DMI - St. Eugene University

Institute of Virtual and Distance Learning

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From the desk of
Dr. T. X. A. ANANTH, BBA, MSW, MBA, MPhil, PhD
President –University Council

Dear Student Teachers,

Welcome to the second semester of the fast track learning programme at DMI – St. Eugene University!

If our IVDL semester -1 was a great success, it is because of the blessings of God the Almighty and efforts of all our stakeholders including you. Together we made it and made the programme a success.

As our Chancellor, Rev.Fr. Dr.J. E. Arulraj , mentioned, it is not just the success for DMI-St. Eugene University alone, it is success for the technology, it is success for the great nation of Zambia and it is success for the continent of Africa. You all made the change in the world of education. Zambia leads the path in modern education.

In the last semester we had distributed the P.C.Tablets. I am sure you are expert in using it by now. Now your world is open to Internet and using the tablet for educational purpose. The very same book you are holding in your hand now is available in your V-Campus portal. All the teaching and learning materials are available in your portal.

You can feel the improvement in the quality of the learning materials in the printed format. Improvement is done in quality of the content and the printing. Use it extensively and preserve it for future reference. This will help you to understand the subjects in a better way. The theories of the subjects have been explained thoroughly and problems have been identified at learners' level. Every unit is mapped to the syllabus and discussed in detail.

I would like to record my sincere appreciation and gratitude to the Honorable Dr. John T N Phiri, Minister for Education, Science, Vocational Training and Early Education for his vision and determination in upgrading the teachers in Science and Mathematics. The officials of the Ministry and all the Provincial Education Officers and their team need a special thanks for the wonderful support.

As the year draws to a close, on behalf of our Chancellor, Members of Staff and on my own behalf, I take this opportunity to wish each of you and your family A Merry Christmas and a prosperous New Year. May the year 2015, bring Health, Wealth, Peace and Prosperity to us, our families and our nation.

Dr. T. X. A. ANANTH
President – University Council

TABLE OF CONTENTS

UNIT – I

AGRICULTURE IN ZAMBIA

Agriculture is the cultivation of animals, plants, fungi, and other life forms for food, fiber, biofuel, medicinals and other products used to sustain and enhance human life. Agriculture was the key development in the rise of sedentaryhuman civilization, whereby farming of domesticated species created food surpluses that nurtured the development of civilization.

The study of agriculture is known as agricultural science. The history of agriculture dates back thousands of years, and its development has been driven and defined by greatly different climates, cultures, and technologies. However, all farming generally, relies on techniques to expand and maintain the lands that are suitable for raising domesticated species. For plants, this usually requires some form of irrigation, although there are methods of dryland farming.

Livestock are raised in a combination of grassland-based and landless systems, in an industry that covers almost one-third of the world's ice- and water-free area. In the developed world, industrial agriculture based on large-scale monoculture has become the dominant system of modern farming, although there is growing support for sustainable agriculture, including permaculture and organic agriculture.

LAND TENURE SYSTEM IN ZAMBIA

Through out history, Zambia has followed a dual system of land tenure. In 1924, the British Colonial Authority divided land into two categories: Crown Land and Native Reserves (Loenen 1999). Native Reserves were designated for the exclusive use of Africans. Land rights on Reserves were granted based on customary law. Chiefs controlled the use and allocation of Reserve land. Upon approval by the Chief and central government, non-natives were permitted to hold land in Reserves, but not for more than five years. In 1947, the British Government carved out portions of utilized Crown Land to establish Native Trusts. On Native Trusts, the Governor, who was designated the leader of Zambia under British rule, could grant rights of occupancy for a 99-year period to non-indigenous people.

Despite such grants, Native Trusts remained under customary tenure and could not be converted to Crown Land (Brown 2005).

Following Zambia's independence in 1964, Crown Land was converted to state land and thereafter administered by the Ministry of Lands. All state land was vested in the President, and any land transaction involving state land required the President's approval. Freehold tenure rights to state land were abolished and converted to statutory leaseholds. Meanwhile, on Native Reserves and Trusts, indigenous populations continued to follow the tenure system which existed under British rule. The Zambian government continued to recognize the Chief's right to regulate the use and allocation of trust and reserve land.

The land tenure system of any given country has a long term impact on the development of the agricultural sector. Hence for developing countries like Zambia which wish to diversify their economies through the promotion of the sector, the land tenure system must be moulded in such a way as to be conducive to agricultural development. Such a moulding, however, and thus the agricultural development, may be achieved only if laws are passed that provide the necessary rules and infrastructures. This is because one of the purposes of law is to achieve development, agricultural development inclusive.

Zambia, being a former colony, has a dual legal system comprising of customary laws and imported English laws. During the colonial period, whilst the white settlers introduced English laws to apply to them and guide their activities, the indigenous Africans were left to their own native customary laws as far as land tenure was concerned, therefore, a dual land tenure system was introduced. Customary rules of tenure applied to land held by Africans, and on the other hand new land laws were enacted to advance agricultural production by white settlers. When the territory attained independence, the only changes introduced were basically political. Most of the pre-independence laws were inherited by the Government from their predecessors. Since these laws passed during the colonial period had the objectives of promoting the interests of the white settlers and of implementing the colonial Government policy, there is a need to review the laws. As regards the customary rules of land tenure, these rules are uncertain due to being unwritten.

Moreover, although they might have been conducive to traditional landholding, the changes introduced by modern technology and new methods

of agricultural production make such rules archaic. Hence, the need for the rules to be changed to suit recent developments, in the mode of production. Despite the good intentions of the post-independence Government, its legislation has not achieved the objective of controlling land and promoting agricultural production. This is because of ambivalence with regard to customary land tenure and non-implementation of development requirements.

A careful examination of the literature would seem to suggest as indicated above that Land Tenure in Zambia has also gradually evolved from the simple to the complex; from the communal types to those where there is more tight control over allocation of land, suggesting more individual control of land.

White (1959) defines land tenure as "the rights of individuals or groups over arable, grazing and residential land, how such rights are acquired, what they consist of, how they operate in the holding, transfer and inheritance of land and how they may be extinguished"

A number of African land tenure systems were identified by White (1959), which included the following:-

(a) Societies in which an individual obtains land rights by residence, without allocation through a hierarchy of estates:-

This was the most prevalent type of land tenure in pre-colonial Africa (and in Zambia) where land was generally plentiful and the populations were sparse. Individual families within a given village usually acquired land by clearing virgin bush; by land transfer; and by inheritance (Conroy, 1945). As long as individuals were politically acceptable in the community/village, they acquired a piece of land after consulting the village headman, who in turn had constant contact with the subchief or chief.

Once an individual had acquired a piece of land, the community protected his/her rights to its use as long as he continued to use it. When not in use, land reverted to the community. The individual did not own the land as such but enjoyed its usufruct. The Chief did not own the land either - but held it in trust for his people. Since the Chief did not own the land, he did not extract surpluses from the subsistence cultivation peasantry in the form of a permanent land tax, although the people could give him gifts of food to-relish (such as meat and fish) and beer especially at special ceremonies to cerebrate the new harvest.

The Chief and his subjects participated in direct production of their own food for
subsistence and the subsistence cultivation peasantry and the produce was controlled by women in their own granaries (Crehan, 1983). Thus, under this system of subsistence production and communal tenure, society was egalitarian and not sharply differentiated. (Cabral, 1969, Yudelman, 1964).

(b) Land holding under the control of lineages:-

In this system, access to agricultural land was exclusively reserved for use by the members who traced their heritage from a common ancestry. Among the Luvale of North Western Zambia, White (1959a) found that the pattern of landholding was closely related to the matrilineages. As a rule, transfer of land rights among the Luvale was between matrilineal relatives or friends, and the land rights of a deceased person were most likely taken over by a matrilineal relative.

However, transformations in land tenure had begun to emerge even under this matrilineal system in which access to land was based on lineage. Owing to the practice of long continuous cultivation of cassava gardens, the permanence of rights over plots of land held by individuals were inevitably strengthened.

White (1959a) further observed that due to land shortage especially in the Chavuma area, commercialization of land as a saleable commodity was quite marked. Transfer of land to persons outside a matrilineage for a cash consideration began to take place and was quite common. According to White (1959a), the sale of land at Chavuma appeared to have reached a more developed form than in most parts of Northern Rhodesia (Zambia). Surplus gardens with crops and surplus resting land were sold and "prices were high". On the whole, the rights of individuals to sell land appeared to be strong enough to enable them to do so without obtaining the consent of their head of the matrilineage. This commercialization of land emerged among the Luvale of Chavuma despite the fact that land had acquired a close association with the matrilineage.

Lineage land-holding was also found among the Lungu patrilineages on the shore of Lake Tanganyika, who emphasised close identification of individual holdings with their patrilineages.

In Ethiopia, Gilks (1975) shows that in the Tigre/Amhara area of the North, the system of land tenure was controlled by lineages and was known as Rist. The land belonged to the founder of the geneology. All male and female descendants had equal claim to the land within the family.

(c) Societies in which Chiefs exercised direct control over allocation of land with a descending hierarchy of estates:-

This form of land tenure was associated with the emergence of centralised pre-colonial states or kingdoms. Skinner (1964) shows that in the pre-colonial semi feudal agrarian-social structure of the Mossi empire in Burkina Faso,the King and the chiefly classes controlled land and assigned land rights to their subjects who included serfs,slaves,eunouchs and bondsmen. In Zambia, Barotseland (now Western Province) evolved a political and land tenure system that could also be described as evolving towards a quasi or semi-feudal type.

Land and other resources on the Zambezi flood plain were scarce and according to Lozi law all land in the kingdom belonged to the king (Gluckman, 1969, p. 253). The king controlled the termite and human made mounds on the flood plain. Other mounds were controlled indirectly by attaching them to the aristocracy (such as councilors/indunas) and the nobility (Princes and Princesses); care takers of royal graves and guardians of the king's cattle. The most prolific fishing sites, reed beds, bird - reserves, grazing sites and turtle lakes were reserved for the king.

The mounds on which the staple sorghum crop was grown were highly productive and they acquired scarcity value. The village/home stead heads allocated the land and tended to monopolise the use of it. Commoners or peasants/serfs obtained land through their homestead heads and could inherit it. Clarence-Smith (1979) is of the view that a quasi landlord group emerged and tended to have privileged rights of access to arable land and other resources and could exclude people from obtaining access to them, although the subsistence cultivation peasantry/serfs had access to grazing land, hunting land and the poorer fishing cites. He adds that the landlord group with political titles owned resources privately and these were inherited within their families usually in the male matrilineal line. Furthermore, "there was often a whole hierarchy of landlords between the primary holder of land and the direct producers".

This system of semi-feudal land tenure made some members of the aristocracy (the indunas) very powerful since they controlled personal/regional military personnel.

(d) Feudal systems with landlords and tenants:-

Feudal systems of land tenure and feudal relations of production emerged in many different parts of Africa, such as in parts of Bunyoro in Uganda and the Mailo
system in Buganda. In the south and west of Ethiopia, feudal land tenure emerged especially towards the end of the nineteenth century. Gilks (1975) shows that the emperor granted lands to the military commanders, the aristocracy; the nobility and the church. Such lands could be leased, mortgaged or sold. Although those groups which were granted land were expected to perform military service and pay land tax to the state they in turn collected various taxes from the tenants (Kiros, 1993, p. 31) such as land tax, education tax, cattle tax, agricultural income tax etc. The tenants/serfs, usually paid rent in kind, and the rent varied depending on the landlord. Usually tenants were expected to pay 50 percent of the harvest. In some cases, the rent was higher. Tenants who defaulted in their obligations could be evicted by the landlords and became landless.

(e) Individualised land tenure under commercial production:-

The imposition of colonial rule in many parts of Africa, especially in sub-Saharan Africa, led to land alienation and the settlement of European commercial farmers. This was the case in Kenya, Malawi, Zimbabwe and Zambia. These settlers were granted individual freehold or leasehold tenure on what became crown or state land. In Zambia, like elsewhere, this process created two different legal systems, the long established customary land law and English land law.

With the passage of time, commercial agricultural production by European settlers in Zambia soon began to diffuse in the 1930s to African subsistence farmers who adopted new technologies such as hybrid maize and ox-drawn ploughs. This agricultural transformation was particularly noticeable among the Tonga people in Southern Province, but also occurred in Central and Eastern Provinces. Among the Tonga, traditional attitudes towards land began to give way to pressures for individualization of land tenure (North, et al, 1961).

After the attainment of political independence, the diffusion of modern agricultural techniques led to the emergence of an indigenous group of commercial farmers (Baylies, 1979), who had interest in securing land tenure rights which were expressed in English/modern law. In this regard, Mvunga (1980) has contended that land tenure systems are not static, but dynamic;

they are modified, restructured and respond to political and economic changes in society.

CONCEPTS OF CUSTOMARY AND PRIVATE LAND TENURE IN ZAMBIA

Customary law

Most Zambians conduct their activities in accordance with and subject to customary law (Hansungule and Mwansa, 1993), but the term is used to cover a host of tribal laws existing in different ethnic groups. Since the colonial era, customary law has been recognized only after it has been found not to conflict with written law. Two contending views are held on customary land tenure in customary law. One view suggests that land and land rights are not individual but commonly shared. The other, increasingly held view recognizes individualism in land relations and tenure (Mvunga, 1977). Both views are valid because they arise from the dynamism of customary tenure, which has evolved from commonly shared land rights to individualization of croplands with continued commonly shared rights to grazing lands, forests and fisheries. Individualization of croplands is a result of agricultural intensification, increase in population pressure and commercialization of agriculture. At present, cultivation rights of individual families are recognized on land where other families are excluded, but communal use of rights may also be recognized (Hansungule and Mwansa, 1993).

Two points define the tenure of trees in customary law: the possibility of individual ownership is recognized, and trees can be owned separately from land. Trees, like land under customary tenure, are subjected to group rights of the indigenous people. Generally, landowners have rights to the trees and crops they may grow on their land. Similarly, the owner of a fruit-tree can exclude the third persons from its fruits. The owner can even put a value on the fruits and sell them. This idea is consistent with common law in which labour invested in growing trees entitles the labourer to possession of the trees and their fruits.

The corner-stones of the customary land tenure system are reflected in the modes of acquiring land: original acquisition, through clearing of virgin bush, outright grants or purchases of improvements on the land; derivative acquisition, particularly through marriage; or inheritance.

Statutory law and private property

The Conversion of Titles Act of 1975 stresses two features: first, the distinction of improvements on the land versus the land itself; and second, the right of inheritance of land. The act does not distinguish trees from land, so trees are included in the concept of land. The introduction of a 100-year lease as the only form of ownership of State land marked the cornerstone of the reform process. Freeholds and other types of estates were abolished. The statute appropriated all economic value of land except for improvements.

An important impediment to rights in leaseholds is the restriction on tenants' dealings in their land: all dealings in land must follow Presidential consent. Another impediment is the requirement for planning permission before any development is attempted. The Town and Country Planning Act is the framework for the control and regulation of all development on statutory leaseholds. Finally, the rights and interests of the tenant in statutory leasehold are subject to compulsory acquisition of land and other property whenever the President deems it in the interest of the people of Zambia.

Comparison of the two systems

Zambia has had the experience of both freehold and leasehold tenure. Supporters of leasehold tenure argue that it allows State intervention if the tenant fails to utilize the land or damages it by mismanagement. They find the unrestricted ownership of land offered by freehold tenure undesirable because it may also result in speculation, fragmentation, underutilization or damage to the land by irresponsible farming practices.

On the other hand, opponents of leasehold tenure argue that it does not convey absolute ownership which the occupier needs for assurance of the security of long-term investments. A leasehold is essentially a qualified right to occupy land for a fixed term which may or may not be renewed. The leaseholder is essentially a tenant of the State, to which rent is paid. The argument in support of freehold tenure is that it conveys absolute ownership to the occupier. The owner is free to develop the land as desired or to sell part or all of it at any time. No rent is payable. Ownership and security are virtually unrestricted. Occupants can invest without fear of dispossession. They can pass on the property to their designated heirs without any restriction.

Customary tenure has by and large been more successful than leasehold tenure in meeting the needs of the people. The administrative procedures are simple and easily implemented. Land issues are dealt with efficiently and decisively. The problem, however, is that the land rights are never registered, although their recognition is guaranteed. No attempt has been made to reform customary tenure. However, the obtainment of title deeds to customary land must be facilitated by a simplified government machinery for land delivery.

In contrast, four different government bodies administer State land or policies governing leasehold tenure. A major component of reform in the land law would be to reduce administrative overlap and simplify the registration procedures.

TYPES OF AGRICULTURE IN ZAMBIA

A) **SUBSISTENCE FARMING:** This is a type of farming where crops are grown mainly for home consumption. It involves the growing of food crops and is meant to meet the day to day family requirements. It can be intensive subsistence agriculture or extensive subsistence agriculture

Extensive Commercial Agriculture - Large scale farming used for the primary purpose of profit, on less expensive land that needs to be used less intensively. There are larger farm units due to low cost. (Example: large scale wheat farming and livestock ranching)

Intensive Subsistence Agriculture - High yield and high population density. This is intensive meaning high input for a high yield proportion wise. Small plots of land and high labour units per land. Subsistence so used for themselves or extras to the market for example. Sometimes is the production of many crops in one field because it is subsistence.

PROBLEMS ASSOCIATED WITH SUBSISTENCE FARMING

1. ***Soil erosion-*** the removal of top soil by agents of erosion such as rain, wind or running water.

2. ***Diminishing yields:*** is the decrease in production mainly due to unsustainable methods of farming e.g. Chitemene.

3. ***Deforestation:*** Due to cutting of trees, by which soil erosion and desertification happens. (Trees are the main source of protection to earth that they firmly hold the soil in position.)

4. ***Bush fires:*** is due to early burning of fields and hunting.

5. ***Lack of capital***: there is deficit of money to purchase inputs or machinery

6. ***Lack of inputs:*** fertilizers, seeds etc.

7. ***Lack of education***- lack of environmental awareness.

8. Unreliable rainfall and droughts.

9. Flooding causes excessive rainfall during some years.

10. ***Mono cropping-*** leads to soil impoverishment.

11. ***Pests and diseases:*** e.g. tripanosomiasis and corridor disease.

12. Poor marketing leading to poor sales.

13. Poor transport especially impassable roads.

14. Long distance to markets especially to urban areas.

GOVERNMENT MEASURES TO IMPROVE SUBSISTENCE FARMING

Provision or creation of co-operatives to buy farm produce at a good reasonable rate and to the benefit of the farmers

Creation of resettlement schemes for the benefit of the farmers

Provision of extension services, to educate the farmers.

Construction of feeder roads for easy access to farmlands and to markets

Use of drought animals to with stand adverse weather conditions e.g. donkeys in the southern province.

Distribution of inputs like fertilizers and machinery to farmers, by government agents and (e.g.) NGOs.

Fixing of purchase price for maize, in order, to avoid briefcase traders.

SOIL CONSERVATION MEASURES AND SUSTAINABLE AGRICULTURAL PRACTICES.

