and often at low cost. The main focus is on promoting beneficial insects that eat the target pests. Biological insecticides, derived from naturally occurring micro organisms (e.g. entomopathogenic fungi and entomopathogenic nematodes), also fit in this category.

6. **Responsible Pesticide Use:** Synthetic pesticides are generally only used as required and often only at specific times in a pest's life cycle. Many of the newer pesticide groups are derived from plants or natural substances (e.g. nicotine, pyrethrum and insect juvenile hormone analogues), but the toxophore or active component may be altered for increased biological activity or stability.

Practices associated with IPM, such as erecting Barn Owl nest-boxes, and the planting beneficial plants, such as *Turnera sp.*, are becoming common in Malaysian plantations. This is an area for further applied research to determine more IPM techniques for different pest or weed management. Appendix 6 overviews IPM practices against common leaf-eating insects in oil palm.

10 http://www.epa.gov/pesticides/factsheets/ipm.htm

Summary of impacts of soil erosion

Table 7. **Summary of potential impacts of pesticide use, suggestions for reducing environmental risks, and monitoring**

Pesticides use		
The Concern	***The Solution***	***Effectiveness Indicators***
1. Use of toxic chemicals harmful to the environment.	Develop a reference database of potentially harmful chemicals and ensure that all chemicals used are re-evaluated.	Chemical register and chemical reference database available.
	Develop specific reduction plans for target hazardous chemicals.	Monitoring of chemical reduction plans (chemical use).
	Research IPM protocols for pests/weeds that involve target hazardous chemicals.	IPM protocols elaborated for target chemicals.
	Develop specific protocols or SOPs for spraying to reduce potential environmental hazards of pesticide use.	SOPs are available and spraying teams are aware of the protocols.

2.2.9. Solid and other polluting wastes

There are a number of waste streams which pose an environmental risk and need to be managed in plantations. These include solid waste from domestic housing and offices; hazardous waste from workshops, clinics, water treatment plants and other facilities; and the septic and greywater wastes usually from housing, shops and canteen areas. Typically, plantations will also have to address construction waste, especially during early plantation development or major refurbishments. The challenge for most plantations is that they are often in remote areas and contracting waste disposal may not always be economically feasible.

A. Solid Waste & Landfills

UNDERSTANDING THE CONCERNS

Solid (non-hazardous) waste generally includes garbage and refuse. Examples of such waste include domestic trash and garbage; inert construction/demolition materials; refuse, such as metal scraps and empty containers.

In general, most of the solid waste from plantations are disposed of in landfills onsite (e.g., trench-and-fill method, where a hole is dug and backfilled with the waste using the excavated material as cover). The solid waste is collected from the housing areas, offices, workshops and general collection of waste that is not considered "scheduled waste" (see section 2.2.9c). Most landfills do not have liners or leachate management systems and can pose a threat to groundwater water quality and potable water in general. The environmental risk is also difficult to assess, as there are often no records of the waste disposed, nor is the groundwater water quality monitored.

The environmental impact of these landfills lies in the fact that each produces leachate, the volume of which will vary with the size, age and contents of the landfill. The concern about environmental damage from such landfill waste leachate largely arises from its high organic contaminant concentrations and much higher ammoniacal nitrogen than is commonly found in typical organic effluents (e.g. such as mill effluent or domestic waste water).

IDEAS FOR SOLUTIONS

What?	How?
1. Create all landfills within your own title boundary.	Determine location of landfills is clearly within titled boundary.
2. Reduce litter.	Create trenches aligned perpendicular to the prevailing wind.
	Use excavated soil to create windbreaks.
3. Avoid siting landfills where there is a risk of potable groundwater (drinking water) contamination.	Ensure landfills are above the water-table (2 m above water-table is recommended).
	Create landfills above clay or water attenuating surfaces and avoid porous or sandy soils.
	Avoid areas that are flood-prone as this increases the risk of surface water contamination.
	Establish exclusion buffers 100 m from surface water and 500 m from buildings or structures.
4. Reduce surface run-off into landfills.	Create a buffer of natural vegetation around landfill site. A 100 m buffer is a good guideline.

Source: Adapted from EPA, 2010

B. Construction Waste

UNDERSTANDING THE CONCERNS

Construction waste is often overlooked. In general, most construction/demolition waste is inert material (wood, metal scraps, glass). However, many potentially hazardous materials are typically used in construction (e.g. paints, solvents, adhesives, caulks, pesticides, wood preservatives, oil, stored materials such as pesticides that have exceeded their shelf life). In older housing, asbestos boards are common, and handling and disposing of such materials needs to be done with care (asbestos fibre has been linked to lung cancer).

IDEAS FOR SOLUTIONS

What?	How?
1. Dispose of construction waste appropriately.	Ensure that all potentially hazardous materials are identified and then disposed off separately from the inert waste.
2. Reduce the volume of landfilled material.	Contractors and plantation managers should ensure that waste construction materials are reused as much as possible.
3. Ensure any collection and disposal of waste follows the law	Ensure records are kept on the location, volume and nature of waste disposed of. It is important that all disposal sites are checked periodically or a system be in place to verify the disposal sites being used (e.g. receipt issued by municipal landfill).

C. Hazardous or Scheduled Waste

UNDERSTANDING THE CONCERNS

Hazardous waste shares the properties of hazardous material (e.g., ignitability, corrosivity, reactivity, toxicity, or other physical, chemical or biological characteristics that may pose a potential risk to human health or the environment if improperly managed (IFC, 2007b)). In addition, in Malaysia, hazardous wastes that pose a significant risk to the environment (e.g., contain heavy metals, chemicals, mineral oils, etc) are regulated under the Environmental Quality Act (1974). This list is referred to as "Scheduled Waste" as it is included in several schedules under this act. For Scheduled Waste, there are specific requirements under the law that ensure that they are segregated, stored safely, labelled and disposed of by licensed contractors.

Problems associated with hazardous wastes include:

- They can pollute land, air or water, and/or endanger human health and animal safety.
- Septic systems can be ruined from contamination by hazardous waste.
- Disposing of hazardous waste with non-hazardous wastes is detrimental to solid waste collection systems, causes problems at landfills, poses a potential health threat to workers, and is illegal if the waste is Scheduled.
- Improper disposal of hazardous waste can lead to costly cleanups. In principle, businesses are liable for improper hazardous waste disposal and hazardous waste spills or releases.

IDEAS FOR SOLUTIONS

What?	How?
1. Ensure that all hazardous waste is identified, risks are assessed, and appropriate disposal methods are identified.	Workplace waste audits should be undertaken regularly (annually or when new materials are introduced): a. What types of hazardous waste are on-site? b. What are the related hazards? c. How are they managed, stored and disposed off? Assessors should be the person in charge of chemical requisitions, storekeepers or health and safety personnel. During a waste audit, all hazardous waste should be identified, regardless of the volume generated. For guidance on identifying hazardous waste, refer to the schedule contained within the Environmental Quality Act (EQA)[12]. Information on potential hazards and recommended disposal methods can be obtained from the product's MSDS, related technical data sheets or the supplier.

IDEAS FOR SOLUTIONS (cont'd)

What?	How?
2. All storage or work areas where potentially hazardous waste is generated should have appropriate measures to control any spillage, and prevent runoff into surface water or pollution of the environment.	Control measures are "containment": creation of bunds, concrete or sealed surfaces or storage tanks; and waste water traps, oil and grease traps, and chemical traps. These should be implemented for chemical stores, chemical mixing areas, fuel depots and vehicle filling areas, vehicle washing bays, workshop floors and drainage, and hazardous waste stores.
3. Waste is stored in a manner that prevents mixing or contact between incompatible wastes, and allows for inspection between containers to monitor leaks and spills.	Include sufficient space between incompatibles or physical separation such as walls or containment curbs.
	Store in closed containers away from direct sunlight, wind and rain.
	Secondary containment systems should be constructed with materials appropriate for the wastes contained, and adequate to prevent loss to the environment.
	Secondary containment is included wherever liquid waste is stored in volumes greater than 220 litres. The available volume of secondary containment should be at least 110% of the largest storage container, or 25% of the total storage capacity (whichever is greater), in that specific location.
	Provide adequate ventilation where volatile wastes are stored.

Source: IFC, 2007b. See also Appendix 7 and 8.

D. Sewage and Greywater Waste Water

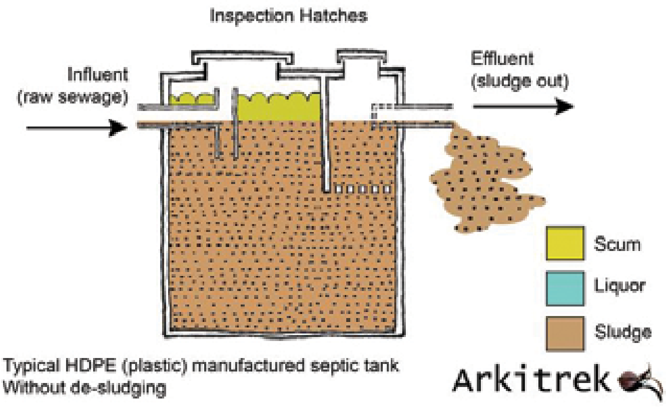
UNDERSTANDING THE CONCERNS

In housing complexes, waste water arises from the sewage lines (toilets or black water) and from washing areas (showers, kitchens) as grey water. Where the population is high, the volume of waste water can be significant and it is important to be aware of the risks.

Domestic sewage/black waste water contains 99.7% water. However, the 0.3% dissolved and suspended matter can contain micro-organisms (such as viruses, bacteria, fungal, and parasitic organisms) harmful to humans, animals and the environment. Contact with waste water or its products may cause a number of illnesses, such as:

- Gastroenteritis (diarrhoea or vomiting)
- Giardia and Cryptosporidium
- Viral infections such as hepatitis
- Infections of the skin or eyes.

Figure 7. **Failure to empty a septic tank regularly may lead to discharge of sludge into the surrounding area.**



Source: Arkitrek, 2012[13]

Typically, sewage/black water is run through septic tanks, and a natural process of decomposition allows it to degrade. The sludge that builds up over time has to be removed and is itself a hazardous waste. When the load in the septic tank exceeds its capacity, sewage bypasses it, and is channelled through the outflow (see Figure 7). Maintenance is needed to prevent this.

11 http://arkitrek.com/in-the-shit-a-septic-tank-guide/

The problem occurs when desludging is not done, the tank is undersized, or unable to function normally. The sludge and untreated sewage are then discharged through the outflow. The characteristic stench of septic tanks is one way to detect malfunctioning. As sewage poses a health risk, it is important that major outflows from housing areas are monitored regularly for *E. coli*, the main bacteria in human faeces.

