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Population Growth and Renewable Resource Management

The challenge of sustaining people and the environment

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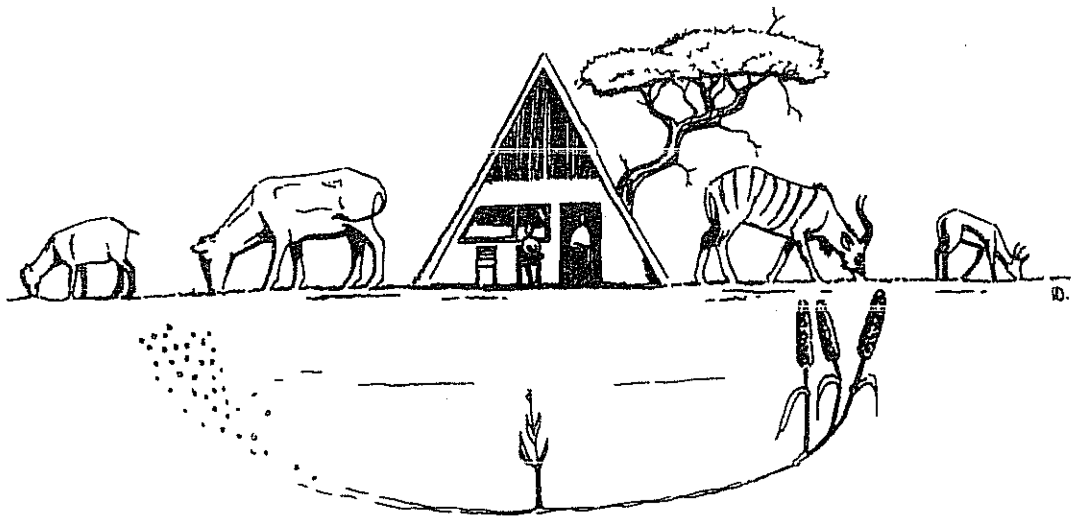

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This series of Research Discussion Papers is intended to present preliminary, new, or topical information and ideas for discussion and debate. The contents are not necessarily the final views or firm positions of the Ministry of Environment and Tourism. Comments and feedback will be welcomed.

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POPULATION GROWTH AND RENEWABLE RESOURCE MANAGEMENT

A: INTRODUCTION

The earth is currently supporting over 5 billion people -- more than ever before -- and the population is still growing at an unprecedented rate. The population increase in the last 40 years equals the total increase in the half million years up to 1950[11]. In the next 30 years, the population will double again.

This news is both good and bad. It is a triumph that advances in human skills, technology and modern energy enable us to reduce death and disease, and increase productivity of the world's resources to such an extent. On the other hand, sustaining this enormous and growing population involves an unprecedented assault on the natural environment. We are degrading life's three essentials, clean water, air and land; running down non-renewable resources, such as oil and minerals; over-exploiting renewable resources, grasslands, soil, forest and fish; and interfering with our most fundamental but least understood ecosystems, the oceans and stratosphere. The question is whether the planet can continue to sustain growing populations, or is reaching the limits of its human carrying capacity. Worse, humankind might not only reach, but reduce those limits: by over-exploiting natural resources we may be permanently reducing the earth's capacity to sustain us.

These issues are particularly pertinent in Namibia, for 3 reasons:

(i) 70% of Namibians depend directly on natural resources, particularly agricultural land, for much of their livelihood; future generations are also likely to do so for some time to come;

(ii) Namibia is the driest country south of the Sahara. Water is scarce, productive land is fragile, and environmental degradation is easy to provoke but difficult to reverse. Therefore the land has limited potential to provide life's staples -- food and water -- and can only support a sparse population.

(iii) Despite the fact that Namibia is sparsely populated by international standards, population pressure is already considerable due to the uneven distribution and rate of growth: over a quarter (28%) of Namibia's total population lives in just over 1% of the land (10,000 km^2) in the Cuvelai drainage area. Population densities here rise as high as 100 people per square km[15] (Figure 6)[(1)]. At 3% per year[28], the population growth rate is high by international standards and if sustained will result in a doubling of the population in 23 years. This growth, combined with the needs and expectations of the majority of Namibians for better living standards, is exerting unprecedented pressure on Namibia's resources.

1 densities across the four northern regions, Ohangwena, Omusati, Oshana and Oshikoto, (with 45% of the total population) average out at 5 to 15 people per km^2, compared to less than 0.5 people per km^2 over much of the rest of the country[28].

This paper examines trends in population and resource use in Namibia, seeking to identify the critical issues and address two questions in particular:

(i) how has population growth affected renewable natural resources to date? (noting but not exploring other factors that have contributed to environmental change)

(ii) given environmental and other constraints, can Namibia's renewable resources support a doubling of the population every 23 years?

These questions cannot be answered conclusively. The causal links are complex: while all people are dependent on natural resources, the pressure individuals place on their environment depends on patterns of resource management and consumption. The effect of population growth is difficult to isolate from other factors, such as low rainfall, affecting productivity of the resource base. Analysis is made more difficult by the scarcity of data, particularly on trends in the productivity and consumption of natural resources. Nevertheless, trends, critical issues, and the need for urgent action, emerge.

Section B provides a brief background, and section C a framework for assessing growing demand for natural resources against sustainable supply. The analysis then focuses on those natural resources most directly affected by population growth - productive land (section D) and water (E) - rather than those used by industry, such as fish, tourism areas, and minerals. Management of the latter is not directly changed by population growth, although through their contribution to economic growth they will have to play a key role in supporting growing populations. The impact of such economic growth on the resource base is briefly considered in Section F. Section G summarises the conclusions and presents their implications.

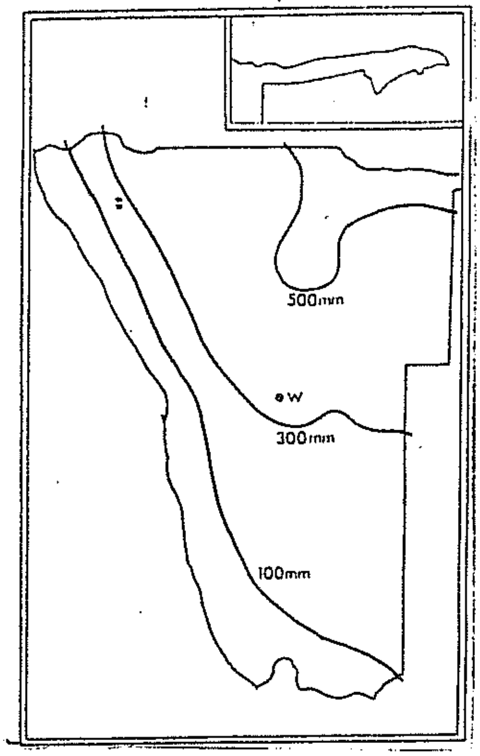


Figure 1: Mean Annual Rainfall[1]
15% of the land along the coast is hyper-arid desert. 40% of the land is arid savanna receiving less than 300 mm of rain per year. A further 37%, receiving between 300 and 500 mm of rain a year, is classed as semi-arid. Only 8% of the country, in the extreme north east, receives more than 500 mm of rain per year

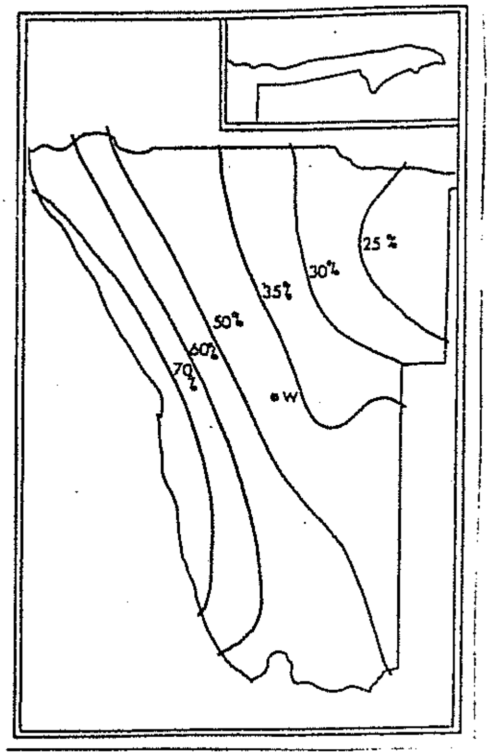


Figure 2: Variability in Rainfall[1]
% indicates typical deviation from the mean. The south west suffers highest variability as well as lowest rainfall. Drought is to be expected: a farmer in a mean rainfall area of 200 mm a year, should plan for between 80 mm and 320 mm.

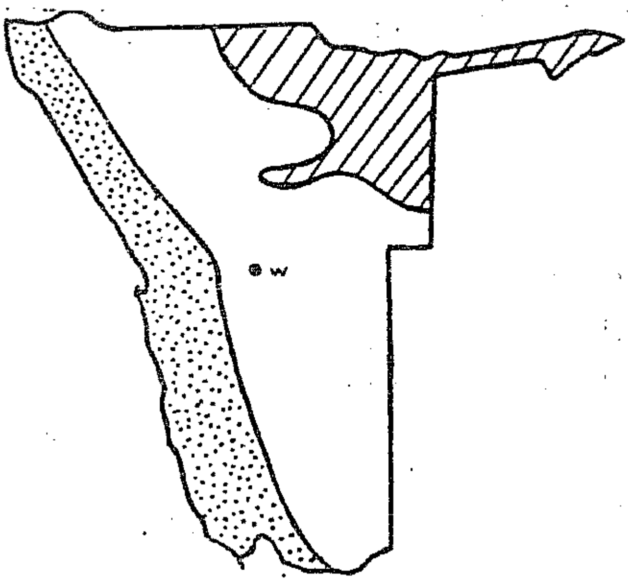


Figure 3: Vegetation biomes of Namibia[2]
desert (stippled); savannas (unmarked) and woodlands (hatched).

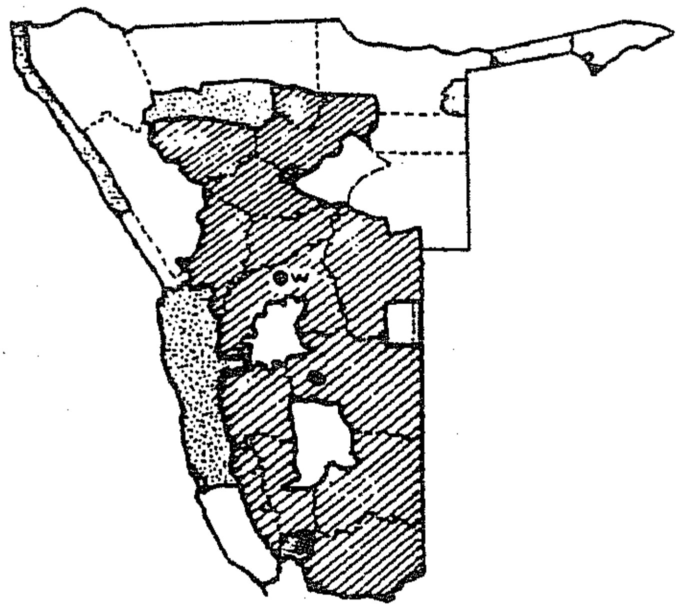


Figure 4: Land tenure[2]
commercial farmlands (hatched); communal farming areas (unmarked)[1] and proclaimed conservation areas (stippled)

[1] Reproduced from Brown, 1993
[2] Reproduced from Namibia's Green Plan 1994

B: BACKGROUND -- GEOGRAPHY AND LAND USE

Namibia is a land of 824 000 square kilometres, with 1400 km of coastline. It has a narrow coastal desert plain, from which the land rises to an extensive interior plateau, 1000 - 1,500 m above sea level.[21]

Namibia is one of the most arid countries in the world. Rainfall is low and variable, evaporation rates high, and there are no permanently-flowing rivers between the southern and northern borders. Rainfall increases from south-west to north-east. As Figure 1 shows, the coastal strip is hyper-arid desert, and only 8% of the country, in the extreme north-east, receives more than 500 mm of rain per year, which is considered the minimum for dryland cropping.[21] The potential rate of evaporation from open water far exceeds rainfall -- by 420% in the north, and 1,750% in the South[21]. Rain falls in short sharp bursts, resulting in low infiltration, and can be highly localised.

Just as critical as average rainfall, is its variability. The driest areas suffer most variability (Figure 2). This means years of well-below-average rainfall, or drought, are to be expected. This variability also demands flexible land-use in order to prevent degradation, because what the land can sustain in a wet year becomes over-exploitation in a dry one.

Climate, soil and water availability determine the three vegetation biomes: desert (16% of the land area), savanna (64%) and dry woodland (20%)[21] (Figure 3). The low, variable rainfall accounts for many of the adaptations developed by plants and animals, and has also shaped the land settlement and management patterns of people. As one of the world's most arid countries, it is not surprising that Namibia is also one of the least densely populated. Average population density is 1.7 people per square kilometre[2]. Countries such as Pakistan and Turkey, of a similar size, support 30 times as many people. In the past, settlement was confined to those areas with reliable water (such as the Cuvelai drainage basin with seasonal "oshanas", along the Okavango river, riverine areas of East Caprivi, and near Windhoek's springs) while transhumance was practised elsewhere (Figure 5). Nomadic pastoralism, as practised by the Himba, is a way of coping with variations in pasture between areas and years.[(2)] Under, current land-use patterns, determined by politics and economics as much as ecology, commercial farms occupy 45% of the country, mainly in the south and centre, communal land accounts for 40% largely in the north, proclaimed conservation areas 13%, and diamond areas 2%[21] (Figure 4).

The key implications of these geographical characteristics are:

* water is scarce: difficult and expensive to locate and extract;
* the majority of the land is only suitable for extensive livestock or game farming;
* the land has an inherently low carrying capacity (of animals and hence humans);
* carrying capacity fluctuates with rainfall;
* there is a risk of irreversible degradation.