1. Contour ploughing- to retain moisture and avoid erosion.
2. Strip cultivation- protects the soil from erosion.
3. Crop rotation- to restore and replace nutrients.
4. Terracing- to retain moisture and check the flow of water downhill.
5. Mulching- covering the soil to retain moisture.
6. Ploughing across the slope to avoid erosion.
7. Controlled grazing- to allow land regeneration.
8. Soil additives- to add nutrients to the soil.
9. Cover cropping- retains moisture and protects soil from erosion.
10. Afforestation-replaces cut down trees.
11. Fallowing- allows soil to regenerate.
12. Irrigation- supplies additional water especially during droughts.
13. Organic farming- use of leguminous plants to fertilise the soil e.g. velvet beans, peas and other legumes.

FACTORS AFFECTING AGRICULTURE

1. **PHYSICAL FACTORS:** The environment plays an important an role in agriculture. It determines the type of agricultural activity that takes place.

. **Slope of land/relief:** Very steep slopes require terraces if the land is to be cultivated. Where the land is flat, cultivation is easy and ditches are required for effective drainage.

. **Soils:** Soil type and nature varies from place to place hence determining the type of crops to be grown and the type of farming techniques to be used.

. **Climatic factors:** Successful farming is dependent on adequate, well distributed and reliable rainfall, moderate temperatures, humidity, winds and sunshine.

. **Pests and diseases:** Numerous pests and diseases afflict crops and livestock. Different areas are prone to different types of diseases and pests. Such areas have to be avoided or reclaimed.

2. ECONOMICAL FACTORS:

. Agriculture is dependent on capital hence the farmer ought to have enough financial resources to meet the operational costs.

. The location has to be fovourable with well-developed transport routes and near high populated centres that offer a market for the agricultural produce.

. The market's demand directly influences the price of the produce and consequently the method of production.

3. SOCIO-CULTURAL FACTORS:

. Culture affects the type of crops grown and animals kept in the area.

. What people eat and like affects their production.

. Religious traditions of different societies also affect the types of crops grown and animals reared by the society.

4. POLITICAL FACTORS:

. Government involvement in farming is a major influence mostly through land ownership. Land ownership influences the way in which land is used and its productivity. There are four main types of land ownership namely:

a) *Owner occupied:* Individual ownership where people work on their own land for their own benefit.

b) *Tenant farmers:* Land is owned by the landlord who receives rent. This prohibits the long-term development of agricultural projects on that piece of land.
c) *Company plantations and estates:* only one type of crop is cultivated on a large piece of land, usually referred to as plantations. Ensures maximum agricultural productivity and mechanization of the land.
d) *State owned:* most of them are research or demonstration farms often attached to a university. In communist countries all land is owned by the state so all farms are state farms.

Subsistence agriculture

Subsistence agriculture is self-sufficiency farming in which the farmers focus on growing enough food to feed themselves and their families. The typical subsistence farm has a range of crops and animals needed by the family to feed and clothe themselves during the year. Planting decisions are made principally with an eye toward what the family will need during the coming year, and secondarily toward market prices. Tony Waters writes: "Subsistence peasants are people who grow what they eat, build their own houses, and live without regularly making purchases in the marketplace." However, despite the primacy of self-sufficiency in subsistence farming, today most subsistence farmers also participate in trade to some degree; though usually it is for goods that are not necessary for survival, and may include sugar, iron roofing sheets, bicycles, used clothing, and so forth. Most subsistence farmers today live in developing countries. Although their amount of trade, as measured in cash, is less than that of consumers in countries with modern complex markets, many have important trade contacts and trade items that they can produce because of their special skills or special access to resources valued in the marketplace.

Subsistence grain-growing agriculture (predominantly wheat and barley) first emerged during the Neolithic Revolution when humans began to settle in the Nile, Euphrates, and Indus River Valleys. Subsistence agriculture also emerged independently in Mexico where it was based on maize cultivation, and the Andes where it was based on the domestication of the potato. Subsistence agriculture was the dominant mode of production in

the world until recently, when market-based capitalism became widespread. Subsistence horticulture may have developed independently in South East Asia and Papua New Guinea.

Subsistence farming continues today in large parts of rural Africa, and parts of Asia and Latin America. Subsistence agriculture had largely disappeared in Europe by the beginning of World War I, and in North America with the movement of sharecroppers and tenant farmers out of the American South and Midwest during the 1930s and 1940s. As recently as the 1950s, it was still common on family farms in North America and Europe to grow much of a family's own food and make much of its own clothing, although sales of some of the farm's production earned enough currency to buy certain staples, typically including sugar; coffee and tea; petroleum distillates (petrol, kerosene, fuel oil); textile products such as bolts of cloth, needles, and thread; medicines; hardware products such as nails, screws, and wire; and a few discretionary items such as candy or books. Many of the preceding items, as well as occasional services from physicians, veterinarians, blacksmiths, and others, were often bought with barter rather than currency. In Central and Eastern Europe subsistence and semi-subsistence agriculture reappeared within the transition economy since 1990.

B) COMMERCIAL FARMING

This is the growing of crops (arable) and keeping of animals on a large scale. Commercial farming basically aims at the production of farm produce for sale in order to generate a profit.Most crops are non-edible e.g. cotton, sisal, rubber etc. Food crops like maize, wheat and beans can also be cash crops depending on the size of the land used so the output can be exported or sold locally.

AREAS OF COMMERCIAL FARMING.

. Along the line of rail- Kalomo, Kapiri Mposhi, Kabwe, Mkushi, Choma, Mazabuka. etc. where they grow maize, vegetables, tobacco, sunflower.etc.

. Copper belt towns where they grow vegetables under market gardening.

. Eastern province towns with groundnuts, maize, cotton.

. Mwinilunga with pineapple estates.

. Luapula- Mununshi for bananas, Kawambwa for tea.

. Kasama for coffee.

. Mazabuka for sugar.

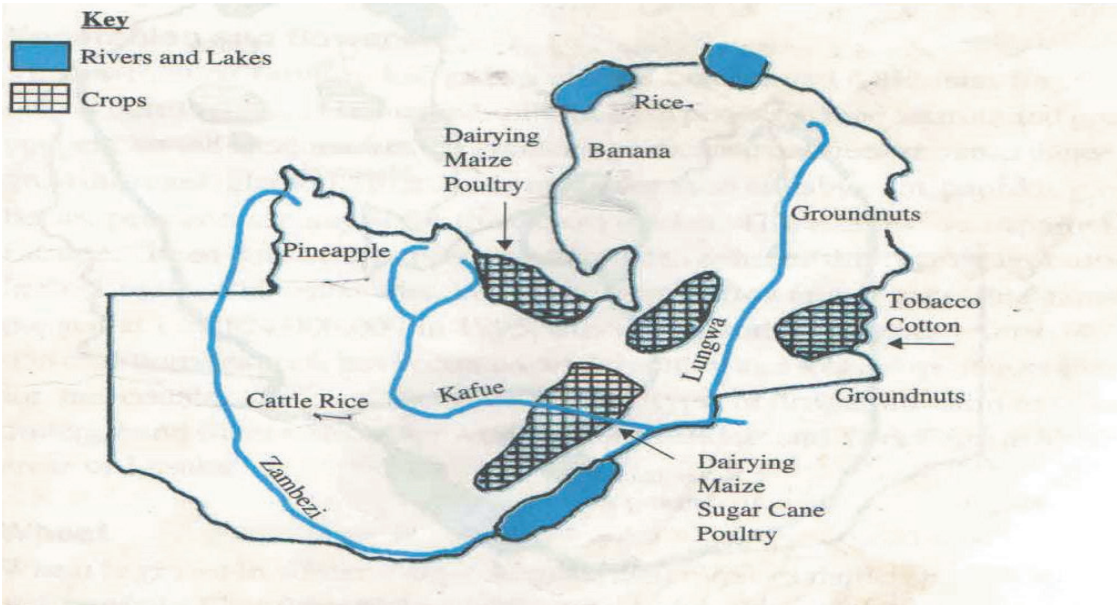


Figure. *** Commercial Farming Areas and Major Crops

C) Shifting agriculture

In this type of agriculture, a patch of forest land is cleared by a combination of felling and burning, and crops are grown. After 2-3 years the fertility of the soil begins to decline, the land is abandoned and the farmer moves to clear a fresh piece of land elsewhere in the forest and the process continues. While the land is left fallow the forest regrows in the cleared area and soil fertility and biomass is restored. After a decade or more, the farmer may return to the first piece of land. This form of agriculture is sustainable at low population densities, but higher population loads require more frequent clearing which prevents soil fertility from recovering, opens up more of the forest canopy, and encourages scrub at the expense of large trees, eventually resulting in deforestation and heavy erosion and leads to global warming.

While this 'slash and burn' technique may describe the method for opening new land, commonly the farmers in question have in existence at the same time smaller fields, sometimes merely gardens, near the homestead there they practice intensive 'non-shifting" techniques until shortage of fields where they can employ "slash and burn" to clear land and (by the burning) provide fertilizer (ash). Such gardens nearer the homestead often regularly receive household refuse, the manure of any household chickens or goats, and compost piles where refuse is thrown initially just to get it out of the way. However, such farmers often recognize the value of such compost and apply it regularly to their smaller fields. They also may irrigate part of such fields if they are near a source of water.

In some areas of tropical Africa, at least, such smaller fields may be ones in which crops are grown on raised beds. Thus farmers practicing 'slash and burn' agriculture are often much more sophisticated agriculturalists than the term "slash and burn" subsistence farmers suggest.

Nomadic herding:

In this type of farming people migrate along with their animals from one place to another in search of fodder for their animals. Generally they rear cattle, sheep, goats, camels and/or yaks for milk, skin, meat and wool. This way of life is common in parts of central and western Asia, India, east and south-west Africa and northern Eurasia. Examples are the nomadic Bhotiyas and Gujjars of the Himalayas.

Food Production & the Environment

Productivity growth in Zambia is critical for meeting the food needs of a rapidly growing and urbanizing population.

a. Yields per hectare have improved slightly for most crops since 2006; however, much of this improvement is due to favorable weather,

b. Yields for all crops in Zambia are well below global averages,

c. However, while national yields are low, the top 10% of smallholders achieve yields that are one to nearly four mts more than average depending on the crop. This suggests the potential for yield improvements in Zambia,

d. National production figures for most crops have trended upward over the last three years, but remain erratic and highly susceptible to rain-fall variations,

e. For the primary food crop grown by Zambian farmers, maize, production growth has been mostly driven by area expansion not yield improvements.

Deforestation

Deforestation is one of the prior environmental problems in Zambia (MENR, 1994). But what is often not appreciated is that there are two types of deforestation. Temporary deforestation, in which the natural forest regenerates, once land is abandoned, and this is associated with various forms of traditional shifting cultivation systems and charcoal-production where stumps, roots, seedlings and seeds are not completely destroyed during forest clearing and subsequent cultivation. This type of deforestation does not necessarily lead to land degradation.

Permanent deforestation in Zambia is associated with commercial and semi-commercial farming, in which land clearing involves the uprooting of trees and deep ploughing with machinery or ox- driven implements that eliminate natural sources of forest regeneration. With good soil conservationmeasures, even this type of deforestation need not result in land degradation, although forest recovery occurs over a longer period than is the case with temporary deforestation.

Studies have shown that temporary deforestation may actually increase the production and availability of useful wild food resources, such as insects, small mammals and vegetables. Forexample,edible caterpillars(*vinkubala*) which are harvested by bending, cutting and occasionally climbing trees, are more abundant in regenerating woodlands on *chitemene* fallows than in mature woodland(MbataandChidumayo,2001). Women and children are disadvantageous when harvesting caterpillars in mature woodland because trees are too big to bend, cut or climb. This is not the case in regenerating woodland where trees are small and can easily be bent and cut by all groups of harvesters,which allows children and women to effectively participate in the harvesting of caterpillars, which are used for home consumption and sale. Woodland clearing, followed by regeneration is, therefore, essential for not only increasing caterpillar abundance but also ensuring equitable access by women and children to the caterpillar resource, which would otherwise be dominated by men.

Other wild food resources, such as small mammals (mole rats and mice), food insects (termites and grasshoppers), and “weed” vegetables also tend to be more abundant in fallow-land and cultivated fields. There is also no

evidence in Zambia of significant effects of deforestation on edible insects, mushrooms, small mammals, wild food roots (*munkoyo*and *chikanda*), vegetables, medicinal plants, bamboos and reeds. Often, depletion of these useful forest resources is largely caused by unsustainable harvesting levels and not deforestation perse (by itself).

However, deforestation does reduce the abundance of larger mammals, honey production and wild tree fruits. Hunting of large mammals and gathering of wild honey are dominated by men and the former is further restricted by government legislation. In most traditional farming systems, fruit and other useful trees are conserved during land clearing. The only problem is that whereas the men decide what trees to leave when clearing land for agriculture, it is the women and children that collectusefulproducts, such as fruits, from the conserved trees. Consultations with women and children by men on what trees should be conserved during clearing would ensure that the needs of these users are taken into account.

Although deforestation is perceived as an environmental problem, the real issue is about the nation deciding on how much of the country should be under forest and how much deforestation should be allowed to sustain human wellbeing. The gross crop-land, including fallow, has increased slowly from about 21% in the1970s (Schultz,
1974) to 22% in the 1980s, and is probably still under 25% at present. Annual rates of deforestation, including re-clearing of forest re-growth, is estimated at <1% in rural provincesandjustunder2%inurbanprovinces.Thus deforestation rates are well below population growth rates and could, if properly managed, be sustained in the medium-term (10-20years). Indeed some deforestation is inevitable given the low level of input use in agricultural production due to economic policies and subsidy removal.

Furthermore, the large dependence on charcoal for cooking in the urban households implies that until charcoal is replaced as an urban cooking energy source, forestswillcontinuetobeclearedtomeeturbanhouseholdenergyneeds.
Currently, themajor hindrance to cooking with electricity among electrified households is the unaffordable prices of stoves/hot plates and the unreliability of supply (World Bank/UNDP, 1990). For households that are not electrified, the high cost of connectionisaseriousobstacletoaccessingelectricity.

Forestland covers about 60% of the country, and about 17% has already been set aside for forest reserves and national parks in which settlements and agriculture are prohibitedbylaw. Butencroachmentintotheseareas has occurred due to inadequate capacity to protect these areas.This capacity has further been crippled by the reduction in law enforcement staff in the Forest Department and the Zambia Wildlife Authority (ZAWA), as a result of the public service reform programme.

Currently, about 5-16% (16% and 5%) of forest reserves and national parks, respectively, have been encroached and their sustainability as conservation areas is not guaranteed. Nevertheless, the country still has about 75% of forestland outside the existing conservationareas. Withsuchahighratiofforestlandtototalland, opportunities exist for increasing the land under forest protection, improving forest management outside the protected areas and allowing sustainable levels of deforestation that is taken into account for basic human needs and rural development.

VEGETATION AND FORESTRY IN ZAMBIA.

Definitions

a) VEGETATION

- Vegetation is the plant cover in a given area of land, which is best adapted to the climatic conditions and soil in the area.
- It can also be said to be a community of plants such as trees, shrubs, herbs and grasses that grow in a given place and give it a distinct character.
- It is an assemblage of plants that grow together in a particular habitat or site.

b) FORESTRY

- A forest is a collection of trees, shrubs, grasses, herbs, fungi, mosses and lichens.
- It is a large piece of land covered by either one or more species of trees that grow naturally or have been planted.
- Forestry is the science of developing, managing and protecting existing forests, in an effort to conserve them in their original form.

FACTORS INFLUENCING THE DISTRIBUTION AND TYPES OF FORESTRY.

i) Rainfall- high rainfall supports the growth of natural forests i.e. over 2000mm.
ii) Soil- deep fertile soils encourage growth of dense forests.
iii) Relative humidity- high humidity supports growth of forests.
iv) Temperature- high temperatures (over 200ºC encourage growth of forests in terms of size and density.
v) Altitude- altitude affects temperature and thereby forest growth and distribution. Forests do well in high altitude areas (up to 3500m above sea level.
vi) Aspect- the windward side of a mountain slope receives high relief rainfall that encourages forest growth.
vii) Human factors- human beings may encourage growth and development of forests (afforestation and re-afforestation) or discourage/destroy forests (deforestation).

DISTRIBUTION OF FORESTS AND VEGETATION IN ZAMBIA.

Zambia has about 70% of its land area under forest cover. The natural vegetation is Savanna which is generally characterized by tall grass and scattered trees. The vegetation here can be generally divided into two groups and these are open forests and closed forests.

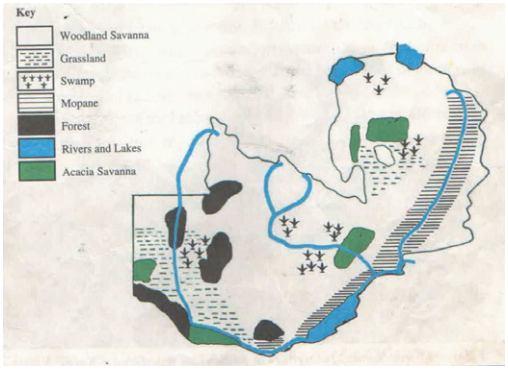


Figure.** Zambia`s Natural Vegetation

A) CLOSED FORESTS WITHOUT GRASS

This covers about 5% of the country and is made up of mainly forests. This type of forests depends upon the amount of rainfall. Some of the examples of the closed forests are:

i) Evergreen forest- these forests are called evergreen because although the trees lose their leaves all the time, there is enough moisture in the ground for new growth all the time. So the trees appear evergreen all year round. These forests are found only in the areas of high rainfall. The Livunda forest is an example. Trees grow to a height of 25-30 metres with a low tree layer, 10-15 metres in height. Creeper called lianas tangle from tree to tree. Examples of trees found in evergreen forest are Mukwa, Kayimbi and Mapundu.
ii) Deciduous forest- these forests are found in the areas where there is a period of very little moisture, during which most of the trees lose leaves. Beneath the tree layer is a layer of shrubs called Mutemwa. These include stands of Mkusi or Teak.
iii) Montane forests- are found on high lands.
iv) Swamp forest- occurs in small patches on the edges of swamps or areas that are seasonally flooded.

OPEN FORESTS:

A) Miombo woodland- areas where trees open out and do not form a closed canopy and therefore allows grass and shrubs to form a thick covering on the ground called woodland. This woodland is called Miombo because of the Miombo trees (Bemba and Ngoni) that are found there. A few of the other trees that are also found here are Mutondo, Mutobo, Museshe and Musaka. The woodland covers about 70% of the country.
B) Kalahari woodland- it is found in the Kalahari sands region. It consists of trees with a dense undergrowth of grass. Trees here include Muzoule, Museshi, and Kayimbi.
C) Munga woodland is open park- like deciduous woodland with mainly acacia thorn trees, Chilusha and Chilobo trees and coarse grass. It is found in drier areas where droughts are common.

D) Mopani woodland- is found along the hot dry valleys. Mopani tree is fire resistant. It is found mixed with Baobab tree.

GRASSLANDS:

Grasslands are of two types:

a) Grasslands of Dambos, Swamps and flood plains, where trees are absent because soils are waterlogged.
b) Grasslands of higher plateaus of the Nyika and Mbala high-lands, where trees have been destroyed by fire and replaced by grass.