IDEAS FOR SOLUTIONS

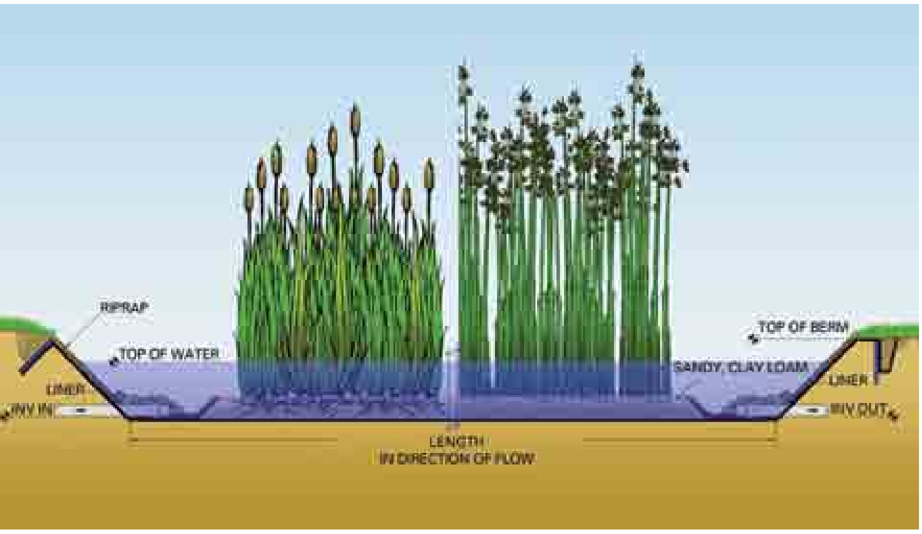
What?	How?
1. Ensure size of tank is suitable for projected capacity.	See Table 8 for suggested dimensions.
2. Avoid outflow of untreated or partially treated sewage into waterways (usually caused by tanks which are full).	Desludging should be done regularly (every 1-2 years). Consider the use of soak-aways and vegetation gardens (e.g., banana groves) as a means of controlling excessive sewage outflow.

Table 8. **Example of technical specifications from a manufacturer of septic tanks.**

Model		A	B	C	D	E
Population Equivalent	Black and greywater	3-5	5-9	5-11	9-16	16-30
	Black water only	5-9	8-16	9-20	16-25	25-50
Effective Volume (litres)		>2,200	>2,700	>3,400	>5,800	>9,600
Inlet/outlet diameter (mm)		100	100	100	100	100/150
Effective volume for retention time (hours)		45	33	40	36	55

Source: Anonymous manufacturer

Figure 8. **A diagram of constructed wetlands to treat waste water**



Source: Natural Systems International[15]

In Malaysia, Indah Water Konsortium (IWK) recommends a Population Equivalent[12] of 5 for each residential unit/house (see http://www.iwk.com.my/sewerage-fact-05.htm). In this scenario, plantation engineers would need to specify septic tanks that are similar to Models A-C in the table above.

Supplementary aeration, either through construction of an aeration system, a leach field or artificial wetland (see Figure 8), can improve the standard of treated waste.

Greywater is wastewater generated from domestic uses, such as laundry, dishwashing, and bathing. Greywater differs from water from the toilet, which is designated sewage or blackwater to indicate it contains human waste. Greywater from typical domestic housing on plantations may contain solid waste (typical litter), organic material (food scraps), soaps and detergents, and vegetable oils. Although the health risk of greywater is less than blackwater, greywater discharge into natural waterways still reduces their water quality, as the organic load will increase algal growth, and cause a concomittent reduction in oxygen availability (a process called eutrophication, see section 2.2.6).

12 For a definition of population equivalent, see http://en.wikipedia.org/wiki/Population_equivalent
13 http://www.natsys-inc.com/resources/about-constructed-wetlands/

One solution for addressing greywater disposal (and also blackwater overflows) is to have a wetland filter out the harmful waste. A schematic diagram for such a waste water system is shown in Figure 8. The size of the wetland should be approx. 0.5-1 sq ft per gallon of water treated.

Plate 8. **An innovative trap for solid waste in drains**
Source: NAHRIM Malaysia - Institut Penyelidikan Hidraulik Kebangsaan Malaysia

Summary of impacts of solid waste and other pollutants

Table 9. **Summary of potential impacts of solid waste and other polluting wastes, suggestions for reducing environmental risks, and monitoring.**

Solid and other polluting waste		
The Concern	***The Solution***	***Effectiveness Indicators***
1. Toxic leachate from landfills.	Ensure all landfills are sited away from any environmentally-sensitive areas (waterways, settlements, water intakes).	All landfills are identified and located on maps (location, date and volume).
	Ensure good segregation of wastes to reduce volume of toxic materials dumped.	Monitor waste segregation system is in operation and managed effectively.
		Records of waste segregated and landfilled.
		Water quality monitoring of any affected natural waterways.
2. Toxic waste discharged into the environment from spillage, uncontained stores or work surfaces.	Ensure all stores, workshop floors and any potential polluting sources are contained (i.e., bunds, oil or pollution sumps and use of spillage kits).	All potential polluting sites and sources are identified and located on maps.
		Field inspection of facilities for effective pollution control (e.g., spillage and accidental loads).
		Water quality monitoring of any affected natural waterways.
3. Construction waste.	Ensure design and construction plans do not use hazardous materials.	Draw up a list of materials to avoid in construction.
	Reduce construction waste by maximising reuse/recycling.	Records of waste segregated, landfilled or disposed by contractors.
4. Sewage.	Ensure capacity of sewage tanks meets or exceeds projected loads.	All potential polluting sites are identified and located on maps.
	Ensure regular maintenance of septic tanks.	Records of maintenance of septic tanks.
		Water quality monitoring of any potentially-affected natural waterways.
5. Greywater	Design waste water treatment using engineering technology or natural wetland vegetation.	All potential polluting sites identified and located on maps.
	Improve septic tank design to accommodate both greywater and sewage waste water.	Water quality monitoring of any affected natural waterways.

2.2.10. Air quality and emissions

Reduction in overall air quality from dust or particulate matter and emissions of greenhouse gases are the two environmental risks associated with plantations.

A. Dust & Particulate emissions

UNDERSTANDING THE CONCERNS

To a limited extent, dust and particulates from exposed earth roads and bare fields pose an environmental risk. This impact may become significant during dry periods. However, the risk is localised to settlements and inhabitants close to the roads or affected areas. One way to mitigate this risk is to map and identify all exposed areas within 100 m of existing/future settlements and make plans to reduce the airborne dust (e.g. water-dousing, sealed roads, resettling housing areas).

Of larger concern is open burning of cleared vegetation in land clearing for new plantings. The voluminous smoke will inject dense particulate matter into the atmosphere, posing health risks to affected communities. In addition, fires are a major contributor to greenhouse gases (see 2.2.10b).

Plate 9. **Illegal burning at night to avoid detection.** *Dave Bakewell.*

Plate 10. **Chipping of palms reduces GHG emissions associated with burning.** *WA/Rick Gregory.*

Plate 11. **Earthworks during early plantation phases need to be managed effectively to reduce erosion and runoff.** *WA/John Howes.*

IDEAS FOR SOLUTIONS

What?	How?
1. The risk of fires is especially high in peat (See Appendix 9).	Strict adherence to a zero burning policy to minimise the risks of fire.
	Mechanisms should be in place to address accidental fires caused by careless contractors, local communities or brought on by extreme drought.
	Ensure that optimum levels of water tables are maintained in planting areas.

Box 4. **Benefits of Zero Burning**

- An environmentally sound approach, as it does not cause air pollution.
- Zero burning reduces greenhouse gas emissions, particularly CO_2.
- Through recycling of plant biomass, the zero burning technique improves soil organic matter, moisture retention and soil fertility, particularly in areas that have been planted with more than one generation of plantation crops. This reduces the overall requirement for inorganic fertilisers and minimises the risks of water pollution through leaching or surface wash of nutrients.
- The agronomic benefits can be enhanced if the oil palm seedlings are planted directly onto the residue piles rather than on bare soil. Through this approach, higher levels of nitrogen, exchangeable potassium, calcium and magnesium can be obtained, and the nutrients are released over a longer period.

  Unlike land clearing by burning, the zero burning technique is less dependent on weather conditions. The zero burning technique has a shorter fallow period than clearing by burning; crop plants and legume cover can be planted within two months of felling and shredding; the latter provides faster coverage of the ground and minimises soil loss and pollution through run-off.
- As the zero burning technique involves progressive felling, application of the technique for oil palm replanting results in additional revenue from continued harvesting of the palms until they are felled. The revenue could offset any additional expenses incurred.
- Analyses of experience to-date indicate that approaches that do not involve the use of fire and removal of biomass ensure economic and ecological sustainability.

Source: ASEAN, 2003

B. Greenhouse gas emissions

UNDERSTANDING THE CONCERNS

A greenhouse gas (sometimes abbreviated GHG) is a gas in the atmosphere that reflects radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary GHGs in the Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone. In a typical oil palm plantation, the likely contributors of GHGs are:

- Vegetation conversion (use of fire);
- Soil emissions (such as from peatlands);
- Methane from effluent ponds (where there is a mill);
- Application of fertilisers (conversions into nitrous oxide or ammonia);
- Vehicle and machinery use (burning of fossil fuels).

Box 5. **What are peat swamps?**

A peat swamp is a wetland ecosystem found in low lying areas where naturally high water tables and waterlogged conditions prevail. Under these conditions, plant material does not degrade completely due to the oxygen-deficient environment. Over time, the partially decomposed material becomes peat. (In one area in Peninsular Malaysia, Pekan Forest Reserve, this measured as deep as nine metres in the centre of the deposit.) The boundary of the peat swamp ecosystem is defined by the boundary of the peat deposit.