Therefore the capacity of the resource base to continue sustaining growing populations is questionable.

2 Arid areas produce intense seasonal variations in the amount of vegetation they support, due to plants' adaptations to dry periods. Some survive as dormant seeds, some by dying back above ground to survive underground, and others remain apparent but provide little food or fodder. The next rain brings a burst of vegetation. These pulses in productive activity determine the animal and human population that can be supported. Nomadic pastoralism is a human adaptation to these pulses - it exploits vegetation when and where it occurs, and avoids excessive pressure on any single area of land during dry periods.

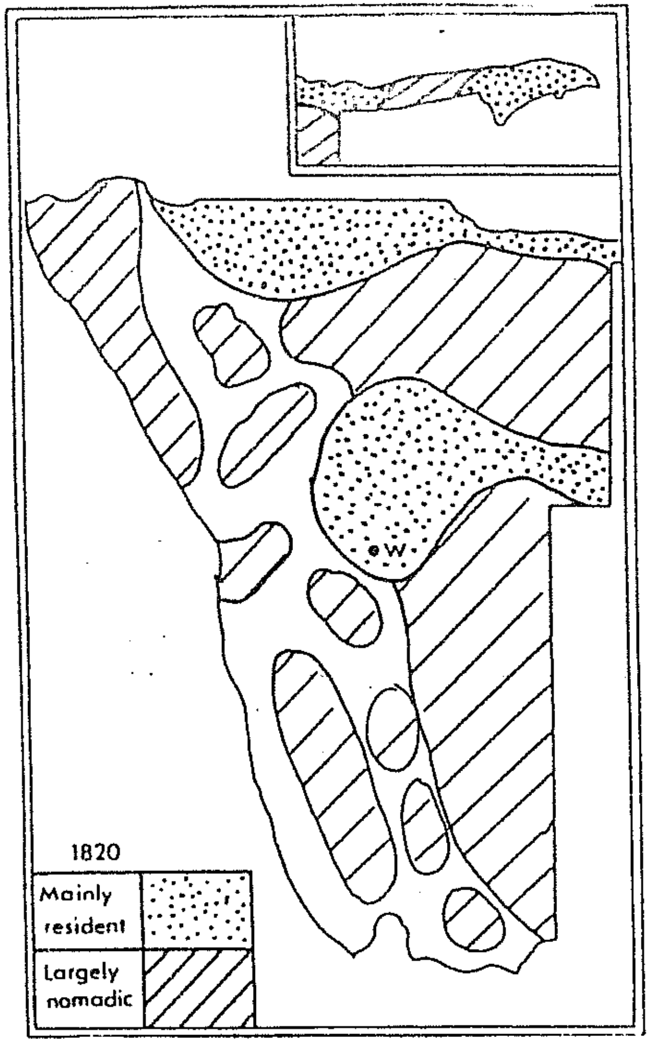


Figure 5: Pre-colonial land use
Geographic distribution of inhabitants of Namibia in ca 1820, before comunities were disrupted by colonisation, showing that settlement was largely confined to areas with available water.

Reproduced from Brown, 1993

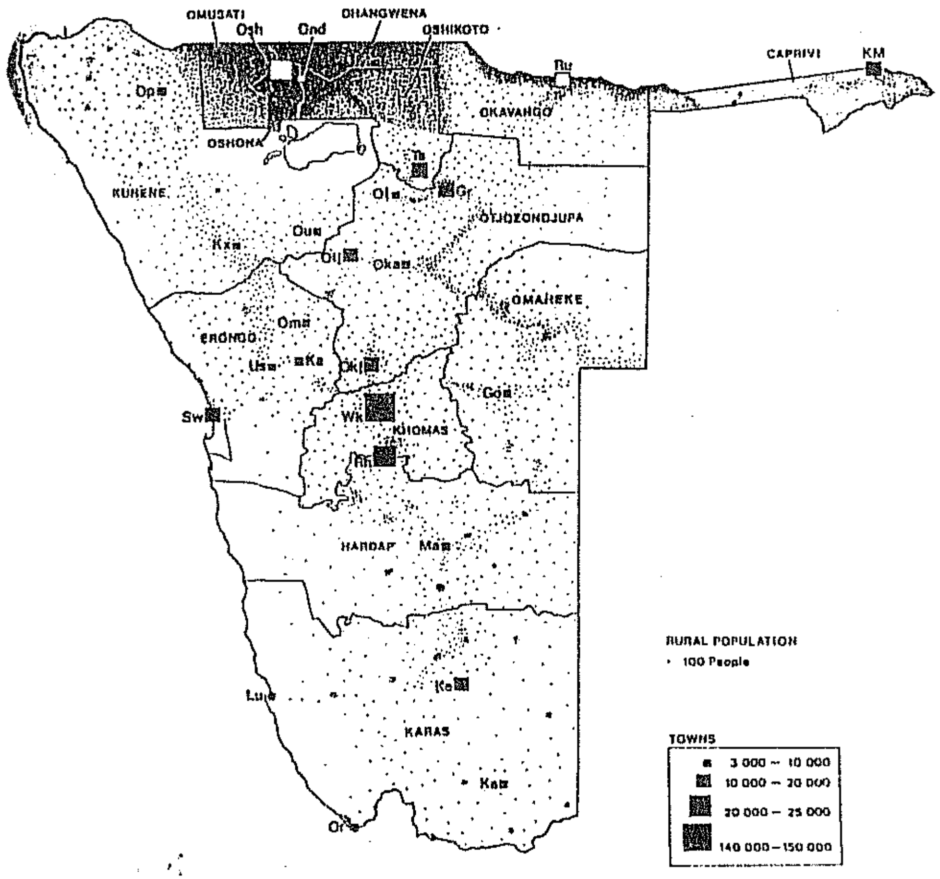


Figure 6: Current population distribution
The dense settlement in the Cuvelai drainage region in the north is clear. These 10,000 km² support 28% of the population.

Reproduced from du Toit et al, 1994

C: BALANCING RESOURCE USE WITH SUSTAINABLE SUPPLY

The relationship between population and environmental change is not a simple one. The pressure individuals place on their environment depends on what each person consumes, how much, and how it is produced. With improved production efficiency, the same resources can support increasing numbers of people. Some people argue that population pressure is the very motivation that drives us to innovation and improvement[3]. But with inappropriate systems, or with rising consumption per person, scarce resources support fewer and fewer people. Excessive pressure can set in motion a vicious cycle of irreversible degradation. This section seeks to identify key concepts for simplifying and analysing these relationships.

The core problem is that as population grows, the demand for resource use can grow inexorably, whereas the maximum sustainable supply, or off-take, of a given stock of renewable resources is relatively fixed. When demand exceeds supply, either some people consume less (make do without or switch to natural, commercial, or imported alternatives), or resource use is excessive, diminishing the resource base and future supply.

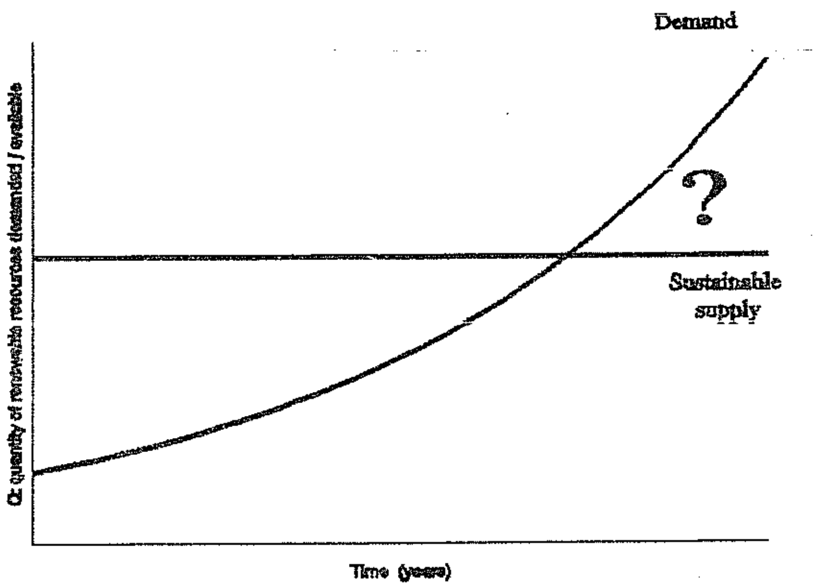


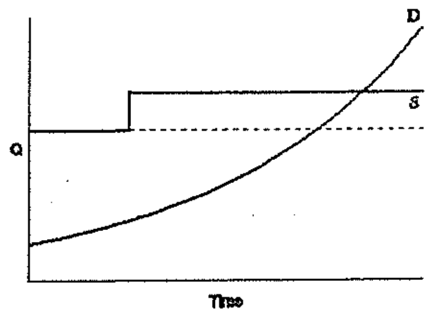
Figure 7: The maximum sustainable supply that can be extracted from the stock of renewable resources stays roughly constant over time, but as population grows, demand increases.

Figure 7 illustrates rising demand with fixed supply over time, while different strategies for resolving the problem are illustrated in the following 3 graphs[4]. The resources can support more people if three strategies are adopted:

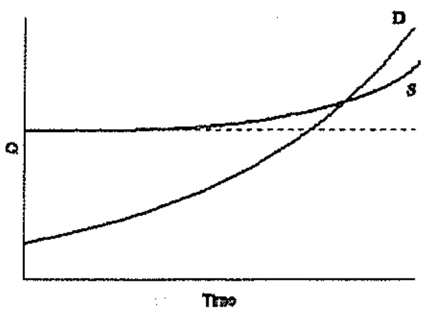
3 See Appendix 2 for examples of such theories.

4 For the sake of simplicity, certain links in the economic and ecological chains have been simplified. For example, the size of resource stocks and level of maximum sustainable supply are inter-dependent and so not fixed as the graphs suggest. Replenishment and expansion of existing stocks is not considered, as this is more relevant to resources such as fish, than productive land and water, but could be incorporated into strategy (i). In strategy (ii) it is often the supply of services from resources, rather than resources themselves, that rises. i.e. these graphs are schematic representations of alternative management strategies, not detailed explanations of economic theory.

(i) **new stocks** of resources are found and exploited; e.g. previously unused forests, water resources, land etc;



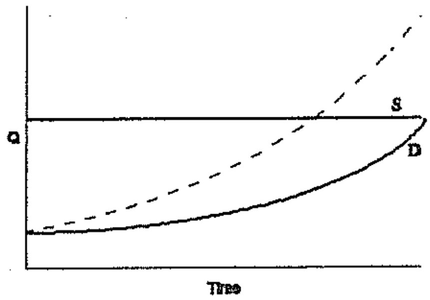
sustainable supply rises



sustainable supply rises

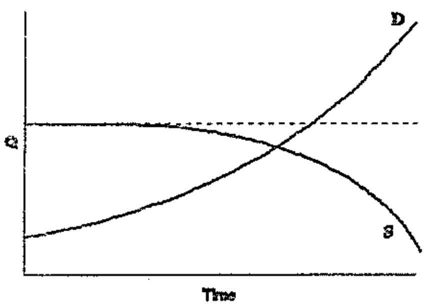
(ii) techniques of production are improved to **increase productivity**, so that the same amount of primary resources provide more benefits; e.g. improved crop yields from arable land;

(iii) **consumption per person is reduced**, so that the same supply meets the needs of more people; e.g. water conservation; switch to alternative fuels and fencing.

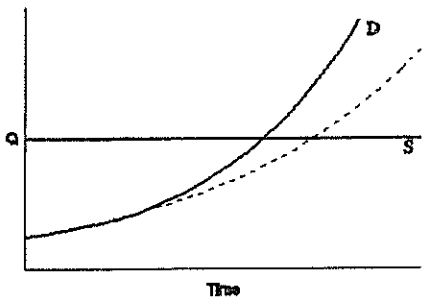


total demand is reduced

However, as the final two graphs show, the resource base will support **fewer people** if:



environmental degradation reduces the productivity or size of the resource base; sustainable supply falls



consumption per person increases; total demand rises.

The following sections seek to use these concepts to ask whether demand has already exceeded sustainable supply of key natural resources? If so, whether over-use is leading to degradation? And whether there is potential for resources to support a doubling of the population through the 3 strategies outlined?

D: PRODUCTIVE LAND AND POPULATION GROWTH

The majority of Namibians derive a substantial part of their livelihood from the land and the resources it supports: livestock, crops, trees and other flora, wildlife and other fauna. 67% of the population live in rural areas[28] and the agriculture sector accounts for 27% of private sector employment.[6] The poorest rural households, without income from migrant labour or pensions, depend almost entirely on the land. As population grows, (and particularly if off-farm opportunities do not) pressure on the land will increase. However, the harsh climate imposes an overriding constraint on the productivity of the land. There is already evidence that agricultural output has not kept pace with rural population growth[(5)] and that excessive pressure on the land is reducing productivity in some areas. This section considers whether or how the land can support the increasing demands of a burgeoning population.

D.1. LIVESTOCK

Livestock farming dominates land use in both communal and commercial areas. In communal areas, livestock fulfils many functions, providing milk, meat, manure, traction, a store of wealth and mark of status. In commercial areas, livestock is reared mainly for sale and often export. Climate determines the type and number of stock that can be supported: apart from the desert with virtually zero agricultural potential, the arid areas support small stock (sheep and goats) at low densities equivalent to over 24 hectares per large stock unit (LSU) while the areas of higher potential to the north and east support cattle at around 8-10 hectares per LSU in a year of "average" rainfall. However, stocking at "average capacity" in dry years leads to over-grazing.

Given the central importance of livestock (particularly cattle) in most communal areas, there is concern that population growth is causing growth in livestock numbers resulting in over-grazing and degradation of the veld. This in turn reduces the potential to support livestock, and hence people, in the future. The following discussion indicates that such concerns are justified, if somewhat simplified.