IMPORTANCE OF FORESTS AND FOREST PRODUCTS TO ZAMBIA:

- Provide construction material for homes and public buildings like schools and hospitals.
- Provide wood timber for railway sleepers, furniture, and telegraph and electricity poles.
- Grass and fibres for making ropes, mats and baskets, building houses and shelters.
- Fuel wood for cooking, heating and lighting.
- Protection of the catchment areas from soil erosion.
- Protection of the soil from drying up.
- Reliable water supply by acting like sponge which holds water and releases it gradually throughout the year.
- Food for both human beings and wildlife.
- Provides shelter to wildlife.
- Source of medicine.
- Forests provide good scenery especially in highland areas hence act as tourist attractions.
- Raw materials for industries such as sawmills, pulp and paper, boat building and floor tiles.
- Water vapour which contributes to the formation of rain.
- Purifies air by absorbing carbon dioxide during the day and releasing oxygen. Forests therefore act as ‘lungs of nature’.
- They act as windbreakers hence prevent the destructive effects of strong winds.

- They improve soil fertility through the decomposition of leaves and undergrowth.
- They generate revenue for the government when products like poles and paper are sold or exported.
- Are a source of employment e.g. forest wardens, carpenters and charcoal burners.

PROBLEMS FACING FORESTRY IN ZAMBIA:

i) Large areas have been cleared of trees for commercial farming purposes.

ii) Shifting cultivation has been responsible for the large clearance of forests and woodlands.

iii) Population growth demands that more forests and woodlands are cleared for timber, farming, building of homes and wood fuel.

iv) Forests and woodlands near large urban centres have been cleared for firewood and charcoal.

v) The construction of industry is responsible for the clearance of many trees. Timber is needed for building houses, public buildings and many others.

vi) Commercial exploitation of timber has led to large areas being cleared of trees. Areas like Kataba, Mulobezi, Sesheke, and Kalulushi have experienced deforestation because of this.

vii) Overgrazing contributes to forest and woodland degeneration. In some cases trees are cleared to make way for grazing of animals as cleared land supports better pasture.

viii) Young and old trees are adversely affected by late bush fires.

ix) Attack of tree species by pests and diseases.

x) Seasonality in rainfall and prolonged drought inhibit the luxuriant growth of forests and retard the rate of forest regeneration.

xi) Lack of enough capital makes it hard for the country to employ effective machinery and techniques to conserve her forest or even exploit the forest effectively.

xii) Endemic corruption in the forestry sector has led to poor forest management.

xiii) Illegal logging where unlicenced people cut down trees for timber and for other forest products.

THE GENERAL EFFECTS OF DEFORESTATION:

1. Shortage of fuel wood.
2. Wildlife such as animals and birds lose homes when trees are cleared.
3. There is reduction in the quality of the environment. An area without vegetation has less scenic beauty than one with plenty of vegetation.
4. Reduction in the amount of rainfall and water supply. Low rainfall is received due to less transpiration.
5. Areas experience falling yields in forest products such as timber, fruits, charcoal and many others.
6. Marked changes in climate-Areas experienced reduced rainfall and increase in average temperatures.
7. There is a general destruction of bio-diversity.
8. Severe soil erosion with the consequence that the land becomes less fertile and may turn into a desert.

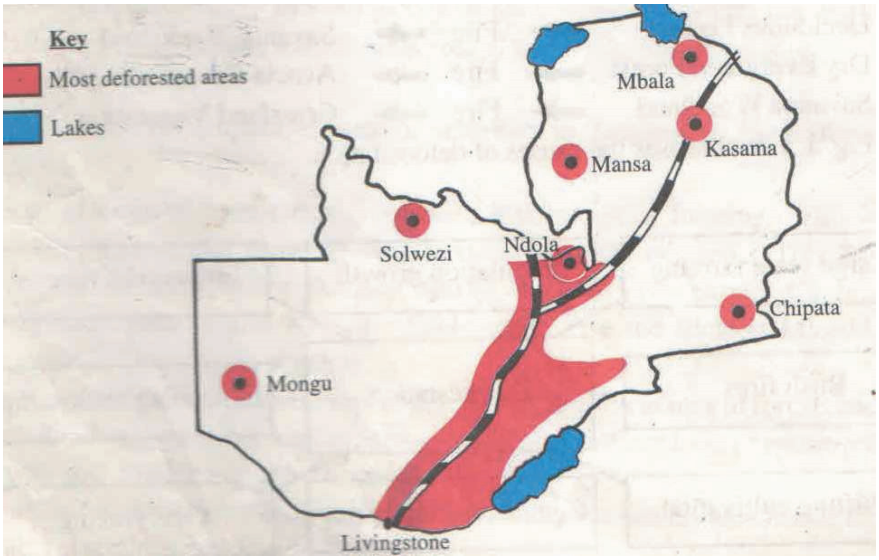


Figure. ** Most Deforested Areas

MANAGEMENT AND CONSERVATION OF FORESTS IN ZAMBIA:

- Management is the successful and skillful handling, planning and effective control of forest resources.
- Conservation is the protection, care, preservation and sustainable use of forest resources while ensuring they are not depleted, damaged or destroyed.
- The measures being undertaken to ensure proper management and conservation of forests in Zambia are:
  1. Creation of forest reserves which protect natural forests from extinction.
  2. Use of alternate sources of energy such as solar energy, wind, hydro- electricity and biomass.
  3. Restricting species and types of trees to be cut.
  4. Fire control.
  5. Regulating tree cutting techniques like trimming of stumps.
  6. Practicing Agro-forestry (this is a system of agriculture which involves the planting of useful trees along with crops. The trees would provide wood fuel, fruits and timber.
  7. Educating communities on the importance of caring for forest resources in their respective areas.
  8. Introduction of tree planting projects at school and community levels.
  9. Practising afforestation and re-afforestation.
  10. Mounting vigorous campaigns against indiscriminate cutting down of trees.
  11. Employment of forest rangers who protect forests from illegal exploitation.
  12. Establishment of the Ministry of Natural resource and the Environment which protects forests from exploitation.

UTILISATION AND MANAGEMENT OF FORESTS AND WOODLANDS.

A provincial Forest Action Plan (PFAP) was launched in 1994. It was a pilot programme undertaken by the Forest Department covering the three provinces of Central, Copperbelt and Luapula. The programme was funded by the Zambian government with some funds and technical assistance from Finland:

Aims of the programme:

- Assess the extent of the existing forests and woodlands in the three provinces.
- Estimate the potential of the forests in the three provinces in terms of timber and other forest products.
- Assess the levels of current use of existing forests in the areas.
- Recommend ways of utilizing and conserving these resources so that they could be used on a sustainable basis.
- Find ways of rehabilitating the degraded areas.

WHAT HAS THE GOVERNMENT DONE TO PROTECT THE FORESTS

It has formulated policies to protect and conserve the forests. This began in 1949 with the establishment of the Forest Department, which is given the following responsibilities:

i) To create and protect forest reserves in the watershed areas against deforestation and soil erosion.
ii) To promote forest programmes like afforestation, re-afforestation and research with the view of achieving self-sufficiency in forest products.
iii) To promote the training of manpower so as to enhance the forest department's contribution to the country's economic and social development.
iv) To conserve indigenous forest by controlling deforestation and re-afforestation programmes.

PROBLEMS FACED IN FOREST MANAGEMENT:

There are many problems faced with those charged with the responsibility of managing forests and some of these are:

- Although the country has large tracts of land under forest, pressure from population growth, the need for farmland, firewood and charcoal has led to widespread deforestation in many parts of the country. As a result the country is losing its forest at the rate of 0.5% per year, which translates to about 6.6 million cubic metres per annum.
- The need for the establishment of the forest plantations has diverted the attention of the forest department from paying attention to the conservation of indigenous forests.
- Re-afforestation programmes are not undertaken as vigorously as in some neighbouring countries.
- While the government has paid some attention to sectors like agriculture and industry, attention to forest industry has been less.

UNIT II

FISHING

FISHING IN ZAMBIA

The **fishing industry** includes any industry or activity concerned with taking, culturing, processing, preserving, storing, transporting, marketing or selling fish or fish products. It is defined by the Food and Agriculture Organization as an activity that includes recreational, subsistence and commercial fishing, the harvesting, processing, and marketing sectors. The commercial activity is aimed at the delivery of fish and other seafood products for human consumption or as input factors in other industrial processes. Directly or indirectly, the livelihood of over 500 million people in the developing countries depends on fisheries and aquaculture

Fish processing:

Fish processing is the processing of fish delivered by commercial fisheries and fish farms. The larger fish processing companies have their own fishing fleets and independent fisheries. The products of the industry are usually sold wholesale to grocery chains or to intermediaries.

Fish processing can be subdivided into two categories: fish handling (the initial processing of raw fish) and fish products manufacturing. Aspects of fish processing occur on fishing vessels, fish processing vessels, and at fish processing plants.

Another natural subdivision is primary processing involved in the filleting and freezing of fresh fish for onward distribution to fresh fish retail and catering outlets, and the secondary processing that produces chilled, frozen and canned products for the retail and catering trades.

Fish products:

Fisheries are estimated to currently provide 16% of the world population's protein. The flesh of many fish is primarily valued as a source of food; there are many edible species of fish. Other marine life

taken as food includes shellfish, crustaceans, sea cucumber, jellyfish and roe.

Fish and other marine life are also be used for many other uses: pearls and mother-of-pearl, sharkskin and rayskin. Sea horses, star fish, sea urchins and sea cucumber are used in traditional Chinese medicine. Tyrian purple is a pigment made from marine snails and (added) sepia is a pigment made from the inky secretions of cuttlefish. Fish glue has long been valued for its use in all manner of products. Isinglass is used for the clarification of wine and beer. Fish emulsion is a fertilizeremulsion that is produced from the fluid remains of fish processed for fish oil and fish meal.

In the industry, the term *seafood products* are often used instead of *fish products*.

Fish marketing:

Fish markets are marketplaces (marketplace) used for the trade in inland (and) the (added) sale of fish and other seafood. They can be dedicated to wholesale trade between fishermen and fish merchants, or to the sale of seafood to individual consumers, or to both. Retail fish markets, a type of wet market, often sell street food as well.

Most shrimp are sold frozen and are marketed in different categories. The live food fish trade is a global system that links fishing communities with markets.

Traditional sector:

The traditional fishing industry, or artisan fishing, are terms used to describe small scale commercial or subsistence fishing practises, particularly using traditional techniques such as rod and tackle, arrows and harpoons, throw nets and drag nets, etc. It does not usually cover the concept of fishing for sport, and might be used when talking about the pressures between large scale modern commercial fishing practises and traditional methods, or when aid programs are targetted (targeted) specifically at fishing at or near subsistence levels.

Recreational sector

The recreational fishing industry consists of enterprises such as the manufacture and retailing of fishing tackle and apparel, the payment

of license fees to regulate authorities, fishing books and magazines, the design and building of recreational fishing boats, and the provision of accommodation, fishing boats for charter, and guided fishing adventures.

FISH makes up 40 percent of annual protein in the diet of Zambians. The direct benefits of fish as a source of food of high nutritional value cannot be overemphasised. The current estimate for annual fish production is about 70,000 tonnes, while the estimated national demand stands at 120,000 tonnes indicating a deficit of 50,000 tonnes. And according to the Fisheries Department, from the 1970s to 1980s the per capita consumption of fish in Zambia was 12 kilogrammes per person per annum. However, recent estimates show a drop in the per capital consumption to 7 kilogrammes per person per annum.

The drop in the per capita consumption has been attributed to the decline in fish stocks in some fisheries as a result of excessive fishing and use of bad fishing methods as well as an increase in demand due to increased human population.

The increase in demand has no doubt resulted in the increase in fishing pressure which is prompting fishermen to employ environmentally-harmful methods of capturing fish.While the Department of Fisheries has put in place measures to sustain fish resources in our natural water bodies such as an annual fish ban which runs from December 1 to February 28, there's need to promote fish farming as a way of supplementing natural water bodies in providing fish as a source of animal proteins.

Looking at the deficit between the production and consumption which stands at 50,000 tonnes, there's room for fish farming to flourish in Zambia.

We would, therefore, like to commend government for working towards promoting fish farming in the country.

According to Mwansabombwe district commissioner Victor Kasuba, Government has just engaged experts from Bangladesh to train local people in fish farming and mango processing.Considering that one of the major long standing constraints in fish farming has been lack of comprehensive training packages and materials, the move will therefore empower more local people to venture into fish farming and

successfully so.

It is, however, hoped that this training will not only be confined to residents of Mwansabombwe but should be spread to other parts of the country to benefit those who are already in fish farming or those planning on starting.

According to the Department of Fisheries, currently there are about 6,000 small-scale farmers operating over 13,000 fish ponds through out (added) the country. At the same time, 16 large commercial farmers have taken up the activity on the Copperbelt, Lusaka and Southern provinces.But these only account for about 5,000 tonnes of the 70,000 tonnes of fish produced annually.Going by the precariousness of the food security situation in many parts of our country, fish farming would definitely help in improving animal protein supply, especially among the vulnerable in rural areas.

Fish farming has the potential to contribute to the country's economy through generation of employment, income and consequently poverty-reduction.

As government endeavours to promote fish farming, it should go a step further to raise the scale of operations by attracting corporate investment into the sector as a way of realising full potential.We implore citizens and especially young people to take the deficit in fish production as a business opportunity and invest in the sector.With the Youth Development Fund in place there's no excuse for the youth to languish.

FISHERIES IN ZAMBIA

Fisheries

Zambia has great potential for increasing fish production from her lakes, swamps and rivers. Significant increase in fish production from aquaculture/fish farming is also possible with improved extension methods. Increased fish production should result in improved incomes, better nutritional standards for the population and exports to earn foreign exchange. Over the past two decades, the performance of the fishing industry has been generally unsatisfactory. Although the total fish catch has increased from 47,000t of fish in 1971 to 66,000t in 1991,

the per capita consumption of fish has decreased from 12kg to only 8kg. Production from fish farming increased from 692t in 1986 to 1,072t in 1988, and is currently estimated at 3,500t annually. This increase is too small compared to the potential production from fish farming in the country.

Major causes for the poor performance of the fishing industry include: inadequate knowledge of the sizes of fish resources in various water bodies, leading to overfishing in some places and under-exploitation of some fish stocks: inappropriate fishing technology; inadequate fishery management services; critical shortage of trained manpower, particularly in the area of fish stock assessment to devise appropriate fishery management strategies and to oversee fishery activities; inadequate communications and infrastructure resulting in limited access to fishery areas; and poor policies of the sector.

Fishery policy should pay more attention to removing these and other constraints. The Ministry's high priority areas should therefore be as follows:-

- Specialised manpower training, particularly in the area of fish stock assessment, so as to strengthen the capacity of the Department of Fisheries to plan the management of capture fisheries in a proper and rational manner.
- Provide trained fisheries technicians to collect accurate data needed to plan development of the fishing industry and to effectively supervise fishery conservation programmes.
- Regulate the fishing pressure exerted on any given fishery in such a manner that highest ecological productivity is attained and conserved.
- Provide specialized manpower to supervise and plan the development of aquaculture in the country, including introduction of cage culture.
- Increase the supply of trained aquaculture technicians at the village level to improve extension services to fish farmers.
- Facilitate and encourage credit facilities to fishermen and fish farmers.
- Improve the supply and availability of inputs to the fishing industry and equip the Department of Fisheries adequately so that it can perform its functions and fulfil its role.
- Promote the exploitation of traditional fisheries, and encourage the harvesting of other aquatic organisms for economic purposes and introduction of territorial fishing rights.

- Fishery management strategies and plans to be based on sound ecological principles. Emphasis to be placed on fisheries and aquacultural research so that adequate information/data to plan the development of the sector is generated.
- Expansion of fish farming practices and techniques to commercial levels.
- Encourage cooperation with other countries on matters related to management and development of fisheries of transboundary water bodies.

1. **LAKE KARIBA FISHERY**

- It is 280km long.
- Fingerlings (baby fish) of Tilapia from Chilanga and Kapenta from Tanganyika were introduced.
- A fisheries training centre was introduced at Sinazongwe.
- Fish caught includes Kalongwe, Mutaba, Bream, Tiger fish etc.

2. KAFUE FISHERY.

- It is 292km from Kafue gorge to Itezhi- tezhi dam.
- Droppings from wild animals and cattle provide rich food for the fish.
- Gill nets, Lines, Spears, clubs and traps are used to catch fish.
- Types of fish caught include Bream, Pike, Barbel, Bulldog and Bottle nose.
- Lusaka provides a good market for the fish.

3. LAKE TANGANYIKA FISHERIES.

- Zambia occupies 1/8 of the lake.
- Fish caught include Nile Perch, Kapenta and Bream.
- Scoop nets and Gillnets are used.
- Commercial firms like Sopelac and Chani operate there using motor-powered boats.
- Distance to the copperbelt for market is a major problem of fishermen.

4. BANGWUELU FISHERY

- This includes the lake and the swamps around.

- Fish caught includes Bulldog, Barbel, Tiger fish and Bream.
- Fishermen use Gill nets, Long lines, Spears and Baskets.
- Fish is dried and marketed due to long distance.

5. LAKE MWERU and MWERU- WANTIPA.

- Extends from Mambilima to the edge of Lake Mweru.
- Gill nets and lines are used.
- Fish caught include Snout fish, Tiger fish, mud suckers, Cat fish, Barbel Green headed Bream.
- Most of the fish is sold fresh.

6. Other fisheries include Upper Zambezi and Lukanga in central. Fish caught include Tiger fish, Mud sucker and Breams.

TYPES OF FISH

Zambia has relatively rich fisheries based on its many lakes, swamps, and seasonally inundated floodplains. Of particular importance is the Luapula valley, which supplies the Copperbelt. Lake Tanganyika is famous for Nile perch and *kapenta*, a deep-feeding freshwater sardine caught at night using special lamps to direct its movements. Lusaka is supplied mainly from the Kafue Flats and the Lukanga Swamp. Of lesser importance is the fishery on the upper Zambezi. There has been a revival of fishing on Lake Kariba, interrupted by the conflict with Rhodesia (now Zimbabwe) during the 1970s. There is a fishery of *kapenta*, which had been introduced successfully from Lake Tanganyika, although the fishery is better established in Zimbabwe, where fishing was not stopped by the war. Most fish is smoked before being trucked to market

OC = a Fish Base occurrence record suggests a specimen from another country outside normal stated range (these vary widely in reliability from obvious mis-identifications to being almost certainly correct)

TYPES

1. *Amphilius cryptobullatus* (Amphiliidae)
2. *Nothobranchius kafuensis* (Aplocheilidae) **Kafue Killifish**
3. *Chetia mola* (Cichlidae)
4. *Cyprichromis zonatus* (Cichlidae)
5. *Julidochromis dickfeldi OC* (Cichlidae) **Brown Julie**
6. *Lamprologus laparogramma* (Cichlidae)
7. *Neolamprologus caudopunctatus OC* (Cichlidae)
8. *Neolamprologus prochilus* (Cichlidae) **Slingjaw Lamprologus**
9. *Orthochromis luongoensis* (Cichlidae)
10. *Perissodus eccentricus OC* (Cichlidae)
11. *Tilapia baloni* (Cichlidae)
12. *Tilapia jallae* (Cichlidae)
13. *Xenotilapia rotundiventralis* (Cichlidae)
14. *Neolebias lozii* (Citharinidae) **Banded Neolebias**
15. *Barbus altidorsalis OC* (Cyprinidae)
16. *Barbus lornae* (Cyprinidae)
17. *Barbus owenae* (Cyprinidae)
18. *Coptostomabarbus bellcrossi OC* (Cyprinidae)
19. *Kneria paucisquamata OC* (Kneriidae)
20. *Chiloglanis macropterus OC* (Mochokidae)
21. *Hippopotamyrus smithersi* (Mormyridae)

Additional endemic freshwater fish species that were described too recently to be included in FishBase 2004 are given below. This list is primarily based on the information from the 13 March 2009's version of the catalogue of Fish data base and includes species described through 2008. In addition to the 21 endemic freshwater fish species listed above, these additional 7 species total 28 species of freshwater fishes known solely from Zambia.