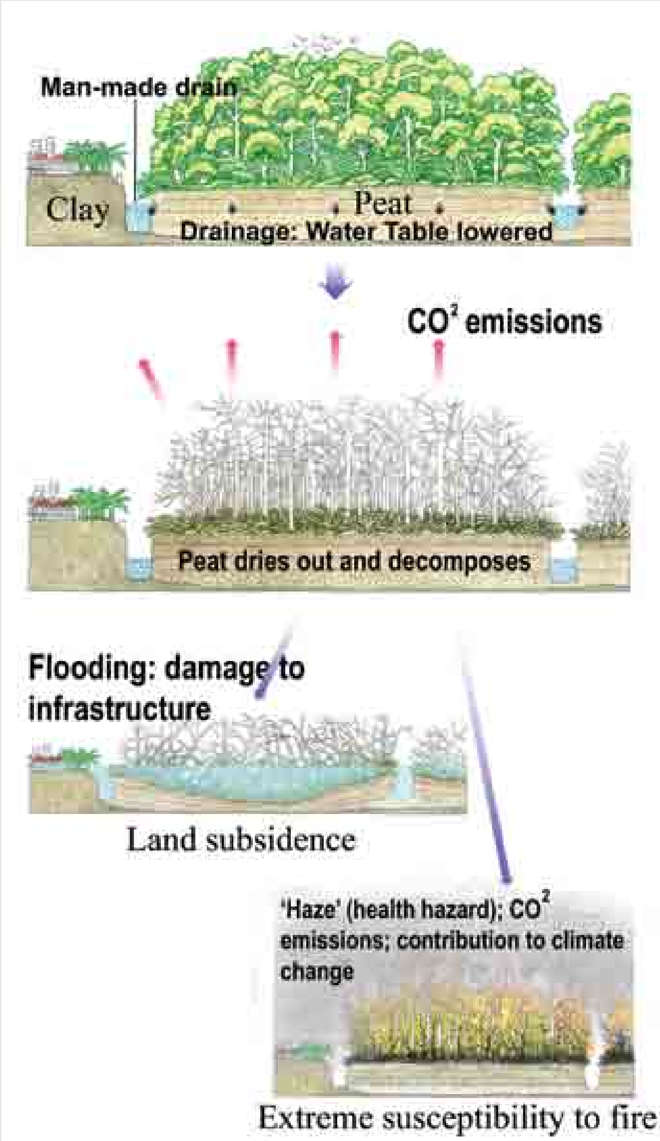
As long as sufficient conditions remain, plant material will continue to accumulate as peat. But, on drainage and exposure to oxygen, peat will oxydize and decompose. Water loss occurs naturally by surface and subsurface flow along gradients of the often dome-shaped peat deposit and through the process of evapotranspiration. In undisturbed conditions, poor drainage of peat swamp forests results in seasonal flooding during the wet season. During drier periods, the water table is close enough to the surface to ensure that most peat remains moist. Altering natural conditions by drainage, such as by digging canals or removing the vegetation cover of surrounding peat soils, has profound impacts on the evapotranspiration process. Together, these alterations affect the hydrology in the ecosystem.

The delicate balance that keeps peat swamp forests alive is therefore determined by a number of often complex hydrological processes. Conserving and sustainably managing peat swamp forests requires that, on average, peat deposits must not lose any more water – through evaporation from vegetation or by seepage into surrounding areas – than it gains through rainfall.

For oil palm planted on peat, the key issue is to manage the water-table at an optimum level to ensure healthy growth of the palms and also to slow down the rate of subsidence. In studies by Murayama & Bakar (1996), it was found that, where water levels were managed at 35-50 cm from the soil surface, the subsidence rate was less than 5 cm/year or an equivalent emission rate of 20-30 t/ha/year CO_2 emm. This is thus an important target to aim for.

In section 3.4 on monitoring, simple protocols for monitoring water-tables and subsidence levels effectively are outlined (see Monitoring Tool 4).

Figure 9. **Impacts of peat drainage.**

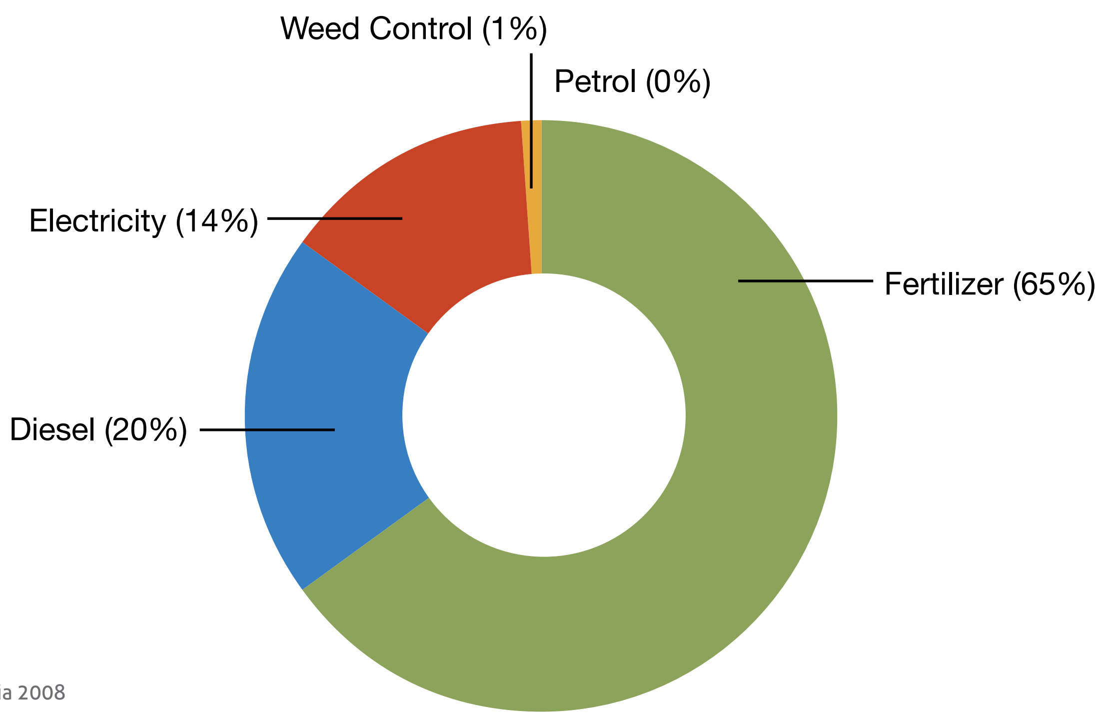


IDEAS FOR SOLUTIONS

What?	How?
1. Assess the standing carbon stock of areas and use the results as part of their decision-making process (i.e., "go or no go").	Engage experts to advise.
2. Enforce a zero burning policy.	
3. Avoid or reduce developments on peat.	
4. Start a process for greenhouse gas reduction.	• Identify sources of GHG emissions for both mill and estate. • Develop a reporting template within each unit to track volume usage (or volume generated) and frequency for each source. • Calculate GHG emission rates based on "rate of use for each source" X "emissions factor". The measurements will provide a baseline from which reduction plans could be developed. • Review the data and set annual targets for reduction.

The following is an example of GHG calculation for a particular estate. In this case, data was available on fertiliser, diesel, petrol, and electricity consumption. The total GHG emission, expressed in carbon dioxide equivalent units, was approximately 5,600MgCO_2eq. As can be seen in Figure 10, the largest contributor of GHG emissions was fertiliser use. Increasing efficiency in fertiliser application or partially switching to alternatives that have lower GHG emissions is one strategy to reduce overall GHG emissions. This figure is a conservative estimate since not all activities that contribute to GHG emissions were included in the study (e.g. the contribution recorded from petrol consumption was negligible. It is not clear if all petrol used was included in the accounts).

Figure 10. **Breakdown of GHG emissions from field operations in one estate in Malaysia in 2006. Total emissions were approximately 5,600MgCO_2eq.**



Source: Wild Asia 2008

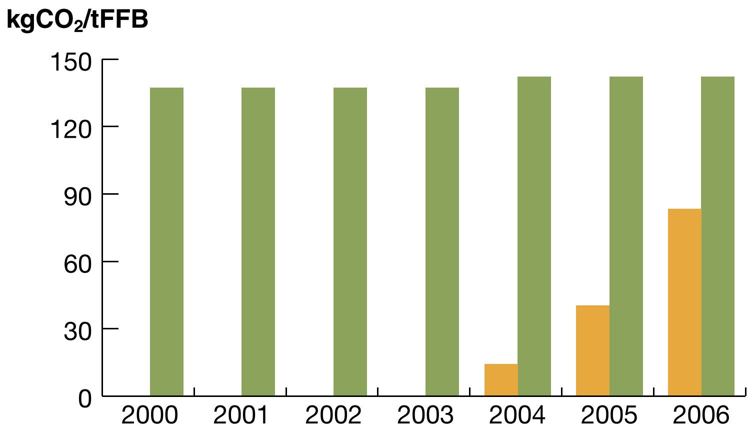
Table 10. **Example of GHG monitoring based on emissions for an estate and mill in Malaysia.**

GHG Emissions (tCO_2-eq/yr) Input Type	2000	2001	2002	2003	2004	2005	2006
Estate							
Diesel (estate vehicles and generators)	-	-	-	-	880	1,200	1,100
Petrol	-	-	-	-	-	-	16
Electricity	-	-	-	-	-	930	850
Fertiliser	-	-	-	-	-	872	3,600
Weed Control	-	-	-	-	-	-	76
Total	**-**	**-**	**-**	**-**	**880**	**2,700**	**5,600**
Total per unit ($kgCO_2$/tFFB)	**-**	**-**	**-**	**-**	**14**	**40**	**83**
Mill							
Diesel (generators and other equipment)	-	-	-	-	1,170	1,010	1,040
POME treatment	27,000	35,000	34,000	36,000	37,000	36,000	35,000
Total	**27,000**	**35,000**	**34,000**	**36,000**	**38,170**	**37,010**	**36,040**
Total per unit ($kgCO_2$/tCPO)	**616**	**663**	**653**	**637**	**688**	**669**	**698**
Total per unit ($kgCO_2$/tFFB)	**137**	**137**	**137**	**137**	**142**	**142**	**142**

Source: Wild Asia, 2008

Figure 11 is an example of how GHG trends over time can be presented in one chart for both mill and estate.

Figure 11. **Example of GHG trend monitoring (visual format) based on emissions for an estate and mill in Malaysia.**



	2000	2001	2002	2003	2004	2005	2006
Estate Total per unit ($kgCO_2$/tFFB)	0	0	0	0	14	40	83
Mill Total per unit ($kgCO_2$/tFFB)	137	137	137	137	142	142	142

Source: Wild Asia 2008

Once the GHG footprint for the estates and mills is known, the plantation company can devise strategies for reducing emissions, enhancing sequestration, and pursuing offset projects. If GHG emissions are increasing, the company should implement appropriate emission reduction strategies, such as reducing commercial fertiliser use, and methane collection for flaring or electricity generation.

Summary of impacts to air quality

Table 11. **Potential impacts on air quality, suggestions for reducing environmental risks, and monitoring.**

Atmospheric emissions		
The Concern	***The Solution***	***Effectiveness Indicators***
1. Open burning of vegetation matter (intentional or accidental).	Enforce a "zero burning" policy for new developments and replants.	Policy available.
	Ensure "zero burning" policy is included in contracts for land development.	Monitoring of land developments for outbreaks of fire and maintaining records of these surveillances.
	Emergency response procedure for fires enforced.	Records of emergency response and knowledge of procedures for those involved in the developments.
2. Peat exposed to air leading to oxydation (GHG emissions).	Develop a "no peat" development policy.	Policy available.
	Ensure field drains are controlled with a series of dams and weirs to allow effective water level management.	Install sufficient monitoring stations for water levels (bores) and peat depth (subsidence)levels.
	Ensure optimal water table height maintained (e.g., 35-50 cm below ground surface).	Water table and peat depth records for each field monitored.
3. Peat areas exposed to fires (intentional or accidental).	Enforce a "zero burning" policy for new developments and replants.	Policy available.
	Ensure "zero burning" policy is included in contracts for land development.	Monitoring of land developments for outbreaks of fire and maintaining records of these surveillances.
	Enforce emergency response procedure for fires.	Records of emergency response and knowledge of procedures for those involved in the developments.
4. Emissions of greenhouse gases (global impact).	Establish baseline data for all known GHG emissions.	Baseline GHG emissions established.
	Develop specific GHG reduction plans.	Reduction plans are available.