<u>Recent trends: scarcity and degradation of pasture</u>

Traditionally most pastoralists in Namibia practised transhumance. In the south and central areas, nomadic pastoralists and their livestock followed the grazing and water. In the north, communities were more settled, but at the end of the wet season, as accessible surface water and grass diminished, livestock were herded to more distant grazing areas.[(6)] Therefore intensive grazing was followed by periods of rest, giving the grass a chance to recover.

Land enclosure and forced relocations under colonialism reduced available land and disrupted pastoral practices for many farmers. During recent years of population growth, three further changes have occurred, which cause many areas to be grazed by more cattle, for more of the year, and hence over-grazed, as shown in Figure 7:

5 The proportion of household incomes derived from agriculture, and probably the absolute amount, is declining in northern communal areas.[26]

6 See chart in appendix 1 of transhumance patterns from the Cuvelai area.

* **livestock numbers have generally risen.** There are approximately ten times as many cattle now in Namibia as eighty years ago.[(7)]

* **sedentarisation of people and livestock** has led to year-round grazing near settlements;

and as accessible, watered, grazing areas become crowded or degraded:

* **marginal and seasonal grazing areas have been opened up to year-round grazing through installation of water points,** particularly in drought years.[(8)]

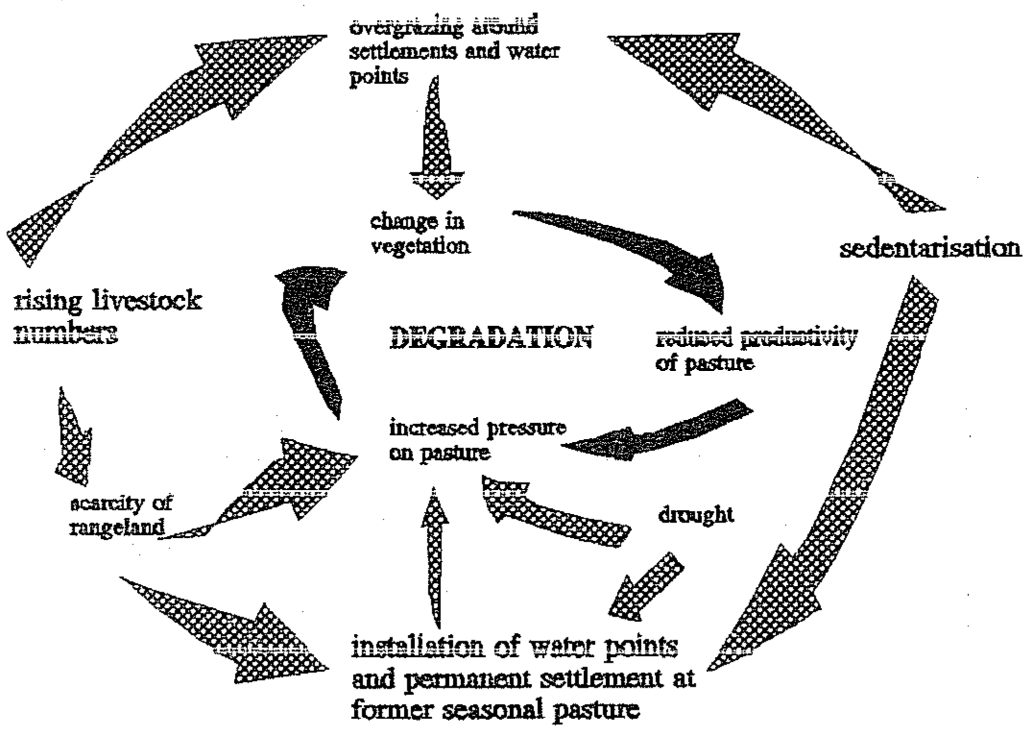


Figure 8: cycle of rangeland degradation

7 There were an estimated 213,000 cattle in 1913, compared to estimates of 2.6 million in 1979, 1.8 million in 1983 (following drought) and 2.1 million in 1990. The total number of cattle, sheep and goats was estimated at 9.1 million in 1979/80, and 7.1 million in 1990, with approximately 48% of cattle, 10% of sheep, and 67% of goats in communal areas in 1990.[2] However, data from the Cuvelai drainage area, suggests that cattle numbers have either stagnated[26] or increased more slowly than population[29] over the last 30 years, therefore the ratio of cattle to people has fallen.

8 For example, in Uukwaluudhi, on the western edge of the Cuvelai, farmers and cattle have moved in from both the alluvial plains to the east and Kunene to the west, to settle at former seasonal cattle post.[15] The changes around settlements and cattle posts exacerbate each other: deterioration in grazing around settlements forces farmers to post their cattle permanently at cattle posts; but settlement and fencing-off of cattle posts, forces other farmers to keep cattle near home because they lose routes and areas previously used for transhumance.

DEGRADATION AND CARRYING CAPACITY IN HEREROLAND[13]

A recent survey for SARDEP found widespread degradation of rangeland in Hereroland. It reported:

Evidence of degradation

> "the grass is virtually absent within a 5km radius of every village"
> Some areas "have been so badly degraded that few animals can be supported at all."
> "Within 1-2 km of the village ... goats and cattle have removed all the browse they can reach. In the same area the indigenous invasive dicot, *Sida cordifolia,* replaces the natural grass."
> "In the northwestern part of Hereroland, near Otjituuo, bush encroachment is particularly severe, some farmers reporting that they have abandoned their farms for this reason."

Resulting decrease in carrying capacity?

There is a paradox: the total stocking rate is only 73% of the purported capacity: with a recommended stocking rate of 10 ha per LSU, the occupied area of 38,000 km^2 should be able to support 380,00 cattle. It currently supports 277 233 LSU equivalents, and yet signs of degradation associated with overstocking are evident. This may result from:

"- incorrect data
- concentration of livestock near water leaving other areas unused
- recommended stocking rates are too high in the light of the existing high degree of degradation and/or inappropriate management systems."

The third option implies that given management systems, actual carrying capacity has fallen below the earlier estimated rate.

Causes of degradation

A comparison of 2 neighbouring areas in Epukiro East -- Ombondiro (lightly stocked and populated) and Owetjombungu (more densely stocked) -- indicates over-grazing as the immediate cause.

> "Owing to the fact that Ombondiro has been fenced off since 1977/8 and is occupied by few people with few livestock, the environment at Ombondiro is in good condition. The relatively good state of the environment is clearly evident in satellite imagery as well as on the ground, and is in marked contrast to the adjacent Owetjombungu which is more typical of Hereroland in that it has been overstocked. Ombondiro has a good cover of grass, higher plant species diversity (particularly geophytes and dicots), and a higher proportion of perennial grasses compared to the relatively sparse grass cover evident at Owetjombungu. Bush encroachment was also less within the fenced area of Ombondiro."

Over-grazing is partly caused by increasing numbers of livestock: cattle numbers have increased by 18.4% and 15.1% respectively in Hereroland East and West between December 1985 and December 1991. The rangeland carrying capacity is estimated at about 8-10 hectares per LSU, but where livestock farming is being practised, this capacity is usually exceeded, sometimes by as much as double that recommended. But over-grazing is not only due to high overall numbers, but concentration of stock around water points, and lack of herding and rotational grazing: i.e. mis-management.

Hence the conclusion that:

> "the principal causes of environmental problems are related to too large a human population endeavouring to maintain livestock numbers that are inappropriately high given the management techniques used."

The report recommends a broad-based programme to promote sustainable production by improving land-management while diversifying resource-use and rural incomes.

Box 1

Population growth is clearly only one causal factor. More people creates pressure for more cattle, water points, drought relief etc. With farmers seeking out new grazing land, it is more difficult for local communities to manage land use, set aside land for rotational grazing, or in general act for the long term. However, degradation has occurred on commercial lands and in previous decades[14,12,1] with lower population densities. Land scarcity is also a result of unequal access and of lack of water in potential grazing areas, while the uneven distribution of stock, and excessive pressure during drought years are essentially a result of **poor land management which allows over-grazing and fails to respond to climatic cycles.** This is associated with a complex web of factors including unplanned provision of water points and drought relief, decline of communal resource management, application of inflexible farming techniques etc.

The result of too many cattle grazing for too long is to reduce the productivity of the veld in the long term[1,20,13] by, for example:

* **loss of vegetation** particularly around settlements, water points, rivers and roads (for example, see Box 1 on Hereroland);

* **less productive grass**: excessive grazing reduces the balance of perennial grasses relative to annuals, which in turn reduces the overall productivity of the land because annuals respond more slowly to rainfall and require more rain to trigger germination and growth;

* **spread of poisonous invasives:** for example in some areas of communal grazing land around Gibeon, the milk bush *(melkblos)* is spreading. It appears to flourish in degraded areas and to repress growth of grass around it.[29]

* **bush encroachment** can be seen on many commercial farms in the east and central areas, affecting an estimated 8 million hectares in total.[1] Over-grazing is one cause, combined with other factors that prevent grass regeneration or encourage woody vegetation. The result is that unpalatable and impenetrable bush encroaches on grazing land.

* **soil erosion** is exacerbated by loss of vegetation and trampling. In other cases, soil around water points becomes compacted and impermeable, reducing water filtration and making it difficult for vegetation to recover.[29]

The resulting loss of productivity has not been measured (and is debated, as indicated in Box 2). Nevertheless, it has clear implications for the question of whether the land can support **increasing** human populations through livestock production.

<u>Future constraints and prospects</u>

The above description of problems suggests that grazing land is already "over-populated" today, in that productivity is being degraded. It also appears that already cattle, if not other livestock, are sustaining fewer people as ownership becomes more concentrated: surveys in former Owambo report only half of households own cattle[32,7]. Further degradation and scarcity of rangeland are likely to exacerbate competition and increase this trend.

IS PRODUCTIVITY OF RANGELAND BEING REDUCED?

The fact that livestock numbers are still generally increasing leads some to argue that localised loss of grazing is not reducing the capacity of the veld to support cattle or people. But although changes in productivity are not necessarily immediate, directly proportional to physical change, or easy to measure, indications of lost productivity include:

* constant or rising livestock numbers can only be maintained at **increasing cost:** the government is paying for water points and systems; communal farmers are spending more on transport, diesel and herders to maintain cattle at more distant posts; and some commercial farmers face high costs for clearing bush encroachment.

* from a pastoralist perspective, the same number of cattle now provides **fewer benefits**: households get much less milk, manure and traction from cattle that have to be kept at distant cattle posts. Some have switched to goats for milk and donkeys for traction.

* localised loss of vegetation and soil erosion may not significantly affect cattle numbers during years of average rainfall, but rather **exacerbate losses during drought or slow recovery after drought.**

* lower quality pasture, longer distances between watering points and grazing areas, or toxic invasives affect **animal health** which can in turn reduce milk production, resistance to disease and drought, and carcass value.

* some farmers suffering heavy bush encroachment are in no doubt that stocking rates have fallen considerably -- in some commercial areas from 10 ha per LSU to 40 ha.[4]

* regional estimates of long term average carrying capacity have been revised downwards. In the late 1970s, the maximum capacity of the Damara Communal area was given as 84,000 LSU, which was just 46% of the carrying capacity estimated in the Five Year Plan produced by the Directorate of Veterinary Services in 1966. Similarly, recent estimates for the Nama communal area are half of the 1966 level. This may well imply that carrying capacities in communal areas today are much lower than in the sixties.[1]

As livestock costs rise and competition for grazing land intensifies, it becomes more difficult for poorer households to maintain herds, so the number of people supported falls.

Box 2

The constraints to increasing total livestock output are severe:

* restoring degraded land is difficult. For example, the cost of removing bush encroachment often far exceeds the market value of the land[27] or the potential increase in beef production;[29]

* avoiding further degradation will involve substantial farming changes. For example: low human and stock densities, rotational grazing, use of species adapted to arid conditions and variable rainfall, rapid de-stocking during drought, management of water points, and sophisticated monitoring to facilitate this.[5] These, in turn, will require changes in cultural values regarding cattle; secure land use rights to encourage long term pasture protection; organisational and institutional change; development of skills and appropriate extension services, and many other changes that could only occur over the long term.

* our understanding of how to sustainably manage higher stock densities is incomplete, through new methods are being tried (such as intensive rotational grazing or "holistic natural resource management").

* productivity of arid pasture cannot be increased with modern technology in the way that equipment in Europe and "green revolution" chemicals and plant varieties in Asia increased crop production per hectare. Attempts to increase output of arid pasture land can be counter-productive, because excessive pressure can set in motion a cycle of environmental degradation.

* grazing areas with naturally-occurring water are already insufficient. Former Owamboland, Kavango, and Hereroland have an estimated total of about 11 million hectares of land unused by stock due to lack of water.[1] However, opening up new land will involve high infrastructure costs that may exceed the value of livestock that could be produced. Such developments would only be sustainable if improved management techniques prevent excessive and inflexible stocking rates.

* recurring drought periods of sparse vegetation requiring reduced grazing pressure cannot be avoided.

* if commercial land was re-distributed to communal farmers it could, theoretically, support a larger number of households. But in practical terms, any increase would be small relative to population growth. At present, commercialisation of a few large communal herds appears more likely than communalisation of large tracts of commercial land.

Nevertheless, there is some potential to increase the overall value of livestock output from the land:

(i) **New land and under-utilised land**
Pockets of underutilised land -- such as northeastern part of former Hereroland, grassland to the north of Etosha National Park, areas in the Ohangwena, Okavango and Caprivi regions, and private land owned by absentee landlords -- could be utilised more productively, if appropriate systems of land use and water supply and use were developed.[(9)]

(ii) **Better use of pasture through sustainable management practices.**
As mentioned above, many measures could and should be taken to restore soil and pasture productivity and prevent any further degradation, though these require far-reaching changes in practice. The Ministry of Agriculture has established the "Sustainable Animal and Rangeland Development Programme" (SARDEP) to encourage such change.

(iii) **Increased value from livestock**
The economic value of any given number of livestock could be increased through improved animal health, higher quality, slaughtering at optimal times, access to

9 However, apparently-unused land may have current value in ecological cycles and drought-coping strategies, which need to be taken into account. Installation of water would increase productivity in the short term, but the long-term increase needs to be critically assessed.

higher-priced markets, and greater processing[(10)].

