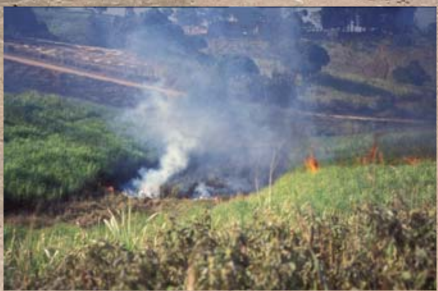
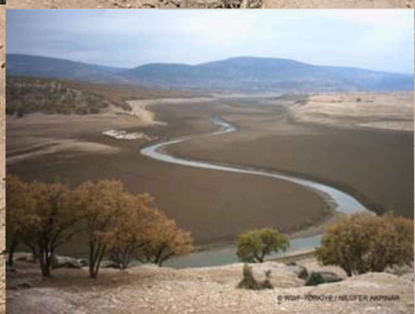
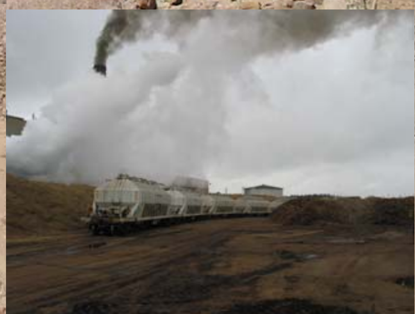
Sugar and the Environment

Encouraging Better Management Practices in Sugar Production and Processing







Water abstraction for sugarcane irrigation

Introduction

More than 145 million tonnes of sugar (sucrose) is produced per year in about 120 countries; open pan (artisanal) sugar production in Asia probably adds more than 10 million tonnes to this total. Annual consumption is expanding each year by about two million tons. Around 60-70 percent is produced from sugar cane with the remainder from sugar beet.

The cultivation and processing of sugar produces environmental impacts through the loss of natural habitats, intensive use of water; heavy use of agro-chemicals, discharge and runoff of polluted effluent and air pollution. This leads to the degradation of wildlife, soil, air and water where sugar is produced and in downstream ecosystems.

Although many of the environmental impacts of cane and beet cultivation are generic to agriculture, some impacts are distinct, particularly in their severity. Impacts relating to irrigation of sugar cane and pollution runoff are of particular concern.

To evaluate the issues concerning the sustainability of sugar, CABI-Bioscience and WWF carried-out a review study of the environmental impacts of sugar. This briefing paper draws on the CABI-WWF study, as well as other sources (see: Further Information)

This paper highlights the:

- **Environmental impacts of sugar production;**
- **Farming and processing practices that cause the impacts;**
- **Better Management Practices that can be used to reduce these impacts to acceptable levels.**

The adoption of Better Management Practices requires support at several levels. This includes changes to national and international policies, investment in appropriate irrigation infrastructure, and a stronger sustainability commitment from the sugar and food industries.

Sustainability does not necessarily mean reduced productivity or profits; indeed measures needed to reduce environmental impacts will often also provide economic benefits for farmers or mills. This provides an opportunity to reconcile environmental and social needs with the long-term development of the sugar industry.

WWF considers that concerted action is required among all stakeholders in sugar production if a more sustainable future is to be guaranteed for this ubiquitous product.

Environmental impacts

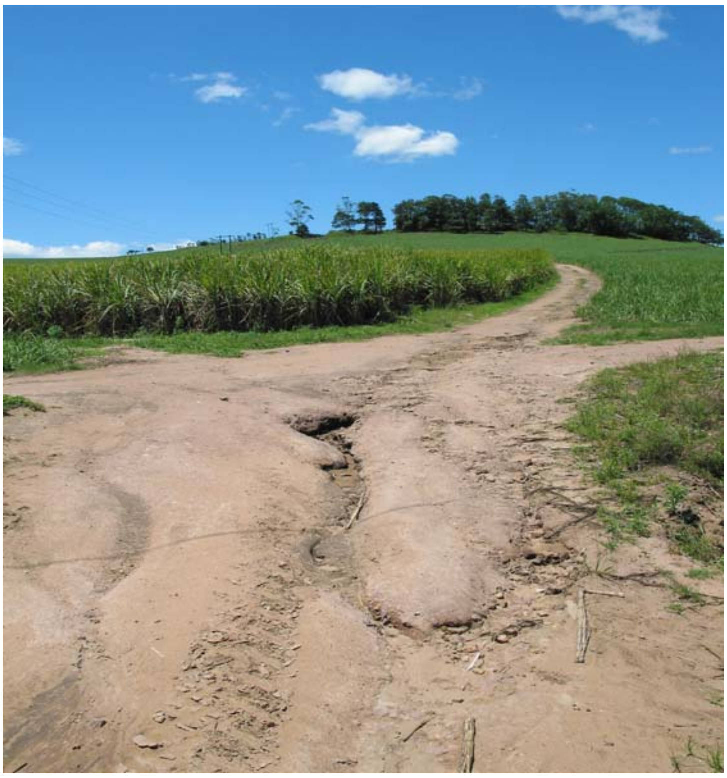
Sugar cultivation and processing impacts on biodiversity and ecosystem functions and services at the field (soil), farm and wider landscape levels.

FIELD LEVEL IMPACTS (SOIL)

An estimated 5-6 million hectares of cropland is lost annually due to severe soil erosion and degradation. Soil is a living, dynamic resource, made up of different sized mineral particles (sand, silt and clay), organic matter and a diverse community of living organisms. Different soil types display different properties, including vulnerability to erosion and salinisation. Cultivation of sugar crops can contribute to soil degradation through negative impacts on soil quantity (by increased rates of erosion and soil removal at harvest) and soil quality.

Soil erosion

Erosion is a significant issue in areas under sugar cane or beet cultivation, particularly in tropical areas (where most cane is grown), because erosion rates in tropical agro-ecosystems are usually greater than the rate of soil formation. The physical loss of soil by erosion is influenced by a range of factors including rainfall and irrigation, wind, temperature, soil type, cultivation disturbance and topography.



Gully erosion due to location of a farm track in a waterway.
Phil Riddell.

Economic and environmental aspects of soil erosion: In agronomic terms, the loss of soil by erosion is a major problem that can affect future yields and ultimately limit the sustainability of sugar cultivation by redistributing or removing soil organic matter and nutrient-rich material. Soil erosion also represents a substantial environmental threat from the washing of sediments, which are often polluted, into rivers, estuaries, and marine ecosystems.

Water-generated soil erosion: Where irrigation application is inefficient or rainfall is high, water withdrawal is generally coupled with the loss of valuable soil from the farm. Worldwide estimates of soil losses to water erosion under sugar cane range from around 15 to over 500t/ha/yr.

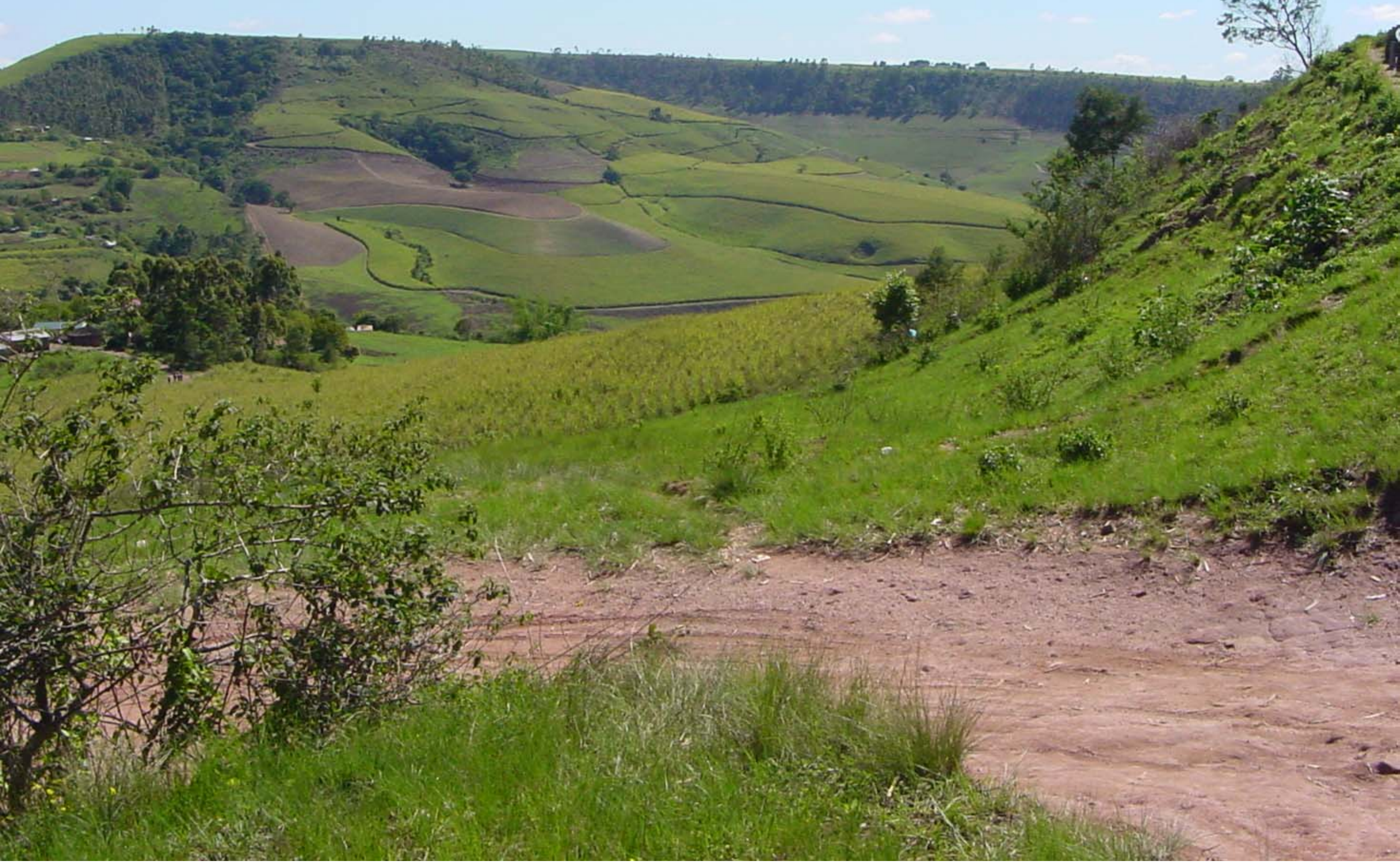
Wind-generated soil erosion: Beet fields in particular are vulnerable to wind erosion as well as water erosion, as they are often left bare over winter.

- *Estimates of soil losses from wind-generated erosion under sugar beet (where the fields are left bare over winter) range from 13 to 49 tons/acre/year in the USA.*

Soil loss at harvest: Soil losses during harvesting, particularly of beet, are cause for concern; 10-30 percent of the total beet harvest weight is soil (tare) (3-5 percent with cane).