2.3. When are impacts most likely to occur?

Environmental impacts of plantation developments are related to the various stages of the development, and how each has an impact on biodiversity, water resources, air and natural resources in general. In the following section, each impact is described and discussed in relation to development plans.

2.3.1. Overview of plantation developments

Each phase of plantation development encompasses a range of activities which will have an impact on the environment. Four phases of plantation development are identified:

i. Land development phase

ii. Immature phase

iii. Mature phase

iv. Replanting phase (adapted from SECD, 2000).

A summary of the development activities in each phase is outlined in Figure 12.

Figure 12. **Outline of the development phases in a typical plantation development.**

Land Development Phase

- **Pre-development.** This stage involves feasibility studies, application/acquisition of land, preparation of EIA, and survey of boundary and plantation blocks;
- **Nursery establishment.** Normally, one hectare (ha) nursery for planting 100 ha. High quality seedlings prepared for planting when the field is ready;
- **Infrastructure establishment.** Basic facilities for workers, management personnel and running of vehicles established;
- **Site preparation.** Existing vegetation cleared to enable earthworks (particularly terracing & drainage). Cover crops planted and maintained;
- **Field establishment.** Field lining and holing. Seedlings from the nursery planted in prepared field.

Immature Phase

- **Maintenance and harvesting.** Planted palms maintained by manuring and control of diseases, weeds and pests. Harvesting normally commences in 2.5 to 3 years of field planting;
- **Housing and facilities.** The housing of people, management of solid waste and machinery is ongoing throughout the lifetime of the project.

Mature Phase

- **Maintenance and harvesting.** Planted palms maintained by manuring and control of diseases, weed and pests.
- **Housing and facilities.** The housing of people, management of solid waste and machinery is ongoing throughout the lifetime of the project.

Replanting Phase

- After completion of the productive life (usually 20 to 25 years), replanting occurs. The size of replants will vary but the basic rule of thumb is to replant no more than 25% of the total planted area.

The following tables (see Table 12 to 14) show the likely risks to biodiversity and ecosystem functions at each of the four development phases. These provide a general guide and may help tune environmental management plans strategically during the different phases of development.

Table 12. **Land Development Phase: Potential environmental risks.**

Land Development Phase		
Key Activities: • Establishment of base camp for development activities. • Establishment of nursery and water intake points. • Land clearing and earthworks for preparing land for planting.		
Environmental Risk	***Risk Score***	***Likely Impacts***
1. Biodiversity impacts.	High	Loss of biodiversity and natural areas; impacts on wildlife movements; fragmentation of natural habitats; increased accessibility leading to wildlife hunting and natural resource harvesting.
2. Stress on water resources.	High	Use of water for nursery; earthworks affecting natural drainage and water availability (culverts, etc.).
3. Eutrophication of aquatic environments.	Medium	Runoff of fertilisers in nursery; domestic sewage and greywater.
4. Soil erosion and loss of productive capacity.	High	Land clearing and earthworks.
5. Pesticides and agro-chemical usage.	Medium	Concentrated use of pesticides around the nursery.
6. Generation of biomass residues and organic waste.	High	Vegetation and other organic debris.
7. Solid and other wastes (greywater, septic, hazardous) .	Medium	Domestic waste from camps; machinery waste (oils, filters, etc.); polybags.
8. Atmospheric emissions.	Medium-High	Removal of vegetation and increased carbon emissions; dependent on soil type (peat) or incidences of fires (clearing debris or accidental).

Table 13. **Immature and Mature Phase: Potential environmental risks.**

Immature Phase		
Key Activities: • Field upkeep and manuring (manual or chemical weeding and fertilising). • Upgrading of base camp and work servicing. • Harvesting operations.		
Mature Phase		
Key Activities: • Field upkeep and manuring (manual or chemical weeding and fertilising). • Housing, office and workshops to service plantation. • Harvesting operations.		
Environmental Risk	***Risk Score***	***Likely Impacts***
1. Biodiversity impacts.	Medium	Human-wildlife conflict from mammalian pests (elephants, pigs, porcupines); impacts on wildlife movements; increased accessibility leading to wildlife hunting, natural resource harvesting.
2. Stress on water resources.	Medium	Early earthwork developments affecting natural drainage and water availability (culverts, etc.).
3. Eutrophication of aquatic environments.	Medium	Runoff of fertilisers in fields; domestic sewage and greywater.
4. Soil erosion and loss of productive capacity.	Medium	Road runoffs and bare ground.
5. Pesticides and agro-chemical usage.	Medium	Immature/field area upkeep and pests and diseases.
6. Generation of biomass residues and organic waste.	Low	Fronds or other waste.
7. Solid and other waste (greywater, septic, hazardous).	Medium	Domestic waste from camps; machinery waste (oils, filters, etc.).
8. Atmospheric emissions.	Low	Dependent on soil type (peat) or incidences of fires (clearing debris or accidental).

Table 14. **Replanting Phase: Potential environmental risks.**

Replanting Phase		
Key Activities: • Felling and chipping of palm trunks (zero burning method). • Earthworks (land preparation, drainage and improving roads or terraces). • Housing, office and workshops to service plantation.		
Environmental Risk	***Risk Score***	***Likely Impacts***
1. Biodiversity impacts.	Medium	Disturbance of mature fields.
2. Stress on water resources.	High	Earthwork developments affecting natural drainage and water availability (culverts, etc.).
3. Eutrophication of aquatic environments.	Medium	Domestic sewage and greywater.
4. Soil erosion and loss of productive capacity.	High	Road runoffs and increased exposed/bare ground.
5. Pesticides and agro-chemical usage.	Low	Minimal applications.
6. Generation of biomass residues and organic waste.	High	Palm trunk and other waste from replanting areas.
7. Solid and other wastes (greywater, septic, hazardous) .	Medium	Domestic waste from camps; machinery waste (oils, filters, etc.).
8. Atmospheric emissions.	Low	Incidences of fires (clearing debris or accidental).

3. Incorporating Biodiversity into Plantation Management[1]

The collection of baseline data on what biodiversity occurs where in the plantation and adjacent landscape forms the foundation on which a biodiversity management plan is built. An effective management plan prioritizes the most important issues and includes a monitoring and review process to determine its effectiveness.

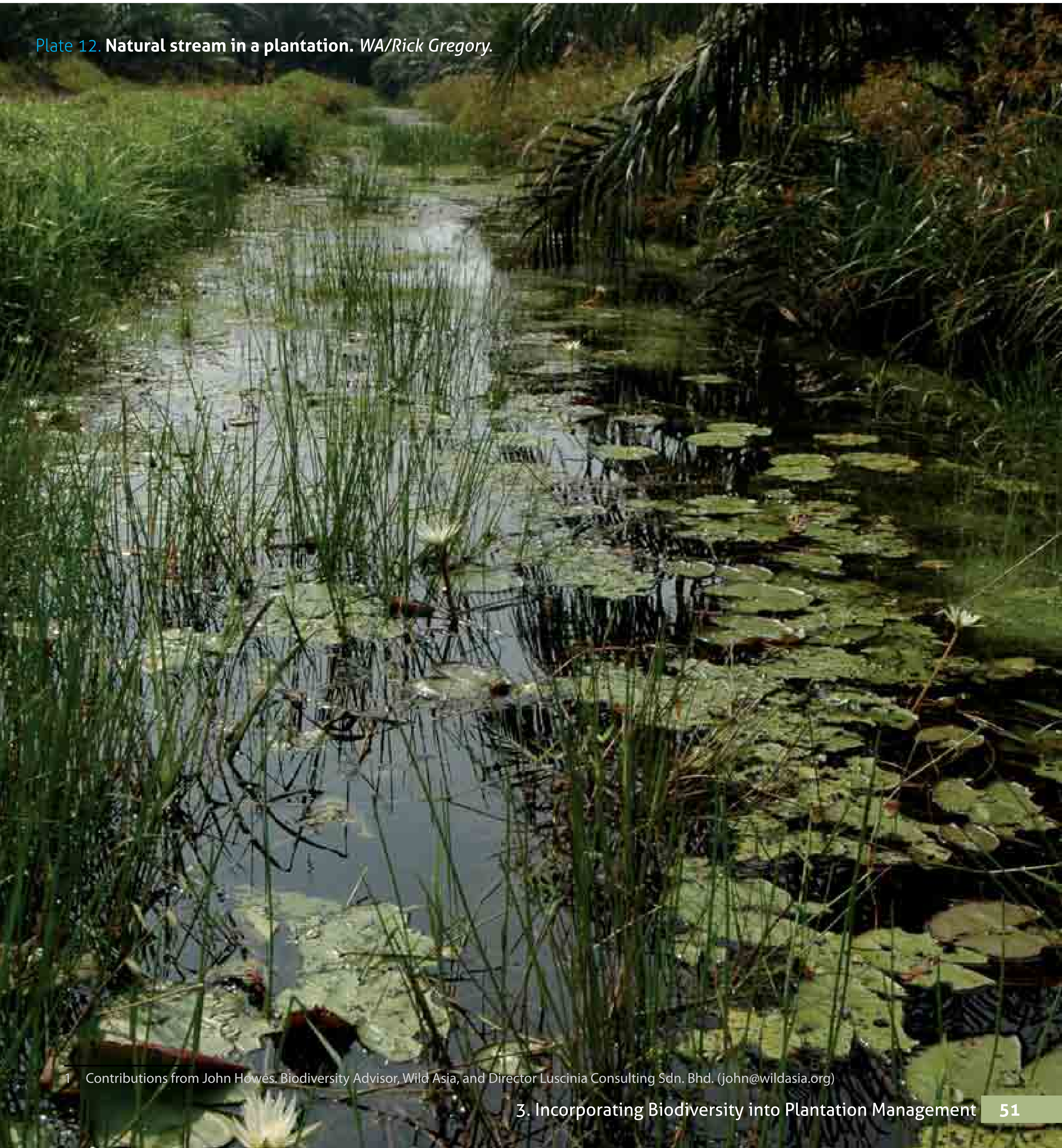


Plate 12. **Natural stream in a plantation.** *WA/Rick Gregory.*

1 Contributions from John Howes. Biodiversity Advisor, Wild Asia, and Director Luscinia Consulting Sdn. Bhd. (john@wildasia.org)

Section 2 has dealt in some detail with the aspects of biodiversity likely to be affected by plantation operations and management, and how the negative impacts of these can be mitigated. This chapter outlines how data on biodiversity can be collected and analysed to inform management priorities and goals.