22. *Benthochromis horii* (Cichlidae) 2008
23. *Cyprichromis coloratus* (Cichlidae) 2006
24. *Neolamprologus cancellatus* (Cichlidae) 2005
25. *Chiloglanis productus* (Mochokidae) 2006
26. *Synodontis ilebrebis* (Mochokidae) 2006
27. *Synodontis lucipinnis* (Mochokidae) 2006

28. *Nothobranchius rosenstocki* (Nothobranchiidae) 2005

Safari Specials

Game fishing is never complete until you have fished the beautiful waters of Lake Kariba. People from all over the world come to these waters to fish for one fish alone, the ferocious **tiger fish**.Good fishing occurs throughout the year, however during the rainy season between October and February, it is extremely hot and humid, and not for the faint hearted.

Tiger Fish

True game fish, they head for the open, believing that sheer strength, speed and somersaults will grant them freedom. And they're right, most of the time .Although not unique to Zimbabwe, it is certainly more prolific than elsewhere in Africa.The tigerfish is extremely streamlined and have a fine set of razor sharp, pointed, inter-locking teeth- it does not attack humans.There are many fish caught these days in the 3 to 6 kgs bracket with some still tipping the scales in the region of 8-10kgs

Catching a tiger - bait and lures:

The tiger can be caught by a variety of methods such as trolling, spinning, drifting and bottom fishing and one can also use live bait or fillet. However, the best dead bait is without doubt the Kapenta. The small sardine (kapenta) was introduced into Lake Kariba some 10 years ago, on a commercialised basis to provide protein for the population. Kapenta account for more than 50% of the tigerfish's diet. Primarily a summer fish on the lower river, but on the Upper Zambezi July and August are prime months

Rods:

Ideally depending on the method one chooses, the rod should be of medium action- 6 1/2 feet to 7 feet in length. The reel should be an open-faced type and capable of carrying 12lb test line. All terminal tackle must be protected by a wire leader to prevent the tiger severing the line with his sharp teeth. 9/10wt Titanium Fly Rod, Sci Anglers Reel fast sinking line Clousers, deceivers, sprats a couple of Circle hook Clousers 6'6" Casting Rod, Baitcaster 17lbs Line 11 and 14 inch magnum rapalas & assorted spinner lures Plenty of steel trace material.

Vundu:

The largest fish in the Zambezi system, only found below Victoria Falls, is the vundu, (Heterobranchis longifilis), a giant catfish which attains well over 60 kg (the very similar barbel, up to 20 kg, is found both above and below the Falls.) A bottom-feeding river species usually taken on fillet bait, strangely, cheap strong smelling soap is excellent bait.The vundu is becoming rare in Kariba and should always be released; there's no point in killing it.

Electric Catfish (Malapterurus electricus)

It also puts on a good fight but only grows to about 5kg. Feeding almost exclusively on other fish, they stun their prey with a high voltage shock at close range.

If you touch it you will more likely to get an electric shock, be put off fishing for life with a jolt of up to 450 volts

Brown Squeaker (Synodontis zambezensis)

Alternative name Chokachok. This is a member of the catfish family and is quite common to the lake . It can be identified by the three spines, one dorsal and two lateral.
The name Brown Squeaker comes from the fact that when these fish are caught, they move their two lateral spines rapidly in their sockets which emits a squeaking sound. These spines are capable of inflicting a painful wound that is very likely to turn septic if not treated at once. Some anglers are known to remove these spines with a knife or side cutters before handling the fish. You will not be the only one trying to catch this fish as the Squeaker is preyed upon by crocodiles and Tigerfish, and the spines can often cause fatal injuries to the predator. Bait - They eat anything, insects, mud, algae and fish, and are mostly caught at night. They are disliked by anglers who are fishing with worm on the bottom, as once they get a bite from this fish that (they) rarely catch anything else.
The Brown Squeaker is surprisingly tasty but plays no significant role in the commercial catches on the lake. The fish seldom exceeds 0.5kg in weight.

Harp tooth Catfish-Barbel (Clarias gariepinus)

This catfish has been known to leap out of the water at birds perched on low overhanging branches. These can be found throughout the lake in the shallow waters and using its ancillary breathing organs, it can survive in almost any type of water. They eat anything including frogs, insects, and fish.Feeding mainly at night, when hooked; the angler will feel a constant steady pull. The fish will not hesitate to attempt to free itself by swimming into obstacles. The Sharptooth is fished extensively for commercial purposes and although the average catch weight is 3kg, they can reach about 6kg.

3. FISHERIES SECTOR

3.1 Demand for fish

Fish is a regular part of Zambian diet and each Zambian consumes on an average 10 kg of fish per year. This level of consumption is equal to what the average Zambian consumes in meat (including 4 kg of beef). The rest consists in checken and other types of meat. Fish consumption was as high as 17 kg/head/year in 1971/72 but consumption was reduced as fish imports were cut to help ease balance of payment problems.

TABLE 3.1

ZAMBIA's PROJECTED DEMAND FOR FISH BASED ON POPULATION AND PER CAPITA **CONSUMPTION INCREASE IN TONS**

	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
At current level of 10 kg per capita	600,250	62,100	63,900	65,800	67,800	69,900	72,000	74,100

At 12 kg per capita		74,500	76,700	79,000	81,400	83,900	86,400	88,900
At 15 kg per capita		93,100	95,900	98,700	101,700	104,800	108,000	111,200

Source: World Bank, Fisheries Development Project.

TABLE 3.2

ZAMBIA FISH PRODUCTION BY MAJOR SPECIES, 1981, IN TONS

Fisheries	**Kapenta**	**Bream**	**Catfish**	**Luciolates**	**Lates**	**Other**	**Total**
Tanganyika	5,188	-	-	1,197	958	639	7,982
Mweru Wa-Ntipa	-	4,759	285	-	-	690	5,734
Mweru Luapula	-	3,470	774	-	-	3,500	7,744
Kariba	1,200	600	-	-	-	200	2,000
Kafue	-	5,483	1,635	-	-	2,501	9,619
Bangweulu	-	6,540	1,868	-	-	934	9,342
Lukanga	-	619	305	-	-	599	1,523
Upper Zambesi	-	4,016	1,138	-	-	1,540	6,694

Total	6,388	25,487	6,005	1,197	958	10,603	50,638
%	13.0	50.0	12.0	2.0	2.0	21.0	100.0

Source: World Bank, Fisheries Development Project, 1984

Because of long distances between fishing areas and consumption centers, and due to the lack of storage and transportation facilities, about 65% of total production is either sun-dried (kapenta) or smoke-dried (bream, catfish, lates and other). Smoke dried and sun-dried fish can be kept for several months, are available all year round in all major consumption centers and are part of the Zambian daily diet. Fresh-fish is prefered but its availability is restricted. Frozen and fresh fish are available on a non regular basis even in the urbanized area of the Copperbelt. Only Lusaka is being supplied on a regular basis, as it is close to the fishing areas of the Kafue river.

3.3 Marketing:

Fish is distributed through a variety of outlets, including retail stores selling meat and other food products; those have this facilities for selling frozen fish. Yet the main outlets are the city markets. The mission has surveyed markets in Lusaka, in Kitwe and in Chipata. The distribution system involves a minimum number of intermediaries. In the case of kapenta from Lake Kariba and Lake Tanganyika quite often there is only one wholesaler between the fishing community and the retailers. In the traditional market where most fish are sold, fishes whether fresh or dry are sold by unit, either of one fish, or one heap or one tin (dried Kapenta and dried juvenile bream). Changes in volume per unit of sales allow price changes without changing price per unit. For instance, in Lusaka, retailers use three sizes of tins: a smaller one for time of short supply, a bigger one for periods of abundance, like when catches are at their maximum in August and the standard one. Yet the price per unit stays the same for long periods.

3.3.1 <u>Taste preferences:</u>

Bream, whether fresh of smoke-dried is the main species supplied on the open markets of urban areas along the railway line, which reflects the fact it is the most important catch. It is also a favorite

fish which in its fresh state commands a higher price than other kinds. For instance a market survey of the main fish market in Lusaka indicated that the average price of bream sold one by one was K8.06 while it was K5.60 for tiger fish, K6.27 for mormyrus and even less for other types of fish. The preference for bream is not as clear when it comes to the smoke-dried fish. In some instances, like for smoke-dried mormyrus sold at K15.00/kg, it does not seem to be the case. It is possible that the process of smoking tends to give a uniform taste to different species of fish but most of all, the samples taken for other species of smoked dried fish are too small to make reliable inferences. The price-ratio between fresh fish and smoke-dried or sun-dried fish confirms a preference for fresh-fish. Even if smoke-dried or sun-dried fish has a food content to weight ratio which is 3–4 times as high as for fresh fish, its price is never more than twice the price of the same fish bought fresh.

3.3.2 Size preferences

One thing which is more evident, at least for the Lusaka market is the preference for bigger size fish. Smaller size fish are sold in heaps of 2 or more fish of similar size sold at K2.00/heap, whatever the number of fish. Heaps weight varied between 0.3 kg and 0.5 kg. Average weight of heap was 0.369 kg for heap of 2 and 0.365 kg for heap of 3. Since fish of a same heap are matched to be of similar size, a fish exceeding 0.250 kg is sold by unit. Fish sold by unit is not weighed but priced according to size. Prices vary in increment of 1 Kwacha occasionally of K 0.50. Bargaining is not a practice very much in use at that level as it is in other African countries. On average, fish sold by unit is sold at K8.06/kg. Price per kg varying from K5.00 to K11.11. The average price per kg for bream sold in heaps of 2 was K5.42, the range being K4.4–K6.67. The average price for bream sold in heaps of 3 was K5.48, the range being K5.00–K6.45. Thus, price of fish sold by unit is 40–50% higher than for fish sold in heaps.

There was a less extensive fish and meat market survey in Kitwe made by an officer from the Fisheries Department. Supply of fresh fish was less abundant, and prices for both fresh and smoke dried fish seem slightly lower than in Lusaka.

In Chipata, there were no supplies of fresh fish on both days the mission visited the market. Dried kapenta was in ample supply, coming mostly from Lake Kariba (yellow kapenta) and to a lesser extent from Lake Tanganyika (silver kapenta). There, as well as in Lusaka, retailers

declared that consumers preferred silver kapenta from Lake Tankanyika to the yellow one from Lake Kariba. Yet this preference does not appear strong enough to justify a price difference. Even if kapenta from Lake Kariba has to travel 604 km more to reach Chipata than to reach Lusaka, it is sold at K1.00/tin compared to K2.00/tin in Lusaka, for similar size tin.

3.4 Fisheries Development

Actions have been taken by the government of Zambia through its Department of Fisheries, in order to reduce some of the constraints which hinder the growth in fish supplies and at least stabilize annual fish consumption to its present level of 10 kg per cap. One of those actions is a $10 million project to be financed through a $7.1 million loan from the World Bank. The project would consist first in extending loans to artisanal fishermen and small fishing enterprises of Lake Tanganyika, Mweru Wantipa, Mweru Luapula and Lake Kariba for buying fishing gear and equipment. It would also serve to extend loans to individual or companies willing to establish fish collection, marketing and distribution systems on Lakes Mweru Wantipa and Mweru Luapula. Also an ice plant would be built in Kafue which would help regulate the supply of fish and frozen fish to the Copperbelt Area and also to the Lusaka market, notably by reducing losses and improving quality. The impact of the project would be to increase total fish supplies by 7,000 T, out of which 1,000 T through reduced losses and 6,000 T through increased catches.

Another action consists in building 500 km of feeder roads leading to fishing communities in order to reduce cost and time of transportation. This project is financed by Canadian International Development Agency, for a total sum of C$26 million.

However, development projects concerning capture fisheries can only increase fish supplies to the maximum sustainable yield, estimated at 74,000 tonnes. Beyond that level, by which the pressure of an increasing demand could soon lead to, additional fish supplies can only come either from imports or fish-farming.

4. FISH-FARMING IN ZAMBIA

The extent of fish-farming in Zambia is not very well known. Most recent estimates give as 313 HA the total surface under production including 47 HA or 15% in government stations, 180 HA or 58% in commercial farms and the rest 86 HA or 27% in rural ponds exploited mostly for self-consumption. This area has an estimate of 313 HA represents a substantial increase from the 1967 estimate of 100 HA

There are 19 governement stations, with a total of 338 ponds, of 1,400 m^2/pond on average. The number of commercial fish-farmers is estimated at 90. Total number of ponds is estimated at 500, with an average of 3,600 m^2/pond (including small reservoirs stocked for fish-farming). There would be around 2000 rural farmers which have included fish-farming in their activities; they would exploit 2,162 ponds with an average of 400 m^2/pond.

Average yield for governement stations is estimated at 2 t/HA which represents a total annual production of 94 t (T) for that sector. Commercial fish-farms are estimated to have average yields of 3 t/HA which would give a total annual production of 540 T. Rural ponds have estimated yields of 1 t/HA (for a total production of 86 t (T). Thus total fish-farming in Zambia would be about 710 t (T). Those figures were estimated in collaboration with FAO/UNDP project management. This nevertheless represents a substantial increase from the 1967 level of production estimated at 88.7 tons.

At its present state of development, fish-farming production would represent less than 2% of total fish production in Zambia. But taking into account that output from fish-farms is sold fresh, it represents around 5% of that fresh fish supply.

Fish-farming development goes back to the colonial period of Zambia but progress has been moderate for many years, notably because of lack in government support as economic conditions have reduced budget required for development programs. Governement backing of fish-farming development has consisted in supplying of fingerlings and providing some technical advice. However the strong development of commercial fish-farming which has happened in the past 5–6 years in private farms and companies has been largely autonomous, with minimum governmental involvement except for supplying of fingerlings. A new fish-farming development project, to be implemented with cooperation of UNHCR (United Nations High

Commission for Refugees) and the Zambian Catholic Secretariat consists in creating 380 rural fish-farming operations of approximately 1200 m^2 each (2–3 ponds) in the Western province. The project would be implemented over a period of three years and, if successful, would add some 45 HA of ponds to the existing fish-farming capacity.

Since 1980, a FAO/UNDP project has been implemented in order to demonstrate the technical and economic feasibility of large scale fish culture. The general objectives of the project were:

1. to increase the total production of fish in the country for additional annual protein for human consumption;
2. to create employment;
3. to substitute fish imports and have foreign currency.

Since its inception in 1980, the FAO/UNDP project has allowed the development and management for three government fish-farming stations at Chilanga, Mwekera and Chipata. Different data collected during development and operational phase have been collected and analyzed during the present mission.

4.1 UNDP/FAO project

4.1.1 Development program

The UNDP/FAO project did realize different renovation and development activities at Chilanga, Mwekera and Chipata. At Chilanga the following activities were carried on:

- clearing and repairing of 17 cemented ponds;
- construction of outlets for 13 ponds;
- construction of duck houses (2) and fencing around ten 800 m^2 earthen ponds;
- construction of fish feed store and incubator room;
- renovation of ducks and ducklings sheds;
- building of a harvesting pitch for Pond 8;
- renovation and clearing of 19 ponds in C-pond complex including construction of two new monks and upgrading of six old ones;
- construction of one pigsty and one duck-house later changed to a pigsty;
- construction of improved type of duck house on the dyke between ponds (19 and 20);

- construction of cropping pits;
- Construction of a whole new pond of 0.5 HA with monk and harvest pit in the second half of 1981.

At Mwekera, development work covered the construction of 16 ponds of 0.25 HA water area, with a maximum water depth of 1.3 m and 0.5 m freeboard and equipped with monk type outlets. Also included in the project was construction of four line feeder canal of 0.4 m × 0.6 m.

In Chipata, project staff proceeded to the upgrading of the old pond networks (clearing and repairing of old ponds, construction of new inflow canals, deepening of canal between dam and road). Yet the major work consisted in the construction of 9 ponds of 0.5 HA. Each to be located on the right bank of the Masupe river downstream from the existing complex.

4.1.1.1 Pond construction cost in Chilanga

The 0.5 HA pond built in Chilanga was completed during the last half of 1981, at a cost of K8,062.20 which is equivalent to K16,124 per HA . The total cost was broken down as follows:

	K
Earthwork (6,500 m^3)	6,839.00
Monk	507.00
Sand (Transport)	80.00
Gravel (Transport)	54.00
Cement (7 Bags)	33.40
Labour (1,120 m.h)	548.80
Total	K8,062.20

The cost of K16,124/ HA (is considered as high as the harvest pit is seen as experimental. It was then expected that building a private fish-farm under normal circumstances would cost K10,000/ HA

4.1.1.2 Pond construction cost in Mwekera

Project included renovation of 34 ponds in 1982 and 1983, and construction of ten new monks. Each monk required 24 m-h and cost approximately K100. Work also included construction of one duck house, of 6 manuring cribs and the fencing of one pond.

The major development work consisted in building 16 ponds of 0.25 HA each, which can be filled to a maximum water depth of 1.3 m, freeboard being 0.5 m, equipped with monks and four line feeder canals of 0.4 × 0.6 m. Construction was started in June 1983 and was finished by November except for installation inlet pipes and construction of 8 monks. The whole construction contract done by Brunelli Construction cost US $86,052.94 (equivalent to K79, 878.34 at 1982 average exchange rate), which brings the cost per HA to US$21,513 or K19, 970. The cost breakdown was as follows:

	$
1 - Clearing and site preparation	9,090
2 - Construction of dikes and pond bottoms	29,098
3 - Excavation of drains	4,411
4 - Construction of culverts	1,972
5 - Construction of feeder canals	8,628
6 - Construction of outlets	12,365
7 - Construction of inlets	3,417

8 - Dressing of dikes	5,848
9 - Contingencies (15%)	11,224
Total	86,053

4.1.1.3 Pond construction cost in Chipata

Like the farms of Chilanga and Mwekera, the UNDP/FAO project included different renovation activities, which are followed in Chipata and are as follows:

- clearing and repairing of old ponds
- installation of asbestos pipes for outlet
- deepening of canal between the dam and the road and lining with three layers of bricks
- installation of an additional siphon on the dam.

Those activities were carried by project staff.

In addition, construction of 9 ponds of 0.5 HA each was contracted out to Brunelli Construction at a cost of US$112,837.61. Those conditions were obtained on the ground that the contract would be paid in US dollars and taking into account the fact that the required equipment had already been brought to the area for implementation of another project.