- *Three million tonnes of soil is lost per year from beet farms in the European Union (EU) and 1.2 million tonnes per year in Turkey alone. It is estimated to cost the European the industry £40 million to separate the soil from the crop.*

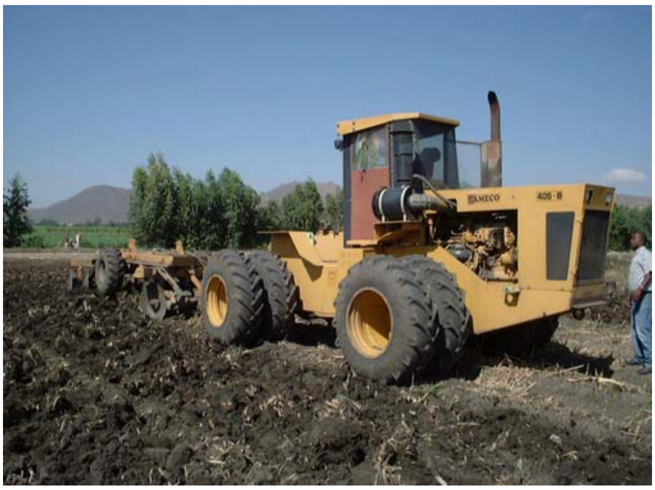
Cultivation on slopes: Sugarcane is currently grown on many steep slopes and hillsides, leading to high rates of soil erosion due to the increased rates of water runoff on sloping land. It is recommended that cane should not be grown on slopes greater than 8 percent, although slopes of 20-30 percent are planted, for example, in parts of the Caribbean and South Africa



Cane planted on steep slopes enhancing soil erosion. Phil Riddell

IMPACTS ON SOIL HEALTH

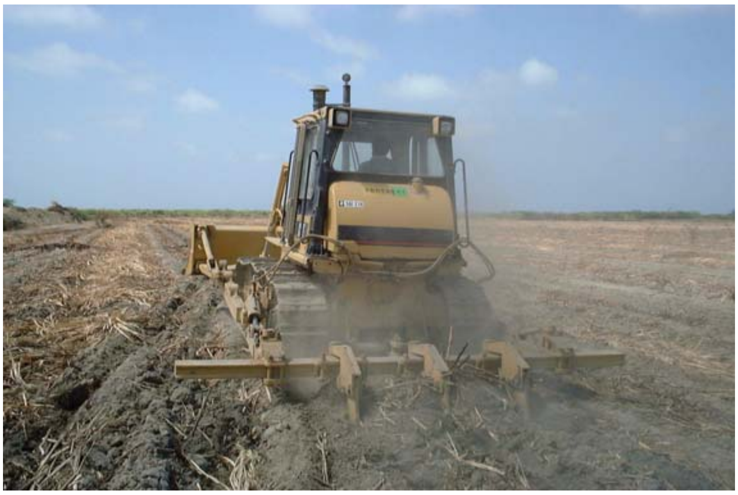
Heavy wheeled tractor with disc plough/harrow. Booker Tate Ltd.



Soil health includes a wide range of biological, chemical and physical variables, but can be broadly defined as the sustained capability of a soil to accept, store and recycle nutrients and water, maintain economic yields and maintain environmental quality. A healthy soil is estimated to contain 1000kg/ha earthworms, 2700kg/ha fungi, 1700kg/ha bacteria, 150kg/ha protozoa and 1000kg/ha arthropods and other small animals. Combined impacts can lead to a loss of soil fertility, a particular risk under cane, which is generally grown as a continuous monoculture.

Soil compaction: A particularly significant impact of cultivation on soil physical characteristics is compaction resulting from a loss of soil structure. Heavy infield transport machinery is most commonly associated with soil compaction problems. Loam-rich soils are more vulnerable to compaction than clays or sands, and compaction risk increases with soil moisture content.

Soil compaction increases bulk density and soil strength, restricting the rooting ability of the crop, and decreases porosity and water infiltration rate, which can negatively affect the soil mesofauna. Soil compaction may particularly affect invertebrates in the upper strata of the soil, and it is in this zone where numbers of certain invertebrates is greatest. Increased rates of surface water runoff due to reduced infiltration can also alter peak flow leading to flooding events

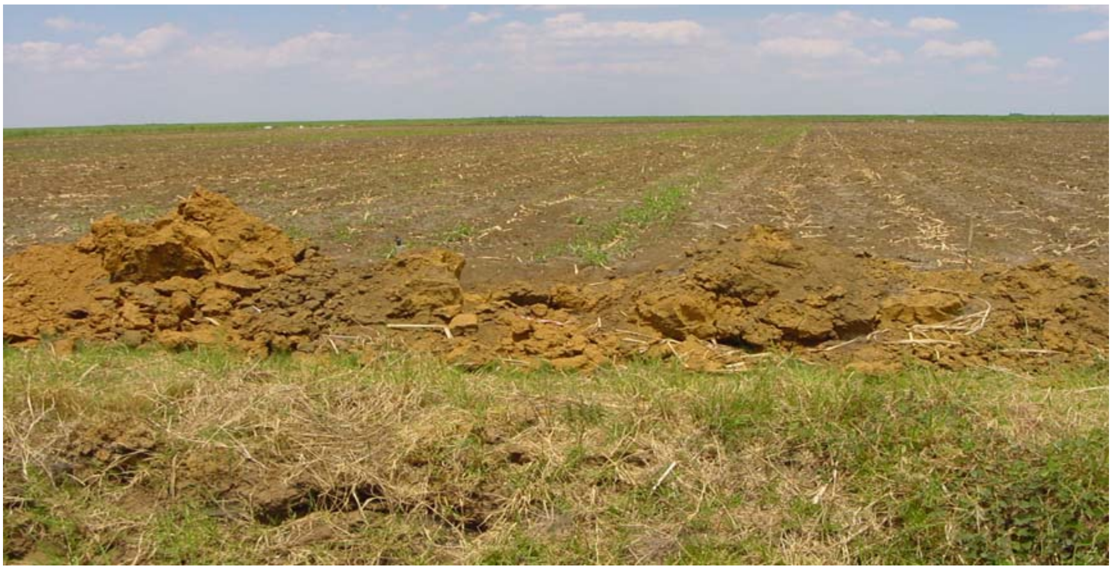


Heavy crawler tractor deep ripping. Booker Tate Ltd.

Tillage: Although zero tillage farming can promote compaction in heavy soils, as the soil is not regularly loosened, conventional tillage commonly promotes erosion by exposing soil aggregates to rainfall. Conventional tillage i.e. deep ploughing, also drastically changes soil structure and is probably one of the most disturbing agricultural practices for soil fauna. In addition, tillage in both cane and beet cultivation systems has been found to promote organic matter breakdown leading to declines in soil structure and health.

- *Soil organic carbon declined by about 40 percent between 1979 and 1996 in cane cultivation areas in Papua New Guinea, impacting on soil fertility*

Soil salinisation: Salinisation of soils is a problem that principally affects cane growers as a result of over-irrigation and inadequate drainage. Salinity of soils has been linked to serious cane yield declines.



Saline deposits on soil.
Phil Riddell.

Soil acidification: Increased soil acidity affects plant health and crop yield. Acidification is also more prevalent in cane than beet growing areas, largely due to the use of inorganic nitrogenous fertilisers such as urea and ammonium sulphate. Under high rainfall conditions nitrate leaching occurs, which also promotes acidification.

- *pH values were found to decrease by about 1 percent in sugarcane cultivation areas in Papua New Guinea.*

Surface sealing: Surface sealing and crust formation can occur on heavily compacted cane growing soils, resulting in a relatively impermeable layer at the soil surface. Sodic soils are particularly vulnerable to sealing, and the loss of organic matter, often associated with cultivation, can also render soils more susceptible to sealing. Sealing reduces water infiltration and increases runoff, enhancing the risk of erosion and pollution of waterways, as well as reducing the water available to the crop and inhibiting seedling emergence.

FARM LEVEL IMPACTS (SPECIES AND HABITATS)

Agricultural systems, or ‘agro-ecosystems’, represent interacting systems of biotic (living) and abiotic (non-living) components that together form a functional unit. Agro-biodiversity is the diversity related to the agro-ecosystem and encompasses the variety and variability of plants, animals and micro-organisms that are necessary to sustain the key functions and processes of the agro-ecosystem and support the production of food.

The suite of micro-organisms associated with a crop is often overlooked, although it plays such a critical role in ecosystem function, for example in the turnover of soil organic matter. Most intensively cultivated agro-ecosystems are relatively lacking in biodiversity.

With the possible exception of birds, vertebrates present in cane fields are often regarded as pest species and subject to control, yet many may be beneficial as natural enemies of weeds and pests. Weeds and pests may also provide important resources for other (non-pest) wildlife which play an important role in the food chain and thus health of the agro-ecosystem.

- *Control of froghopper (*Aeneolamia flavilatera*) pest populations in Guyana was only seen following withdrawal of insecticide application due to the recovery of the non-pest froghopper predator was vulnerable to insecticide use*

LANDSCAPE LEVEL IMPACTS (ECOSYSTEMS)

Impacts of sugar cultivation on downstream ecosystems: Agriculture is arguably the predominant influence on the Earth's land surface and undoubtedly represents the main cause of wetland habitat loss. This occurs through the runoff of polluted effluent into water courses, due to the heavy abstraction of freshwater resources upstream of wetlands habitats, or by altering the natural flow regime.

The impacts felt downstream are the cumulative result of a complex set of land and water use decisions in a river basin. Within this context, cane or beet can play an important role in some sugar producing countries:

Removal of riparian vegetation and drainage in a valley bottom. Vaughan Koopman.

- *The sugar industry in Australia has been a significant player in major infrastructural projects, including damming of the Burdekin, Tully and Barron Rivers, which has altered the pattern of freshwater flow into the Great Barrier Reef. The sediment and nutrient loads have also been shown to increase, particularly following heavy rainfall, which can carry these materials into the sea, suffocating offshore reefs as well as near-shore environments. The sediment deposition rate in the lower South Johnstone River has been estimated at 300,000 t/yr (equivalent to cane field erosion rates of 150 t/ha/yr).*

- *Cane producing areas in KwaZulu Natal, South Africa, are mainly situated in the catchment areas of gently to steeply undulating land from which runoff flows into the major rivers of the Natal seaboard, including the St Lucia World Heritage Site. A lack of adequate integrated soil conservation practices on these farms has been linked to soil erosion, leading to degradation of the rivers and estuaries.*

- *Nutrient-rich runoff from sugar cane fields in Florida is held largely responsible for the decline of the Everglades. The Everglades is a naturally nutrient-poor wetland where sawgrass thrived because the low levels of phosphorous (an important plant nutrient) inhibited the growth of more aggressive species, such as cattails. However, spreading phosphorus on the cane fields in the Everglades is common practice. Runoff from the fields first caused the sawgrass to grow abnormally large before dying back to give way to cattails, which have now spread across more than 50,000ha of conservation areas, crowding out willow and bay and excluding fish.*

- *Sugar beet irrigation in Andalucia, Spain, is contributing to lowered water levels in rivers such as the Guadalquivir, limiting the water reaching important wetlands during the summer. These wetlands include Doñana, where many bird species rely on a health habitat (griffon vulture, booted eagle, red and black kites, short-toed eagle, Baillon's crake, purple gallinule, great spotted cuckoo, scops owl, red necked nightjar, bee eater, hoopoe, calandra, short-toed and thekla larks, golden oriole, azure winged magpie, Cetti's and Savi's warblers, tawny pipit, great grey shrike, woodchat shrike and serin).*

- *Over the last 60 years the construction of dams, barrages and irrigation systems in Pakistan have lead to a 90 percent reduction in the amount of freshwater reaching the Indus Delta. Sugarcane cultivation is consuming significantly more water per unit area than any other crop grown in the Indus Basin. The Delta supports the world's largest expanse of arid land mangroves, which rely on an inflow of freshwater. Of the 260,000 hectares of mangrove forest recorded in 1997, only an estimated 65 percent remains and is dominated by just one salt-tolerant species. The endangered Blind River Dolphin (*Platanista minor*), found throughout the Indus and its tributaries 100 years ago, now exists in just six totally isolated sub-populations.*

Drying out of Esmekaya Reed Bed in Turkey due to agricultural water abstraction. WWF Turkey / Cagri Eryilmaz.