In order to effectively manage biodiversity in plantations, managers and staff need to acquire knowledge of:

- What biodiversity values exist on and around the plantation
- Their location and extent
- Their significance (in terms of conservation value and ecosystem services)
- The extent and nature of threats to their existence

Acquiring this knowledge will probably require the input of:

- Specialists (ecologists, technical experts – environmental consultants and universities, NGOs, etc.)
- Other stakeholders within the landscape (including workers and staff, people who live within the landscape, including indigenous people, neighbouring land-users and downstream inhabitants, government departments, etc.)

In most cases, gathering baseline data is a one-time event – usually through a field survey or assessment, review of existing information and / or interviews. However, it should not be limited to this, as situations change and new information comes to light, and this should be incorporated into the baseline.

Once baseline data has been gathered, how can it be used to influence actual management decision-making? This usually happens by means of a management plan; a document which lays down a set of agreed actions that guide the user towards an agreed goal within a specific timeframe (not unlike the harvesting and operation plans put together by plantation managers on a regular basis).

The basic format for a management plan is outlined below:

a. Prioritise management actions,

b. Set management goals

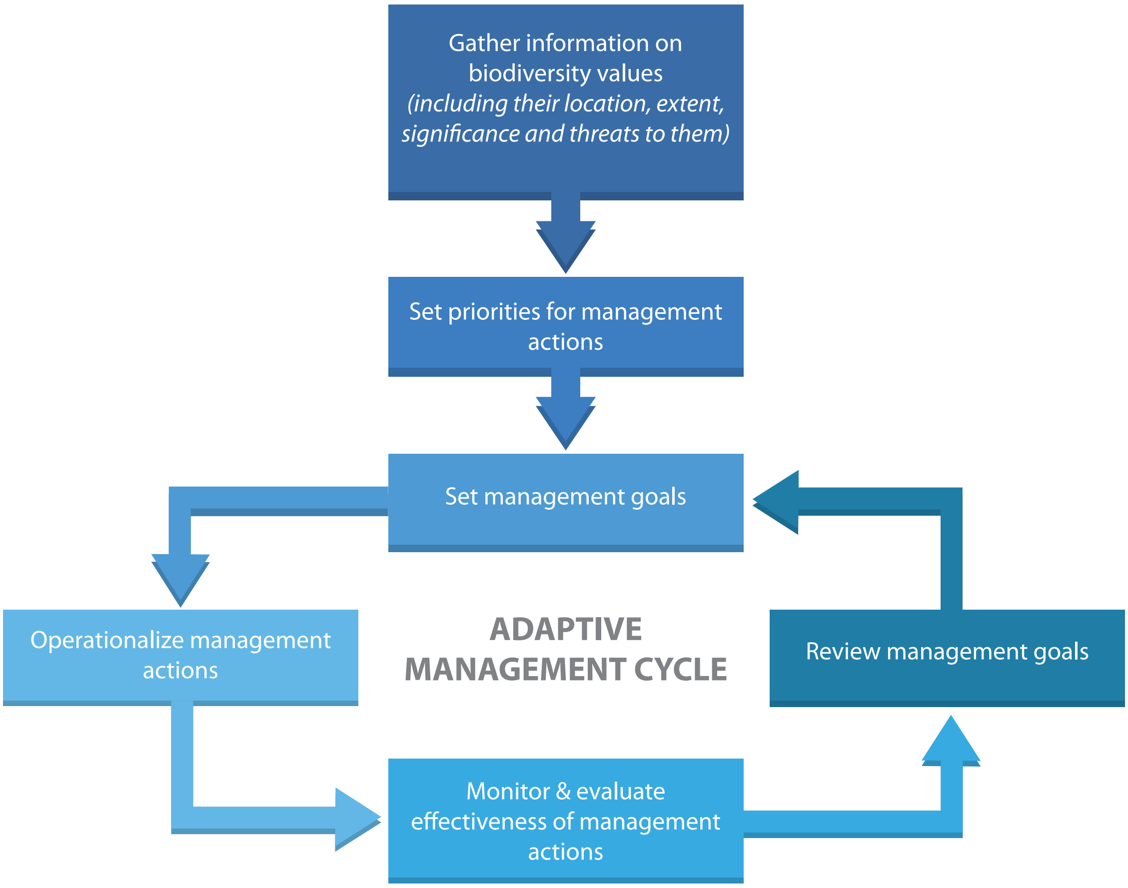
c. Operationalise management actions

d. Monitor and evaluate the effectiveness of management actions

e. Review management goals

These steps can also be viewed as a cycle (see Figure 13):

Figure 13. **The Adaptive Management Cycle**



Box 6. **What is Adaptive Management?**

One of the biggest fears most people have is that of failure. However, good resource management, or adapting to new working environments, is one area where we need to be able to learn from our mistakes and improve. One of the best fits for management systems in such a scenario is called Adaptive Management (Holling 1978). *Adaptive Management* (AM), also known as adaptive resource management (ARM), is a "structured, iterative process of optimal decision making in the face of uncertainty", with the aim of reducing uncertainty over time via system monitoring (see 3.4). In this way, decision-making simultaneously maximises one or more resource objectives and, either passively or actively, accrues information needed to improve future management. Adaptive management is a tool which should be used not only to change a system, but also to learn about the system. Because adaptive management is based on a learning process, it improves long - run management outcomes. Those people familiar with the typical ISO management system of "Plan-Do-Check-Act" will find these steps very familiar.

Useful link: http://www.pwrc.usgs.gov/moorevideo/index.cfm

3.1. Setting priorities for management actions

Given that all plantation operations work within limited budgets of time, money and manpower, ordering of priorities is necessary and desirable, so that the most important needs receive the most attention, time, finance, etc. But, how does one determine 'importance' when it comes to biodiversity? One manager's perspective or knowledge may be different from another.

One way to determine priorities concerns conservation value (see Appendix 2). There are several published guidelines to help determine this. One of the most useful for the Malaysian context is the *High Conservation Value Forest (HCVF) Toolkit for Malaysia* (WWF-Malaysia 2009).

High Conservation Values, where they exist, should receive very high priority for management actions.

In order to make decision-making about priorities practical, a system of scoring (assigning numerical value) is proposed. It is suggested that each HCV category present should be given a score of 5.

Box 7. HCV Categories (Stewart et al. 2008)[2]

HCV1. Areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, endangered species, refugia).

HCV2. Globally, regionally or nationally significant large landscape-level areas where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance.

HCV3. Areas that are in or contain rare, threatened or endangered ecosystems.

HCV4. Areas that provide basic ecosystem services in critical situations (e.g. watershed protection, erosion control).

HCV5. Areas fundamental to meeting basic needs of local communities (e.g. subsistence, health).

HCV6. Areas critical to local communities' traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities).

See Appendix 1 for interpretation of some of these values in the Malaysian context.

Another way to determine priorities is to evaluate the seriousness of threat, in terms of:

i. **Frequency:** How often does it occur?

ii. **Scale:** To what extent does it occur?

iii. **Severity:** How serious/long-term are the impacts?

2 http://www.hcvnetwork.org/site-info/The%20high-conservation-values-folder

Tables 15 and 16 provide a framework for assessing the frequency, scale and severity of each identified threat. This will help determine the urgency and importance of taking remedial action to reverse or halt negative impacts.

Table 15. **Threat assessment matrix – Frequency and Scale.**

Nature of Threat:	Name each identified threat here				
	Scale				
Frequency	**Very small – a few square metres**	**Affects one area in the plantation**	**Affects several areas in the plantation**	**Affects many parts of the plantation**	**Affects the landscape beyond the plantation**
Very rare (< once in 5 years)	1	2	3	4	5
Rare – less than annual.	2	3	4	5	6
Once or twice a year.	3	4	5	6	7
Several times a year.	4	5	6	7	8
Most of the time.	5	6	7	8	9

Table 16. **Threat assessment matrix – Frequency and Severity.**

Nature of Threat:	Name each identified threat here				
	Severity				
Frequency	**Temporary and easily reversed**	**Short-term impact, reversible**	**Medium-term impact, costly to reverse**	**Long-term impact, difficult and costly to reverse**	**Catastrophic and irreversible**
Very rare (< once in 5 years)	1	2	3	4	5
Rare – less than annual.	2	3	4	5	6
Once or twice a year.	3	4	5	6	7
Several times a year.	4	5	6	7	8
Most of the time.	5	6	7	8	9

For each identified threat, the frequency, scale and severity of that threat is ranked. For example, a threat happening infrequently (once or twice a year) and over a small scale (one part of the plantation) would be normally be a lesser priority for management action than one that occurs several times a year, and impacts similar or larger area.

Tables 17 and 18 show examples for two situations commonly encountered in oil palm plantations: sedimentation of waterways and illegal hunting of wildlife.

Table 17. **Comparison between two concerns identified in a hypothetical plantation, and identification of values and threats.**

Nature of threat	Sedimentation of water courses	Illegal hunting of wildlife
Values affected		
Presence of HCVs	None (in this particular example).	Adjacent lowland forest HCV3, rare species HCV1 (in this particular example).
Ecosystem services	Water supply to Mill and Nursery.	Pest control, pollination.
Threats		
Impacts	Sedimentation and blockage of field drains.	Loss of biodiversity and rare species.
	Flooding.	Degradation of HCV forest.
	Reduced water for Mill and Nursery operations.	

Table 17 identifies the presence or absence of HCVs, as well the threats posed by the concern. Table 18 provides a working example of how these threats can be ranked (using the two threat assessment matrices provided in Table 15 and 16).

Table 18. **Use of threat assessment matrices to rank priorities for management action.**

Sedimentation of water courses		Illegal hunting of wildlife	
Frequency: several times / year	**Score**	**Frequency: most of the time**	**Score**
Scale: many parts of plantation	**7**	Scale: part of plantation	**6**
Severity: long term impact. Difficult and costly to fix	**7**	Severity: short term impact, reversible	**6**
HCVs impacted: none	**0**	HCVs impacted: HCV1, HCV3	**10**
TOTAL SCORE	**14**	**TOTAL SCORE**	**22**

Notice, that in the example above, if only seriousness of threats was included in the evaluation, sedimentation would receive a higher priority (14) than illegal hunting of wildlife (12). However, recognition of the different conservation values impacted changes the picture significantly. It is equally possible, in another scenario, that illegal hunting may not present a significant threat to HCVs, whereas sedimentation of waterways could have an impact on HCVs, in which case, this would change the priority scenario.

Table 19 provides an example of how this scoring system can be used to rank priorities for management action.