(i) involves the first strategy outlined in Section C -- exploiting new resources, while (ii) and (iii) represent the second strategy of increasing productivity. However, whether these actions would sustain **more people** depends also on the use of rangeland per person, and particularly the distribution of livestock and access to grazing between farmers.

Whether such measures could increase the value of livestock output as fast as population grows remains in doubt. But it is clear that without changes in land and livestock management, the future trend is towards further **reduction** rather than improvements in carrying capacity as population grows.

D.2. CROP PRODUCTION

In the Cuvelai drainage area, where population density is high and seasonal water available, production is mainly of millet for subsistence, with some sorghum, maize, beans and vegetables. Commercial crop production is found around the Tsumeb, Grootfontein, Otavi triangle, and in the south at the Hardap irrigation scheme. Namibia is not self-sufficient in staple foods, importing the majority of wheat, maize and vegetable requirements from South Africa. Nor are communal crop-producing households self-sufficient: commercial maize-meal is imported to crop producing areas to bridge the deficit in most years. i.e. crop production has already fallen behind population growth. The question is, to what extent does population pressure cause land degradation and what are the future prospects given further population growth?

Recent trends: scarcity and degradation of land

According to a 1990 report on agriculture in the north, "household crop production may be in secular decline in Owambo. Arable farming in the region is stagnant, and it is certain that agricultural incomes per capita have declined absolutely in recent years."[26] Population growth has led to:

* **scarcity of arable land**
  Most arable land in the Cuvelai area is already being used for cropping and progressively more marginal land is being settled.[20,15] In Okavango, approximately half the farmers interviewed in a 1992 survey identified lack of land as a constraint to increased crop production.[36]

* land scarcity in turn leads to **degradation of arable land**
  land scarcity results in greater pressure on the cropped areas. For example, in Okavango, traditional techniques of slash and burn with minimal crop rotation and

10 However, this would require infra-structural investment, and it should be noted that communal livestock currently has economic value apart from its meat sale value (milk, traction, social value, etc.) and a shift to a more commercial approach to achieve higher market returns involving higher off-takes, processing, export markets, etc. could decrease some of these other values.

manure application were appropriate when farmers could switch to new fields every few years, but lead to reduced yields now that they are confined to the same field. Research indicates that the most productive arable land has already been over-utilised: millet productivity is no higher in riverine villages than inland areas, suggesting that the inherent advantages of alluvial soils have been eroded over time. Also, land distant from villages (which has been farmed less intensively than land nearby) is significantly more productive.[35]

* other changes associated with population pressure, particularly deforestation and rangeland degradation, exacerbate the loss of productivity by constraining women's time (through fuel collection), availability of dung for manure (fewer less accessible cattle, and use of dung for fuel), and availability of oxen for ploughing. A 1992 survey found that millet yields for women-headed households were less than three quarters those of male-headed households.[4] The difference is most likely attributable to their greater scarcity of time, manure, and ploughing animals.

Reported yields are around 250 - 2,000 kg[15,26,29] of millet per hectare, or 4-8 months[15,29] grain supply from a 2-3 ha family field. Therefore farming households have to maintain subsistence through other means -- commercial purchase of 3 months supply of mini-meal would cost a household of 6 in Omusati around $330[29] -- almost 3 months' pension. The effect at national level is increased imports, and increased reliance on commercial crop production (including irrigated production -- the nation's biggest consumer of water).

Future constraints and prospects

This shortage of unused arable land, and degradation of existing land, will severely constrain the potential to increase crop production in line with population. On the other hand, productivity is low by international standards, even for such sandy, infertile soil, and an overview of the multiple causes of low productivity indicate that some could be addressed.

Key constraints include;

* low and variable rainfall;

* infertile, sandy, soils, vulnerable to salinisation, with little potential for boosting yields through artificial fertilisers or irrigation. 95% of the country is classified as having little to no irrigation potential[8] and even in those limited areas with theoretical potential, the capital and operational costs of delivering irrigation water would generally exceed the value of potential produce. Caprivi is an exception, with 10% of the land assessed as having moderate to good irrigation potential, but there the problem is distance from markets for produce.

* few farmers adopt improved cultivation practices, such as inter-cropping, agro-forestry, mulching and water conservation. For example, 90% of households surveyed around Uukwaluudhi make no use of waste water although crops grow close to the home;[15]

* farmers lack access to equipment, seeds, and seasonal labour and oxen for ploughing. In the same Okavango survey, the major constraint identified by the vast majority of households was lack of equipment, particularly ploughs.[36]

* there is a shortage of seasonal labour, particularly for ploughing and planting, due to male migration, multiple pressures on women's time, and the low returns to investing time in crops.

This suggests that there is virtually no scope for bringing more land under cultivation to keep up with population growth (strategy 1), but there is limited scope for increasing productivity (strategy 2) by addressing the second and third constraints. i.e. researching and encouraging improved cultivation techniques, and promoting access to equipment. In turn, higher yields plus labour-saving investments could partially alleviate the labour constraint. The fact that non-poor households in Okavango on average gain higher millet yields per hectare suggests that such investments can increase productivity[36] despite low rain and soil fertility. Other measures to increase the value of cropping, such as reduction in post-harvest losses, and crop drying, preservation, processing and marketing are also essential if limited land is to support growing numbers. The costs and benefits, in terms of financial and physical resources, household and national food security, of such investments in communal cropping need to be compared with costs and benefits of alternative strategies, such as continued imports and public support for commercial agriculture.

D.3. FOREST, TREES, AND OTHER VEGETATION

Though only 20% of Namibia is classed as woodland, 80% of the land supports trees and shrubs. These woodlands and savannas are essential to environmental stability, sustainable agricultural production and food security, because they protect watersheds, facilitate groundwater recharge, stabilise soils against wind and water erosion, and support bio-diversity. In rural areas, trees are vital sources of construction timber and cooking fuel. They also supply shade, material for household implements, fruits and nuts for nourishment, bark, leaves, berries and roots for medicine; and a habitat for edible caterpillars and birds.

Not only trees but other wild plants are a vital resource for many households. For example, in the Cuvelai basin wild spinach and tubers add to nutrition and food security, particularly in times of drought.[20] Indications of diminishing availability of wild foods are anecdotal rather than carefully documented.[(11)] The rapid disappearance of trees and woodland is more evident to the naked eye and more clearly documented.

11 for example, during field work in 1994, a women selling wild spinach cakes at a market in Oshana region reported that she could harvest ten times as much decades ago. Mopane worms sold in Oshakati market come from Angola, indicating scarcity nearby.

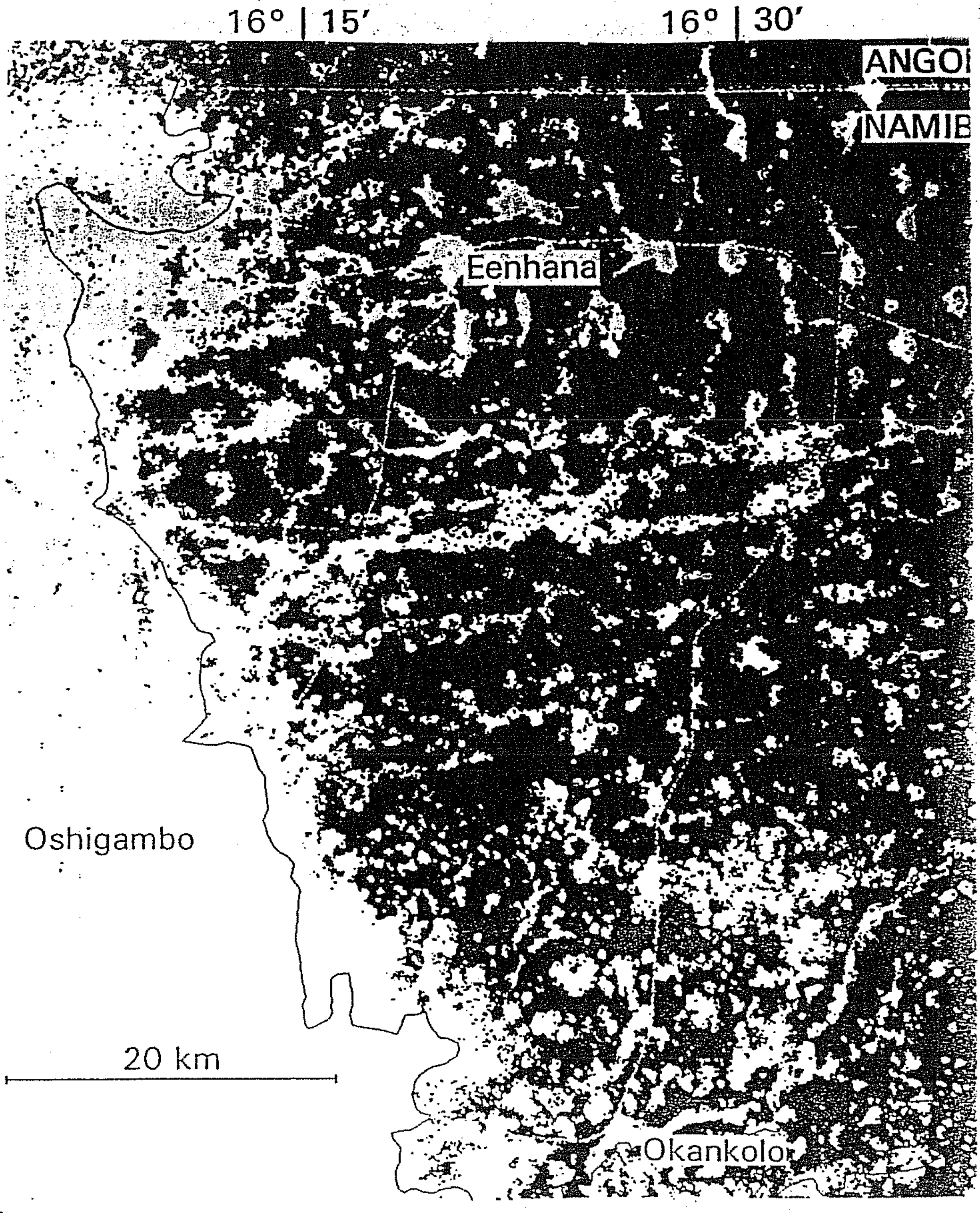


Figure 9: Deforestation of dry deciduous forest in Owambo

Comparison of the forest edge recorded by satellite 1989 with the boundary recorded on topographical maps in 1975 suggests the boundary has moved eastwards. Light patches indicate that the uniform forest areas are breaking up into smaller woodlots.

Source: South West Africa 1:250 000 topographical sheet 1716 Eenhana, second edition, 1975. Landsat MSS image of 1989. Interpreted at University of Joensuu.

Reproduced from Erkkila and Siiskonen, 1992

Recent trends: deforestation

Though woodland is, in theory, a renewable resource, in practice human exploitation has far exceeded the rate of renewal. Destruction of woody vegetation was first recorded from the area around Walvis Bay. Uncontrolled felling of trees started before the German colonial period and continued until supplies were exhausted.[12] This century, dramatic deforestation has occurred in the northern communal areas, where growing populations have converted former dense woodland into low shrubland and grazing ground. For example, in 1866, missionary Hugo Hahn recorded a 60 km belt of mopane woodland between the Uukwanyama and Ondonga kingdoms. Fifty years later the belt was 40 km wide, and in the 1950s, 10 km wide. Today it no longer exists.[12] Figures 9 and 10 give indications of the extent of deforestation and loss of vegetation in the central Cuvelai area. In contrast, key fruit-bearers, such as marula *(sclerocarya caffra)* and *Berchemia discolor* have been protected and are planted within homesteads. Deforestation has also been acute along rivers on the northern border with Angola because rivers attract people and river terraces provide good soils for cultivation. For example along the Okavango, about 70% of riparian forest has been lost, and with it associated forest species.[21]

The main causes are clearance of land for agriculture and felling of trees for timber.[(12)] For example, around Oshakati and Ondangwa, mopane woodland has been transformed into 1-2 metre-high shrubland and cultivated fields.[12] In the north, 80% of homes are built using indigenous timber and thatch, and traditional Owambo construction methods which are estimated to consume more wood than any other form of traditional architecture in southern or central Africa[(13)]. This has put great pressure on the most popular termite-resistant hardwoods, such as mopane *(Colophospermum mopane),* leadwood (*Combretum imberbe*), purple-pod terminalia and silver terminalia (*Terminalia prunioides and sericea*). As timber becomes more scarce, people build fences with smaller trunks and branches, and less resistant woods which need faster repair and replacement (3-4 years instead of 6-50). Hence felling of more trees, more frequently, becomes necessary.

Hardwoods are also the favoured fuelwood, but as they become more scarce, other woods and biomass are increasingly used. Consumption of fuelwood is estimated at 850,000 m^3 in the former Owambo and Okavango regions, 150,000 m^3 in the other communal areas, and 250,000 m^3 in commercial areas.[36]

The extent and impact of deforestation is evident from:

- reported haulage distances for timber and fuelwood of 30 to 40 km.[12] Traders are felling trees in the less populated areas of the north, such as Uukwaluudhi, to transport and sell to the centre.[15] Households that have their own vehicles or donkey carts increasingly use them for collecting wood rather than going by foot.