Impacts of sugar and bi-product processing on downstream ecosystems: Discharge of effluents from sugar mills and from processing bi-products (e.g. molasses) has been shown to result in the suffocation of freshwater biodiversity, particularly in tropical rivers that are already naturally low in oxygen.

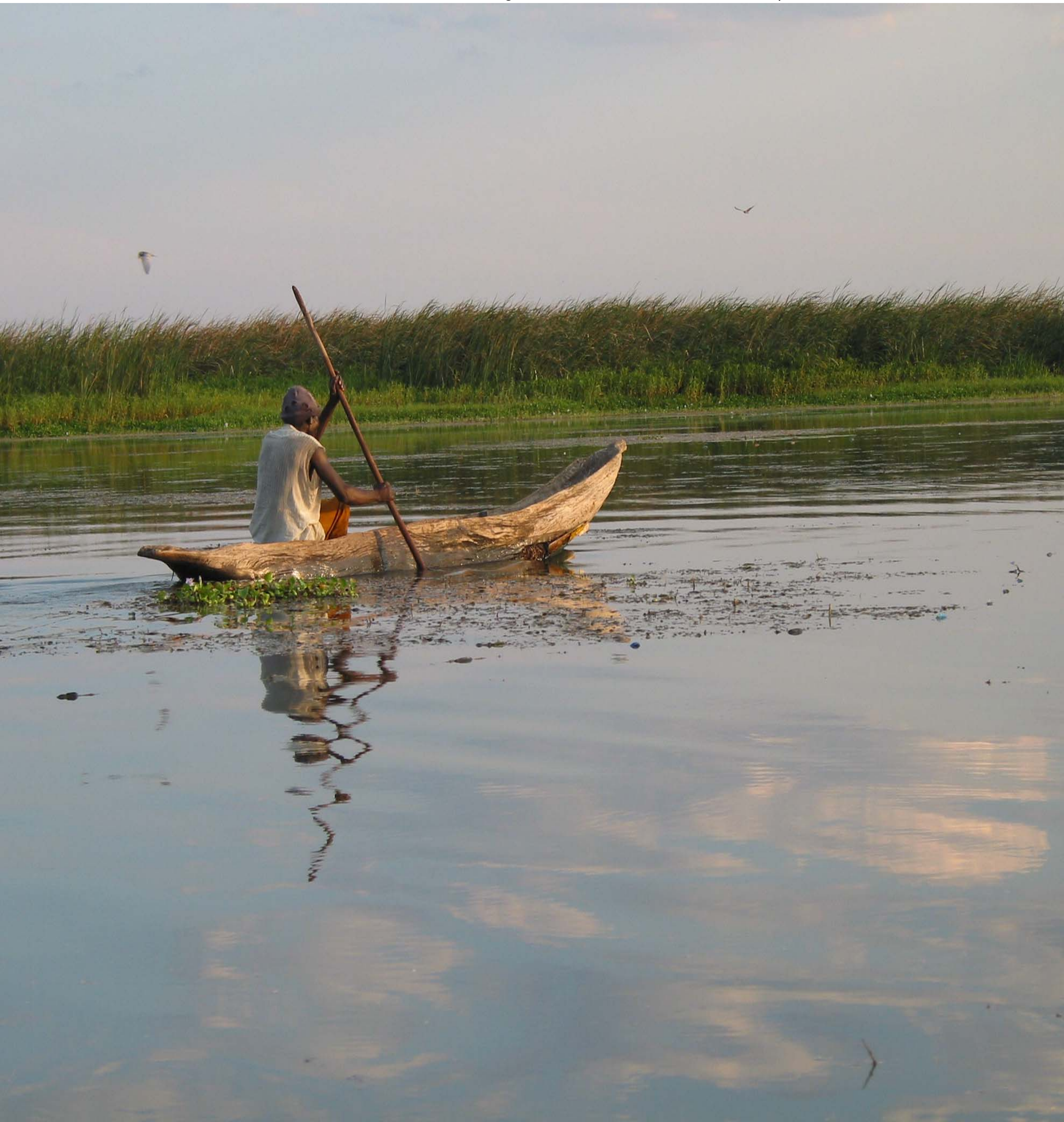
- *In 1995, the annual cleaning of sugar mills in the Santa Cruz region of Bolivia resulted in the death of millions of fish in local rivers.*

  - *In Cuba the oxygen deficiency from discharge of sugar factory waste water (amongst other activities) led to dominance of aquatic macrophytes, resulting in thick mats of weeds that impeded the water delivery capacity of canals and affected sport fishing and tourism.*
  - *The pollution of Danish coastal waters by sugar factory effluent has been linked to the occurrence of bacterial pathogens and an ulcer syndrome in the cod Gadus morhua.*

Impacts of sugar cultivation on downstream livelihoods: Agriculture, including irrigated cane cultivation, not only threatens the biodiversity of natural wetlands, but can also threaten the traditional cultures and livelihoods of communities that rely upon them.

- *The mangroves in the Indus Delta provide an excellent nursery for young fish and shrimp, upon which many livelihoods depend. Shrimp are a major export commodity, making up 68 percent of the US$100 million that Pakistan earns in foreign exchange from fish exports. Abstraction of water for irrigation (wheat, rice, sugar and cotton), coupled with drought, has meant that about 80 percent of the five million people who once earned a living from fishing or river boat work in Pakistan have left in search of work in slums of Karachi.*

Fishing on the Kafue River, Zambia: is an important livelihood. Phil Riddell.



Main Causes of the Impacts

HABITAT CLEARANCE

Habitat destruction for cane cultivation

It is quite likely that the production of sugarcane has caused a greater loss of biodiversity on the planet that any other single crop. Fifteen countries around the world devote between 10 and 50 percent of their land area to cane cultivation and in seven countries sugarcane covers more than 50 percent of the land. Substantial areas of biodiversity-rich habitat have been cleared for cane cultivation, such as tropical rain forest and tropical seasonal forest. Land clearance not only results in the direct loss of species and habitats, but underlies a range of wider impacts on ecosystem function, including changes to hydrology and increased soil erosion.

Recent land clearance for cane cultivation: Although the greatest land clearance for sugar cane cultivation is historic, the area under cultivation in some areas has continued to expand in recent years.

- *A programme to use sugarcane as the raw material for fuel alcohol production led to the deforestation of new areas in the State of Alagoas, Brazil, such that only 3 percent of the original rain forest cover remains.*
- Recent studies have also shown an 85 percent reduction in Brazilian Cerrado vegetation in the regions of Franca, Araraquara, Ribeirao Preto and Sao Carlos due in part to clearance for sugar cane cultivation.
- *There are plans to increase the area under sugar cane in the Indian Punjab from 80,000 to 136,000ha.*

Wetland habitat loss: Half of the world's wetlands have been lost to drainage and conversion to agriculture (70-90 percent in Europe and USA), and even protected wetland areas are subject to agricultural impacts. Low-lying and alluvial areas in particular have typically been reclaimed and drained for sugar cane cultivation, as they often support the richest soils and enjoy a good natural water supply.

- *Large areas of the Everglades wetland habitat have been reclaimed for the expansion of agriculture. Nearly 200,000ha is under cane cultivation, resulting in dramatic declines in biodiversity. In addition to habitat loss, ecosystem impacts include major redistribution of water flows and subsidence due to shrinkage, compaction and accelerated microbial decomposition of drained soils.*
- *Clearance of land for cane cultivation has resulted in substantial loss of coastal wetlands in many cane growing areas of Australia:*
    - *A 60 percent reduction in wetland habitats occurred in the Johnston River catchment between 1951 and 1992.*
    - *In New South Wales, cane is often grown right up to the banks of streams, leaving no natural vegetation.*
    - *Around 45km of stream bank vegetation was cleared in the Herbert River catchment, Queensland, between 1990 and 1995.*

Sugarcane in Queensland planted into a flood plain. © WWF Canon / Tanya Peterson

Habitat destruction for beet cultivation

Substantially smaller areas have been cleared specifically for sugar beet, as the crop has only been cultivated relatively recently and in many cases has been grown on land that was already under some other form of cultivation.

OVERUSE OF WATER

Water abstraction for sugarcane irrigation

Agricultural water use: Agriculture is by far the biggest user of water worldwide. Seventy percent of global freshwater withdrawals are for irrigation, rising to more than 90 percent in some developing countries. Major irrigation projects have often been promoted for development reasons, yet returns have frequently been insufficient to service the capital debt or cover running and maintenance costs. Their planning has often not adequately addressed environmental or social needs. This has led to impacts on downstream ecosystems and livelihoods of communities that rely on fisheries.

Sugar cane water use: Although sugar cane is an efficient converter of biomass from water, it still needs about 1500-2000mm/ha/year and ranks among a group of crops noted for their significant water consumption (along with rice and cotton). It is a deep-rooted crop, which remains in the soil all year round and is able to extract soil water to depths well below one metre. In areas where sugar cane growth relies on rainfall, the crop can influence river flows as it intercepts run-off from the catchment into rivers and taps into ground water resources.

- *In the Indian state of Maharashtra, sugar cane covers just three percent of the land yet corners around 60 percent of the state irrigation supply and is a cause of substantial groundwater withdrawals; the water table has dropped in places from 15 metres to around 65 metres in the past 20 years.*

Sugar beet water use: Around one fifth of the world's beet cultivation is irrigated. However, there are questions over whether irrigation is actually necessary in some of the areas where it is practiced since: i) beet is not particularly sensitive to water availability; ii) the crop is principally grown in temperate areas, where sunlight rather than water availability is the limiting factor for plant growth; iii) in Europe the economics of beet production are skewed by fixed quotas per country and high guaranteed prices which mean that sugar beet is not grown in either the most suited or least cost regions.

Vanishing Carsamba River in the sugar beet belt of the Konya Basin, Turkey. WWF Turkey / Nilufer Akpinar

Irrigation inefficiency:
The principal irrigation systems available are: i) surface (flood/furrow), ii) overhead sprinklers (drag line/centre-pivot), and iii) drip/trickle techniques. Drip and trickle techniques tend to be the most water-use efficient but require significant financial investment. Surface techniques are generally less efficient but do not require farm machinery or complex infrastructure to operate. Due to poor management, in many areas of the world only an estimated 30-35 percent of the water withdrawn for farming reaches the crop and the rest is lost from irrigation channels by evaporation and through run-off from the field.