Table 19. **Working example: Assessing biodiversity management priorities.**

Identified concern	Frequency vs. Scale	Frequency vs. Severity	HCV Score	PRIORITY RANKING (points)
Sedimentation of waterways.				
Soil erosion in replanted areas.				
Soil erosion from field roads.				
Bank instability and slumping.				
Degradation of forest patches.				
Illegal hunting.				
Degradation of corridors linking forest patches.				
Illegal harvesting of forest products.				
Chemical pollution of waterways.				
Degradation of catchment areas.				
Eutrophication and vegetation overgrowth in water bodies.				
Saline intrusion in areas adjacent to mangrove.				
Damage to replants by wildlife				
Human-wildlife conflict.				
Etc.				

The advantage of drawing up a priority list is that it gives a clear understanding of where to start, and also ensures that the most urgent and serious concerns are addressed first.

This exercise can be repeated periodically (perhaps annually), since, as management steps begin to take effect (as evidenced by regular monitoring), what were serious issues previously should become less serious. Once management actions are in place for these issues, they may take up fewer resources, so that other concerns can be addressed.

3.2. Setting management goals

Much has been written about setting good goals, whether from a business or personal perspective. Setting good goals for biodiversity management relies on similar principles, and is largely a matter of applying common sense.

Goals should be:

i. **Positive:** *A statement of what you want rather than what you don't want.*
Example: I want a vegetated buffer zone to trap sediments along all waterways (rather than "I do not want sediment going into the waterways.").

ii. **Specific:** *The more clearly you can describe it, the easier it is for others to understand and more likely that they will work toward it.*
Example: 5m vegetation buffer zones along all waterways <5m width, comprising native shrubs and trees.

iii. **Achievable:** *Realistic goals set within a specified time frame are more motivating than vague ideals.*
Example: Vegetated buffer zones will be established in Year 1 and by Year 5 growth of desired species will be optimum.

iv. **Measurable:** *It should be possible to know whether and to what extent progress is being made, and whether the goal has been met or not.*
Example: Buffer zone to contain 25 species of native plants (herbs, grasses, and others) and supplementary planting of 5 native tree species. Survival rates of planted trees should be >85% after 5 years.

v. **Holistic:** Each goal should contribute toward the larger vision of the plantation/company. This, in turn, will be an expression of its beliefs and values.

Other considerations for setting management goals:

- Management goals that have been developed WITH the people responsible for their operationalisation will always be more effective.
- It is important to involve all levels of staffing (managers to field workers, contractors and their workers, etc).
- Involve other stakeholders, such as residents, suppliers, buyers, etc.
- Training will be necessary to ensure that everyone understands each management goal.
- Management at the landscape level is different from at the plantation level.
Example: River basin and river course management relies on the goals set by up-stream users, and their activities and impacts on the river basin.
- Not all management goals can be set by the plantation in isolation from other land users.
- Setting management goals provides an opportunity to liaise with and involve other stakeholders.
- In such cases, achieving cooperation with other land-users may be a major component of the management plan.

3.3. Operationalising management goals

For each management goal to be reached, a set of management actions needs to be developed. These need not be any different to existing management planning procedures within the company. Table 20 provides a framework for tabulating management actions for each goal. A template such as this can be used as the basis for a management plan, with identified responsibilities, timeframes, etc.

Table 20. **Example of a template for outlining management actions to meet a management goal.**

Management Goal: Reduce soil deposition into water courses within 3 years, through establishment of mixed species riparian buffer zones of 5m width on banks of water courses of 2 - 5m width.	
Action 1.1	Test and measure existing rates of soil deposition into water courses (to obtain a baseline number).
Action 1.2	Identify and map water courses along which to implement buffer zones, mark in the field.
Action 1.3	Identify and mark palms to be removed in buffer zones.
Action 1.4	Identify and mark vegetation / species to remain intact in buffer zones.
Action 1.5	Poison and remove marked palms.
Action 1.6	Cease cutting and removal of vegetation re-growth within identified buffer zones.
Action 1.7	Cease spraying and chemical application in buffer zones.
Action 1.8	Identify tree species suitable for enrichment planting in buffer zones.
Action 1.9	Source (locally) and nurture suitable tree species in nursery.
Action 1.10	Enrichment plant buffer zones with suitable tree species.
Action 1.11	Undertake limited weeding and vegetation control to ensure survival of newly planted tree species.
Action 1.12	If necessary, fence newly planted trees to prevent grazing and damage.
Action 1.13	...
Action 1.14	...

For each Management Action the following questions should be addressed in an Action Plan Table:

1. Who is responsible?
2. Who will it involve?
3. What will it cost?
4. When will it be done?
5. How long will it take?
6. How will success be measured?

Table 21 provides a template for developing an Action Plan, based on the hypothetical Management Goal outlined above.

Table 21. **Example of a template for outlining management actions to meet a management goal.**

Management Goal: Reduce soil deposition into water courses within 3 years, through establishment of mixed species riparian buffer strips of 5m on either bank of water courses of 2 - 5m width				
Action to be taken	**Responsibility and staffing requirements**	**What will it cost?**	**How long will it take and when?**	**How will you measure success?**
Action 1.1	Manager Assistant manager Field staff x2	RM 5,000 (identify budget line, e.g., BL 12.2: Miscellaneous Field Costs)	June-July 2012 (10 man-days)	Field assessment after 6 months, 12 months and 24 months to monitor vegetation establishment and assess rates of sedimentation against baseline levels

These frameworks are provided as guidance. If they can be adapted to be incorporated into the company format for Standard Operating Procedures (SOPs) for Plantation management and the Annual and Monthly plantation work plans and budgets, this will cut out unnecessary extra paperwork.

3.4. Monitoring and monitoring tools

Monitoring in adaptive management is about gathering insights, data or direct observations as information as a basis for decision-making. Some of the information provides direct feedback to management (e.g. is something being done or not?) or indirect inferences (e.g. soil loss measurements to assess the effectiveness of prevention efforts).

Building a regular programme for inspection of key activities or work areas is part of good management monitoring. Environmental inspections can be developed as part of a routine programme or be dependent on work schedules. Thus, inspection of new plantings or replants may be a specific activity when potentially risky activities take place. It is useful for all field inspections to be documented and to generate specific actions for follow up (i.e. what needs to be done, by whom and when) and that these follow-up records are also maintained. This enables management to keep track of environmental mitigation tasks.

One way to develop field inspection checklists is to look at the mitigation activities under each environmental impact (see summary tables 2 - 5, 7, 9 and 11). These provide a list of points to check. An example might be monitoring of field activities for reducing soil erosion (see Table 5 and Monitoring Tool 1).

Monitoring of the environment is also another way of gathering information on the effectiveness of management. Some methods which can be used for monitoring biodiversity, water quality, soil loss and subsidence (for peat areas) are outlined below (see Monitoring Tools 1 to 6).

To measure the success (or failure) of your management actions, each management goal and action should be regularly monitored. This involves:

- Developing a regular field inspection programme for key activities or activity areas.
- Developing adaptive field inspection programmes on an "as needed" basis (e.g. during critical periods such as re-plants and severe weather events).
- Field inspection programmes can be standardised using simple checklists (see example below).
- Identification and training of staff to undertake field inspection programme will be necessary.

Monitoring Tool 1. **Monitoring of Field Practices for Reducing Soil Erosion**

Critical Periods: During replants or earthworks

People required: Manager or Assistant(s)

Frequency: Weekly (during early phase)

Methodology Checklist:

No	Item	Observation		Comments
		Yes	No	
1	Contractors are aware of SOP and critical steps to reduce soil erosion.			
2	Policy and procedures are in place to control heavy machinery in fields.			
3	Terracing construction is optimal (e.g. terraces slope inwards, size of terrace, terraces follow natural contours).			
4	Stone barriers, vegetative cross-slope barriers (including frond piles), terraces, or drainage and diversion canals are used to prevent water or wind erosion.			
5	Silt-laden runoff (especially from roads and bridges) is directed into terraces, fields, or areas with vegetation to avoid direct runoff into waterways.			
6	Appropriate cover crops are planted.			
7	All major river vegetation buffers have been demarcated and procedures are in place to reduce disturbance to these areas.			
8	Soft-grasses are maintained in natural depressions where run-off water collects.			
9	Use of organic matter is documented.			
10	(If other items, please insert).			

An important aspect of monitoring is using the results to fine-tune management goals and management actions for the estate. This can be done effectively through an annual review of management goals and actions. Each estate can develop an internal review process, and involve external reviewers to audit / cross check outcomes for each management goal.

Another important aspect is to include consultation meetings in the review process. Consultation meetings enable the management to present the findings of the review to staff and contractors, and make recommendations for changes in management priorities, goals and actions, as well as deal with re-budgeting issues and sources for new budgets (if required).

Monitoring Tool 2. **Monitoring of Common Birds Using Mackinnon Checklists**

Frequency: Annually; seasonal variations of species and numbers might occur between Mar-Apr and Oct-Nov during the bird migration seasons

People required: Supervisors trained in basic bird identification or bird experts

Source: Bibby *et al.* 2000.[3]

Summary of Methodology:

MacKinnon Checklists are a useful tool to build up a picture of bird diversity in a habitat. Some examples of natural habitats found in mature plantations include: open areas (including new replanting areas); open freshwater; lowland forest remnants; riverine forest and, of course, oil palm (mature and immature).

Lists are compiled by slowly walking along a transect within a discrete habitat type and recording each new species observed or heard until a predetermined number of species have been recorded. In extensive natural habitat, where bird diversity is known to be high (such as lowland forest), this number may be as high as 20 species. In less diverse habitats, such as oil palm or forest fragments, this number should be set lower. Normally, 5 is a good target figure for lists made in oil palm, and 10 in areas where fragments of natural habitat remain. Once the predetermined total is reached, another list is started and the process is repeated. Care must be taken not to "double-count" individuals already recorded on the previous list. Generally, birds flying over are excluded, unless they are clearly associated with the habitat. Ideally, lists should continue to be made until there are no further new species recorded on three or four consecutive lists (i.e. the aggregate total plateaus), but the number of lists which can be made may be limited by other factors, such as the habitat area and time available.

MacKinnon Checklists can be analysed in several ways.

By plotting the number of new species recorded on successive lists onto a graph, one can get a good idea of the *species-richness of a site*. For example, if after recording 10 separate lists, new species are still being recorded, the 'species accumulation curve' for that site will be steep, and this suggests that there are yet more species at the site which have yet to be observed (i.e., the site is 'species-rich'). If, on the other hand, after 10 lists, largely the same species are occurring on each list, the species accumulation curve will plateau, indicating that the site has relatively low avian diversity.