Some problems were met namely, that of construction activities which was delayed for two months since some villagers had planted maize on planned site, despite warnings from officials. Also contrary to what appeared on plans, Masupe river was flowing on portion of planned pond site. Therefore, the river had to be diverted, which involved more earthwork than initially planned. Construction work was completed between May 1983 and December 1983. In Kwacha, construction cost comes to K141,118 (average rate of exchange for 1983: $ 0.7996) which is equivalent to K31,360/ HA Applying the 1982 average rate of exchange the cost per HA would have been K26,906 (US$25,075).

Construction costs in Chipata were broken down as follows:

	$
1 - Clearing and site preparation	10,497
2 - Construction on dikes and pond bottoms	46,279
3 - Excavation of drains	9,074
4 - Construction of outlets	9,599
5 - Construction of feeder canals	8,618
6 - Construction of inlets	2,518
7 - Dressing of dikes	11,534
8 - Contingencies (15%)	14,178
Total	112,838

Construction costs in Chilanga, Mwekera and Chipata indicate the trends in pond development cost. All were machine-built, over a period of three years. The first operation, at Chilanga concerned construction of a single 0.5 HA pond with special outlet structure, therefore, should have been relatively costly; yet the final cost came to K16, 124/ HA. The second operation in Mwekera concerned a 4 HA pond complex development with 0.25 HA ponds where cost per HA came to K19, 970. The last operation in Chipata involved 0.5 HA ponds on a development covering 4.5 HA; the cost per HA came to K31, 360. The rise in cost comes mostly from the trend in rate of exchange of the K which went from $1.1516 on average in 1981 to $1.0773 in 1982 and $0.7796 in 1983. If the cost per HA is expressed in US$, the difference in cost of construction per HA between the three sites is much smaller:

TABLE: 4.1
POND CONSTRUCTION COSTS INCURRED UNDER UNDP/FAO PROJECT

	CHILANGA	MWEKERA	CHIPATA
Year of construction	1981	1982	1983
Total pond area developed (HA)	0.5	4.0	4.5
pond size (HA)	0.5	0.25	0.5
Total cost	K8,062	US$86,053	US$112,838
Average rate of exchange ($/K)	1.1516	1.0773	0.7996
Total cost in K	8,062	79,878	141,180
Cost/ HA in K	16,124	19,970	31,360
Cost/ HA in $	18,568	21,514	25,075

Construction cost/ HA, **US$**	
Chilanga	18,568
Mwekera	21,514 (+16%)
Chipata	25,075 (+17%)

4.1.2 Fish-farm management (Chilanga)

The UNDP/FAO project also introduced new management techniques in the three government stations under project, once the renovation and development phase was completed. The results obtained will be used as reference when planning for fish-farming development and management. However, only the Chilanga station has so far managed to produce a production record, which can be used as a basis for planning. In Mwekera, only very recent harvest yields have been recorded. In Chipata, difficulties like insufficient supplies of fingerlings have kept yields at a level which cannot be considered as a basis for planning.

During the years 1976–1979 before the UNDP/FAO project started at Chilanga, yields varied from 156 to 463 kg/ HA/ year. After the start of the project different management options were applied namely feed with fertilizers, pig cum-fish and duck-cum fish, stocking either with a mixture of O. andersonii, O. macrochir and T. rendalli or monoculture of O. andersonii or C. carpio.

4.1.2.1 Feed and fertilizer:

A first cycle started in February 1981 and ended in May-June 1981, was done on the 16 cemented ponds, stocked with the three mentioned species at a density of 3–4/m^2. Superphosphate (46% P_2O_5) and Sodium nitrate (15% N) was applied. Feed consisted in a mixture of maize bran and sunflower oil cake. Production cycle lasts for 113 days for 10 ponds, 102 for 2, 74 for 3 and 70 for 1.

Yields varied from 1.938t/HA/yr to 4.932 t/HA/yr, with an average of 4.640 t/HA/yr.

A second experiment was made in 6 cemented ponds with the three species of fish stocked separately. Stocking density was lower at 2.5/m^2. The cycle last longer from August to January (275 days). The same fertilizer mix was applied and a mix of 50% maize bran, 50% sunflower oil cake was used to the amount of 69.25 kg/100 m^2 for the whole cycle. Yields were lower than in the first experiment ranging from 1.53t/HA/yr to 2.11 t/HA/yr (T/ha/yr). Food conversion ratios varied from 3.3:1 to 4.5:1.

A cycle period more than twice as long might explain the difference in yields, although this is not specified. The impact of change in stocking method is not mentioned either.

Further experiments in the C-pond complex using maize bran (40%) and sunflower oil cake (60%) and a stocking density of 425 fingerlings per 100 m^2 gave yields of 3.62 t/HA on a basis of 365 days production per year and 3.02 t/HA on a basis of 304 growth days per year (taking into account the cold period of June and July where growth is almost nil). A lower stocking density of 200/m^2 could give comparable results like for pond C15 in 1983, when yields reached 2.88 t/HA/yr on a 304 days basis.

4.1.2.2 Pig-cum-fish:

A series of experiments with pig-cum-fish option were on a 17 ares pond, between July 1981 and January 1984. Records show following results

Production period	**Stocking density (per acre)**	**Yields t/HA/yr**	**Corrected yield**
30-7-81 – 31-1-82	279	7.22	6.0
11-2-82 – 24-8-82	369	6.38	7.7
9-9-82 – 20-1-83	435	9.84	8.2

3-3-83 – 5-9-83	215	5.07	7.1
0-1-84 – 2-3-84	254	9.93	8.3
5-1-84 – 2-4-84	255	7.39	6.2

A corrected yield was computed in order to take into account the fact that production cycles not covering the months of June and July would give overestimated production yields, while it would to the contrary for cycles including those two months. The correction is done by referring to a 304 days /yr which does not include the cold months of June and July.

Production results indicate that stocking density is not a significant factor in yield differences, as for instance 254/100 m^2 gave yields slightly higher than yields obtained with 435/100 m^2 (see table).

Initially, the number of pigs per HA of pond was 114; it was later reduced to 94. Pigs are bought as weaners at 25 kg and sold after 5 months at a weight ranging from 70 to 100 kg. Feed conversion ratio observed for pigs was 5:1. Pond yields with pig-cum-fish have varied between 6.0t/HA/yr and 8.3t/HA/yr during that period.

4.1.2.3 Duck-cum-fish

Experiments were made in 1981 with Muscovy ducks stocked at a rate of 1000/ HA (caps). Each female gave 54 eggs/yr (year) out of which 90% were fertilized. Natural incubation was used resulting in an average of 4 ducklings per female per year. However the Muscovy ducks did not stay long enough in the water to produce adequate manuring. Therefore, this species was replaced by Peking ducks in March 1982. Natural incubation was replaced by artificial incubation using 2 incubators of 600 eggs capacity each. Peking ducks are transferred to fish ponds when they are three weeks old, the optimal stocking density is 500/ HA.In the early trials, yields obtained with duck-cum-fish option averaged 5 t/HA/yr, based on one year production. Project management has later realized yields of 7t/HA/yr.

4.1.2.4 Polyculture of Cyprinus carpio and Tilapia:

Experiments were made of raising tilapia in association with C. carpio of Japanese origin. Only daily growth rates have been kept. Records also show that carps naturally bred in the pond. However, incidence of poaching was high and otters, which prefer big size fish, took their toll. The problem of poaching and predators, added to problems of broodstock supply for this non-indigenous species, and product marketability, do not encourage further development of this type of culture.

Experiments at Chilanga showed that a pure strain of O. andersonii gave better growth rates than the original mixed stocked used before start of the project. Other experiments also show that bisex culture of O. andersonii give growth rates more or less similar to mono-sex culture.

4.1.2.5 Mwekera fish-farm:

In Mwekera fish-farming station, at the start of the project, existing ponds were upgraded and renovated. Some of them were stocked with O. andersonii broodstock in order to produce fingerlings for the new ponds, some with O. andersonii in mono-culture or with carp fingerlings, others with carp fingerlings only. All ponds were fertilized with chicken manure at a rate of 5–10 kg (dry) per day (5 days/week), except Pond N° 7 which was stocked with ducklings. Chicken manure was thus bought from Copperbelt Power Company at K2/50 kg or K0.04/kg. However information available is not sufficient to provide yields.

It was observed that the presence of ducks reduced predation by tadpoles and frogs. Ducks also clear aquatic weeds.

The completion of the new pond complex at the beginning of 1984, allowed the implementation of a production program. All ponds would be stocked with O. andersonii at 2.5/m^2. Two ponds would be under fish-cum-pig culture; two under fish-cum-duck; two with inorganic fertilizers; two with feeding soyabean cake and maize bran; two would include polyculture with common carp (1/10 m^2), using chicken manure and local feed; six would be fertilized with chicken manure of three possible types.

So far only one production result has been fully recorded. That was for Pond N° 7 (2793 m^2) on which 150 ducks had been put. Production cycle started on February 2, 1983 with stocking of O. andersonii (2.5/m^2). On March 31st, 1983, 100 carps fingerlings were stocked. Initial stocking was 279 kg (40 g per fingerling). Production after 7 months was 1.634t. This is equivalent to a yield of 8–9 t/HA/yr not counting months of June and July, if the estimated weight of fish stocked is correct.

One harvest was taking place during the mission on Pond 16 and the results were not available then.

4.1.2.6 Chipata fish-farm

Before the management program introduced by the UNDP/FAO project, ponds at Chipata station was drained every two-three years and production rates were low.

Development program at Chipata was started in May 1983 and completed in January 1984. Management program was initiated, based on the use of maize bran, rejected maize and floor sweepings from the local mill (200 kg/day). New ponds were stocked with O. andersonii. One pond of the new complex was used for breeding purposes as the old part could not meet the requirements. Stocking density was 2.5/m^2.

Management options used were: duck-cum-fish, mill sweepings, mill sweepings and compost. Feed is given 5 days per week at the rate of 2 kg per breeding pond and 25 kg per production pond. Computation of yields is complicated by the fact that both stocking and harvesting operations were done in many sequences. During year 1984 which was the only full production year since completion of expansion, best results were obtained on Pond Nº (n°) 1 where duck-cum-fish was applied and when yields per (one) 140 days cycle were 6.444 t/HA/yr. In another experiment with ducks yields were only 1.355 t/HA/yr, but with a low stocking density of 20 fingerlings/acre. Mill sweepings and compost gave yields varying between 2.135 t/HA/yr to 4.433t/HA/yr. Mill sweeping only gave yields of 1.614t/HA/yr and 3.158 t/HA/yr.

Production results were impaired by difficulties in producing fingerlings in adequate quantities.

It must also be mentioned that ducks were fed with mill sweepings, and rejected maize as project budget could only cover the

cost of the expert. Yet ducks fed on that diet could reach an average weight of 2.35 kg in 16 weeks.

Method	Gear	Targetspecies	Comment
Surroundingnets	Purseseine(intheIndustrialFisherywithseparatelightboats)	*L stappersii*	Zambia only
	RingNets(Chiromilaseine)	*Stanganicae*	Only found in Nsumbu region of Zambia
	Surround net with divers (Aquariumfish)	*Mixed*	Aquarium fish
Liftnets	Liftnet,1,2,3 (one,two and three)boats	*Stanganicae*	Very uncommon in Zambia,but common elsewhere
Gill nets	Bottom Set -gillnets	Mixed-littoral.Selective	Locally the numbers of gillnets targeting the littoral and sublittoral give cause forconcern.
	Floating Gill net	River and estuary	Not common gear
	Encircling gillnet(with boat and divers)	Littoral	Used in aquarium fish trade
	Drive in gill net	Mixed littoral	Only ones seen in Zambia have illegial mesh sizes
	Seinedgillnet	Mixed littoral	An attempt to get round the local banonen circling gillnets with frightening device
	Stakedgillnet	Now probably not used	Used near reedbeds

1.1 Without gear

Fishing without gear means picking up the fish with the hands, or with very simple instruments such as a stick, macheteoriron hook which has the effect of lengthening the hand.The fisheries without gear noted in Zambia have been as follows:

1.1.1
By hand

People capture fish by hand, normally catfish, (*Clariassp*), particularly, but any fish in practice, in the ponds, rice paddies and swamps adjoining the lake. Any subsistence level farmer or fisherman takes advantage of a fish trapped in a drying pond at the beginning of the dry season, or when migrating over-land (*Clariasgariepinus*).These catches are incidental to agricultural subsistence activities and are not generally significant. Many individuals whose farmland is adjacent to the lake admit to benefit from these opportunist captures.

1.1.2 Extensions to the hand

The use of extensions to the hand to assist in the capture of the fish by hand of the fish.This is widespread for example in the wet season Zambian fishermen of KakulaVillage set out with machetes to search thes wamps of Chitutabay for migrating fish, and the fishermen of the Chisala River in Zambia use axe handles as clubs to capture *Clariassp*.

1.1 Stupefying devices

1.1.1 Plant-poisons

Plant poisons stupefy fish by directly affecting their respiration in someway.In that case, the use of any poison in the lake is illegal it is very difficult to obtain accurate information on the use of plant poisons.

In Zambia, rivers running into the lake and other inland waters poisoning is carried out, but not reportedly in the lake itself.

In Zambia the plants used for fish poisoning are:-

Scientific Name	Local or common name	Toxic-part used
Dolichossp	No local namegiven	roots
Tephrosiasp	Nolocal name given	Leaves and pods
*Syzgiumguineese*subsp	No local name given	Bark-chips
	Giant euphorbia	Whole plant
	Kancense	tuber
	Cantulia	fruit
	Kantemya	Leaves and roots

2.4 Lines

The principle of using a line is that the fish voluntarily takes a bait of some sort and cannot spit it out before being removed from the water. In Lake Tanganyika hooks are used on the lines.The hook can be baited or unbaited, barbed or barbless.

On Lake Tanganyikaall hooks are curved (in the shape of a"hook") and made of steel.There are no circle hooks or gorges in use.Some hooks are home-made and donot have a barb, but the majority are shop bought, manufactured by Mustad™ of Norway.One other brand, Eagle™,made by Maruto of Japanis also sometimes available.All the commercial hooks are Kirbed (have an offset crook, and coated against corrosion., usually with a blue ingmaterial,but sometimes they are tinned or bronzed.Mustad™ hooks are available round the lake in Sizes1-20(20=smallest),with sizes8–20 being most commonly used.

Avariety of lines are available. For handlines Nylon mono filament is preferred. For bottom-lines multi-filament of Polyethylene is preferred. Nylon is recycled as twine which is commonly used for making fishing nets.

2.4.1Vertical handlines

Vertical hand lines, "simple-lines" are one of the most basic forms offishing, requiring just a baited hook, aweight and a piece of line.The fishing operation takes place from any platform, usually a boat out in the lake.

In Lake Tanganyika the line used is nearly always nylon (PA) monofilament. (PE) monofilament, from unraveled PE multifilament has been observed as has single strand PE film from Mealie

(Mealsacks). The line is store do any convenient line holder, which can be an old float, a bit of polystyrene, a soft drink bottle,a bit of cork or a specially made line holder,usually in an 'H'-shape.The length of the line depends on the depth to be fished.

Crews of cargo vessels in Mpulungu Harbour fish with simple lines when in harbour.They just throw a baited hook on a weighted line over the side of the boat.

Themajorityofsimplelinesareusedbyfishermenfrom smallboats,either dug out or planked.They can be found in every village on the lake side.They are extremely common.

The gear depends on the fisherman's preference, and there are many variations on the general theme. Usually between1and 4 Mustad™ kirbed hooks of size 8-12 are attached on short droppers (8-15cm), and weighted with as to the weight tied in to the line with rubber inner tube or directly to the mainline. Sometimes lead weights are used.Old spark plugs, vehicle parts, a drill bit and bits of reinforcing rod have also been noted.

Baits observed by FPSS in1999 and 2000 in vertical hand-line fishing are:-

- Worms dug up in damp soils adjacent to the lake; a preferred bait as any one can do this; used through out the lake.
- Soap.This can be moulded in the hand into a ball of the appropriate size for the hook being used
  Yellow laundry soap made inTanzania
  Blue and white laundry soap made inTanzania
- Small chiclids,other tilapine fishes andsardines
- Barley grains (from the brewery in Bujumbura,used by fishermen of Burundian cargo boats in Mpulungu Harbour)

And as ground bait

- Brewery waste (from the Bujumbura brewery used off vessels in theharbour at Mpulungu)

Fishing takes place in all depths where fish live (up to 200m in the southern part of the lake where the oxygenated zone is deepest).

The target species depends on the depth and the substrate. Nearly all of the fish in Lake Tanganyika will accept bait, even those usually reported to be herbivores. That said however, an individual fisherman knows at what depth and on what substrate he is going to catch a particular species, so the fishermen can target what they wish to catch.

Line fishing is selective in that very small fish will not getcaught on a large hook. However, there are vast numbers of handlines, with a very large number of hook sizes available, fishing in most depths and substrates, so it is safe to assume that all carnivorous demersal species atmost stages of their life cycles are being caught.

Handlines contribute to the general fishing effort round the lake. In highly populated are as there are many handlines, and their catches are probably contributory to the decline in numbers of fish in these areas.

2.4.2 Pole and line

Pole and line fishing is ubiquitous ininhabited reaches of the coastline of the lake and through out Zambia.

The gear is used by male children of school age, many of whom are not attending school for one reason or another. During school holidays there is a noticeable increase in the number of pole and line fishers, indicating that many fishers do actually attend school when it is term time. Some young adults also pole and line fish.

The pole is about a metre and usually of wood.The line is up to10 times the length of the pole and the hook is launched by swinging it round the head (sometimes to oneside of the body) and releasing it.(See a typical example from Zambiain Gear Plan1).The pole is used as a striking device, increasing the length of the hand, and serves to jerk the fish out of the water and on to the shore behind. It can alsobe used to jerk the line, especially if an unbaited hooks are being used, to give some action to the hook and attract the fish.It is also used as a storage device for the line.

The crews of some Congolese refugee cargo boats, fishing from the wharves and their boats in Mpulungu harbour, use as line holders and

poles, sticks cut from near by trees with nails or pegs in them,the line being struck to ground with the nails/pegs.These sticks are sometimes decorated with ornate designs.They are also used to cast or retrieve the hook.The length of the line however, is far greater than other pole and line examples,and reflects the fact that they are fishing with the gear in various locations, and off the boats themselves,quite far up from the water.

The best areas for fishing are close to"features"; the margins of reed beds,clear areas in weedy areas, paddy fields,wharves and harbours (where accessible) and in the small streams that run into the lake. However, many villages do not have such features, so the children just fish in the margins.

The species composition of the catch depends on the substrate being fished.

As a general rule it seems that the catch volume is dictated by quantity required rather than time or quantity available. A fisherman will continue to fish until enough fish has been caught to satisfy the requirements of the day.Typically the catch is between 300 and 500grammes, and presumably this is considered enough to feed the average family, or provide the necessary proteinaceous addition to the menu for the day.The catch is taken home and cooked whole, usually fried, and though small in weight is important to the diet of many marginal households.