Inefficient water use: flood irrigated sugar cane. Maqbool Aktar.

- *Water application in sugarcane cultivation in the Amaravathy River Basin, India, was 28 percent higher than the recommended levels.*

- *In Mackay, Australia, irrigation of sugarcane has resulted in additional runoff and deep drainage, amounting to 29 percent of the irrigation water applied.*

Irrigation and human health: Over-irrigation or inefficient irrigation systems that leave water standing in fields can enhance the incidence of water-borne parasitic infections such as Bilharzia (schistosomiasis).

- *In the South Coast Irrigation System in Puerto Rico, the prevalence of* Schistosoma mansoni *infection rose from zero before 1910, to around 25 percent by 1930 following the establishment of irrigation systems for sugarcane cultivation.*

- *The prevalence of* S. mansoni *infection in children at one camp in the Wonji sugar estate, Ethiopia, rose from 7.5 percent in 1968 to 20 percent in 1988. Prior to irrigation development in the area both the disease and the host snail where unknown in the area.*

Over-irrigation and pollution: Since irrigation management is often very inefficient, high water withdrawal is generally coupled with the runoff of polluted irrigation water containing sediment, pesticides and nutrients.

Water use in processing: Both beet and (to a lesser extent) cane factories use large amounts of water to wash off the considerable quantity of soil removed with the roots at harvest (beet 10-30 percent and cane 3-5 percent).

INTENSIVE USE OF CHEMICALS

Pest control: Intensive agricultural food production in general uses high levels of pesticides (herbicides, insecticides, fungicides, nematicides, rodenticides, plant regulators, defoliants or desiccants), with herbicides representing about 50 percent of pesticides used in many countries. A wide variety of pesticides are used in the cultivation of sugar crops. Herbicide use in sugar beet is among the highest compared to other crops.

Impact of pesticides on crop yields: Long-term agrochemical, microbiological and ecological experiments on the use of pesticides on sugar beet in Russia have demonstrated accumulation of toxic substances in roots and aerial parts of the crop plants, resulting in retardation of growth and a decrease in sugar content when maximum doses were used. In cane cultivation, a growth regulator, such as Ethephon, or an herbicide, such as Glyphosate, is applied 45 days before burning to desiccate the plant. When harvesting is delayed, the yield loss can be as high as 5 percent due to the reduction of sugar content.

Social impacts of pesticide use: Many large-scale pesticide applications, including the spread of rodenticides, are carried out using aircrafts. The negative impacts of pesticide use on human health are considerable; the World Health Organisation estimates that there are 25 million cases of acute chemical poisoning in developing countries each year related to pesticide use in agriculture. Despite widespread concern over pesticide misuse, the total value of world sales has increased 2.5 times in the last 20 years, to US$30 billion.

Overuse of fertilisers: Inorganic fertilisers typically supply nitrogen, phosphorus and/or potassium in mineral form. Environmental impacts generally arise because the nutrients in the fertilisers are not entirely taken up by the crop but move into the environment. The overuse of fertilisers on cane or beet crops is typical of farming in general.

- *Nitrogen (N) fertiliser use in the Australian sugarcane industry increased substantially in the post-war years, and for more than a decade, N fertiliser use was almost double that required to produce the actual cane (and sugar) yields obtained by the industry. In the Tully River catchment (North Queensland) alone, the area under sugarcane and bananas doubled and N fertiliser use increased by 130 percent between 1987 and 1999.*

- *Increased application of N fertilisers in Australia has led to acidification, contamination of ground and surface water and enhanced greenhouse gas emission.*

- *Only 8-44 percent of fertiliser applied to rotation systems including sugar beet in Europe was taken up by crop plants directly (although around one third was incorporated in the soil organic matter and remained available to plants over long periods of time).*

- *Research in Austria demonstrated that with conventional rates of fertiliser application, only 50 percent of soil nitrogen was taken up by the crop, 20 percent remained in the soil, and 30 percent was lost.*

Steam and ash production from sugar cane processing. Phil Riddell

DISCHARGE OF MILL EFFLUENTS

Perhaps the most significant impact from cane and beet processing is related to polluted effluent. In some countries, with weak environmental laws, when sugar mills are annually cleaned, a tremendous amount of matter is released, which is usually discharged straight into streams. Cane mill effluents tend to be relatively rich in organic matter compared to other sources, and the decomposition of this matter reduces the oxygen levels in the water, affecting natural biochemical processes and the species inhabiting those freshwater systems. Potential pollutants in these effluents include heavy metals, oil/grease and cleaning agents.

- *In the Gorakhpur district of Nepal, discharge into a stream of improperly treated water from two sugar factories and a distillery rendered the stream's water unfit for drinking, bathing or irrigation.*

The production of alcohol from cane or beet can also result in significant pollution as the by-product, known as 'vinasse', is in some cases discharged into rivers. Every litre of alcohol produced from sugarcane produces 13 litres of vinasse

PRE-HARVEST CANE BURNING

Pre-harvest cane burning. Vaughan Koopman

In many sugar producing countries, the cane fields are burnt immediately before harvesting to make it easier to handle (e.g. pest and disease control, lower volumes to cut and haul, easier post harvest cultivation). 'Green cane' harvesting (without burning) is also practiced. Although it has some benefits, as noted above, pre-harvest burning leads to:

Air pollution: Substantially elevated levels of carbon monoxide and ozone in the atmosphere have been found around sugarcane fields in the state of Sao Paulo, Brazil, at the time of pre-harvest burning.

Soil degradation: There is evidence that sustained pre-harvest burning of sugar cane can contribute to a decrease in soil quality, by causing a decline in soil microbial activity and the physical and chemical properties of the soil; pre-harvest burning may be responsible for as much as 30 percent of the annual nitrogen removal in a cane crop

Loss in productivity: Cane burning can reduce the quality of sugar recovered from the cane as well as reduce the quantity of cane retrieved by as much as 5 percent.

Better Management Practices to Reduce the Impacts

Sustainability in the sugar industry does not necessarily imply reduced productivity and profits; indeed, measures to address environmental impacts can provide economic benefits for farmers or mills through cost savings from more efficient resource use. This provides an opportunity to reconcile the needs of environment and people with the long-term development of the sugar industry. Better Management Practices (BMPs) do just this, addressing environmental concerns such as habitat loss, water overuse and pollution; social needs such as availability of clean water for drinking and sanitation; and economic considerations such as crop yield and maintenance of long-term soil health.

There are a range of BMPs in use or under development that tackle the main environmental and social impacts of sugar growing and processing as summarised below.

EFFICIENT IRRIGATION SYSTEMS

The effectiveness of irrigation strategies can be assessed by an analysis of Water Use Efficiency (WUE): the ratio of crop yield to water consumed by the crop. Drip irrigation systems, which deliver water to the crop plant (surface drip) or root zone (sub-surface drip), are generally the most water efficient, followed by centre-pivot systems, other sprinkler systems, furrow irrigation, and finally flood irrigation.

Low-tech skip-furrow irrigation for increased water use efficiency on small-scale farms. Rachel Wiseman.

The key to improving water productivity is to match the irrigation system to the soil type, climate, farm management and affordability – e.g. furrow irrigation can be the most efficient in some cases.

Increased water use efficiency: One of the main benefits of implementing better irrigation systems is increased water use efficiency, meaning that more water is available for other needs, such as those of the environment or communities; new institutional mechanisms may be required to share out water saved in an equitable manner.

√ *In Swaziland, water application efficiencies for sugar cane have been estimated to be 72-89 percent under drip and centre pivot systems, 49-88 percent under dragline, and 48-75 percent under furrow irrigation.*

A ridger for cutting furrows into fields. Rachel Wiseman.

Larger-scale farmers are able to implement advanced commercial drip, sprinkler, or centre-pivot systems while small-scale farms, and even some large estates, mainly use inefficient flood irrigation. Low-cost drip systems are available for small-holders, provided that micro-credit is available for purchase of the equipment and sufficient ongoing technical support is provided. Furrow irrigation only requires a ridger to cut the furrows and with alternate furrow irrigation substantial water savings can be made:

√ *In Pune, India, water savings in cane fields of 36 percent have been achieved by flooding alternate (rather than all) furrows.*

√ *Alternate furrow irrigation in beet fields in Iran at six day intervals used 23 percent less water than irrigation in every furrow at ten day intervals, maintaining yields and increasing water use efficiency by 43 percent.*

Improved irrigation techniques can also be combined with trash mulching for further water savings:

√ *Increases in water use efficiency of 43-66 percent have been achieved in Tamil Nadu, India, by using alternate furrow irrigation in cane fields, with the greatest increases attained in combination with mulching.*

√ *Studies in Pune, India, found that the use of a cane trash mulch enhanced water savings gained with drip irrigation by a further 16 percent.*

Irrigation scheduling, including the use of tensiometres to monitor soil moisture, and tail-water recycling (where water-runoff from field is collected and reused for irrigation) are also ways of improving irrigation management:

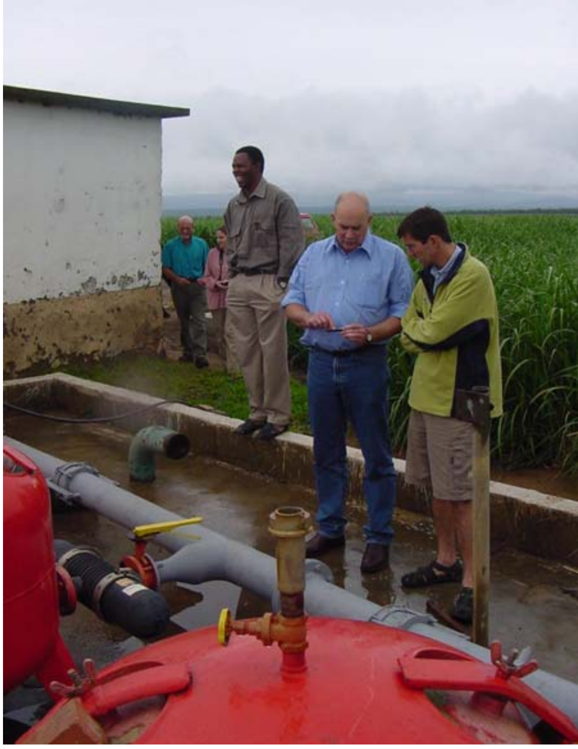
√ *Severe water restrictions in Zimbabwe led to a revised system of scheduling for sugar cane irrigation that provided a potential saving in water use of 32 percent when compared with conventional practices, without reducing the sugar yield.*

√ *A report from Mexico asserts that water consumption can be reduced by 94 percent with production losses below 10 percent when water-recycling is implemented.*

Decreased fertiliser and pesticide requirements with drip irrigation: Drip fertigation is the application of fertiliser through the drip system, delivering nutrients only to the plant base (surface drip) or root zone (sub-surface drip). Drip fertigation is of particular interest as it combines the increased water use efficiency of a drip irrigation system with the potential to manage fertiliser applications more effectively and thereby reduce fertiliser use.