- increased use of other fencing materials: wire, mopane brushwood, palm leaf stems.[20]

12 Cutting live trees for firewood is unusual, but may be occurring more frequently due to fuelwood commercialisation.

13 Total construction and fencing of a typical homestead requires 21 600 poles -- 100 cubic metres of wood.[12]

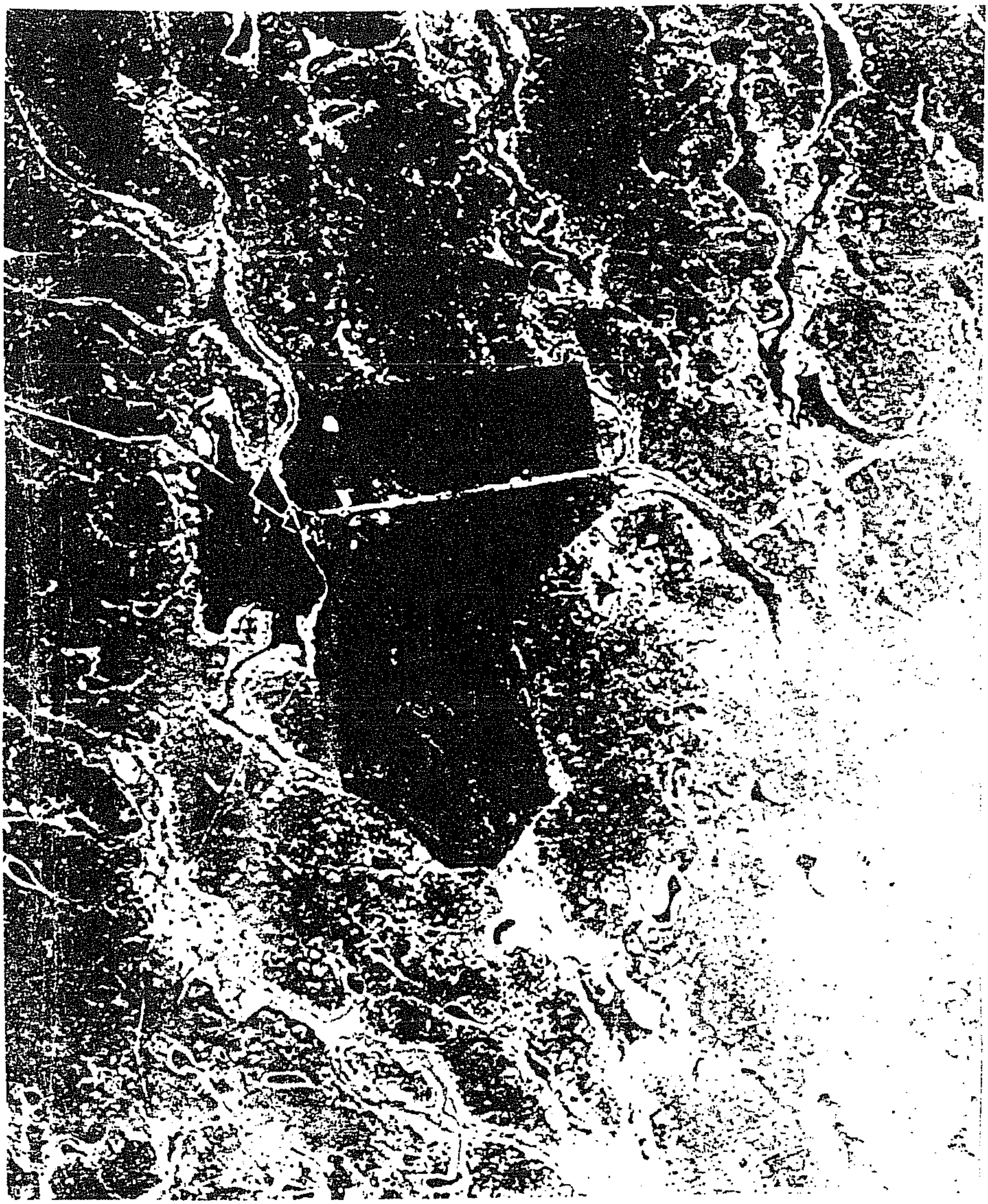


Figure 10: Satellite image of northern Namibia showing vegetation loss
The satellite image shows the contrast in vegetation between the populated areas around Ogongo Agricultural College in Omusati Region, and the relatively undisturbed vegetation inside the college. Satellite images of the Namibian--Angolan border show a simarly sharp change in vegetation between the heavily-populated Cuvelai basin and less densely populated southern Angola.

Credit: National Remote Sensing Centre

- increased use of alternative, less desirable cooking fuels (crop residues which emit more smoke and less heat; cattle dung which could be used as fertiliser)[14]; development of a commercial market in fuelwood; and reduced use of fuelwood[15].

Future constraints and prospects:

It is clear that human pressure has caused extensive deforestation. As a result, the timber and fuelwood supply has already fallen well behind population growth. The worst impact is on those who can least afford to purchase commercial alternatives, and have to spend longer collecting supplies or reduce consumption. Indirectly, everyone suffers through environmental affects such as soil erosion and destabilisation of river banks (see Section E.3.).

The prospects for reversing deforestation do not look good. The need of growing populations for agricultural land, building material, and cooking fuel is inescapable. The cost of commercial substitutes is beyond the means of most: e.g. $60 per month for fuelwood, over $2,000 to fence a 3 ha farm with wire and poles, in Oshikoto Region. The only way to assist people to cope with diminishing supplies, and to limit further degradation, is to promote alternative building materials and cooking fuels, improve forest management, and increase awareness (i.e. reduce consumption -- strategy 3; and improve productivity -- strategy 2). At present, traditional construction continues, use of solar or electric energy for cooking is a distant prospect, and local management of land clearance and forestry practice is weak. However, this doesn't make change impossible. The constant or even increasing population of fruit-bearing trees within homestead areas, indicates that tree planting and conservation is possible if people have the economic incentives and opportunity. The coppicing vigour of mopane means that coppice forestry has great potential in some areas. The Directorate of Forestry and other organisations are initiating research and fieldwork with communities. Without such change, the human and environmental costs of growing population and tree use will escalate.

D.4. WILDLIFE

Recent trends: disappearance

Perhaps the most dramatic recent decrease in natural resources has occurred in the wildlife population in the north. A 1991 survey reported: "Large mammals as a group have become virtually extinct in Owambo in the last half century. This region which harboured a diverse large mammal community in recent times has the worst record of species loss anywhere in Namibia."[19] In just 50 years, several large wildlife species including zebra, elephant, oryx,

14 for example, a high proportion of residents of Onaanda report using dung, tree roots, makalani nuts and small shrubs as their primary source of fuel, whereas in the past these were only reserve fuels.[4]

15 for example, in the most densely populated part of Uukwaluudhi district, where over 50% of households have to travel over 5km in search of fuel, wood is not used for lighting. In contrast, further west in less settled areas, a majority still use wood for lighting.[15]

springbok, and a 25,000-strong herd of wildebeest have disappeared from the region (except for those remaining in Etosha National Park who occasionally stray into the northern areas).[20] The decrease is mainly due to loss of habitat to humans and livestock, hunting, and fencing. In other communal areas, less dramatic decreases have been observed.[30] With the loss of mammals, hunting and trapping of birds has increased.

However, the pressure of growing human population and land use is only one cause. With exceptions, wildlife can be complementary to livestock under appropriate management strategies. But it has not been a commonly-managed resource, so utilisation has been well above sustainable levels. This is because communities have had neither the rights nor incentive to manage wildlife. In contrast, in commercial farming areas wildlife numbers of some species have risen in the last 20 years. This is not so much due to low population density, as to economic incentives which were provided to commercial farmers under a 1967 ordinance. Farmers can profit from game culling for sale or own use, live sale, game hunting, and photo-tourism, so they have an economic incentive for wildlife conservation. Similarly, some densely populated areas of industrialised countries enjoy high populations of wildlife, because of their economic value.

Future constraints and prospects

The implication is that population growth could be compatible with a growth in wildlife numbers in some areas, if communal farmers have rights and management structures to utilise and profit from wildlife, whether through subsistence hunting, commercial sale, or tourism. This is the rationale underlying the Ministry of Environment and Tourism's proposed policy to establish "conservancies" - a defined area within which communal residents manage their own wildlife.

Combining livestock and wildlife generally increases the overall carrying capacity of land, because wildlife has different grazing, browsing and watering behaviour, and is well-adapted to arid climates. On prime wildlife land, returns from photo-tourism are estimated to be significantly higher than from agriculture.[(16)] Revenue from game, whether from hunting, culling, or tourism, is also subject to different cycles than livestock farming, so enables poor households to diversify their income and risk. Increasing wildlife numbers can therefore be an appropriate response to the challenge of supporting more people from limited productive land.

However, there are also constraints to this. Communal management systems that regulate hunting and consumption by individuals are needed. This is more difficult if outsiders are moving into the area. In addition, a switch to commercial game utilisation from stock farming requires changes in skills, transport, marketing and infra-structure, etc.

16 A forthcoming Directorate of Environmental Affairs Discussion Paper on the economic potential of wildlife utilisation will give details and examples.

E: WATER RESOURCES AND POPULATION GROWTH

Apart from the rivers on the northern and southern borders, and an abundance of water in the ocean, Namibia suffers from an acute scarcity of water. Of the rain that falls, it is estimated that 83% evaporates, and 14% is transpired by plants. This leaves 2% to enter drainage systems where some can be harvested from reservoirs, and just 1% to re-charge groundwater resources[8(17)] (Figure 11).

Recent trends: water scarcity

Namibia's population and economic activity have already reached such a scale that the 3% that enters drainage and groundwater systems is insufficient to meet water needs. Ground water sources meet about 57% of water demand and surface reservoirs about 20%. The remaining 23% comes from perennial rivers on the borders.[21] Currently they service mainly towns and villages along the bank, but in future they will have to meet increased demand nationally, as exploitation of ground and surface water supplies will reach their limits.

The ultimate resource base -- rainfall -- cannot be either increased or depleted (cloud seeding and global warming aside), but the available resources, particularly ground water, are vulnerable to degradation. Run-off and infiltration can be disrupted, for example by dams or soil erosion. If extraction from aquifers exceeds the long term rate of recharge, the water table drops. This not only threatens future water supply, but can provoke many other changes in the eco-systems on which life depends. There is evidence that over-use of ground water sources has already occurred: for example in the Kuiseb River, the water table was 2-3 m below the surface before increased abstraction began in the early 1970s to supply coastal towns and mines. Today it is about 13 m below the surface and only 4 m above the bedrock[21] so abstraction has had to be dramatically curtailed. Trees that have survived hundreds of years and several droughts are dying, indicating that the drop in water level is unlikely to be drought related.

Population growth is one of many factors creating increased demand for water. Total demand also depends on the rates of urbanisation and rising living standards (both of which are associated with higher per capita water consumption) and demand of productive sectors, including livestock, irrigation and industry. As Figure 12 shows, irrigation and livestock currently account for the bulk of water consumption. The 7,000 ha currently irrigated require an average of 15,000 m^3 per ha per year.[8] Figure 14 indicates that irrigation will still be the largest consumer in 2005. The impact of these other sectors on the sustainability of Nambia's water supply must be borne in mind in the following sections on the impact of population growth on water resources (dealing separately with urban consumers, rural consumers, and protection of water resources).

17 Estimates from Water Affairs.[8] In wetlands, more water is lost through evapotranspiration than evaporation.[34]

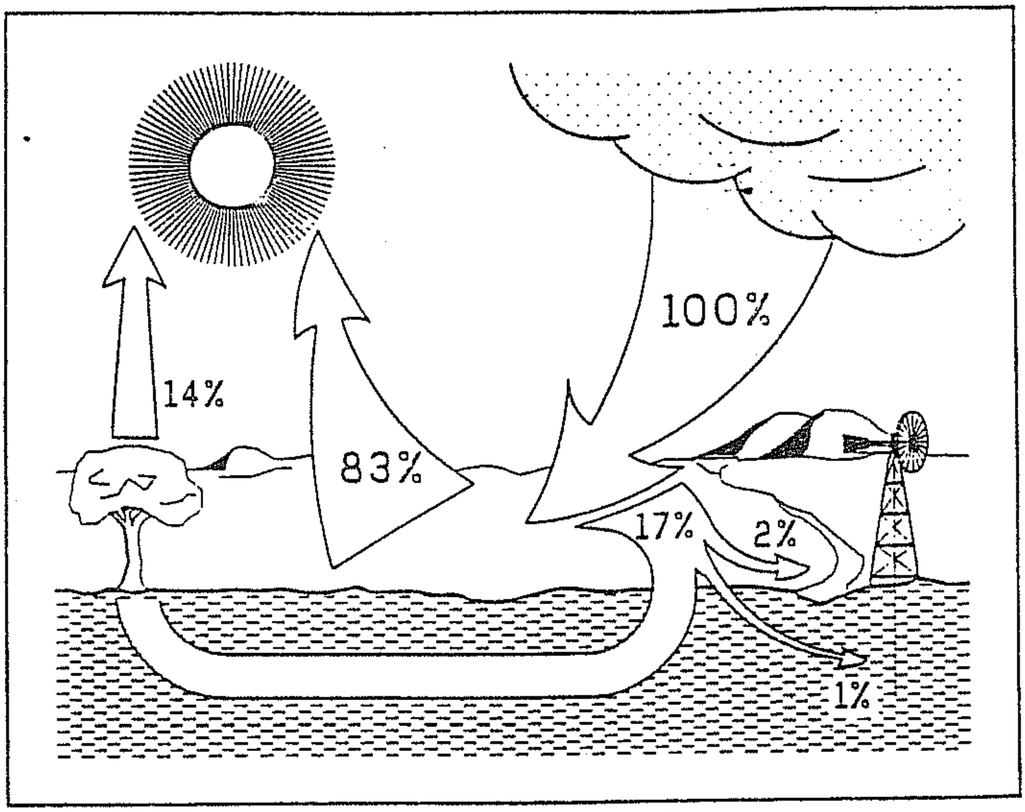


Figure 11: The hydrological cycle in semi-arid Namibia
Reproduced from Department of Water Affairs, 1991

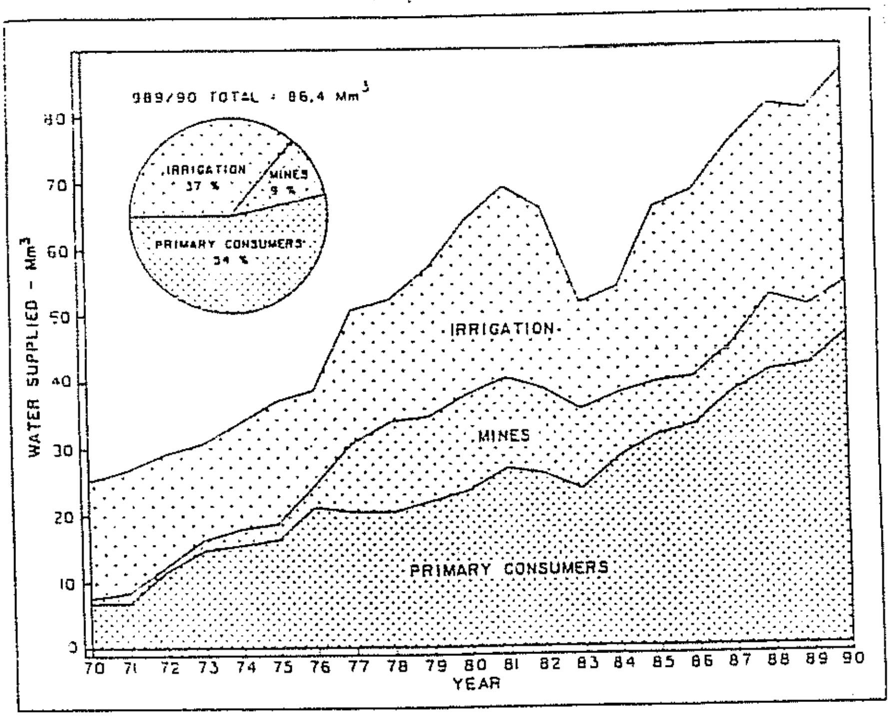


Figure 12: Water supplied by the state to major consumer groups, 1970-90
"Primary consumers" represents domestic and industrial urban consumers, rural residents, and livestock. In 1990, the share of total water consumption by these groups was 17%, 11%, and 25% respectively.