2.4.3 Vertical handline, jigging (epipelagic and littoral)

Many fishermen use jigged vertical handlines to catch pelagic fish in the surface layers of the lake, or in shallow water. The fish see the moving hook and mistaking it for prey bite at it and are hooked so they cannot escape.

The line for a sardine jigging line is monofilament, of varying sizes,but typically0.7mmØ; with a lead or stone weight, though spark plugs and engine parts are also used.Upto18 Kirby hooks size14-16 are attached, on 5-8cm droppers at 12-18cm spacing.The hooks are completely bare.The line is let over the side of a boat in the epipelagic zone and jigged until fish are caught.The depth that fishing is done depends on trial and error,finding where the fish are,but is

more than 8meters, down to 20m.In the littoral zone it is jigged just above the bottom,in water of up to30m.

Once the line is at the appropriate depth the line is jigged up and down with the hand, until fish are felt to be attached, after which it is retrieved into the boat and the fish removed.

Epipelagic jigging is done in the day and the target is *Limnothrissamiodon*.Fishing occurs in the late afternoon and early morning, when the fish [presumably] are aggregated in the epipelagic zone,(Coulter1991). Evening fishing ceases when the lightn intensity reduces with the on set of night (the fish cannot see the hook?); and morning fishing when the sunrises and the schools disperse to the depths.Thus the period available for epipelagic fishing is very limited.

Sardines do not aggregate everywhere, nor at fullmoon, and can be difficult to locate. As a result only really experienced fishermen go out fishing just for *Lmiodon*. Most fishermen go fishing with baited vertical handlines, and if a *Lmiodon* is captured on one of the larger hooks of the vertical handline on the way up from the bottom, the fisherman will immediately swap to his smaller hooked sardine jigging line and start fishing for sardines instead.Some fishermen just use their bottom vertical handline to jig for sardines, but the two gears have different numbers of hooks on them,and of different sizes of hooks; the vertical handline for bottom species thus not being an effective way of catching *Limnothrissamiodon.*

Because of the size of *Limnothrissamiodon*, and the limited time available for catching them, catches are not large. Even pulling in 6to 8 fish with each haul, and hauling every 2 minutes,in an hour one has only caught 210 fish–a small bucket full.

In the littoral zone jigging without bait is also widely practised. The target is *S tanganicae* and any other carnivorous demersal fishes, such as *Bathybates ferox.*The line is let to the bottom and then retrieved far enough that on the“down”cycle of the jigging movement the weigh treaches to just above the bottom.The gear is a standard vertical handline, used to jig instead of with bait.

The boat used is typically a one or two man planked canoe, paddle powered and with perhaps a sail. Dug out canoes are also used.This type of fishing occurs throughout the lake. Exact catch figures are unavailable.The method is small scale and does not much threaten the stocks or biodiversity generally.

2.4.4 Vertical handline, jigging, unbaited (Mesopelagic)

This method of catching *Luciolatesstappersii* is widely practiced in the Swarm of the Zambian part of the lake (with a depth of more than 250m), and in the S.E.arm where deep water is reasonably close to the shore.

The gear used in Zambia is a nylon monofilament of diameter of 0.8mm.16hooks are placed on a line of more than150m.The gear is jigged at depths of between100 and150m,in the mesopelagic zone.Fishing is done during the early morning day light hours.There are typically two people per boat,but single handed canoes are not uncommon.Zambian boats leave the village at 3.00am and return at 10.00am.The boats catch significantly less *Lstappersii*than in other parts of the lake,but fishermen take the opportunity to use the same gear to fish for *Lmariae* at great depth, using whole small littoral fish as bait (the gear is then not jigging gear,and becomes a vertical handline).Their catch is a mix of *Lstappersii* and,form the deep bottom fishing, *Lmariae*, all of which is smoked.

The boats used in Zambia are small, 5–6m, planked with frames.There is no sail.

This method (mesopelagic jigging) is only targeting *Luciolatesstappersii* and as such is not considered to be a threat to biodiversity.

2.4.5 Bottomset long lines

The fishing principle in all bottom set long lines is that along line is laid along the bottom. Attached to this long line are shorter branch lines with baited hooks on.The fish takes the hook and cannot get off. In Zambia the main line and the branch lines are usually, but by no means always,mono-filament to the same breaking strain.

The hook size varies with the target species and substrate.No two long lines round the lake are the same.The line is weighted at each end with a stone or iron vehicle part.A float, usually of bark or polystyrene, though sometimes of wood,is attached to one end,with enough spare line to reach the surface from the bottom.

The fisherman chooses his fishing area using his experience of where there are no snags and there is a likelihood of a good catch.After a period(soaktime) the line is hauled and any fish that have been hooked retrieved.This period depends on location,but typically lines are set in the evening and retrieved in the morning.They are then taken home, repaired if necessary, (sometimes rebaited at home),and then re-set again in the evening. Some fishermen fishing offshore for large catfish and *Luciolatesangustifrons* use a forcing rod to assist them to bring the fish into the boat.

The baits that have been seen used by longline operators include:-

- Worms dug from the lake shore
- Soap.This can be moulded in the hand into a ball of the appropriate size for the hook being used
  Yellow laundrysoap made inTanzania
  Blue and white laundry soap made inTanzania
- Sardines
- If a fisherman wishes to catch lake turtles (a protected species), the lines should be baited with meat,preferably beef,but goat will serve.

When not in use or for hauling and shooting the gear, the lines are stored in any available container. Old wooden fish boxes are popular, but half-plastic 20litre jerrycans, old cooking pots and even half-plastic footballs have all been noted.

A boat is needed to set the line.These are usually the common planked paddling boats with framesof between4.5and 6meters that are found in abundance round the lake.Dug out canoes canal so be used.

One fisherman is all that is needed to shoot and haul a long line.Thus

most boats only have one fisherman on board.Sometimes however, especially if another fishing method is to be used on the same trip, two people occupy the boat.

The target species are large tilapine fishes including *Boulengerochromismicrolepis*, catfish, *Bathybatessp* and *Luciolatesangustifrons* and *Lmariae*.These find are ready for market fresh, among the relatively affluent commercial class in towns, can be smoked, and can also,ofcourse, be consumed by the fisherman and his family.

Given the size of the hooks commonly used in the fishery, the majority of the small chiclids (<15cm) and small tilapine fishes would not be caught.

2.4.6 Staked-lines

A staked line is a set line with one hook, anchored firmly to a stake with the baited hook in the water.The line is unattended.

Of interest is that one example of this gear was observed which employed a twine made from the strands of film polyethylene from mealie mealsacks.Three strands are woven together and the twine is knotted together every 20–30cm to allow a longer twine to be constructed than just that of the length of the film polyethylene.The resultant strand of twine is between two(2) to four(4) metres in length and is tied to a pole stuck firmly in the reed bank.

The hooks of size number 6 are preferred.The target and catch are *Clarias.sp*.

In the Lufubu River,at a fishing camp approximatelyone kilometer up stream from the lake,the Zambian FPSS team found a staked line.Unfortunately a return visit to re-check the gear to measure and photograph it was unsuccessful as theNational Parks Authority had ejected all the fishermen from the banks of the Lufubu in that area,and burned to the ground their fishingcamps.There mains of one

staked line was observed,stuck forlornly into the bank at the site of an old fishing camp;this one was employing a Polyethylene 280d/15multifilament as the mainline, but most of the line was lost and there was no end tackle.

One can conclude that atleast; two of these gears were operating in the Lufubu River until the end of 1999.

2.4.7 Sport-fishing

Sport-fishing is included here because

- It is permitted in Nsumbu National Park,on payment of the appropriate fee.
- It is one-way in which LakeTanganyika's aquatic biodiversity can generate international currency for National Parks, thus contributing economically to conservation.

Sport fishermen use the following methods on the lake (nearly always with a rod and line to control the end tackle and store the line)

- Epipelagic trolling
- Demersal trolling
- Vertical bottom-line with baited hooks
- Midwater vertical line fishing with baited hooks and float
- Dead baiting (using a whole dead fish as bait in one of the practices above)
- Live baiting (using a whole live fish,usually trolled or on a vertical line)
- Fly fishing

Sport fishermen are in reality very inefficient fishermen, being prepared to spend relatively vast sums on very low returns, the catch merely serving to enhance the fisherman's self-esteem.The catch is minimal in quantity and of mature fish.The variety of the gears used to achieve this meager return reflects their large budgets, imagination and vanity more than their actual fishing needs.As sports-fishermen knowfancy gear catches fishermen, not fish.

The target fish are *Luciolatesangustifrons* and *Hydrocynusgoliath*,the

giant tiger-fish, though the latter is rare and difficult to catch. Fishermen alsofeel fulfilled with the capture of the“Englishfish”,*Boulengerochromismicrolepis*,and of particular rarity and attraction to sportfishermen at Nsumbu is the presence in Nkamba Bay of the fabled“Golden”Nile Perch of LakeTanganyika,several examples of which can be seen affixed to the walls of the lodges.This is a local variety of *Luciolates angustifrons* which is golden yellow when alive.The colour fades rapidly on death.Not many are captured.

Once a year theZambia National GameFishingCompetition is held and the lodges are full for two weeks. During Christmas and Easter the lodges are also full.

The sport fishery in Nsumbu National Park in Zambia is a commercial enterprise, in that the lodges charge visitors,most of whom fly in from The Republic of South Africa,for the pleasure of persecuting the stocks of the national park with rod and line.The lodges materially assist the National Park authorities in their efforts to stop fishing in the protected parts of the lake. It is in the interests of the lodges that the fish are preserved, for Nsumbu is poor in four footed game and a long way from any where.Without fish there would be few visitors.In addition, to paying the lodges the fishermen pay ZK5000/day to the park authorities.

Whilst the catch of sport fishermen does not much affect biodiversity, sport fishing is the main stay of the 2 lodges located in Nsumbu, and through them provides employment and income to the local populations. It is revenues from the fishing visitors that help protect the reserves’lake resources, and so in this manner sport fishing actually protects biodiversity.

2.5 Traps

2.5.1 Bottom set non-return traps

The principle of non-return trap fishing is that the fish enter the trap voluntarily and then are unable to find their way out due to advice which stops them exiting.

Reeds are used to make non-return traps in the Kalambo River region of Zambia/Tanzania and Rattanw oven traps also exist (usually without non-return device and probably not actually in the Lake itself). Congolese refugees on cargo boats in Mpulungu Harbour use wire.Variations in individual construction abound.The non-return traps in the Zambia section of the Lake are very different from those in the Burundi/Congo frontier area, in the Ruzisi Delta, being more closely woven in reed, and longer relative to their width.

The entrance to the commonest type of non-return trap found in Zambia is not central.The fish have to swim upwards, into the funnel of the non-return device, and then once they have passed through the funnel, drop down into the body of the trap.They then do not swim up, to the entrance of the trap which is near the top, to try and escape. When the time comes to remove the fish the fisherman removes the trap from the water, turns the trap upside down and removes the fish by hand.

The wire traps made by Congolese in Mpulungu have a central entrance.

The traps are usually by no means always, checked every 24hours.They can be left for days, and since the fish donot escape and do notdie and spoil.The target species are catfish and tilapine fishes.

Bait is often used. In streams where there is an approach, wherein, the trap fills this approach, then bait is not necessary.In reedy areas and swamps balls of cooked maniocor maize flour are used, where it is available as brewing waste.

The catchi salive when collected is also very saleable, because of its freshness and size.

2.5.2 Pelagic non-return fish traps:

Near Kabyolwe village,on the border of Nsumbu Game Reserve in Zambia, approx 2kms East of the village; the FPSS in1999 found a Pelagic fish trap.This was situated about 120meters offshore from a rocky shore in a small bay under a very large float made of about 20 sticks(~9-12cmØand1.4mlong) was strung 4 yards (3.68m) under water,by two ropes of liana,a large three chambered trap.The trap was attached to the bottom, this being in 45yards (41.4m) of water depth, the weight being a large stone, and the rope being further lengths of liana.

The trap was made of wicker work, bamboo lattice work bound with bark lashings, with square meshes of about 10cmx15cm.The whole structure appears to have been made of 3 baskets woven together with the mouths of each basket joined in the middle.Thus the trap was three chambered. Each chamber was approximately1.6m long by 85cm round.One end of each chamber was woven over in the manner of a basket.

Where the three baskets were connected together the triangular gap in the uppermost side had been woven over and there was attached to the middle a bunch of grass and the liana ropes to the float. On the underside the entrance is woven so as to be circular. The rope to the weight is attached to the side of the entrance. Inside the"foyer"of the trap are three non-return entrances, made of sharpened sticks, one for each of the three chambers (orbaskets) of the trap. Inside the trap were 9 large (8-12kg) *Dinotopteruscunningtoni*,a large cat fish,eight in one chamber and one in another.The third chamber had been broken into and the fish inside stolen.The trap had been there from Sunday toTuesday,two days soak time.

The mode of operation is that the trap is placed in a likely place, and the fish arrive.They,despite being catfish, and bottom lovers who usually live amongst big stones,swim up the rope to the trap ,and enter it.The fisherman supposed that this was because they liked the shade created by the trap and the grass on top. The grass on the top of the trap had been put there to increase the shade.The fish are removed from the three discrete chambers through a small patch in the wicker

work at the top of each chamber, which has to be undone each time for the purpose.The fisherman uses a spear to remove the fish,though the spear was not available for inspection.

The fisherman reported that there used to be a lot of this type of trap in Zambia, but only a few people now knew how to make them and they were dying out.Two others in addition to the one at Kabyol we were recorded in the water off Chisanza village in the S.E.Arm in Jan2000. There are now perhaps 4 or 5 in the country.They last 6 months and the rainy season is the best time to use them.

They are very rare gear, but seem to be very efficient at catching adult *Dinotopteruscunningtoni* from the place where a large numberofthem are present,they maypose a threat to this species,but given that they are so rare, they are more a curiosity than a threat to biodiversity.

These traps (two chambered but otherwise similar) are described in a report by the Game and Fisheries Department of Zambiain1965 as such:-

The Chisowe is a basket trap with three sections.A central hall section, easily entered by fish, leads off by funnels into two side sections,which are said not to be baited.The trap operates either on the bottom or in mid-water.Fish are said to swim up the anchor rope for an unknown reason and enter the trap.This trap catches Dinotopterus exclusively.

This method of fishing also has a tradition of fishing attached to it.Persons using this method are apparently unable to shake hands for if they do the victim will die and will there after drive fish into the trap for the fisherman.

2.5.3 Tubular traps

Tubular traps restrain the catch by the pressure of the water flow restricting the fishes ability to swim out of the trap.

The method requires quite a strong current or a fish weir to increase the current. Near the lake, only one tubular trap was found on the Zambian side of the Kalambo River in Zambia.

This tubular trap without non-return device, set in one of the side streams of the river in the valley of the Kalambo, approximately, 2kms upstream from the lake.A barrier of stones is placed across the stream and in the middle is placed a tubular trap.The fish are thus directed down the trap.The fish enter and cannot return or escape due to the strength of the flow of water into the trap.

The trap is conical,1.60 cms long and 40cms wide at the mouth.The trap tapers down to the other "thin" end where the reeds of which it is made are tied together.The reeds are fastened to a circular wooden hoop (ofØ2cmwood) at the open end with strips of bark.There is only one hoop, about 5cms from the entrance.The reeds are fastened together further down the net 6 further times with bark lashings,though there are no further supporting hoops. Through the base of the trap, 10cms back from the entrance, is thrust a 105cms pole of wood, 35cms ticking out each side of the trap.This is used to jam the trap into the stones that make up the guide/barrier in the stream.

During the dry season the fish down the river towards the lake and are caught in the trap facing upstream.In the wet season large numbers of traps are placed facing down stream, to catch fish migrating up the river.These have a non-return device but are otherwise similar.

Several other examples of this kind of trap (some with non-return devices) were observed by the FPSS in 1999/2000, but never insitu.They were always being used as decorations in Hotels and Lodges.

2.5.4 Labyrinth traps

A barrier/labyrinth trap catches fish by the mentering the trap voluntarily and then not being able to find their wayout. The fish are guided into the trap by the sides of the trap which often have fences attached to them (not in LakeTanganyika).

A simple labyrinth trap was found in the reed beds at the mouth of the Kalambo river in Zambia.This is a wet season gear and there would typically be 6 or 8 of these constructed in the wet season.The trap was V-shaped, made of reeds and with each arm of the V308cms long on

the outside.The entrance was 6cms wide at the base of theV (see Gear Plan 2).

Another labyrinth trap, a heart-shaped one was observed in Kapata village, Chituta Bay,Zambia. It was reported that in the middle of the wet season, about 6 were built in the village. The trap is built in a channel in a reed bed.It is made of a sheet of reeds, held together with rubberized nylon multifilament twine of approx 1.0mmØ removed from worn out car-tyres.The reed wall is supported by 9 wooden posts driven into the mud of the reed bed, and attached to the reed wall with further lengths of rubberized nylon from car-tyres. From above, in plan view, the trap is heart-shaped with the entrance to the trap being in the bottom of the V of the top of the heart-shape.The opening is restricted to the bottom 10cms of the reed wall,and is relatively small,being about 5cms across at the widest. The trap is built so that the entrance faces towards the main body of the lake, so the trap catches fish entering the reed bed from the lake.(To breed?).The reeds used for the reed wall are approximately1.8meters long (including the sections under the water and stuck in the mud), and the posts used to hold the structure up are1m–1.20m long.The trap itself is1.6m long and 1.2metres wide.

These traps are wet season traps, particularly effective when the water level has risen from its dry season low. The target species are *Clariassp* and Tilapine species.Ten kilos in 24hours is a good catch.The fish are removed from the trap using a small scoop net.Some theft of fish from these traps is reported.

2.5.5 Fish fences and fish weirs

Fishfences and fish weirs are usually associated with fish traps,or some method of restraining the fish once it has passed over or through the weir,or been herded by the fish fence.
Three fish fences and weirs have been noted by FPSS1999/2000 in Zambia.These are:-

- A fish fence on the Lunzua river,at Simumbele village upstream fromKapata village near Mpulungu.This was seen in the dry season,(October1999),when the stream was low,and was a remnant of the fence built in the wet season of early1999.Exactly how this fence worked ishazy,but it presumably isused in association with woven rattan type tubular traps,common in the interior of Zambia.
- A similar type of weir was reported(early Jan 2000) to be placed on the upstream Lufubu (“where the water runs fast”) several

miles upstream from Kabyolwe village.The weir blocks the river completely,and raises the level of the water upstream of the weir by (in this case) about 15cms above the down stream side.The water flow is directed through three sluices,each of which is blocked with a tubular trap, (which filters all but the smallest fishes). This weir/trap construction was said to be the cause of a complete absence of fish from the upper reaches of the Lufubu,and was destroyed in late January 2000 by the National Parks Authority, as it was operating in the Nsumbu National Park.

- In the Kalambo a tubular trap in conjunction with a barrier (fence) of stones was noted and is described above.

The weirs on the Zambian part of the lake are said to target *Alestes.sp* and *Clarias.sp.*

Where fish weirs block off the whole water flow, and filter all the fish passing down the river into traps, they pose a serious threat to the populations of fish in the rivers where they are placed. Several species travel uprivers to breed, or travel from rivers to the lake.All of these would be filtered by the weirs and traps on their journeys down the river to the lake. In any legislation that may have been acted in response to concerns on over fishing or biodiversity, the use of fish weirs in conjunction with traps should be included.