- √ *Studies from Mauritius and Australia suggest that drip fertigation allows N fertiliser inputs to be reduced by 25-50 percent without impairing cane productivity.*

In addition, the application of soil pesticides can be reduced by 30 percent when applied directly to the root zone. By using drip irrigation, a farmer can use the least toxic pesticide at or below recommended dosages.



An advanced drip irrigation system for highly efficient water use on commercial farms. Rachel Wiseman.

Increased agronomic benefits: Enhancing water use efficiency not only benefits the environment, but provides a range of financial benefits to the farmer including reduced water and/or electricity costs and yield increases:

- √ *Modification of furrow shape with alternate furrow irrigation in Burdekin, Australia, reduced water use in cane fields throughout the season by 45 percent, representing a saving of $218/ha/yr to the grower and a potential saving of $1.74 million annually to the Burdekin sugar industry.*

- √ *In Maharashtra, India, the government provided a subsidy for the installation of drip irrigation. The cost of a drip irrigation unit was Rs36,423 per farm, providing a yield increase over surface irrigation of 24.32 tonnes per hectare, equating to Rs13,989 per year. This would provide a return on investment within three years.*

- √ *Yields with drip irrigation have been shown to increase by around 20 percent in Thailand and India.*

- √ *In the Simunye sugar estate in Swaziland the cost of conversion to a subsurface drip system for sugar cane cultivation was US$2542/ha, versus US$868/ha to retain the sprinkler system and replace worn-out parts. Benefits from the new system equated to US$472/ha/yr in terms of labour cost savings, increased sucrose yields and water savings, providing a financial benefit within two years.*

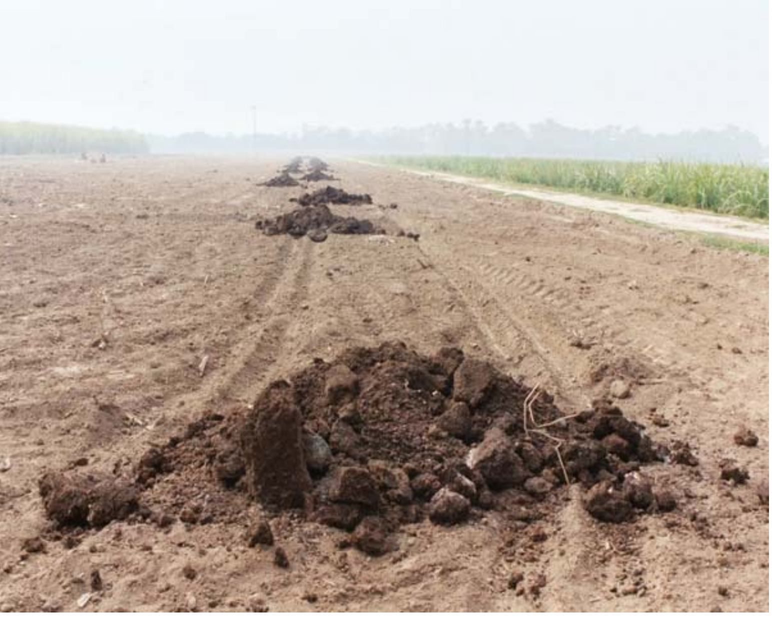
- √ *An agro-economic analysis of drip irrigation for sugar beet production in Wyoming, USA, concluded that economic returns from drip were 11 percent greater than with furrow irrigation.*

RATIONAL CHEMICAL USE

Reduced fertiliser use

In many areas of the world, nitrogenous fertilisers are routinely applied in sugar cane cultivation at rates of around 50-200kg/ha/year, contributing (amongst other things) to the process of soil acidification. There is a direct economic incentive for farmers to reduce fertiliser inputs, as these represents significant costs and over-use of N fertiliser reduces sugar yield. Many sugar industries have consequently published recommendations on fertiliser use and incorporate these in guidance provided to their farmers.

Fertiliser application to dual row sugar cane. Booker Tate Ltd



Press mud by-product from a sugarcane mill applied as a biofertiliser. Rachel Wiseman.

Approaches for reducing fertiliser use in cane cultivation systems include a more site-specific assessment of fertiliser requirements, cultivation of leguminous green manure crops during fallow periods or rotations, the use of biofertilisers (combinations of nitrogen-fixing micro-organisms and organic amendments), and 'green cane' cropping.

- √ *The use of biofertiliser in place of chemical fertilisers, could reduce inorganic fertiliser requirements by 20-25 percent and reduce the risk of nitrate leaching.*

Crop logging, used to monitor plant weight and leaf nutrient content can be used in sugar cane cultivation to assess the foliar nutrient levels and adjust the fertiliser rate or other elements only if needed.

Aside from producing sugar, sugar beet's role as a break crop in arable rotations can contribute to a reduction in pesticide and fertiliser inputs during other phases of the rotation, by interrupting a potential build up in pests/diseases associated with other crops, and by contributing organic matter to the soil in the form of root fragments, leaf material and/or beet tops ploughed in ''following harvest. However, fertiliser inputs for beet cultivation are still significant:

- √ *A 50 percent reduction in total nitrate inputs to beet fields in the UK would result in yield reductions of only some 10 percent.*

RESTRAINED CHEMICAL USE

"The Indiscriminate use of pesticides creates a number of problems, such as development of resistance in pests, upsurge of secondary pests because of elimination of natural enemies, pollution of the environment making it hazardous for human beings and animals and moreover, they are expensive and increase the cost of crop production" (Dr Zafar Altaf, Chairman of the Pakistan Agricultural Research Council).

Although the control of pests in sugar and beet cultivation has relied heavily on insecticide use, there is an increasing move towards reduced use:

- √ *Over 70 percent of Queensland cane growers have completed a voluntary one-day course and have been accredited in the use of farm chemicals, resulting in a marked increase in proficient use and reduced application rates and frequencies.*

- √ *Between 1982 and 1998, the total insecticide input to UK beet cultivation fell from around 11kg/ha to just over 5kg/ha due to a shift away from spraying towards seed treatment. The use of nematicides (seen as the most toxic group of agrochemicals) fell by around 50 percent between 1994 and 2000.*

- √ *In sugar beet fields in the Irish Republic, plots where weeds were allowed to grow, compared to plots treated with herbicides, supported greater numbers of soil Collembola, enhanced numbers and diversity of ground-dwelling arthropods, and had considerably smaller numbers of the pest aphid* Aphis fabae.

- √ *Populations of a cane weevil parasite in Hawaii were enhanced where field margins contained plants that could act as nectar sources. Continuous elimination of such plants with herbicides resulted in a decrease in populations of the parasite, compromising its role as a biological control agent against the weevil.*

BIOLOGICAL CONTROL AND INTEGRATED PEST MANAGEMENT

Laboratory production of parasites for bio-control in sugar cane, Indonesia. Booker Tate Ltd.

In some parts of the cane growing world, there is a greater emphasis on non-chemical control methods, particularly for insect pests. There are numerous examples of successful Integrated Pest Management (IPM) programmes in sugarcane. IPM combines biological control with a variety of other appropriate physical, chemical and mechanical control methods to achieve a more holistic and sustainable approach to pest control.

- √ *Papua New Guinea is considered to be the centre of origin of sugarcane. The sugar industry there is consequently more afflicted by pests, diseases and weeds, most of which are native and may have co-evolved with the ancestors of the crop. Control of the stem boring larvae of the of the noctuid moth (*Sesamia grisescens*) is based on a sound knowledge of the biology of the pest species and included identification of resistant cultivars and optimum planting times, rational pesticide use, biological control, close monitoring of the situation in the crop and the use of pheromones for trapping or mating disruption.*

- √ *The white grub (*Phylophaga sp.*) pest which feeds on the roots and causes severe losses in cane production typically controlled using high quantities of the chemical Ethroprop. However a fungus (*Beauveria bassiana*) which feeds on grub's larvae, can be used efficiently to control the pest. In addition, white grub adults can be caught by the use of night-illuminated traps during larvae production. Since 70 percent of adults are females and each female produces an average of 35 eggs each, the control method is very efficient.*

Valuable lessons can be learned about the impact of pesticides on non-target species which may be of benefit as natural predators of pests:

- √ *Populations of the froghopper pest in cane cultivation in Guyana declined to low levels after attempts at chemical control were discontinued, even without the release of specific biological control agents. This reduction in pest numbers was due to the recovery of existing natural enemy populations following the withdrawal of insecticide treatment.*

MAINTENANCE OF SOIL HEALTH AND PREVENTION OF SOIL EROSION

Sustainable systems of cane and beet cultivation that maintain or improve soil quality are required not only to mitigate environmental and social impacts but to ensure the future of the sugar industry. A wide range of measures has been proposed and investigated for the reduction of soil erosion and improvement in soil quality in sugar cane and beet cultivation systems. These measures include mulching/trash retention in cane cultivation, maintenance of beet as part of a crop rotation, terracing, contour and strip planting of cane on slopes, maintenance of "live barriers" (hedgerows, riparian zones), and modified (reduced or minimum) tillage.

Trash blanket mulching in cane cultivation

The shift from pre-harvest cane burning to 'green cane harvesting' (where the cane is harvested without being burned first) and 'trash-blanketing' (where the cane leaves are cut from the plant and left on the soil as a mulch while the stalks are taken away for harvesting) provides a range of environmental benefits. Any disadvantages of these methods to the farmer (increased harvesting costs, complications in irrigation and fertiliser application, slowing of tiller emergence) appear to be significantly outweighed by the benefits (elimination of aerial pollution and direct burning impacts on soil, improved soil and water conservation, enhancement of soil organic matter, weed suppression and increased yields).

A cane trash blanket for reduced erosion and enhanced soil fertility. Rachel Wiseman.

In recent years there has been a shift away from pre-harvest burning towards green cane harvesting and trash blanketing.

- √ *In 1997, 65 percent of Queensland cane was harvested green, compared with just 18 percent in 1987.*

Increased soil fertility: Retention of a cane trash blanket can result in up to 10-20 t/ha of organic matter from the cane leaves that is left on the soil surface after harvest. This has been shown to increase microbial biomass C and basal respiration in the surface soil and also to enhance the size of the earthworm community. In the long term trash blanketing can be expected to raise soil organic matter content by around 40 percent after 60-70 years.

- √ *In Lucknow, India, trash mulching was shown to improve soil organic carbon by 0.13 percent, available N by 37 kg/ha and available phosphates (P) by 10 kg/ha. Conversely, trash burning reduced the organic carbon by 0.02 percent, available N by 15 kg/ha and available P by 16 kg/ha.*

Reduced water erosion: Trash mulching is particularly recommended on slopes greater than 15 percent to reduce the impact of raindrop action and soil erosion during the wet season, especially if insufficient crop cover has developed.

Reduced risk of soil acidification: The shift away from pre-harvest burning means that pH-increasing ashes are no longer being returned to the soil, reducing the problem of soil acidification.