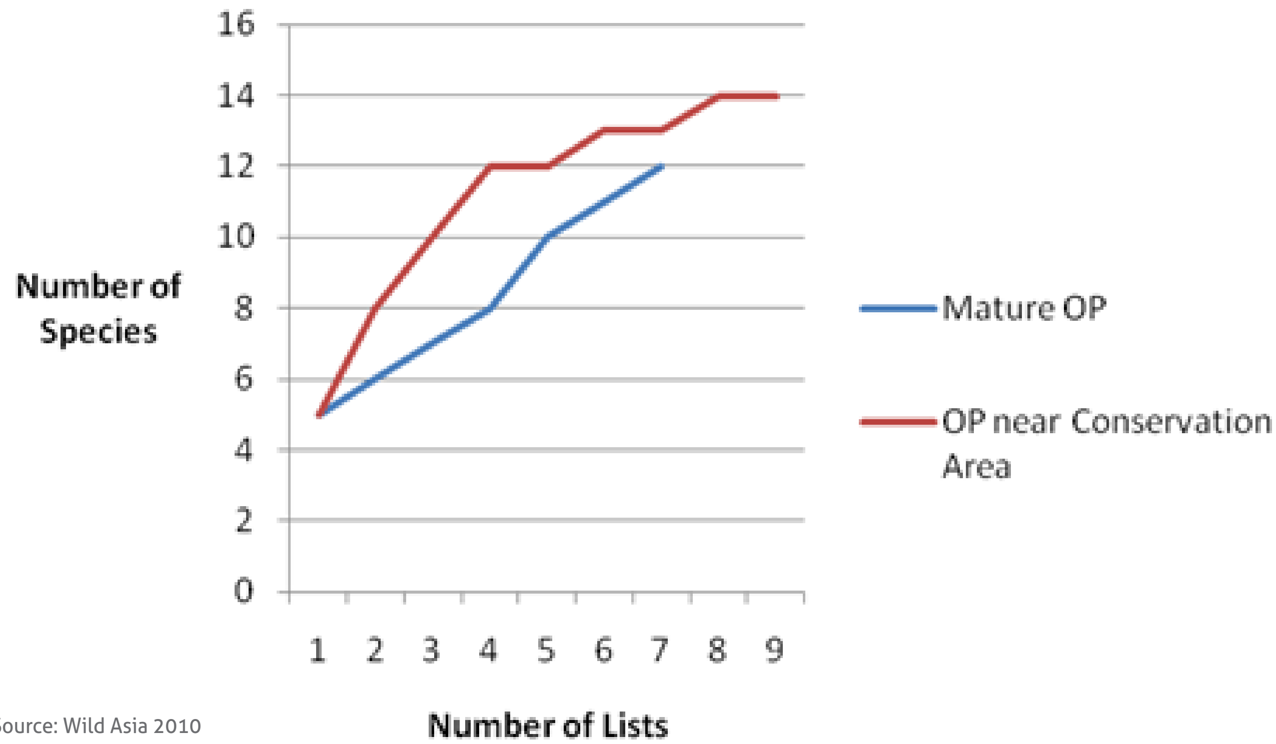
Another way of analysing the same data involves calculating the *abundance of species*, by counting how many lists each species was recorded on. For example, if White-throated Kingfisher is recorded on 27 out of 78 lists compiled for "mature oil palm" habitat, it has an abundance value (AV) of 21%. Another species, Javan Myna, is only recorded on 5 out of the same 78 lists, indicating its lower abundance, with an AV of only 4%. The value for each species reflects abundance at the location; the higher the value, the greater the abundance.

MacKinnon Checklists can also be used to compile species lists for each habitat simply by adding the aggregate total of species recorded.

3 Further information: Bird Census Techniques http://books.google.com.my/books?id=Ld5wkzPp49cC&lpg=PP1&pg=PP1#v=onepage&q&f=false

Plate 13. **Bird counts as part of a joint survey by ZSL and LIPI on a Wilmar plantation in West Sumatra.** *ZSL.*

Figure 14. **Sample of Species Accumulation Curves (adapted from MacKinnon and Phillipps 1993)**



Source: Wild Asia 2010

Table 21. **Sample MacKinnon Checklist data sheet with data from field surveys.**

Species / MacK List	Mature OP							Total Lists	OP <300m from conservation area									Total Lists
	1	2	3	4	5	6	7		1	2	3	4	5	6	7	8	9	
Cattle Egret									1									**1**
Little Egret		1					1	**2**										
Red Junglefowl							1	**1**								1	1	**2**
White-breasted Waterhen												1						**1**
Spotted Dove					1			**1**										
Green-winged Pigeon										1			1		1		1	**4**
Greater Coucal				1	1	1		**3**		1			1					**2**
Collared Kingfisher					1		1	**2**	1					1		1	1	**4**
Yellow-vented Bulbul										1								**1**
Bold-striped Tit Babbler	1	1		1				**3**	1	1	1		1	1	1	1		**7**
Oriental Magpie Robin	1	1	1	1	1	1	1	**7**			1	1	1	1	1			**5**
White-crowned Shama														1		1		**2**
Ashy Tailorbird												1						**1**
Rufous-tailed Tailorbird	1		1		1	1		**4**	1	1	1	1		1	1	1	1	**8**
Yellow-bellied Prinia	1	1	1	1			1	**5**			1				1			**2**
Pied Fantail	1	1	1	1			1	**5**	1			1	1				1	**4**
Brown-throated Sunbird											1							**1**
Dusky Munia						1		**1**										
Black-headed Munia			1					**1**										
TOTAL SPECIES PER HABITAT TYPE								**14**										**22**

Monitoring Tool 3. **Monitoring of Wildlife in Plantations**

Frequency: Every six months or annually

People required: Supervisors trained in basic mammal identification or wildlife experts

Source: Wild Asia.

Summary of Methodology:

Nocturnal surveys target nocturnal mammals and birds in particular (although reptiles are also recorded). If done regularly, they provide useful information on wildlife around the plantations and changes in their abundance over time.

The most efficient method to cover large areas of a plantation and forest edge is to drive slowly (< 20 kph) along estate and edge roads with two spotters using high wattage lamps to detect "eye-shine" on either side of the vehicle. In general, spotting lamps can easily detect eye-shine up to 30 m away and once an animal is detected it is identified using binoculars. In difficult situations (where the animal hides, climbs a tree or moves away before identification), one observer with a portable spotting lamp can descend from the vehicle and walk towards the animal to identify it. Night walks using high-powered portable lamps can also be undertaken. Mileage and time at the start and end of each survey are recorded to enable an estimate of the population densities (animal numbers per kilometre of road) or relative animal abundance (number of recordings per survey hour).

Table 23. **Sample data sheet from nocturnal surveys.**

Estate	Date	Time Started	Time Finished	Distance Covered	Species	Number	Odometer Reading
1	04.04.11	2150	2230	7.0 km			
					Masked Palm Civet	1	1.0 km
					Leopard Cat	1	1.0 km
	05.04.11	2020	2200	14.5 km			
					Leopard Cat	2	3.4 km
					Leopard Cat	1	5.4 km
					Leopard Cat	1	9.6 km
					Leopard Cat	1	9.9 km
					Common Palm Civet	1	10.0 km
2	04.04.11	2000	2100	17.0 km			
					Leopard Cat	1	6.0 km
					Leopard Cat	1	6.0 km
					Leopard Cat	1	6.0 km
					Black-crowned Night-Heron	1	12.0 km
					Leopard Cat	1	15.0 km

Camera traps (digital cameras fitted with a motion and heat sensor, enclosed in a protective case) can be set up by fixing cameras to trees overlooking paths, gaps in fences, stream crossings, etc. Any creature using the track will trigger the heat and motion sensor, firing the flash and camera and be 'captured' on the camera's datacard. Data on the card is downloaded periodically for identification. The advantage of this method is that no trained personnel are needed on site – the data can be sent to specialists for identification. This method is particularly effective for recording mammals rarely-seen due to their nocturnal habits or shy nature. Often individuals can be identified from their markings visible on the photographs, enabling an estimate of the population in the area. Poachers have also been 'caught' by camera traps! The major disadvantage is the expense. It is reported that about 20% of cameras are lost – mostly theft by humans, with a few destroyed by elephants or monkeys.

Plate 14. **A 'camera trap' set up in suitable habitat.** *RESCU/Lim Tze Tshen.*

Monitoring Tool 4. **Monitoring of Peat Subsidence & Water Table in Peat**

Frequency: Every month

People required: Supervisors trained in basic assessment methods

Source: Wild Asia.

Summary of Methodology:

One of the basic management goals of planting on or near peat is to ensure that the water table is managed optimally, 30-50 cm below the surface of the soil. Having the tools to monitor the water table and peat level are two information sources that will help managers control their field and drain levels optimally.

Water table

A simple method is to create permanent bore holes using standard PVC pipes with small holes bored in them to allow water to enter. These pipes (c2-3 m long and 8-10 cm in diameter), are sunk into the peat well below the water table.

A small cap of PVC material is placed on top to prevent rainwater from entering the bore holes. A weighted measure (e.g. a weight tied to a length of twine) can be used to measure the water table depth. The information is recorded in a log book with the date and field number.

Peat Subsidence

Measuring peat subsidence (the drop in level of peat) can be done simply by installing monitoring poles in the peat. It is important to ensure that they are deeply embedded and not easily dislodged in floods or moved with changes to the water table. Markings are made on each pole to enable easy reading of peat level (see Figure 15). Peat level can be monitored annually or every six months. Trends will need to be calculated to determine the rate of peat subsidence. The goal here is to provide data on peat subsidence rates to the management. The trends could determine if subsidence occurring is natural or affected by management of the area.