2.6 Bag nets

The principle is that the fish are filtered from the water by the mesh of the net, which is swept through the water.

2.6.1 Scoop net (hand operated)

Scoop nets are used in the reed beds of Zambia.The hoop is about 35cms diameter with a mesh of approximately one inch made of 210d/30 and used in the wet season for the capture of *Clarias.sp*.The fish are seen before capture.The FPSS in1999 found one example,in Chitutabay,which because of the dry season was not in use and in bad repair.

2.7 Seine nets

A seine net sweeps an area.The fish are typically herded into the path

of the net by drawlines which increases the area affected by the seine. Beach seine nets concentrate the fish against a beach, and may have a bag into which the fish are further concentrated.

2.7.1 Beach seine (day)

The principle behind a beach seine is that an area of the lake off the beach is enclosed by the net and the draw lines, which are paid out from a boat.The boat returns to the beach and the drawlines on each side are then hauled in by manpower which concentrates the fish in the path of the net section in a herding action. Eventually the drawlines are completely hauled in and only the net is left in the water,with the fish concentrated in it.Then the net of the seine are hauled and the fish are further concentrated in to the centre of the net.This central section of the net is then pulled up on to the beach and the fish removed.

Sometimes the boat is used to provide extra floatation to the bunt of the net, particularly if a bag is incorporated in the net design.

In many areas the seine is not operated on a beach only, but is very mobile, the boat and haulers moving from beach to beach, up and down the coastline, fishing wherever possible.

On Lake Tanganyika there is no mechanization of the hauling and man-power has to be collected in sufficient numbers to operate the gear.A minimum of 6 people are needed on the small seines, but some of the larger seines may require up to 20. In urban or village settings there is nearly always a large crowd looking on and willing to assist for the chance of a few free fish.

The beach seines on the lake are very basic pieces of equipment.They are very large though and they catch a lot of fish.Typically they are about 80m long and have rope drawlines of about 200m each side.Large ones may be 250m with upto 1.5km of drawline on each side. A typical example from Zambia is illustrated in Net Plan 3.

In Zambia beach seines are banned everywhere except on Lake Tanganyika.

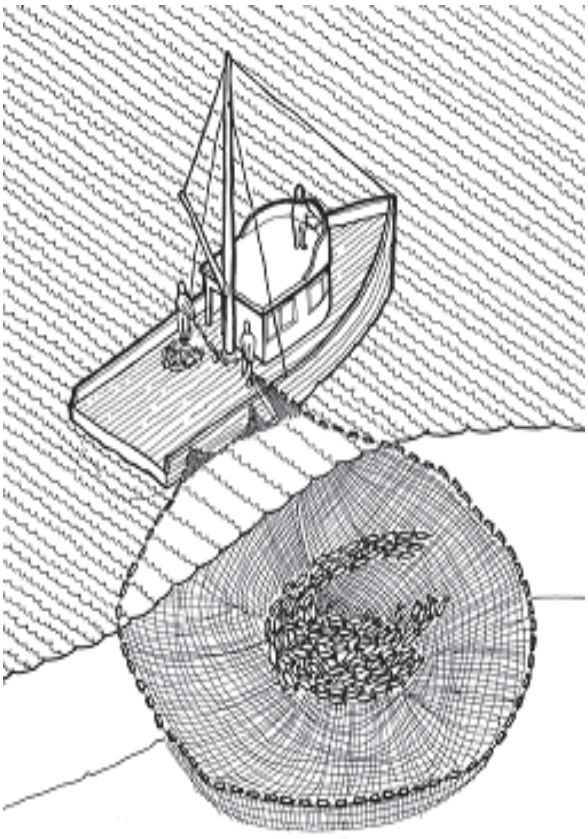
2.7.2 Light assisted beach seine

Whilst in theory any seine can be used at night, using lamps to attract the fish to the area to be swept and into the path of the net as it is pulled in, is a distinct method and there are seines developed to do this specially. The target fish are sardines, prawns and immature sardines and the mesh of the wings of the nets are correspondingly low (~6-8mm), as compared to a standard "day" beach seine (~20-35mm).

In Zambia according to Petit (1997):-

Light boats leave the shore at dusk, gather fish and come back to the inshore zone where the beach seine is cast. They aim at catching Clupeids. The nets are made of stretched meshes of 10 and 8mm mostly, the one used widely round the Lake for the lift-net. The difference is the intensive use of mosquito nets for the pocket or even for the net. In Chituta,a seine was nearly made only of mosquito net.

PURSE SEINE – FISHING NET



The catch varies considerably, with moon phase, season, and turbidity.Recently in some Zambian areas of the lake catches from light assisted beach seines have been so low that the owners have given up and gone into farming and trading. Petit (1997) reports catch of 2–5kilos perhaul. Not enough to cover the kerosene used in the lights.

The lamps used by fishermen are not on all boats, and many are just kerosene pressure lamps on floats. This enables a light boat to have more than one set of lights, which increases the light boats' effectiveness.

In Zambia, sometimes the fish do not follow the light boats into the shallow water near the beach and the beach seine operators are in a bit of a pickle. They cannot see beach seine the light attracted sardines. When this happens frequently the fishermen will modify their beach

seine to make a small shallow water purseseine, so as to be able to reach their prey. This modified beach seine is called a “mutobi” in Zambia.

2.8 Surrounding nets

2.8.1 Industrial purse seine

Industrial purse seining has been much studied by the Research for the Management of the Fisheries on Lake Tanganyika. AFINNIDA/FAO project, and a serious student of the industry would be best advised to study their reports in depth.

A simple description of the industrial fishery method and gear, with a net plan, is given by Andrianos,E (1976). Not much has changed, the fishing operators being a conservative lot. If any thing the nets have become simpler, though many of the vessels have now been equipped with **power blocks** to assist hauling the net.

POWER-
BLOCKS

The industry used to be based in Burundi, but moved to Zambia during the 1980s and early 1990s as it became increasing unprofitable to operate in the North of the lake.

In Mpulungu the boats, towing between 2 and 6 light boats, leave port in the late afternoon and move towards the fishing grounds (which in late1999 were about 30 miles North West of Mpulungu). Once there, the fishermen illuminate the area in order to attract the fish. Fish aggregate and then the fishing operation starts.If not the boat moves on and tries again. Once fish are found, then the light boats are released. The boats start up their own lights which are generator powered. The seiner also illuminates its lights.After a period,dependant on the moon and the wish of the captain, two of the lightboats move to the seiner.The seiner turns off its mainlights and the fish are attracted to the seiners' lights.The seiner then shoots the purse seine round the two lightboats, and retrieves the net using a hydraulic power block and electric winches,operated by the skipper and 7-8 men.Some older boats without powerblocks used a two boat system and more extensive manpower to haul the net.

The catch is between 0-4t typically 200-400kg, and is bought aboard using a brail.The operation is then repeated with the other light boats. Upto 4 hauls can be made in a night, particularly by the boats equipped with a net hauler.Just before dawn the boats head home, arriving in port sometime after 8.00am. In1999 the boats averaged less than 750kg per trip over the year.

The boats stop operating for 4-6days over the fullmoon period, as the fish do not aggregate adequately over an area.

The *L.stappersii* that feed on the *Stanganyicae,* for atleast some of the year, used to be predated on by the larger *Lates.*species.These larger predators have just about disappeared from the catch, and it may be that the lack of predation on *Lstappersii* has allowed the *L.stappersii* to proliferate and their predation has reduced the sardines.

There are two further theories (Dorr1999) regarding the cause of the decline in numbers of

Stolothrissa in the Southern part of the lake:

- *Luciolates stappersii* feeds on *Stolothrissa* larvae and has been increasing in numbers since I970s; the combination of fishing pressure on *Stolothrissa* plus predation by *Luciolates* caused the decline.
- *Stolothrissa* is an offshore, cool-water species during adult life, average lake water temperature has risen a degree from 23to24°C in the last 20 years, therefore, temperature increases may have also contributed to its decline.

2.8.2 Shallow water purse seine

The shallow water purse seine is a beach seine for sardines, modified for use in shallow water when the fish do not follow the light boats to the shore, and so cannot be trapped by a conventional beach seine.It is only found commonly in Zambia.The fish will not come in close to the shore if they can see the bottom, which occurs when there is a combination of effects; the moon providing light and the water being particularly clear.

In essence, the net is the same as a light assisted beach seine for sardines, as used through out the lake. The net is modified by the addition of rings along the foot rope and a line of the beach seine is used as a pursing line through these rings.The net is then shot in water away from the beach and pursed as in a purse seine, round the light boats that have aggregated the fish.The water that this can be used is not deep, as the net is relatively small, both in depth and length, so cannot be used in open water.
The method catches the same target fish as a night operated beach seine targeting sardines.

2.8.3 Ring nets

A Chiromila seine is a ring net. A hybrid between a lamp net and a purseseine.The net is pictured in the FAO Catalogue of Small Scale Fishing Gears and described in Coulter (1992).There is confusion over the name, with various authors calling it a seine or a purse seine. It is here called a ring net. It is only used in Zambia, and targets sardines in open water.

Raw data for 9 months in 1999 from Nsumbu in the Swarm (unpublished from DOF in Mpulungu) shows:-

Boats fish 266days per year (Extrapolated figure)
Average catch of 359kg/day
Average 3.76 light boats each.Range 2-7
Average 3.6 draws per night.Range2-6
Average catch per draw ~100kg
Extrapolated catch per unit per year-95.5tonnes
16 seines in Zambia ~1500 tonnes per year

The nets are the basis of the sardine fishing industry in the Nsumbu region and contribute immensely to the economy there.

2.8.4 Under water seine (aquarium fish trade)

This net is a very simple piece of 4mm knotless netting which is used only in the Aquarium fish trade in Zambia. The width and length of the net were not recorded by FPSS as no nets were available to be measured.The net is set underwater at a depth of 40m in a curved form.Two divers or more go down and drive the fish into the net.The fish are trapped by the net and removed with a scoop net.When the fish is captured it is kept in a 200litre plastic container which has small holes drilled in it and is covered with a piece of 10mm netting on the mouth.This container is used to store the fish in deep water and to decompress them.

The species targeted are:-

Cyphlotilapiafrontosa

BenthochromistricotGreenwoodromi.sp

Gnathochromis.sp

And other related species

Divers usually fish at about 40m deep.They do sometimes go down to 70m deep and given that there are no decompression facilities any where near LakeTanganyika,mortalities among the fishermen are to be expected.

2.9 Lift nets

A lift net is a sheet of net ting, or shaped bag of netting, placed under the water and lifted up when fish swim voluntarily between the net and the surface.

This gear is not covered in detail here as only one lift net was observed by FPSS in Zambia in 1999/2000, and that was owned by an expatriate bar owner and bon-viveur. In May 2000, the LTR project reported five lift nets operating in Zambia (Reynolds,pers. com.).There donot seem to be enough sardines about to justify their high running costs. Zambian fishermen tend to use ring nets and light assisted beach seines in anycase.

2.10 Gill nets

The principle of the gill net is that the fish swims into the net and is caught by its head,on the gill covers,in a mesh.There are a variety of types,but in all the catching principle is the same.Even those gill nets typically called "encircling" rely on the fish getting trapped in the mesh of the net. (Some large fish are also caught incidentally in encircling gill nets, and are not gilled, but these are the minority of the catch). In general therefore the size of the fish that will be caught is related to the size of the mesh of the net, in that a fish with a big head will not be able to get its head and gills stuck in a small mesh; and a small fish will merely swim through a large mesh.

2.10.1 Bottom set gill nets

There are a series of mesh sizes for set gill nets.The nets are targeting two distinct zones.The littoral demersal from the depth of the net to about 45m depth, and the deeper demersal waters offshore above the anoxic zone.The pelagic water column in the lake is not generally targeted by gill nets. In the littoral demersal the target fishes are chiclid sand tilapine fishes, whereas off shore the targets are larger cat-fish and nile perch.The common mesh sizes used are:-

In the littoral– 1, 1.5,2,2.5 and 3inches
In the shelf areas- 5, 7,8andupto11inches

The lengths of the nets in use can be quite dramatic.Nets of 500 to 600

metres is typical and others of more than a kilometer are not frequently found.

2.10.2 Floating gill net

The net is set across the river Lufubu with one person in a boat moving from one end to another keeping the net in position as it drifts.The net can drift many hundreds of meters down the river before being retrieved.

The fish species caught are mainly Characids, which live in tributaries and marshes.

Only one(1) drifting/floating net was recorded at Masansa fishing camp.A return visit to Masansa fishing camp to accurately measure this gear in December1999 was unsuccessful as the National Parks Authorities had burnt down the fishing camp, since the Lufubu River is part of Nsumbu National Park, and the fishermen living there were naturally assumed to be fishing in the river.

This net would appear to be a serious threat to biodiversity in the river where it is used, to those fish travelling up or down the river for breeding purposes, or other inhabitants of the habitat.The net sweeps the whole water column in the river for a considerable distance, presumably catching all of the target fish in its path, since it has a variety of mesh sizes.

2.10.3 Encircling gillnet (with boat and divers)

The method is used in shallow water by the aquarium trade in Zambia. A monofilament gill net is used in shallow water. It has half inch mesh size, 9min length and 1.5min depth.When an area rich in fish is found

the net is set round the area and divers with aqualungs drive the fish out of their hiding places and they are gilled in the net

The species targeted are:-

- *Tropheusmoorii*
- *Eretmodus.sp*

Wire framed fish cages covered with 10mm netting is used to store the fish in shallow water.Plastic bags are also used for storage to avoid bruising and loss of scales.

2.10.4 Encircling gill net (without boat)

A net being used for encircling fish in the shallows was observed in Musende bay near Mpulungu in Zambia.It appeared to be about 15m long and was only half inch mesh size.It was very similar to the nets used in the aquarium trade underwater with divers (indeed it may have been one). It was impossible to measure this as the operators were extremely hostile once they realized that an interest was being taken in the net. This may be because the legal mesh size for monofilament net is 120mm in Zambia and the fishermen were aware of this.

2.10.5 Dragged gill net with listening device

This is a Zambian fishing gear that seems to be no longer used on Lake Tanganyika. It is included here merely for interest.

The fisherman goes out in a one man paddling canoe, and using his paddle as a“sonar”device, locates a shoal of *Limnotilapiadardenii, L.dardenii* apparently identified by a characteristic grunting heard when in shoals, and it is this sound that the fisherman is listening for. Using his knowledge of the habits of these fish, and the information from the

sound of the shoal gathered by his paddle, he can work out which way the shoal is moving.

It was impossible to find any of these gears in use, so an exact description is not given here.

The practice of listening to the sound made by fish with a paddle is seemingly, well known among traditional fishermen; usually the elderly fishermen.

2.10.6 Drive in gill nets

It has been reported to FPSS that in Zambia a night-time drive in gill net fishery has started near Chisanza to the NE of Mpulungu.The gear is a bottom set gill net,set in shallow water, and the fish are frightened into the net by lights.The net is set in the dark and then in the light-lit.

The canoe with the light passes down the net about 10m from the net.The fish are frightened by the light, swim away from it, and become meshed in the gill net. FPSS was unable to locate any of these gears so was unable to measure the impact and monitor the fishermen involved.

2.10.7 Seined gill net

Using the principle of a gill-net is an attempt to get round the enforcement of the local bans on the use of encircling gillnets in Zambia.

This is a truly unusual method, not mentioned in von Brandt (1972), or in the FAO Catalogue of Small Scale Fishing Gear (1975). It appears to be relatively new in Zambia.The fish are gilled so the method is still correctly classified as a gill-net, though the manner of operation is like a

seine. The method is only applicable in areas of shallow water, with a sandy, unobstructed bottom.Chituta Bay is found to be a very appropriate place.

15 of these gears were reported in the Kapata village and there would presumably be more in the other villages round Chituta Bay. It does however, seem that these gears are restricted to the Chituta Bay area and areas north with suitable substrate, as no others were found by FPSS near Mpulungu or in the Western arm.

The gears are locally a threat to biodiversity in that gill-nets are identified as one of the major contributors to excessive fishing effort round the lake.

2.10.8 Staked gill nets

These gillnets are described in a report by the Game and Fisheries Department of Zambiain 1965 as such:-

The “Mbwa” and “Itapi” nets are very similar but are named differently in different areas.

……..They are made up of heavy grade nylon with an “8” stretched mesh and are normally about 50 yards long.The net has no corks or leads but is fence-like in that the bottom and foot ropes are held apart by poles at 4-foot intervals. The two end poles are very long and these are pushed into the mud from the surface and hold the net upright. It is a moderately successful net usually catching large Nshinga (*Dinotopteruscunningtoni*) and Poloko (*Auchenoglanisoccidentalis*). Traditionally only chosen people may use the net and there is a great deal of prescribed ceremony in its use.It is said that any pregnant woman seeing the net is liable to abort.

It was also generally acknowledged that any menstruating woman

stepping on these nets during construction will bleed to death; thought is belief seems to have now died out; with the nets perhaps?

The FPSS survey in Zambia in 1999 did not find these. Apparently there are just not enough large fish left the lake tojustify their use.

Fish Processing & Fish Products

The term **fish processing** refers to the processes associated with fish and fish products between the time fish are caught or harvested, and the time the final product is delivered to the customer. Although the term refers specifically to fish, in practice it is extended to cover any aquatic organisms harvested for commercial purposes, whether caught in wild fisheries or harvested from aquaculture or fish farming.

Larger fish processing companies often operate their own fishing fleets or farming operations. The products of the fish industry are usually sold to grocery chains or to intermediaries. Fish are highly perishable. A central concern of fish processing is to prevent fish from deteriorating, and this remains an underlying concern during other processing operations.

Fish processing can be subdivided into

(i) Fish handling, which is the preliminary processing of raw fish, and

(ii) The manufacture of fish products.

Another natural subdivision is into primary processing involved in the filleting and freezing of fresh fish for onward distribution to fresh fish retail and catering outlets, and the secondary processing that produces chilled, frozen and canned products for the retail and catering trades.

Processing methods:

• Dagaa processing methods include Sun-drying, deep frying and hot smoking. Salt is added to fresh Dagaa as a means of preservation before it is sundried, deep fried or smoked. Milling Dagaa into fish powder and using it as an ingredient of health foods is on the increase.

• Dagaa is an important nutritive sauce to the staple starch foods of the low-income groups and a component of the weaning foods in the region.

• A Manual on improved processing methods for processing small pelagic fishes was based on Dagaa.

• Sun-drying is the main and widely used method in small pelagic fisheries in Africa. Hot smoking adds flavour to Dagaa products. Deep-frying is a recent method and produces 'crispy' Dagaa products ready for eating.

• Dagaa is rich in unsaturated fat, protein, iron, Zinc, calcium and Sodium as shown in the following Table.