MODIFIED TILLAGE

Prevention of soil erosion: In South Africa, minimum tillage is advised on slopes greater than 11 percent on erodible soils, 13 percent on moderately erodible soils, and 16 percent on erosion-resistant soils. Whilst conventional tillage is acceptable on slopes with shallower gradients, ploughing should be carried out across the slope, and should be discontinued with the onset of high-intensity rains.

- √ *Zero tillage reduced soil loss rates on slopes of 5-18 percent in Australia, from 148t/ha/year (conventionally cultivated) to <15t/ha/year.*
- √ *In Mauritius, minimum tillage caused no loss in yield over a complete cane cycle of five years or more, protected the soil structure, and resulted in better weed control (with the exception of heavy soils).*
- √ *Use of reduced tillage systems reduced soil losses from 49, 19.5 and 13.1 ton/ac/yr to 17, 5.5 and 13.1 ton/ac/yr, respectively, in a three year experiment in Wyoming, USA.*

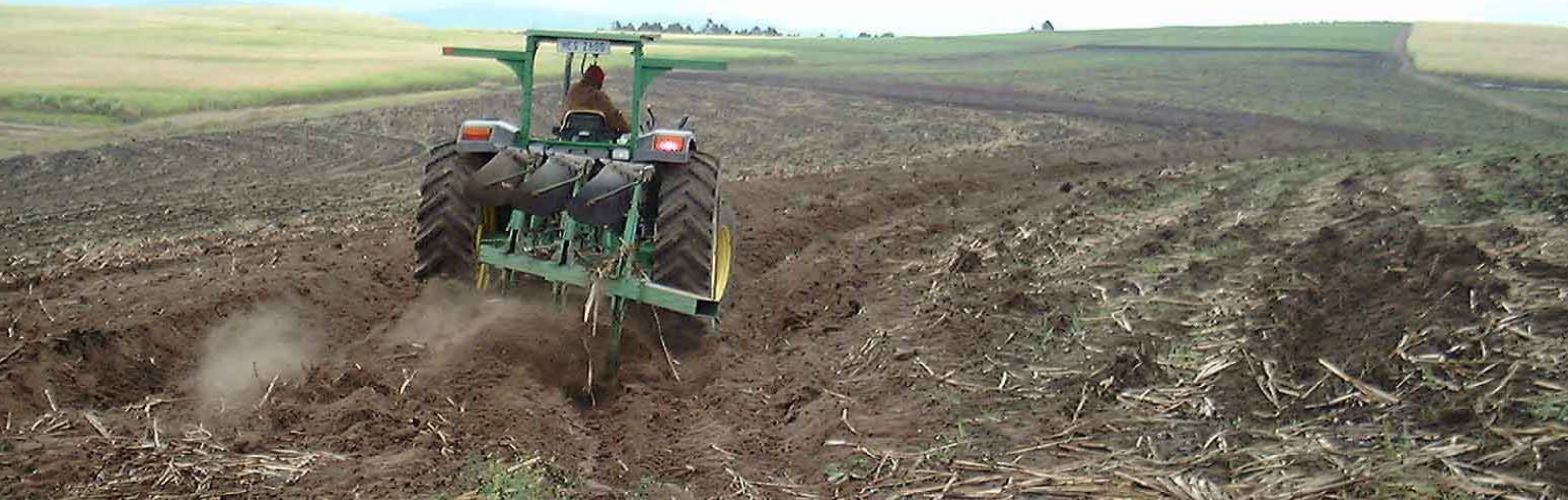
COVER-CROPPING, TERRACING AND STRIP PLANTING IN CANE CULTIVATION

Prevention of water erosion: Compared with other arable systems, sugar cane can represent a relatively effective cover crop as the crop tends to remain in the ground for a number of years producing an extensive root system and a closed canopy that protects the soil from the erosive effects of rain.

However, on sloping land the risk of soil erosion is still high. Farmers could benefit by taking these areas out of production and replanting with tree crops if the rainfall for the area is sufficient. This will improve water retention and provide a more gradual water release. Where land is kept in cane cultivation, cane terracing (where a soil lip is built at the edge of each terrace) of slopes is recommended. The general rule is: the steeper the slope, the narrower terraces and cane rows should be aligned at right angles to the slope.

To further prevent soil erosion on slopes, the practice of cane strip planting is recommended. Under this practice, strips of cane rows at different stages of development are established in adjacent terraces. Mature and maturing strips provide barriers against erosion from the relatively bare strips (those with cane at the earliest stages of development, or where harvesting has just occurred). Strip planting is advised on all slopes greater than 2 percent.

Building terraces on sugarcane fields to prevent soil erosion.
Vaughan Koopman



PHYSICAL AND LIVE BARRIERS IN BEET CULTIVATION

Reduced wind erosion: The creation of ridges and live barriers in beet fields can help to reduce the impacts of wind erosion, which causes damage to sugar beet seedlings as well as loss of soil, thus affecting beet yields.

- √ *In the UK, beet yields increased from 8-10 to 15-17 ton/ac when ridges were created between rows of beet to reduce wind erosion.*
- √ *A single-row shelterbelt of coppiced* Robinia pseudoacacia *significantly reduced wind erosion on beet fields during a dust storm with high winds in Poland. The estimated yield of sugar beet on the protected area was 32 percent greater than that obtained by re-sowing unprotected areas after the storm.*
- √ *The use of Lucerne as a cover crop in beet rotation reduced erosion by around 33 percent in comparison with arable crops (maize, wheat). Lucerne cover reduced run-off by around 50 percent.*

MAINTAINING BEET IN ROTATION

Maintained soil fertility: Soils in continuous arable production (even with rotation of crops) remain at risk of degradation and thus crop rotations are important both for the farm's short term results and for maintaining long term soil fertility.

- √ *Trials in Poland of sugar beet grown continuously for 6-25 years or in rotation with spring barley, winter rape, winter wheat and* Vicia faba *showed greater yields when grown in rotation; root and leaf yields averaged 44.6 and 46.5 t/ha, respectively, in rotation and 30.9 and 27.4 t in continuous cultivation. White sugar yields were 7.5 and 5.11 t in rotation and monoculture, respectively.*

Reduced water erosion: In South Africa the importance of appropriate waterway management to regulate the transfer of runoff waters and sediment from fields into natural watercourses is recognised. The courses of natural but rarely flowing (ephemeral) streams are ideal channels for the carriage of runoff waters from cultivated land. In addition, storm water drains can be established to prevent uncontrolled runoff of storm waters from natural habitats, roads, buildings and forestry areas. through cane fields. Appropriate design of culverts is also an important consideration in the management of runoff waters.

The planting/maintenance of indigenous vegetation in waterways is recommended to control water erosion. Bundles of cane tops are also recommended for lining waterways until protective native vegetation becomes established.

REDUCING POLLUTION FROM SUGAR MILLS

Sugar mills can be sited downwind of populated centres to minimise nuisance from gaseous emissions and isolated from natural ecosystems to minimise the impacts of effluent discharge on rivers and coastal areas.

Reducing fly ash production: Bagasse can be dried prior to its use as boiler fuel, which increases the efficiency of burning and reduces emissions. Basic dust control measures are cheap and simple to install in most cases.

- √ *Modifying the combustion process and adopting emissions-control systems in a Colombian cane mill reduced concentrations of particulate matter by about 98 percent.*

Reduced gas and odour production: Hydrogen peroxide in place of sulphur dioxide in sugar mills has been shown to reduce air pollution and resulted in a higher quality white sugar product while requiring no new equipment.

Various odour control measures are available in the management of sugar beet factory wastes, such as the use of enzymes and organic scavengers for control of H_2S.

Reducing effluent runoff: A range of techniques is available for treating sugar mill effluents, including the treatment of mill sludge with micro-organisms that accelerate the rate of decomposition.

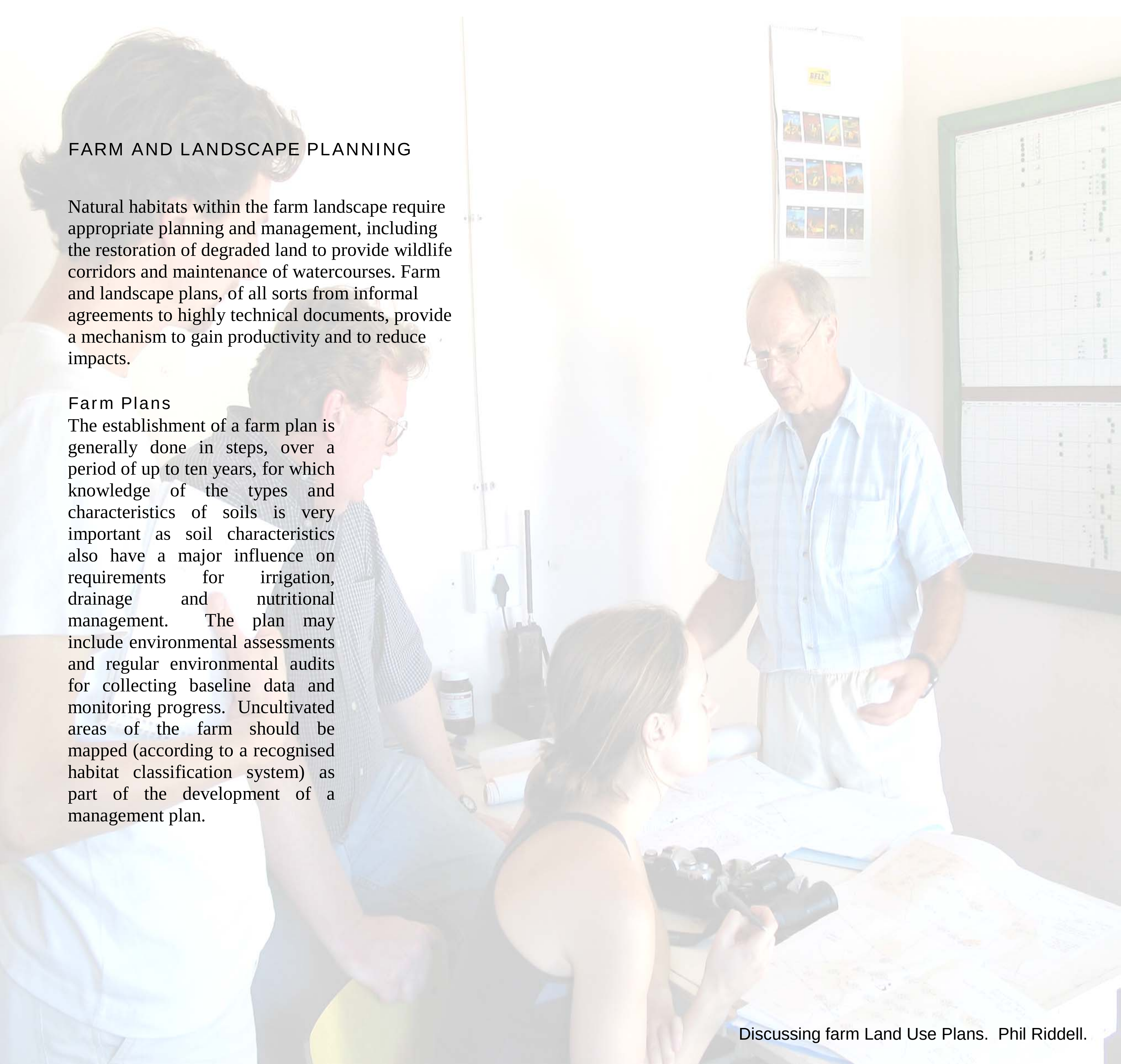
- √ *Treatment in an open fermentation chamber decreased wastewater COD by 82 percent in three days in a Polish sugar beet factory.*
- √ *Zero pollution has been achieved in some Indian sugar mills by totally recycling treated effluents as make-up water for cooling towers and spray ponds.*

FARM AND LANDSCAPE PLANNING

Natural habitats within the farm landscape require appropriate planning and management, including the restoration of degraded land to provide wildlife corridors and maintenance of watercourses. Farm and landscape plans, of all sorts from informal agreements to highly technical documents, provide a mechanism to gain productivity and to reduce impacts.