Reproduced from Department of Water Affairs, 1991

Location	Characteristics	Water consumption (litres per person per day)
Rural	With nearby standpipe or own well	25
Urban[1]	Squatter Low income Middle income High income	25 70 200 615

Figure 13: Water Consumption per person, by income group and residence

1: based on figures for Windhoek, 1991. Estimates used for planning purposes by DWA are lower.
Source: Department of Water Affairs, 1993

CONSUMER	DEMAND ON WATER SOURCES (Mm^3)							
	Perennial Rivers		Ephemeral Surface		Groundwater		TOTAL	
	1990	2005	1990	2005	1990	2005	1990	2005
Domestic	12.6	40	13.4	30	41.0	45	67	115
Stock	3.7	10	-	-	60.3	65	64	75
Mining	2	10	2.5	10	7.5	10	12	30
Tourism	-	2	0.3	1	0.7	2	1	5
Irrigation	39.7	95	33.8	50	31.5	30	106	175
TOTAL	58	157	51	91	141	152	250	400

Figure 14: Estimated Future Demand on Water Resources

The table indicates that the fastest growth in demand is expected amongst domestic consumers, but irrigation will still be the largest consumer by 2005. Most of the increase will be met by increasing supply from perennial rivers (by 170%), with a smaller increase in supply from ephemeral surface water and virtually no increase in supply from groundwater.

Reproduced from Department of Water Affairs, 1991

E.1. URBAN WATER SUPPLY

In the 1980s, urban populations grew three times faster than rural populations, due to urban migration.[28] Between 1981 and 1991, Windhoek's population grew by 46%, Rundu's by 911% and Katima Mulilo's by 3000%.[11] Urbanisation puts increased demand on water supply, because most urban people consume more water than rural residents, and are concentrated far from scattered water sources. However, the pressure on water resources depends not only on the rate of growth of urban populations, but on their income group, the extent to which municipal water services meet their needs, and associated industrial growth. High and middle income Namibians consume 25 and 8 times more water per day than urban squatters (or rural residents)[9], because they enjoy more washing machines, swimming pools, and well-watered lawns (Figure 13). Since Independence, Windhoek's water consumption has grown even more rapidly than population, largely due to the influx of high income residents and foreign missions. In coming years, overall population growth is expected to continue at around 10%, but water consumption may grow more slowly because low-income migrants cannot afford or access water services.[9]

Whether urban populations swell with better-off, high-water-consuming residents, or low-income residents, there is no doubt that continued urbanisation will multiply urban water demand in coming decades. According to the Central Area Water Master Plan, which covers an area of 246 000 km^2 including Walvis Bay, Windhoek and Rundu, two thirds of the urban population and one quarter of the rural population, water demand in 2020 is expected to be 3.6 times current levels. An additional 144 Mm^3 of water per year will be needed.[9]

Can Namibia possibly meet these demands? The answer is probably yes, just, for the next 30 years, but only by using up local supplies and drawing on more distant water sources and advanced technology, at ever-increasing cost and energy input. The increased water demand can only be met by adopting three complementary strategies: making better use of existing resources; tapping new water sources, and reducing per capita water use (i.e. strategies (i), (ii) and (iii)).

Maximising the sustainable yield from the existing resources requires hydrological monitoring and planning of optimal use, prevention of soil erosion (as siltation reduces recharge of alluvial aquifers), recharge enhancement measures, and reliance on a diversity of water sources. For example, the innovative Omdel dam in the Omaruru river stores water underground in order to minimise evaporation and increase recharge. Such measures enable the limited resources to support more people within the constraints of sustainability. However, what is sustainable from the perspective of national water supply, may nevertheless be unsustainable and create localised environmental impacts at the location of a borehole or dam.

Second, urban residents will become reliant on new water sources: the Okavango River for the central area and, eventually, the ocean, through desalinisation, for coastal towns, and The former involves transporting water over long distances, and both will require much higher energy inputs and costs per unit of water than current water supply systems. The estimated cost of supplying water will rise from approximately \$4 per m^3 at present, to \$6-8 for desalinated water and \$7-10 for water piped from the Okavango. The necessary infrastructure, power generation, and possible interference with the ocean and river, may well have adverse environmental implications.

The third element, water conservation, must become a way of life, rather than a temporary concern during periods of drought. There is considerable scope for conservation by richer urban residents, whose current water consumption is high by international standards. Higher prices that reflect the real economic and environmental costs of water, and public education, are needed to encourage efficient use. The Windhoek, Swakopmund and Walvis Bay Municipalities already make use of recycled effluent, and Windhoek is increasing prices to users. Economic pricing would also encourage more efficient water use in industry and agriculture, and over time will swing the balance of industries towards those using relatively less water compared to other inputs.

E.2. RURAL WATER SUPPLY

Increasing rural populations also place increased pressure on water resources, not only in terms of how much water is needed, but also where it is supplied and how used.

a) Water demand

In rural areas, 75% of people still depend on wells, boreholes, rivers, canals, and lakes for drinking water.[28] Given the effort required to secure water, estimated consumption is relatively low at 25 litres per person per day.[9] Nevertheless, growth in rural population puts pressure on water resources because:

* an important aspect of rising living standards is improved access to water. As access increases, so does consumption. As development aspirations are met, so rural domestic water consumption will grow even faster than the rural population;

* livestock consume more water than rural people (45-55 litres per LSU per day).[9] To the extent that a growing rural population results in a growing livestock population then water demand will increase further;

* crop irrigation is highly water intensive: a 1 ha plot of irrigated land uses as much water as nearly 1,000 cattle or 1,600 rural residents.[8] If growing rural populations bring more land under irrigation, water consumption will rise further;

The rural population in the north is already too large to be supplied solely from ground and surface water. For example, the layer of fresh groundwater (Main Shallow Aquifer) that sits on top of a brine lake in the Cuvelai used to be sufficient to support the local population. But as off-take increased, the layer shrunk and residents find only brackish water for increasing months of the year. In the western sandy plains, where the majority of households rely on omufima (wells), people complain they have to dig deeper and deeper every year as the water table is dropping.[15] In order to meet demand for piped water in the Northern regions, water is being piped from the Caleque dam on the Kunene River in Angola. The Department of Water Affairs (DWA) plans to upgrade and extend this piped network to double the quantity of river water extracted.[3]

While increasing households' access to clean and reliable water, water conservation measures to encourage more efficient use of this valuable resource are needed. Rural water prices must be low to be afforded, but a low price is much better than no price: those who pay nothing for water (in time or money) are likely to use many times more litres, much less efficiently, than those who pay a nominal amount[18].

b) Water supply and usage

To cope with increasing rural population pressure and settlement into new areas, the DWA aims to create 300 new rural water supply points each year for the next ten years.[10] Irrespective of the increase in **volume** of increased water used, the major environmental impact of meeting rural water demand depends on the **location and use of new water points**. Often new water points are provided in areas that were previously used only for seasonal grazing. This is for a number of reasons including human and livestock population growth, which push farmers to settle more marginal areas, and periodic drought, which leads to calls for water points in areas where expected seasonal grazing has failed. Once the water point is in place, access to piped water is such a benefit that many more people and stock settle there (a water point for "emergency drought relief" is not removed after the drought). So an area that was previously used for seasonal grazing becomes an area of permanent grazing. As described in section D above, the result is often over-grazing and soil erosion. For example, around water points on the new pipeline extending south from Oshakati towards Lake Oponono, the surrounding grass is already disappearing within a radius of 0.5 km. The taps have been open for only 18 months.

Thus the expanding rural population, the social and political imperative of meeting their water needs, and the shift from transhumance to settlement combine together to result in land degradation and lost productivity. The only way to deal with this -- given that we cannot return to nomadism, prevent population growth or refuse to supply water -- is to adopt sustainable land-use management practices wherever water points are provided. Regulation by external bodies is generally not practical, so DWA is promoting local participation in conservation and management of water through approximately 800 local water point committees.

E.3. PRESSURE ON WATER RESOURCES

Over-extraction of water for public consumption is one risk to water resources. The DWA strategy of maximising use of accessible, cheaper domestic water sources before drawing on more expensive long distance transport is designed to diversify risk and reduce costs. However, a multitude of small-scale extractions carries a risk of multitude of localised environmental disruptions, the total cost of which may exceed the cost of moving to water on the borders more quickly. Even if the nature of the effect is not clear, there is no doubt that state water supply will impinge on Namibia's ground and surface water resources across the country over the next decade.

18 At 10 cents per bucket (20 litres), rural households would actually be paying N$5 per m^3 - a realistic cost-recovery price and much more than urban residents currently pay. A lower, affordable price should not be impossible. Perhaps greater problems arise with the institutional mechanisms through which communities and water committees manage the charges, and over payment for water used by livestock and irrigation.

However, there are also other threats to water supplies. Groundwater can be contaminated by pollution (see section F on industrial activity), and wetlands disrupted by human and industrial activity. The impact of any resulting degradation can extend well beyond the public water supply network: wetlands (which includes rivers, floodplains, pans, and ephemeral rivers) play a key role in sustaining bio-diversity, a range of ecological functions, and productivity of natural resources. For example, the mixed subsistence economy within the Cuvelai drainage basin is dependent on the seasonal floods to regenerate grazing, replenish the water table and soil nutrients, and provide a rich protein source of fish.

Degradation of wetlands appears to already be occurring. For example, in Okavango and Caprivi, water pollution has increased with increasing human settlement. Siltation of the Okavango has increased due to clearing and over-grazing of forests and vegetation, which cause soil erosion. This ultimately affects the flood and flow of the river.[31] Both researchers and local people perceive a decline in fish stock sizes and diversity, attributable to a range of factors including siltation, changed flooding, heavy winter-season grazing and harvesting of reeds and grasses in the floodplains, chemical pollution, and over-fishing.[31]

In the Cuvelai basin, infra-structure such as roads and canals have been built without sufficient provision to allow normal water flow. For example, the Ombalantu-Oshakati canal, built in 1959, running west-east altered the flow of water in the oshanas. As a result there is less water available south of the canal for groundwater recharge and vegetation growth.[20]

Pressure on these sites is likely to continue as growing populations result in increased demand for water, grazing, cleared land, timber, hydro-power, fish, etc. Because the benefits of wetlands are often long-term, indirect, and shared by many people rather than by individual owners or managers, they are often not appreciated. However, recognition of the value of wetlands and wise management strategies will be essential if further degradation, and hence declining productivity of local ecosystems, is to be avoided.

E.4. WATER AND POPULATION: FUTURE PROSPECTS

The stark conclusion is that if population were to grow as predicted, while water supply systems and consumption per person remained the same, Namibia simply could not cope. Present water supplies are insufficient. The water needs of the growing population can **only** be met by increasing use of diverse water sources, increasing efficiency of extraction, tapping new resources further away **and** using water more efficiently to reduce consumption (i.e. strategies 2, 1,and 3 respectively).

Efficiency and conservation measures will have to be implemented in agriculture and industry too. For example, at Hardap, flood irrigation is used even though it is estimated that similar yields could be obtained with a fraction of the water under drip irrigation.[3] Nationally, research and appraisal of water-use methods, the suitability of irrigation and water-intensive industry, demand management and tariff structures, are needed.

Even with expanded supplies and managed demand, water will still be scarce and increasingly expensive. The cost (for example, up to $300 per month for a household consuming 30 m^3 per month) will be a significant weight on either government or household budgets. If population grows at 3% per year, there will be little capacity to meet aspirations for improved and increased access to water services. Furthermore, capacity to meet further demand after 2020 is unclear. Meanwhile, careful monitoring is necessary to prevent over-usage of any water resource, research is needed to supply the energy and infra-structure for desalinisation and long-distance transport at minimal environmental cost, and land use planning is essential to avoid a cycle of degradation arising from water supply points, and from pressure on wetlands, rivers and other water resources.

F: URBANISATION AND ECONOMIC GROWTH

This paper has focused on the renewable resources that most directly support the Namibian population and are unavoidably affected by population growth: water and productive land. However, population growth affects other natural resources, even if less directly, through, for example, faster urbanisation, and demands for infrastructure and faster economic growth. A brief review of these is needed.