Figure 15. **A measuring post buried in peat to monitor subsidence.**

Monitoring Tool 5. **Monitoring of Soil Loss Using Erosion Pins**

Frequency: Every month

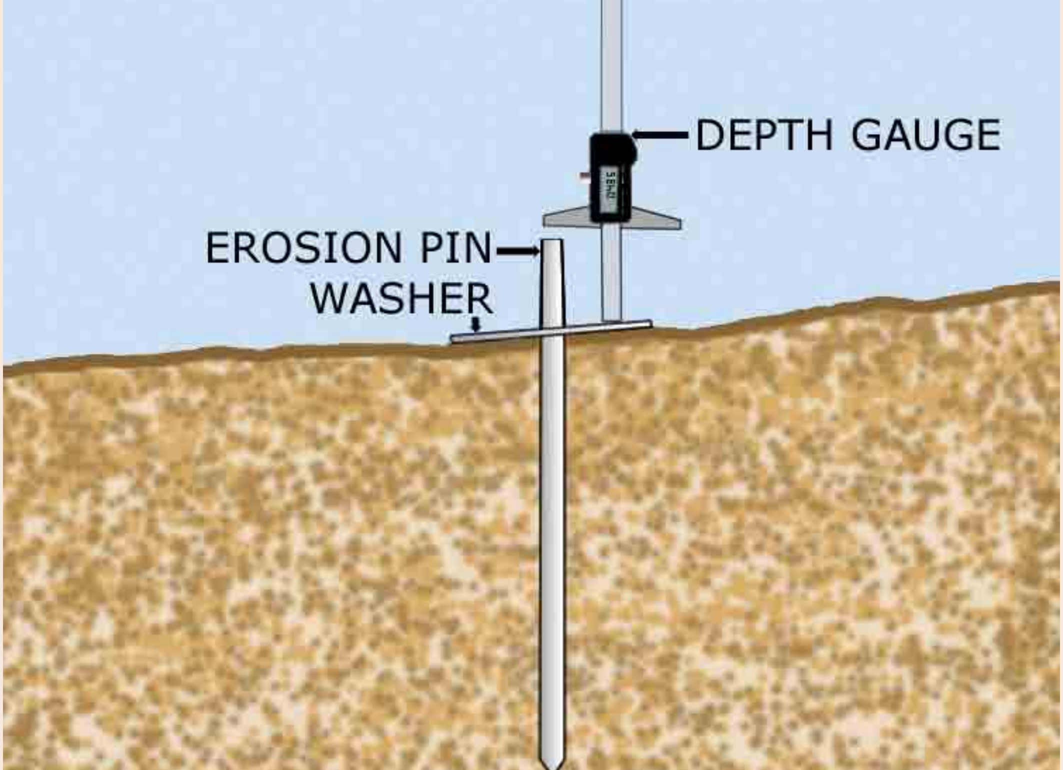
People required: Supervisors trained in basic assessment methods

Source: Adapted from FAO resources[4]

Summary of Methodology:

Regular monitoring of soil loss provides useful information to management. There are "reconnaissance methods" developed for rural agriculture that can be applied in the plantation. One such tool is the use of "erosion pins" which are pegged in a sample grid in a study area. Each pin is driven into the soil so that it is the reference from which changes in the soil level can be measured. The pins can be of any material which will not rot or decay within the study period and which is readily and cheaply available.

Figure 16. **Diagram showing how erosion pins can be used to measure changes in soil level.**



Source: Adapted by Dave Bakewell from http://www.fao.org/docrep/T0848E/T0848E00.htm

The pin should be of sufficient length to be pushed or driven into the soil to be stably anchored: 300 mm is typical, shorter for a shallow soil, longer for a loose soil. A small diameter of about 5 mm is preferable, as thicker would interfere with the surface flow and cause scour. Working within a rectangular or square grid layout, a random distribution of points can be determined. The spacing between sample points should be appropriate to the area being studied.

4 For further information, see http://www.fao.org/docrep/t0848e/t0848e-07.htm

Monitoring Tool 6. **Monitoring of Stream Water Quality Using Rapid Water Quality Assessment Methodology**

Frequency: Every six months or annually

People required: Supervisors trained in basic assessment methods or wildlife experts

Source: Adapted from Sabah Department of Irrigation & Drainage and Christian Schriver (CS Consulting and Management Sdn Bhd)

Summary of Methodology:

The RWQA is based on simple visual technologies. This method is useful for small streams and may need to be adapted for larger, deeper, rivers. The RWQA is based on **four visually-derived** indicators of water quality at any sampling station along a river. The indicators used are:

a. Photos

Photos provide a macro view of the water quality and river environmental conditions. They also make historical record-keeping easier and track changes in the river morphology and environmental condition.

b. Visual grading of water samples

This provides an indicator of the Total Suspended Solids (TSS). It will indicate the extent of erosion arising from land clearing in the catchment, especially during rainfall events.

c. Visual grading of river environmental conditions

This provides an indicator of the physical conditions and chemical constituents in the water at a water quality sampling station. It supplements the visual photo record and provides information on the appearance of the river morphology.

d. Visual grading of river biotic conditions

This provides an indicator of the biological state of the water. It supplements the information provided by photos on the aquatic habitat (bio-physical conditions).

Each of the four indicators is assessed at a selected water quality station and the results of each observation recorded in a standard water quality assessment form.

Assessment procedures are as follows:

a. A water quality assessment station is selected along the river. It is important that the station is easily accessible. In smaller catchments it should be downstream towards the bottom of the catchment. In larger catchments, several stations may be established.

b. The geographical coordinates of the station are recorded using a Global Positioning System (GPS). This is to ensure that future assessments are done at the same station as well as for easier marking of the station on a digital map.

c. Photos

- **i.** At the station, photos are taken upstream and downstream.
- **ii.** For rivers wider than 50 metres, photos of both riverbanks are taken as well.

d. Visual Grading of Water Sample

- **i.** In-stream river water is sampled using a standard sampling bottle.
- **ii.** The sample is then photographed against a white background for its colour to be discernible.
- **iii.** The colour is recorded.
- **iv.** A photograph of the sample is compared against the Visual Grading System of Total Suspended Solids (TSS) developed for this method of assessment (see Plate 15). The visual grading and classification of water based on its 'fitness for use' is given in Table 24.

Table 24. **Visual Grading and Classification of Water.**

Visual Grade	TSS Value (mg/l)	Department of Environment Ambient Water Quality Class
G1	0	-
G3	25	I
G5	50	II
G7	150	III
G8	225	IV
G9	300	IV
G11	500	V

The TSS values are defined in the DOE National Ambient Water Quality Standard. Plate 15 shows the visual grading by classes in Table 24.

Plate 15. **Visual Grading of TSS.** *Christian Scriver.*

e. Visual Grading of River Environment

i. The visual description is carried out at two locations - in-stream and at the riverbanks.

ii. Observations are carried out around 50 meters along the river from the station, taking/looking at samples/sites on both banks and at the centre of the stream.

iii. The results are findings of presence (YES) or absence (NO) of the indicated materials in Table 25.

iv. An assessment of the environmental condition is then carried out based on the number of YES Scores for the 6 parameters. The maximum possible number of YESes is 12.

The interpretation of the YES Score is given in Table 26.

Table 25. **Form for River Environment Observation.**

Material	In-stream	River Bank
Oil Slicks	Yes/No	Yes/No
Foam/Stable Bubbles	Yes/No	Yes/No
Colour	Yes (what colour?)/No	Yes (what colour?)/No
Moss	Yes/No	Yes/No
Slime	Yes/No	Yes/No

Table 26. **Level of Organic/Pollution Load.**

YES Score	Level of Organic/Pollution Load
1 to 4	Low
4 to 8	Moderate
8 to 12	High

f. Visual Grading of River Biotic Condition

i. The visual description of the river aquatic habitat is used as an indicator of the biological state of the water. It is also carried out at the two locations stated in e).

ii. Observation is made on a c50 m stretch of the stream near the station, looking at both banks (if possible) and the centre of the stream, picking up and turning over rocks, wood, leaves, sand and other cover.

iii. The results recorded are the presence (YES) or absence (NO) of the indicated species in Table 27.

iv. The presence of a species generally indicates the biotic condition of the river. Aquatic insects in abundance is usually an indication of good water quality, and aquatic worms usually of poor water quality.

Table 27. **Scoring of River Biotic Condition Observation.**

Species	In-stream	River Bank
Aquatic Insects (stoneflies, mayflies, caddis flies only)	Yes/No	Yes/No
Fish/Frog Fry	Yes/No	Yes/No
Snails	Yes/No	Yes/No
Aquatic Worms	Yes/No	Yes/No

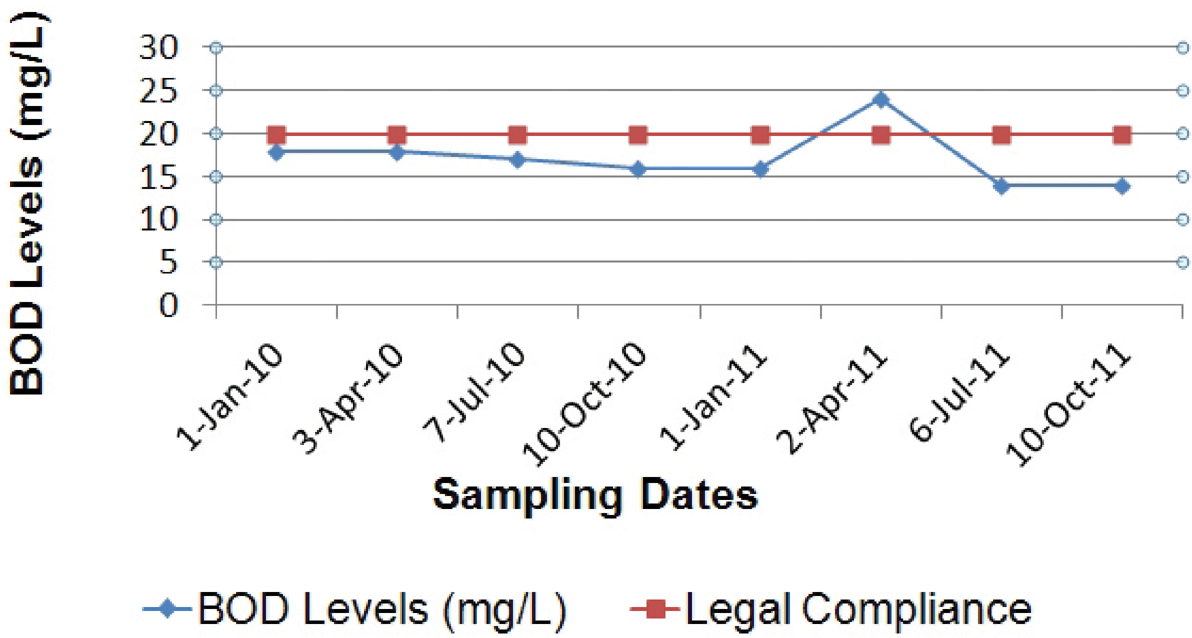
3.5. Suggestions for management review

Reviewing the monitoring information, reports and plans is key to ensuring that the Adaptive Management process continues and is effective. It is usually a learning process, one that drives forward the changes to be made in how things are done. It is the feedback required to make better management decisions.

There are ways to improve the management review. One can invite knowledgeable experts to be part of the review team to assess the operations and plans for their effectiveness. This consultation can be extended to key stakeholders, such as government authorities, neighbours, NGOs. Understanding the trends is also key to the management review. We should be looking at relevant trending data, which should provide a perspective on how we are doing. An example is trending the mill effluent final discharge BOD levels over time (see Figure 17).

Finally, direct observations of field activities or operations will provide useful information in a management review. This provides an opportunity to understand why certain procedures are not followed or where pollution controls are inadequate. In one example, during a review, it was learnt that natural rehabilitation of a river bank was hampered by cattle. So rehabilitation would have been futile without first controlling the cattle.

Figure 17. **Example of a trend analysis of the Biological Oxygen Demand (BOD) levels at final discharge for an oil palm mill in Malaysia.**



Source: Wild Asia