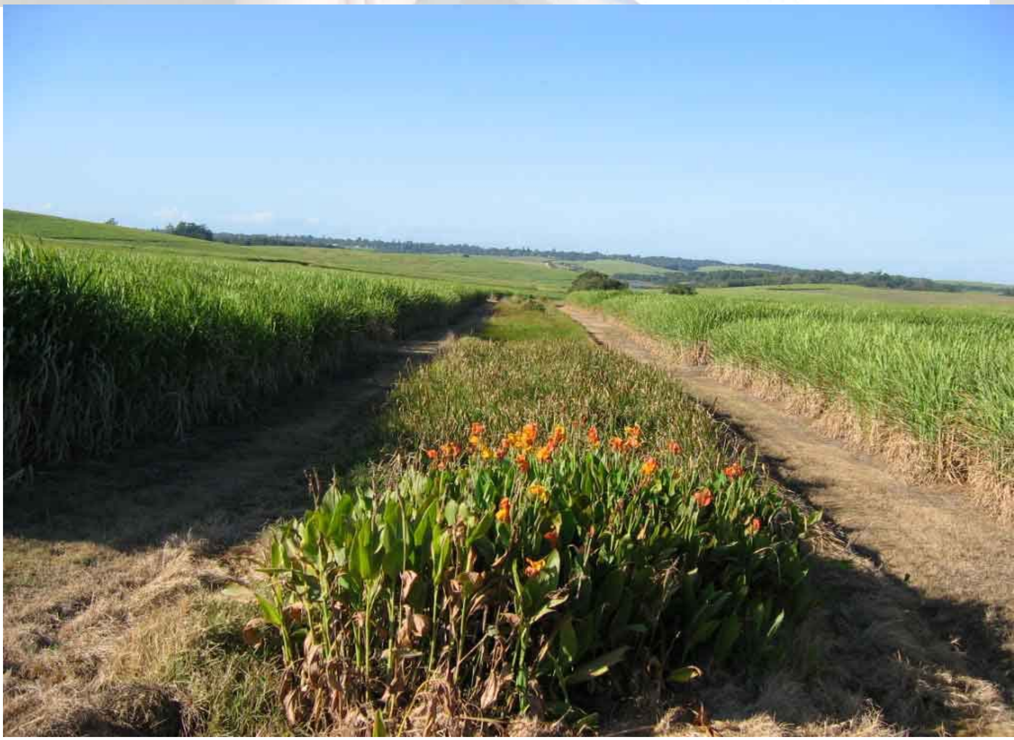
Farm Plans

The establishment of a farm plan is generally done in steps, over a period of up to ten years, for which knowledge of the types and characteristics of soils is very important as soil characteristics also have a major influence on requirements for irrigation, drainage and nutritional management. The plan may include environmental assessments and regular environmental audits for collecting baseline data and monitoring progress. Uncultivated areas of the farm should be mapped (according to a recognised habitat classification system) as part of the development of a management plan.



Discussing farm Land Use Plans. Phil Riddell.

Riparian vegetation: Natural riparian vegetation plays a particularly important ecological role, providing habitat for wildlife, and influencing water quality and temperature, stream morphology, and ecosystem dynamics. It can also provide a buffer between agricultural systems and waterways. Riparian habitats can reduce sediment loads and agrochemical concentrations in waters running off from cane fields.



A rehabilitated waterway. Vaughn Koopman

Field margins: The characteristics of field margins and adjacent land parcels are also important influences on invertebrate diversity and abundance in cultivation systems.

√ *In Poland the number and diversity of insects were greater on the boundary of sugar beet fields than in adjacent fields. In particular, predatory carabids and hoverflies, and parasitic Hymenoptera, predominated in the field margin.*

Beet diversity in rotation: Sugar beet is typically grown as part of a crop rotation, and is therefore (to some extent) already part of a diversified system of agriculture which has environmental benefits over less diverse systems.

Financial benefits: There are also agronomic advantages in maintaining diversity within the standing crop itself; domination of large cane growing areas by single varieties in Australia has led to serious problems with disease outbreaks.

PROTECTING NATURAL HABITATS IN SUGAR CULTIVATION AREAS

Fragments of natural habitats that persist within the agricultural landscape can represent important refugia for indigenous biodiversity.

√ *Coastal heathland remnants of 500ha amid cane growing areas of New South Wales have been found to contain high densities of 'natural-vegetation-dependent' bird species.*

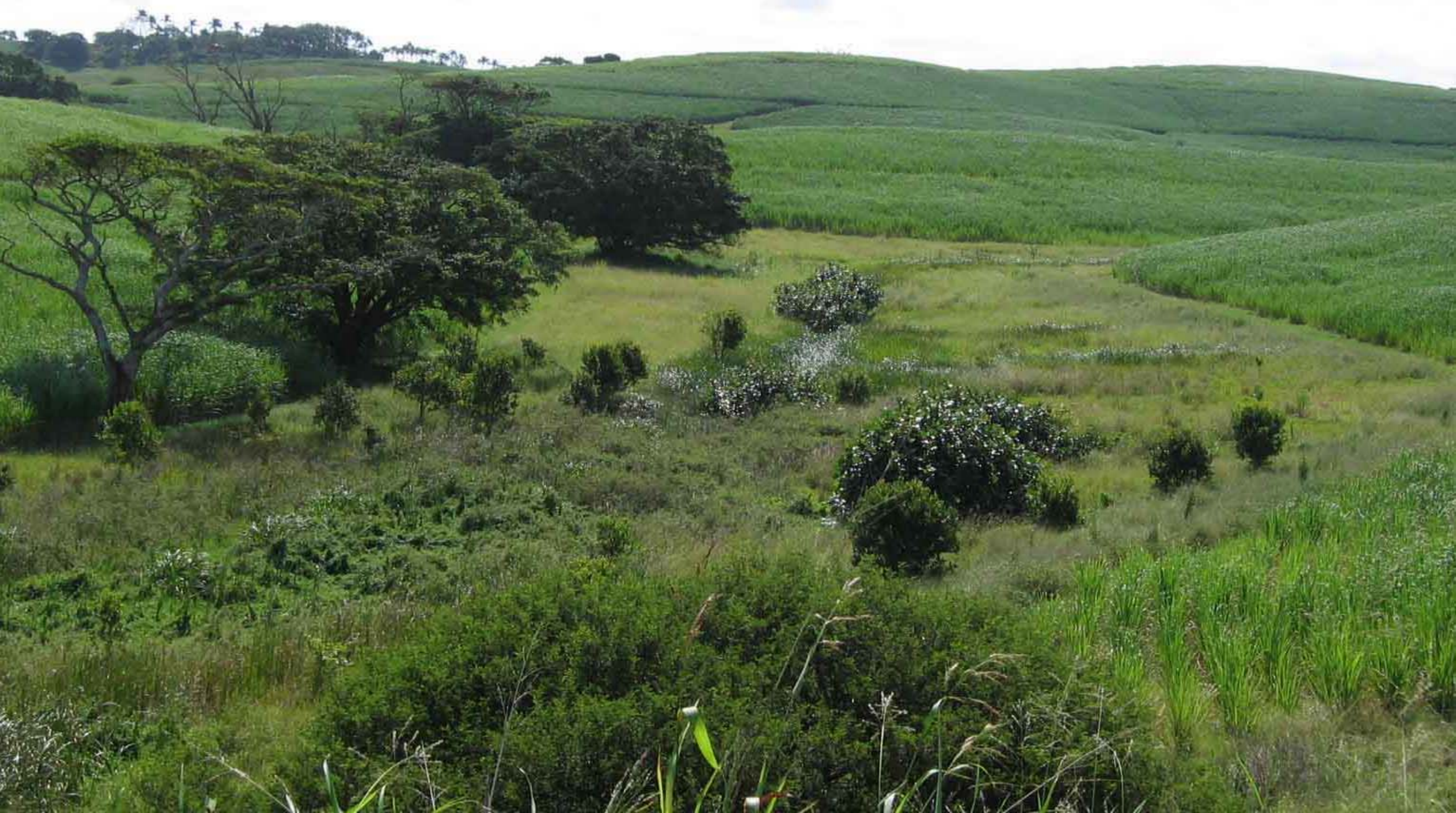
√ *Botanical surveys in Sao Paulo, Brazil, showed that botanical diversity was similar in a 20ha protected fragment of cerrado habitat in an agricultural area including sugar cane, compared to that measured in other cerrado areas.*

However, questions generally arise over conservation management strategies where areas of natural habitat survive in agricultural landscapes. For example, although approximately 19 percent of the 11,200km^2 of Terai grassland in northern India is now included in Protected Areas (PAs), the PAs are situated within a landscape of forests, sugar cane and paddy fields, scattered hamlets, and small townships. Wildlife management plans typically address the PAs alone or just the forest management, whereas an integrated landscape approach, encompassing all elements of land use in a holistic manner, is required if the ecological interests of the Terai grassland ecosystem are to be secured.

There is increasing recognition in some parts of the world of the need to protect natural habitats against the impacts of cane

In South Africa, regulations apply to the cultivation of virgin land, and to the cultivation of cane in close proximity to certain natural habitats. For example, a permit is required before any virgin or new land can be planted with cane – in this context, any area that has not been cultivated for ten years or more is regarded as virgin land. Natural wetlands are also protected from drainage and cultivation by a Conservation Act and cane should not be planted within 10m of indigenous forest, wetland or riparian habitats, or in flood plains.

A correctly buffered wetland in South Africa. Vaughn Koopman.



USE OF BY-PRODUCTS

Sugar is not the only product of cane or beet and in fact only represents 17 percent of the biomass of sugarcane plant. In addition to the use of cane bagasse for boiler fuel, there are many other sugar processing by-products that can be used for a range of purposes. This increases the efficiency of the crop and, where by-products are used as soil improvers, provides organic alternatives to chemical inputs.

Soil conditioners and fertilisers: Filter press mud from cane mills is often incorporated into soils as a conditioner and fertiliser.

- √ *In combination with effective microorganisms (EM), sugar cane filter cake was superior to farmyard manure and poultry manure in sustaining crop yield and soil properties in irrigated wheat fields in Faisalabad, Pakistan.*

A number of studies suggest that vinasse and treated waste water from sugar cane mills is suitable for irrigation, although there is concern that these products have the potential to pollute soils and groundwater and cause salinisation, especially if used in large amounts. Irrigation with cane effluent was found to suppress germination of peas in Balrampur, India.