F.1. URBANISATION

Today, just under half a million Namibians live in urban areas. By 2006, almost one million will.[28] Limited or declining agricultural potential in rural areas is one factor fuelling the migration, along with education, aspirations, job opportunities, municipal services, industrialisation and other factors.

Urbanisation raises a different set of environmental challenges. On the one hand, migration from rural to urban areas relieves population pressure on the land. Urban services and manufacturing offer greater potential for increasing productivity per worker, and therefore for supporting a growth in population and living standards without squeezing more and more out of the fragile land. Another advantage is that it is easier to supply household services, such as energy, to urban concentrations, rather than widely dispersed settlements.

On the other hand, urban populations place heavy demands on the environment because their consumption of renewable resources is generally higher, and dense conglomerations of people raise new environmental problems. Urban residents are still dependent on rural natural resources in many ways -- for food, water, fuelwood ... anything that is not produced in town or imported. Therefore this can increase, rather than reduce, pressure for greater productivity from the land. Convenient supply often also means increased usage, for example of water and energy. Furthermore, whereas the early development of towns such as Windhoek and Grootfontein centred around reliable water sources, many centres have now expanded beyond the capacity of local water supplies. Therefore water has to be transported over long distances. A high concentration of people puts great pressure on the local environment, through for example local waste and pollution, and commercial fuelwood extraction (these effects are summarised in Appendix 1). Such effects can be mitigated through wise planning and adoption of conservation measures, but not prevented.

F.2. INDUSTRIALISATION AND ECONOMIC GROWTH

A population growing at 3% a year needs an economy growing at 3% a year at least. The impact of potential growth strategies on the environment is certainly an issue for research and concern, but is beyond the scope of this paper. This section touches on how natural resources will constrain, or contribute to, the goal of economic growth.

Natural resources will continue to play a vital role. Agriculture will doubtless continue to be the major source of employment and livelihoods, although as section D indicated, the scope for sustainable increases in primary production from communal land is limited (and potential for growth in commercial agriculture is thought to be lower[23]). Meanwhile, fishing and tourism are two of the fastest growing industries, and are the only two sectors anticipated to generate increases in jobs, foreign exchange, government revenue and national income during the period of the First National Development Plan (1995-2000). Mineral output will diminish over time as minerals are non-renewable resources, but meanwhile should provide resources for investing in building up other sustainable industry. More importantly, there is potential to diversify the economic use of natural resources into more profitable activities, involving higher value-added in Namibia. Tourism, based on wildlife and wilderness, processing of fish and other animal products (such as leather), and farming of game and ostriches, can vastly increase the economic value of renewable resources in a sustainable way.

However, two key constraints must be borne in mind. Firstly, exploitation of renewable resources must be kept within the limits of sustainability. The previous dramatic decline in fish stocks indicates the dangers of over-use. There is a point at which faster economic growth must come from industries that do not rely on renewable resources. Secondly, water scarcity is a constraint on all industries. If water costs were \$10 per m^3 some industrial processes simply would not be cost-efficient. Therefore industrialisation will have to focus on those industries that use relatively less water. There are of course many trade-offs to take into account: fish-processing can double or quadruple the value of the fish catch but consumes a vast quantity of fresh water. Similarly leather production consumes water and produces chemical effluent that poisons groundwater unless expensively treated. Alleviating the water constraint through desalinisation would require vast amounts of energy, which Namibia has to import or generate domestically at environmental cost (until, that is, solar energy is sufficiently developed for Namibia to make use of one of her most abundant natural resources: sunshine). Therefore on-going assessment of appropriate forms of economic development, given the ecological constraints, is needed.

G: SUMMARY AND CONCLUSIONS

Recent experience

A look back over recent decades of population growth indicates some trends and warnings for the future. The first question to address is: how has the rapidly growing population affected the resource base to date?

* There is evidence not only of increased pressure on resources, but of excessive pressure and unsustainable use in areas where the water table has sunk, forest and wildlife species disappeared, pasture given way to bush encroachment, marginal land been settled and over-grazed.

* As a result, the productivity of the resource base, and its capacity to support humans, has been reduced in some areas.[19] There is no measurement of the overall impact, but the result has been lower, rather than higher, living standards for many. e.g. people have to dig deeper for water, can sustain fewer or more distant livestock, walk further for fuelwood, enjoy fewer non-marketed resources such as fish and fencing. There are signs of growing competition and inequality in resource use (such as fencing of communal pasture), exacerbating the shortage for the poorest. At the macro level, this environmental degradation decreases food security, agricultural sales, bio-diversity, and capacity to cope with drought.

* There are indications that individuals are already adapting to these pressures. Some coping strategies mitigate environmental pressure, such as no longer using fuelwood for lighting, protecting fruit trees within the homestead, buying wire for fencing. But others, such as settling, clearing and grazing new land, or burning dung instead of wood, exacerbate the degradation. Many of the problems affect communal resources and complex ecological linkages, as with over-grazing, deforestation, and soil erosion, so cannot be addressed at the individual level alone.

* However, population growth is far from the only factor causing unsustainable resource use. Equally important are:
    - rising consumption per person: e.g. water consumption in urban areas;
    - collapse of traditional sustainable management practices (such as transhumance, collective regulation of access to water and grazing), and use of inappropriate management techniques (such as managing commercial farms according to a fixed carrying capacity rather than year-by-year conditions);
    - inappropriate responses to drought: over-using stressed resources in an attempt to maintain "normal" resource output.

  It is also worth noting that resources that are managed commercially, and are not directly subject to pressure from growing populations, such as fish and commercial farms, have also been over-exploited.

19 This long term reduction in productivity is quite different from short term reductions in availability of water, vegetation, and pasture that can be expected in dry years, and from which the ecosystem recovers in the next wet spell.

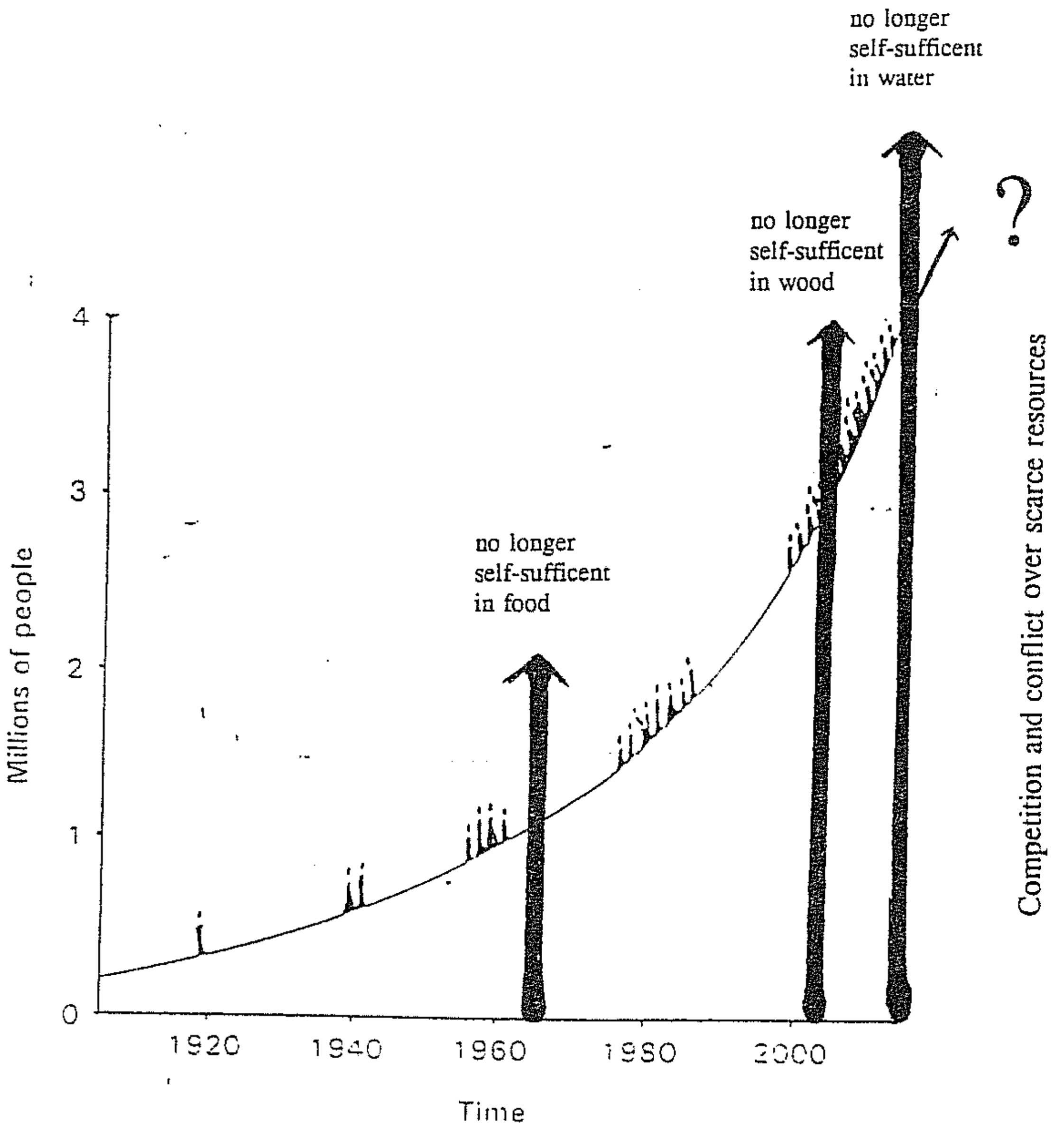


Figure 15: Postulation of resource crises, given current trends

Assuming population continues growing at present rates, resource management strategies are not improved, and consumption needs are unchanged, the vertical lines indicate the points at which self-sufficiency in key resources is no longer possible.

These are indicative not carefully calculated. An "end to self-sufficiency" implies that supplies of the resource are so diminished or localised, that extraction to supply national needs is either no longer possible or economically not viable.

Prospects for the future

Can Namibia's resource base cope with the anticipated doubling of the population every 23 years?

First, we need to consider what would constitute "not coping." People would still derive water, food, shelter, heat, materials, and income opportunities from their environment. But, they would have to spend increasing time and energy to maintain their living standards, and in many cases make do with less. Meanwhile, a vicious cycle of degradation would mean that year by year, excessive pressure would lead to further reduced productivity of the resource base.[20]

The above analysis of the most vital resources suggests that, in the face of rising population and continued dependence on natural resources, the first priority is:

* **sustainable management to prevent degradation**
  Resources must be managed in ways that ensure long term productivity, even if these mean restrictions on resource use for short periods, such as during drought. For example, seasonal use of grazing land, limiting ground water extraction to recharge rates, combining land-use planning with water point provision, planning for drought, designing strategies to combat desertification. These require long term and fundamental changes in practice.

Furthermore, the resource base **could** support growing numbers through a combination of the three strategies outlined in section C:

* **increase productivity**
  Some limited resources can provide more value and support more people if new techniques are used. For example, land can support more animal mass if game and livestock are combined; arable land supports more people if farming techniques are improved to increase yields, post-harvest losses are reduced and processing increased; processing of livestock, game and plant products increases their economic value.

* **avoid wasteful consumption / manage demand**
  If resources are used more efficiently this limits or reduces consumption per person. For example, water and energy conservation should be a permanent way of life, through pricing, other incentives, and promotion of practices such as re-cycling.

* **tap new resources where possible**
  for example, in the case of water, desalinisation of ocean water will be needed.

20 The prognosis of "collapse" rather than decline is discussed in Appendix 2.

If these changes are not adopted, Namibians will be dependent on a diminishing resource base (Figure 14). With such changes, there is some scope for natural resources to support more people, but it is unlikely they can keep up with a doubling of population every 23 years, and clear that they cannot provide **higher** living standards to such a population. Irrespective of human ingenuity and technology, the harsh environment of Namibia provides a binding constraint on the number of people that can be supported from renewable resources. The stark conclusion then is that to avoid declining living standards and to achieve development, Namibia must also:

* **reduce and stabilise the rate of population growth;**

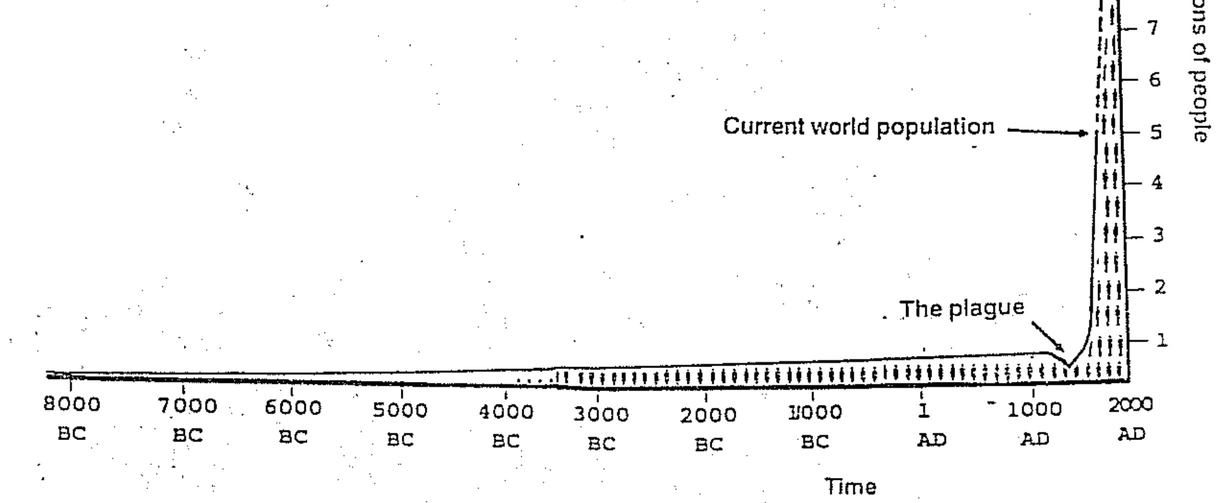
* **reduce reliance on natural resources.**
  For rural residents, this means diversifying their livelihood - this requires decentralised development of processing, markets, transport etc. For all enjoying or aspiring to higher living standards, it involves a redefinition of luxury, which excludes excessive use of scarce resources. And for the economy as a whole, it means development of manufacturing and service sectors, particularly those that use scarce resources such as fresh water and land most efficiently.