Bagasse has been used as a mulch to aid re-vegetation and stabilisation of denuded land on road verges and can also be used as an excellent substrate for mushroom cultivation, with the cultivation residue potentially used in animal feed.

Paper production: Bagasse is used in a number of countries in production of paper and particle board.

Bagasse stacked ready to be used for chip-board production. Rachel Wiseman.

Sugar beet tops can be left on the soil surface of fields, as a source of nitrogen for the next crop in the rotation.

Animal feed: The value of sugar beet by-products as animal feeds was recognised very early in the cultivation of the plant. Fresh beet tops can be grazed in the field (common practice when they are fed to sheep) or removed from the field to be fed directly to livestock or to be used for silage. Vinasse production from beet molasses can also be used in animal feed, as can beet pulp residues, either directly or mixed with molasses and dried.

Filtration: Fly ash extracted from boiler chimney gas can be used as a filtration aid in the sugar mill and can also be used for the removal of the lindane and malathion pesticides from wastewater.

- √ *Up to 97-98 percent removal of lindane and malathion was obtained under optimum conditions in India, providing an inexpensive and effective option for filtering waste water.*

Chemical production: Bagasse is a potentially valuable cellulose source for the production of chemicals, such as pentosans (including furfural) and allied substances.

Yeast production: Molasses produced in the processing of cane or beet sugar is an important raw material for the fermentation industry and in the production of yeasts.

Alcohol production**:** In some parts of the world alcohol has traditionally been produced as a by-product of the sugar industry, through the fermentation of molasses and subsequent distilling, typically to produce rum. However, river pollution near distilleries was a problem in Brazil, even before the National Alcohol Programme was launched in 1975.

Fuel production: Juice extracted from cane can also be fermented directly and the products distilled to produce alcohol for fuel (bioethanol). The primary argument in favour of bioethanol as a fuel is that it results in less air pollution than fossil fuels. Other potential advantages include the renewable nature of bioethanol, reduced dependence on foreign oil, enhanced local employment opportunities, the creation of “added value” in a sugar industry afflicted by unfavourable world commodity prices and cutting the escalating CO2 emissions associated with fossil fuels, as the plant absorbs more CO2 during growth than is released during its subsequent processing.

Electricity production: Sugar cane has the advantage in most countries where it is processed of producing surplus steam and electricity from bagasse which is effectively ‘free’ and increases the sustainability of sugar production.

Encouraging the use of Better Management Practices

Sugar produced in a more sustainable way can improve financial returns to farmers and millers through increased yields, sustained soil health, reduced inputs and quality of production.

Specifically with regard to water resources this means increased farm productivity (more crop per drop), wider benefits for species and the environment (more drop per ecosystem) and local communities through an increase in available clean fresh water (more drop per person), and socio-economic development, as water will be available for other uses such as fisheries or ecotourism (more dollar per drop).

Evidence is building that the use of Better Management Practices (BMPs) for various agricultural products, including sugar, usually provides significant benefits to farmers and to businesses that use the commodity in their products. For investors, companies that use BMPs present fewer risks, good potential longer-term partners with reduced supply chain risks and potentially higher returns on investment.

In sugar production the uptake of such practices is beginning, but there are still constraints to overcome, such as:

- Few incentives to implement BMPs e.g. no penalties for polluting, or charges for the quantity of water used;
- Inadequate allocation of irrigation water which means that crops do not receive the right amount at the right time;
- A lack of regional, national and international policies that encourage sustainable sugar production;
- Manufacturing companies, that buy large quantities of sugar, not recognising the impacts that conventional sugar production has on people and the environment;
- Information not reaching farmers about BMPs that improve productivity and reduce impacts;
- No access to (micro) credits needed by farmers to invest in BMPs.

To overcome these constraints action is needed at local, national and international levels:

Local government extension services and NGOs: Support Farmers' Organisations or Water User Associations among groups of farmers to encourage participation in the use of BMPs.

Local government and mill extension services: Support the widespread uptake of BMPs by developing schemes interactively with farmers.

Sugar mills: Encourage BMPs that benefit the factory and the farmer e.g. use processing wastes for soil improvement.

National government ministries: Establish policies which support and facilitate the uptake of BMPs:

- Sucrose-based payments instead of cane-weight;
- Demand-driven irrigation water allocation, water rights for farmers and the possibility to sell or barter any excess;
- Protection natural areas to prevent expansion of cultivation into unsuitable areas;

National sugar associations: Develop BMP guidelines and support programmes e.g. the BMP programmes of the South African Sugar Association and the Australian Canegrowers Council.

Multinational food companies: Help to drive the uptake of BMPs by preferentially buying sustainably-produced sugar for their products; this would also help these companies to protect well-known brand names and their competitive edge.

Governments to reform sugar subsidies: The unfavourable international market for sugar is perhaps the single largest constraint to increasing the sustainability of sugar production.
80 percent of world sugar production and 60 percent of international trade is at subsidised or protected prices. The EU, the US, and Japan, which together account for 20 percent of world production, have average producer prices that are more than double the world market price. Such policies contribute to low and volatile world sugar prices. Where producers have to compete on price alone in such markets the industry is unable to grow and process sugar in ways that are either good for the environment or for workers in the industry. Rich country subsidies need to be cut and policies reformed so that they enable and encourage the global sugar industry to be more sustainable.

Without support in the form of subsidies sugarcane would not be grown in Florida. Citizens of the USA pay US$800 – 1900 million in subsidies to plant sugarcane in the Everglades and also pay two-thirds of the clean-up bill to restore the ecosystem that has been destroyed by sugarcane cultivation. At the same time the government pays millions of dollars to buy back the sugar which cannot be sold.

Without the EU sugar regime guaranteeing a price for European beet at three times the world price there would be no irrigated beet in Europe. The European taxpayer funds the EU sugar regime to the tune of €1.5 billion/year directly but European consumers pay about €7.5 billion/year in higher prices.

A study by the Centre for International Economics, in October 2002, estimated that if all protection for sugar (EU, Japan and US) was removed the world price would increase by around 60 percent. It estimated that removal of EU support for sugar on its own would raise world prices by about 16 percent.

TIME FOR ACTION

WWF considers that the severe impacts caused by sugar growing and processing cannot be allowed to continue. Not only is conventional sugar production degrading the environment in many countries around the world, it is also leaving the poorest farmers in a poverty trap from which they cannot easily escape.

Concerted action is required among all stakeholders in the sugar and food industries if a more sustainable future is to be guaranteed for this ubiquitous product.

Further Information

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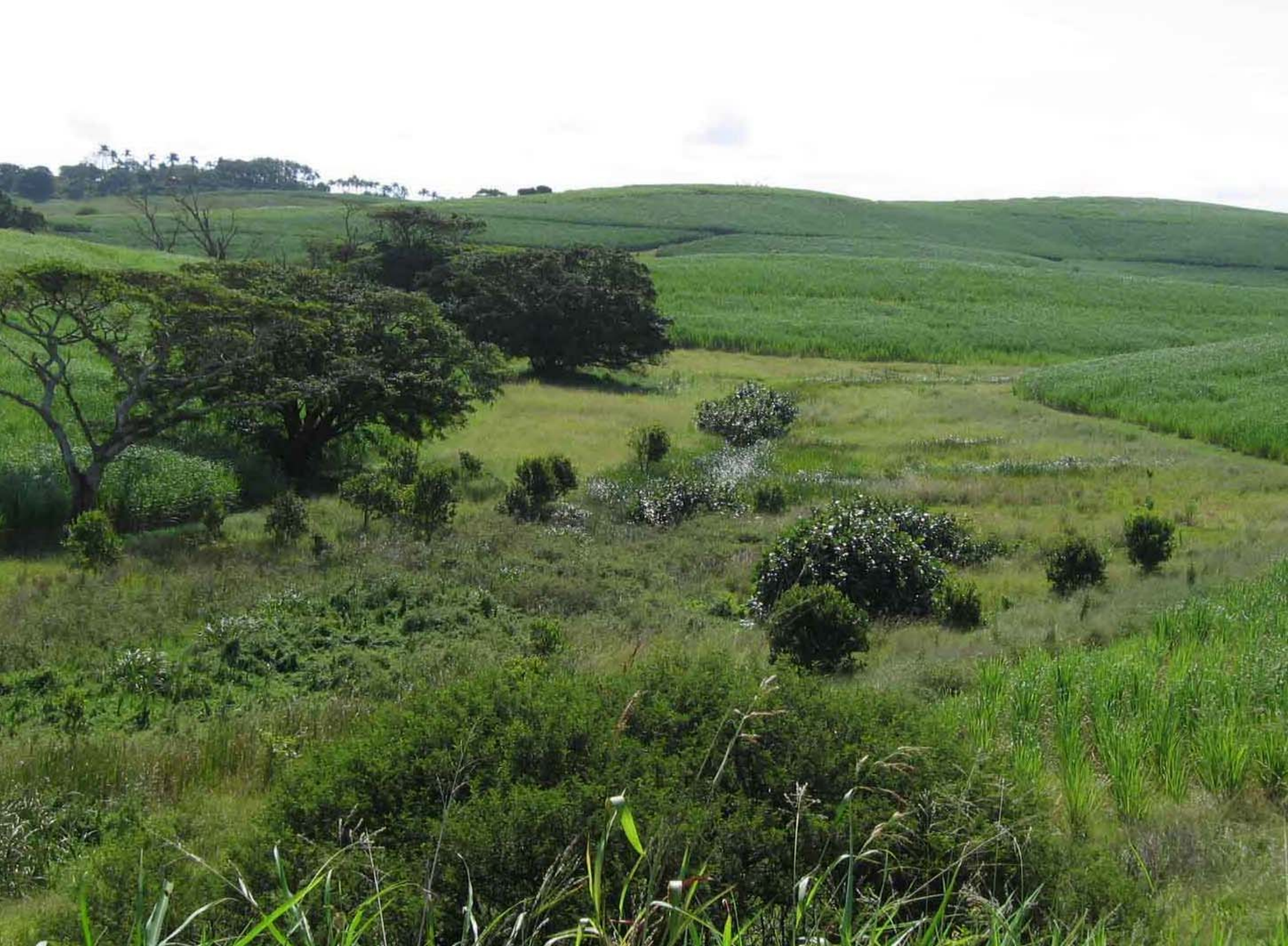
* To be published end-November 2004. Copies can be ordered from CAB International's website (www.cabi-publishing.org), or from WWF (contact freshwater@wwf.nl).

Cover image: Cane planted on steep slopes enhancing soil erosion. Phil Riddell
Frontispiece image: Water abstraction for sugarcane irrigation
Inside back cover image: Top - Sugarcane in Queensland planted into a flood plain. WWF Canon / Tanya Peterson.
Bottom - A correctly buffered wetland in South Africa. Vaughan Koopman

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WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by:

- **conserving the world's biological diversity**
- **ensuring that the use of renewable natural resources is sustainable**
- **promoting the reduction of pollution and wasteful consumption.**