Growing pressure on scarce renewable resources may fuel ingenious innovation, but also fuels competition and conflict. Only by managing renewable resources in ways that are both more sustainable and more productive, while reducing Namibia's economic dependence on the land, can such risks be avoided.

Appendix 1: Supplementary figures

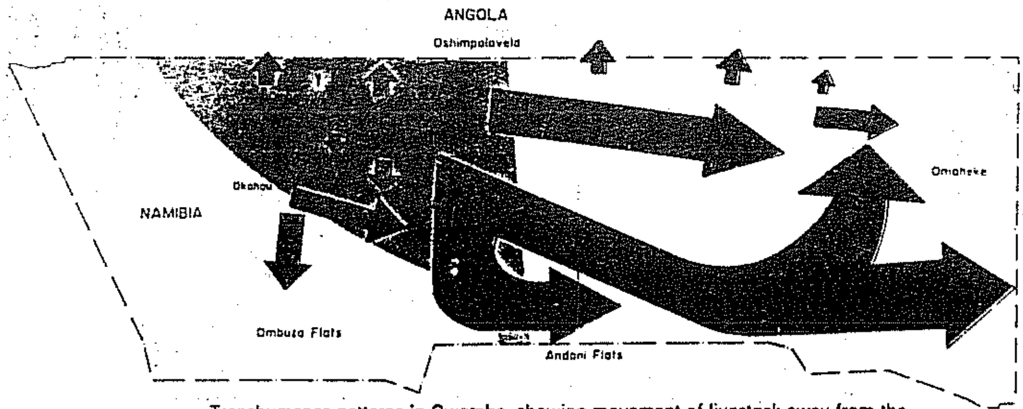
The graph shows the phenomenal growth rate of numbers of human beings. the increase in the last 40 years is equal to the total increase during the half million years from the emergence of people until 1950.

For 99.9% of humankind's existence, the maximum world population was less than 10 million.
The first billion mark was only reached around 1830.
It took only another 100 years, until 1930, for another billion to be added to the first.
The third billion mark was reached by 1960 (30 years later), the fourth billion by by 1974 (14 years later), and a fifth by 1987 (13 years later). When viewed from the perspective of time, this is an almost instantaneous increase in human numbers.



Ap.1: Growth of world population

Reproduced from du Toit et al, 1994

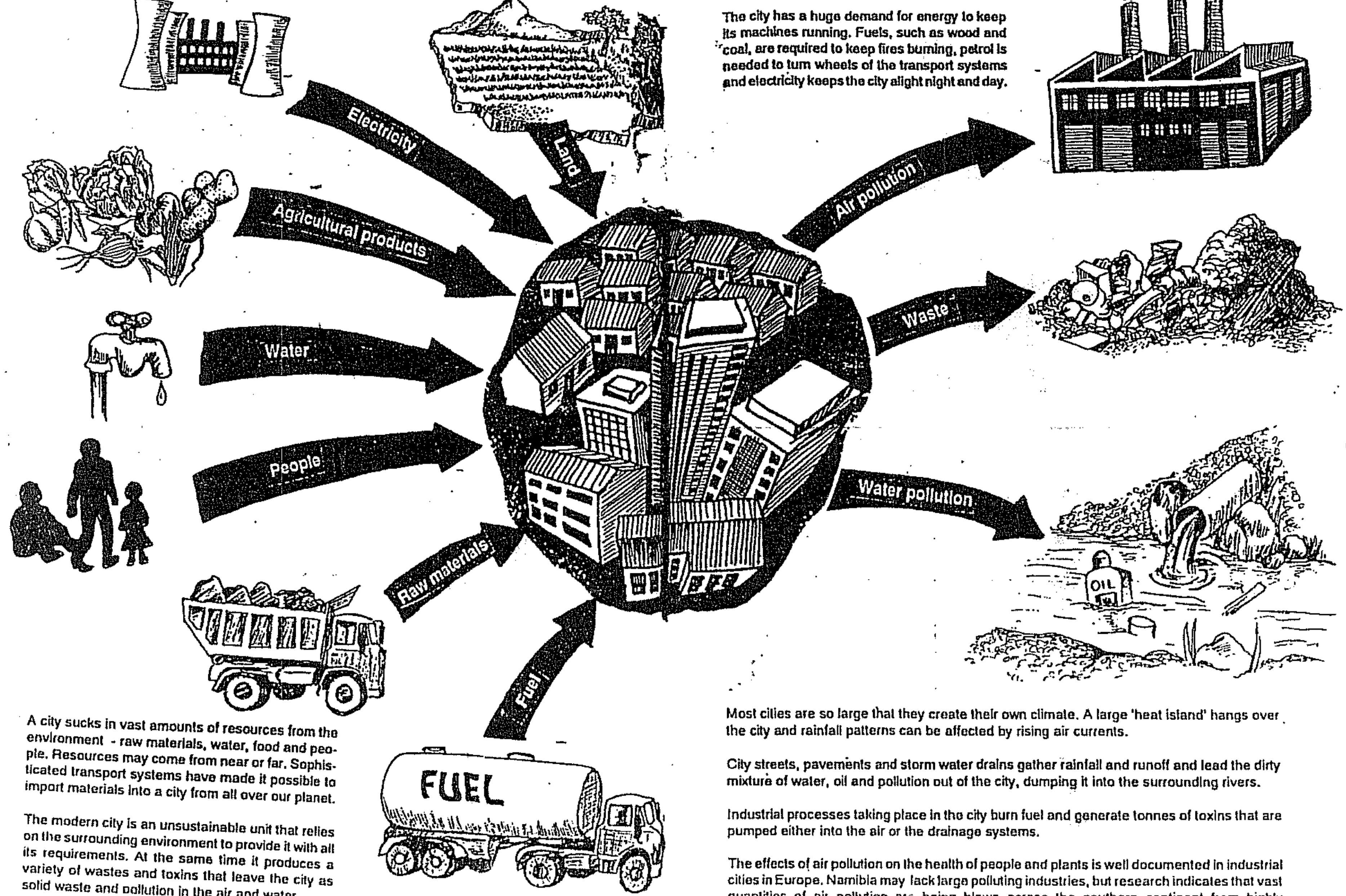


Transhumance patterns in Owambo, showing movement of livestock away from the oshana area in the dry season. The patterns of movement are reversed in the wet season.

Ap.2: Transhumance patterns in northern Namibia

Reproduced from Marsh and Seely, 1992

The hungry city: what it takes from the environment and what it gives in return...



As the city uses up resources it expands outward, upward and even downward. Outward expansion often destroys prime farm land.

The city has a huge demand for energy to keep its machines running. Fuels, such as wood and coal, are required to keep fires burning, petrol is needed to turn wheels of the transport systems and electricity keeps the city alight night and day.

A city sucks in vast amounts of resources from the environment - raw materials, water, food and people. Resources may come from near or far. Sophisticated transport systems have made it possible to import materials into a city from all over our planet.

The modern city is an unsustainable unit that relies on the surrounding environment to provide it with all its requirements. At the same time it produces a variety of wastes and toxins that leave the city as solid waste and pollution in the air and water.

Most cities are so large that they create their own climate. A large 'heat island' hangs over the city and rainfall patterns can be affected by rising air currents.

City streets, pavements and storm water drains gather rainfall and runoff and lead the dirty mixture of water, oil and pollution out of the city, dumping it into the surrounding rivers.

Industrial processes taking place in the city burn fuel and generate tonnes of toxins that are pumped either into the air or the drainage systems.

The effects of air pollution on the health of people and plants is well documented in industrial cities in Europe. Namibia may lack large polluting industries, but research indicates that vast quantities of air pollution are being blown across the southern continent from highly industrialised areas in South Africa.

Ap.3: Environmental impacts of urbanisation

Appendix 2:

GLOBAL PERSPECTIVES ON THE HUMAN-ENVIRONMENT BALANCE

Some researchers predict "**collapse**" rather than decline if humankind continues over-exploiting resources as at present[1]. They argue that environmental degradation will lead to dramatically increased death rates and reduced birth rates, and hence population decline.

They stress that tinkering at the margins is not enough, and a radical overhaul of our behaviour is needed. For example, the Club of Rome's seminal work "Limits to Growth" published in 1972 concluded that at present growth rates of population and the economy, both population and industrial output would collapse in about 100 years. In 1992 Meadows, Meadows and Rander updated the 1972 model, and concluded that:

* economic and population growth at current levels, with no change in technology, management or consumption would lead to collapse around 2010;

* doubling resource levels, by finding and exploiting new sources, only postpones collapse by a few years;

* introducing 4 technological fixes to reduce pollution and energy consumption would also simply delay collapse;

* if population growth is slowed to replacement levels by 1995, population reaches 7.4 billion in 2040, after which population growth and economic decline.

* a sustainable scenario is achieved by slowing population growth to replacement levels in 1995, limiting consumer goods per capita to $350 (constant 1986 prices), and implementing the 4 major environmental protection technologies. The result is dynamic equilibrium, with 7.7 billion people, and sufficient resources for an average life expectancy of 80 years and global living standard equal to that of western Europe today.

Other researchers[2] reject the concept of a limited "human carrying capacity" arguing that the number of people an area can support changes with so many factors (quantity and type of resources consumed, changes in technology, culture, inventions, expectations, trade etc) that no fixed or maximum number can be assigned. Some argue that population pressure leads to ingenuity, adaptation, and more productive use of natural resources.[3]

Both these approaches are doubtless extreme, but are relevant to the debate in Namibia. There is certainly potential to apply human ingenuity and technology to increase the sustenance obtained from resources. Most resources -- cattle, crops, fish -- are used for primary production, and are not processed. Carrying capacity can increase.

On the other hand, there is little prospect of dramatically increasing output from the most basic resources of land and ocean. Land is arid and fragile. Fish stocks replenish at rates determined by nature not human engineers. Thus, the call to reduce pressure by changing production and consumption patterns and slowing population growth must apply just as strongly to Namibia as to the globe.

1 Beginning with Malthus in 1798, Indian demographer P K Watal in 1917, and many twentieth century environmentalists.

2 dating back to 18th century rationalists such as William Godwin, including 20th century researchers such as Esther Boserup (1965, 1981).

3 for example, a recent study "More People, Less Erosion" on farming areas of Machakos District in Kenya (Tiffen, Mortimore, and Gichuki, 1994).

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C: BALANCING RESOURCE USE WITH SUSTAINABLE SUPPLY

The relationship between population and environmental change is not a simple one. The pressure individuals place on their environment depends on what each person consumes, how much, and how it is produced. With improved production efficiency, the same resources can support increasing numbers of people. Some people argue that population pressure is the very motivation that drives us to innovation and improvement[3]. But with inappropriate systems, or with rising consumption per person, scarce resources support fewer and fewer people. Excessive pressure can set in motion a vicious cycle of irreversible degradation. This section seeks to identify key concepts for simplifying and analysing these relationships.

The core problem is that as population grows, the demand for resource use can grow inexorably, whereas the maximum sustainable supply, or off-take, of a given stock of renewable resources is relatively fixed. When demand exceeds supply, either some people consume less (make do without or switch to natural, commercial, or imported alternatives), or resource use is excessive, diminishing the resource base and future supply.

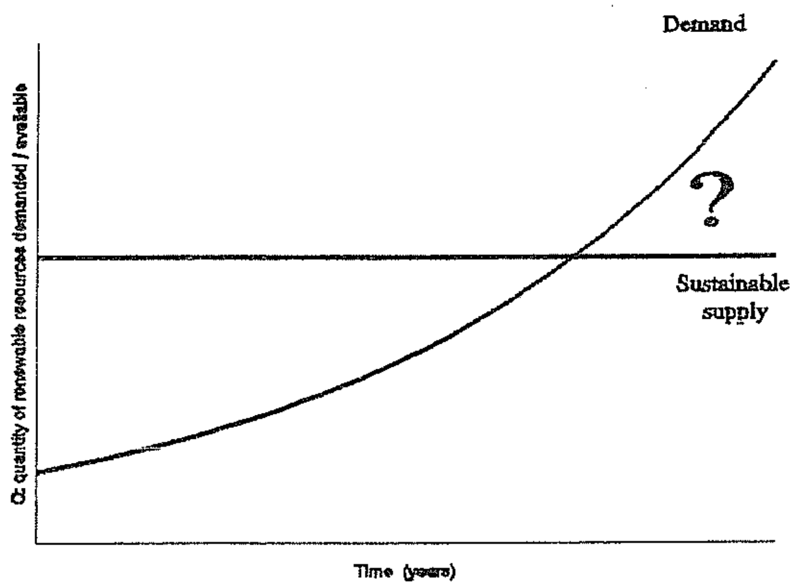

Figure 7: The maximum sustainable supply that can be extracted from the stock of renewable resources stays roughly constant over time, but as population grows, demand increases.

Figure 7 illustrates rising demand with fixed supply over time, while different strategies for resolving the problem are illustrated in the following 3 graphs[4]. The resources can support **more people** if three strategies are adopted:

3 See Appendix 2 for examples of such theories.

4 For the sake of simplicity, certain links in the economic and ecological chains have been simplified. For example, the size of resource stocks and level of maximum sustainable supply are inter-dependent and so not fixed as the graphs suggest. Replenishment and expansion of existing stocks is not considered, as this is more relevant to resources such as fish, than productive land and water, but could be incorporated into strategy (i). In strategy (ii) it is often the supply of services from resources, rather than resources themselves, that rises. i.e. these graphs are schematic representations of alternative management strategies, not detailed explanations of economic theory.

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