General

Most fish landed in Zambia is caught overnight by artisanal fishing through gill netting and seine-netting. The gill-nets are set before dusk and hauled in during the early morning hours. The time that the nets are in the water ranges from 11 to 14 hours. Research surveys in the Kariba area show that an average of about 35% by weight of the total catch of Hydrocynus vittatus spoils due to bacterial attack and autolysis if nets are set for more than 13 hours (Fig 1). Percentage of spoilage was calculated as the total weight of fish found rotten or showing signs of spoilage through general appearance over the total weight of catch from a particular haul as shown below:

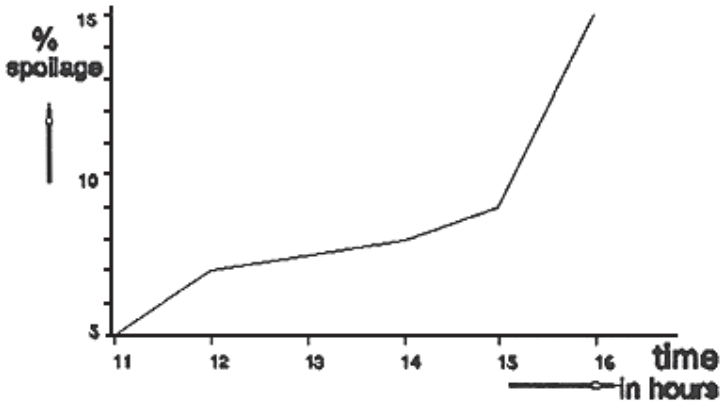
$$\text{Percent spoilage} = \frac{\text{Total weight of spoilage}}{\text{Total weight}} \times 100$$

The results were obtained from loss assessment surveys made between April 1986 and April 1990.

2. TRADITIONAL METHODS OF HANDLING FRESH FISH

Traditional methods of handling fish do not include gutting or the use of ice and as a result the quality of fresh fish suffers greatly before it can be processed. Fishing is done mostly at night by artisanal fishermen.

Fig 1. Relationship between fresh spoilage and time after death at ambient temperature



The fishing ground can be as near as 30 m from the harbour but many kilometres may be covered by fishermen using dugout canoes during their fishing exercise.

There are no proper containers on the boat for collecting fish during the fishing exercise and as no ice is used, aquatic weed is used as a cover to protect the fish from the tropical heat. Even among commercial fishing companies like those active on Lake Kariba, very few if any have adopted the use of ice or chilled water and consequently the quality of kapenta is usually very poor. Bacterial contamination on the fish is high because of these unhygienic handling

methods. The reasons why the use of ice is uncommon among fishermen in Zambia are wide and varied:

i. Lack of ice plants near fishing areas.
ii. Cost of the commodity (ice) is very high.
iii. Due to the warm environment ice melts quickly and is lost before it can achieve the desired results for which it is intended.

Fresh fish is sold whole and ungutted, directly from the boat at the harbour. The majority of fish traders are women marketeers who use anything, from metal buckets to dishes as containers for carrying fish from the harbour to the markets. Some marketeers wash the fish before packing but the water at the harbour is rarely clean. A little crushed ice may be sparingly sprinkled on top of the fish in the container and then covered with a sack to temporarily preserve the ice both during transportation and before marketing of fish. The available sawdust can be used as the best insulation material for keeping the ice intact for a long time. In most cases only water weeds are used to keep the fish fresh in the absence of ice.

2.1 Dried Fish Handling

Because of the scarcity of ice and the cost involved in procuring it, about 80% of fish caught in Zambia is traditionally processed by drying. Some of the factors which make dry processing of fish a popular method are:

- the product can be stored for up to nine months before it is marketed;
- poor transport network makes it difficult for fish to be transported in its fresh form;
- Consumer preferences: many Zambians prefer to eat fish which is processed by drying, salting or smoking, since this is part of their culinary tradition.

3. TRADITIONAL METHODS OF SUN-DRYING FISH

The most popular traditional method of processing fish in Zambia is sun-drying with mild smoking depending on the size and species of the fish and also on the fishery. Most fish are dried on wooden boards and reeds and grass mats which are laid on the ground

(giving no protection from rodents, ants, insects, chickens and probably dogs). Since the fish is laid on the ground, water accumulates around it instead of draining away. Traditional drying process offers no protection to the product from rain and high humid environment (Fig. 2b). A 10% contamination of sand, grit and dirt has been recorded due to the above drying methods.

Chisense from Lakes Mweru/Luapula, Mweru-wa-Ntipa and Bangweulu are dried in a similar manner. However, kapenta (sardine) from Lake Tanganyika is dried on concrete slabs or cemented floors which are used as an improved alternative. Fig 2a illustrates an improved drying rack.

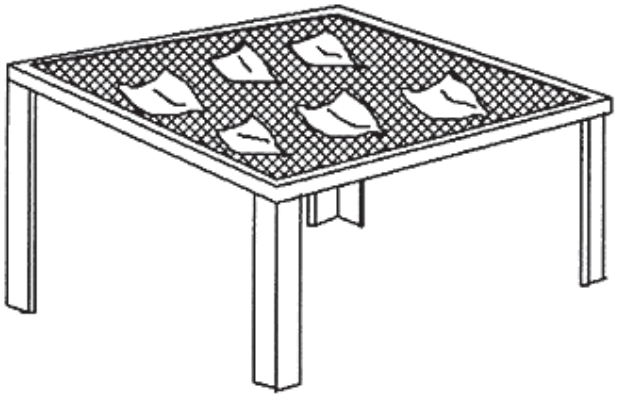


Fig. 2a. Fish drying rack

The inadequacy of drying the fish makes it susceptible to blowflies, mould and beetle attack. As a result, fishermen and fish traders have resorted to insecticides in order to reduce losses. A gas chromotograph analysis carried out on dried fish samples obtained from fish traders operating around Siavonga on Lake Kariba showed a content of about 0.224 ppm of Deltametrin. Since no maximum residue limits have been set internationally for most of the insecticides on cured fish, emphasis should be on better drying methods to prevent the use of insecticides as a way of prolonging the shelflife of cured fish. In Zambia the use of insecticides as a means of preventing post-harvest fish losses is banned although some fishermen and fish traders use them illegally.

Almost all cichlids in Mweru-wa-Ntipa of medium size are scaled, gutted and cleaned but not split. They are sun-dried for about 20 min to remove surface moisture and then smoked for 2–3 days.

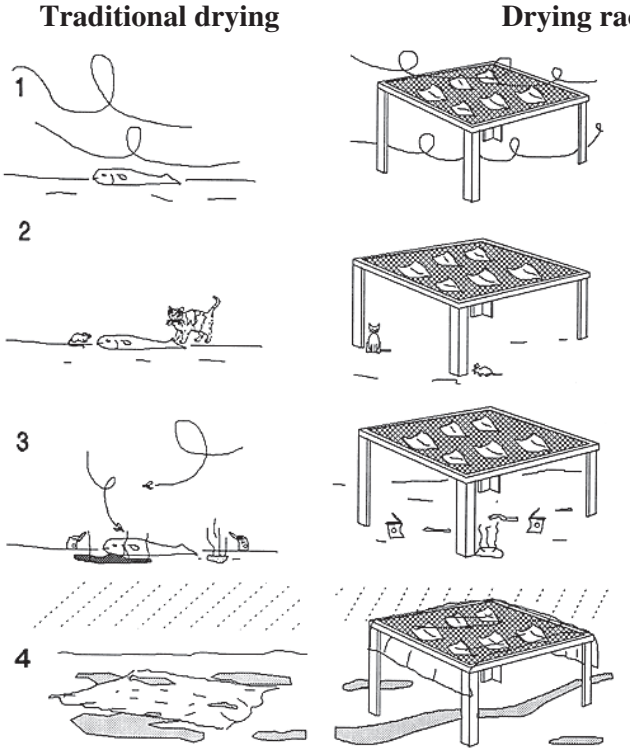
In swampy areas like Lukanga and Bangweulu smoking is difficult due to lack of wood fuel. Fishermen have to buy wood and transport it long distances across the swamps in dugout canoes.

3.1 Salting

The use of salt for curing fish is not widespread in Zambia since salt is an expensive commodity in the country and not readily available in some areas. Because of this, fishermen are reluctant to use brine although research has shown that salt has the following effects on fish:

- it improves the quality of the product;
- it achieves longer storage life and improves texture of the cured fish;
- it inhibits microbial and mould growth;
- it reduces fragmentation;
- it reduces losses from insect attack by more than 50% and the shelflife is longer.

Fig. 2b. Traditional drying versus drying racks



Traditional dry salting techniques are used extensively around Lakes Mweru and Mweru-wa-Ntipa. This is so because cheap salt is found around the area (Mweru-wa-Ntipa). The local residents have devised a technique of processing salt which is later sold to fishermen or fish traders.

3.2 Smoking

Hot smoking is another popular traditional method of processing fish in Zambia. The fish is smoked on pits or raised smoking racks where the control of heat is difficult. The fish thus processed results into an overdried, brittle and irregularly shaped product. Wet weather is also a constraint when processing as most of the traditional processing methods offer no protection to the product and the processor from the rain. Smoke densities and temperatures are very crudely controlled by regulating the fire and the process requires a high degree of supervision by an experienced operator. Apart from drying, hot smoking partially cooks the product and also imparts a smoky flavour.

Investigation on fish processed by fishermen show that about 10% or more of fish losses are due to fragmentation.

As a means of preserving fish, traditional methods have certain technical limitations. Very fatty fish may not dry satisfactorily and in wet weather fish drying may not be possible at all.

4. TRADITIONAL PRACTICES OF HANDLING, STORING AND DISTRIBUTING CURED FISH

The storage period of fish in Zambia is short due to a high demand for the commodity. However, a fish trader often spends 6–8 weeks in a fishing camp buying fish before it can be transported to the markets (peri-urban and urban).

Research findings have shown that beetle attack can start as early as the first week of storage. Watanabe and Cabrita (1971) estimated that 10% of the processed fish produced is spoiled due to beetle infestation. Packaging techniques in Zambia offer very little protection to the dried product from fragmentation. Often the dried fish is wrapped in a bundle. This can be made either from reeds or grass and at times brown paper mainly from empty cement bags. It is tied with flexible sticks and fibre which act as a frame. The bundles are then transported by road from the camps to the markets where they are sold. The fish is either sold in bundles or in small heaps depending on the size of the fish.

5. IMPROVED PROCESSING METHODS

5.1 Sun-drying

The introduction and construction of raised fish drying racks during sun-drying has brought the following advantages:

- it protects fish from being eaten by animals like dogs, cats and some insects;
- there is less contamination from dirt and dust;
- drainage of water from the wet fish is facilitated;
- air currents or winds can pass both above and underneath the fish hence effecting a quick and efficient drying process;
- during wet weather fish can be protected from rain and ground water by covering with a sheet of plastic or any other waterproof material. The use of drying racks has become popular among the kapenta commercial fishermen along Lake Kariba. Fig. 2b illustrates the difference between traditional and raised drying racks.

5.2 Improved Smoking Processes.

Various research findings and recommendations have been made in Zambia on improved processing techniques. Watanabe and Joeries (1967) proposed a drum-smoker for processing the catch of an individual fisherman. This design had one or two advantages over the traditional open-pit method of hot smoking used throughout Zambia. It is much easier to regulate temperature and smoke concentration inside the kiln. The product produced is less brittle and has an attractive yellowish-brown colour if the right smoke density is applied. One of the disadvantages of the drum smoker was its limited capacity; very little fish can be processed at a time.

Watanabe and Cabrita (1971) proposed a smoking kiln for a medium or large scale smoking operation under rural conditions.

Clucas (1976) recommended the mud and pole type of a smoking kiln which was easier and cheap to construct.

The Chorkor fish smoker proved to be the most appropriate technology for fish smoking for the Zambian environment. This was a recommendation of the FAO Expert Consultation on Fish Technology

in Africa (1985). Materials for the construction of the Chorkor smoker can be obtained locally and cheaply.

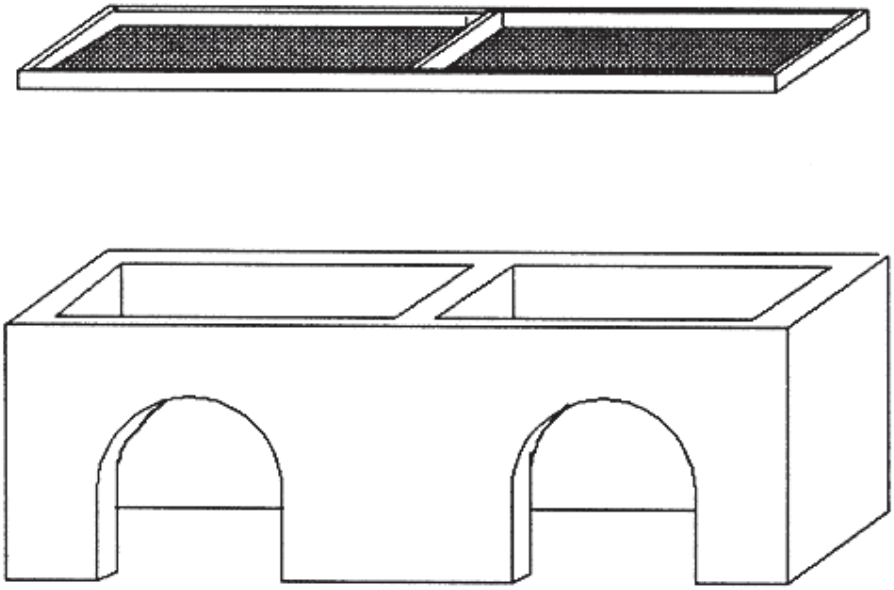


Fig 3. Chorkor oven with tray (up to 15 trays can be stacked)

5.3 Improved Storage Facility

Cured fish is usually stored at the processing site, at intermediate collecting centres and at the point of marketing and distribution. There are various reasons for storage, some of which include the need to accumulate an economic load for transport, evening out seasonal variations in supply, waiting to find buyer/transport and commercial strategy. The duration of storage at each point in the chain varies substantially. Although the storage period of processed fish is short in Zambia, severe damage on the fish still occurs due to bad storage facilities.

A good storage facility should provide:

- security, appropriate to the location;

- a roof to shade the stored fish, to keep off rain and reduce any possible overnight formation of dew on fish;
- Protection from groundwater, either by raising the product above the ground or by providing a floor incorporating a water vapour barrier.

MATERIALS AND METHODS

Sample Collection:

The number of samples collected for each product depended on the number of processors or vendors dealing in the product. Efforts were made to collect each sample from at least three processors or vendors. The samples collected were categorized by processing method which included fresh (unprocessed), deep fried, smoked and sundried (includes salted) products. Although mukene is a sundried fish product, in this study mukene (which is commonly called omena in Kenya and dagaa in Tanzania) is considered as a separate category of LVFPs because the dynamics of its harvest and trade differs from other sundried LVFPs that were studied.

Fresh LVFPS:

Fresh skins, frames and heads of Nile perch (L. niloticus) were acquired from the same filleting factory. Nile perch eggs (roe) were acquired from artisanal LVFP processors in Katwe food market while Mukene was acquired from fisherfolk at Kiyindi landing site.

Deep Fried Products:

Some of the fresh skins, frames and heads described above were taken to artisanal processors who deep fried these products to generate the deep fried samples used in this study. Artisanal processors deep fried these LVFPs using the oil they were using to deep fry other products for their usual business. Oil used for deep frying was a mixture of vegetable oil and oil generated from Nile perch by-products. Most processors used vegetable oil as base oil to start off the frying process but the volume of deep frying oil was maintained by adding fat pads generated from perch frames. None of the eight processors interviewed could tell for how long they had used the oil. Other food products that were deep fried in the same oil included chips of fresh sweet potatoes and fresh cassava.

Salted and Sun-Dried Products:

Dried perch heads, frames and chips (also called trimmings or off-cuts) were bought from artisanal processors at the Busega by-

products processing site. In general, traders were not willing to sell sundried products. Hence, samples of about 2-3 kg each of heads and frames (without head) were obtained from four artisanal processors. The samples of chips (about 1 kg in total) were collected from two processors

Mukene:

Freshly dried samples of about 10-15 grams were bought from artisanal processors that were drying mukene at landing sites in Kiyindi and Buvuma islands. Other samples were collected from traders that were airing mukene at Kiyindi landing site. Older samples were collected from retail fish mongers in food markets around Kampala. Salted, dried mukene samples were collected from a commercial processor at Kiyindi landing site.

Smoked Products:

Freshly smoked samples of fish skins were purchased from the by-product processing site in Busega. Freshly smoked samples of juvenile perch were bought from artisanal processors in Buvuma islands. Older samples of juvenile Nile perch were purchased from retail fish mongers in food markets around Kampala; however, since vendors get products through middlemen, it was not possible to determine how long these samples had been on the market. With the exception of salted mukene and perch fillet, all LVFPs assessed were collected from artisanal processors to allow for generalizing of findings to usual processing conditions. All samples were put on ice bags in thermo cooling boxes immediately after they were collected in order to reduce spoilage during transportation.

Sample Preparation:

Sample preparation involved cooking (steaming or boiling) fish samples and extracting edible tissue from the cooked products. Edible tissue was extracted from the bones on day of collection manually using a kitchen knife. Extracted edible tissue was then ground using a heavy duty blender to obtain a homogenate which was stored in non-transparent plastic containers in a freezer. Mukene samples were stored as purchased and ground right before nutrient determination. All samples were analyzed within 1 week of collection.

Nutrient Determination:

All experiments on determination of moisture content, crude protein, fat and minerals (calcium, iron and zinc) were performed in triplicate.

Determination of Moisture Content:

Moisture contentwas determined using the dry oven method AOAC[7]. For each low-value fish product, three samples of3 - 4 g were placed in dry moisture dishes of known weight and weighed using a digital food weighing scale.Dishes with sample were then placed in oven and dried for4 hours at 125°C after which dried samples were weighed again to determine moisture loss.

Determination of Crude Protein:

Crude protein was determined by the Kjeldahl methods (AOAC 954.01) using sulphuric acid for sample digestion. Total nitrogen was quantified by titrating the distillate against 0.05M hydrochloric acid. Methylene blue and methyl red mixture was used as indicator. Crude protein was determined by multiplying the nitrogen value by the conversion factor of 6.25.

Determination of Crude Fat:

Crude fat was determined using AOAC methods [7]. The sample was extracted with petroleum ether (BP 40-60°C) in Soxhlet type continuous extraction apparatus.

Determination of Mineral Content:

Calcium, iron, zinc and sodium content were determined quantitatively using atomic absorption spectrophotometric methods [7].

Statistical Analyses:

Results were subjected to analysis of variance (ANOVA) using Stata statistical software (Stata Corporation, Texas, USA). Multiple comparisons of means were done using the Bonferroni method and p-values < 0.05 were considered statistically significant

Fishing Regulations in Zambia

The Department of Fisheries in the Ministry of Agriculture and Cooperatives is mandated through the Fisheries Act, Cap 200 of the Laws of Zambia, to manage the fisheries resources of the country. In order to ensure the sustainable utilization of the fisheries resources in line with the provisions of the Act, the following control measures are employed:

- Annual Fishing Closure, from 1 December to 28 February the following year. This coincides with the rainy season and was introduced to protect the breeding of the commercially preferred species (mostly Tilapia species) whose breeding peaks in this period. The flooded plains provide ideal breeding grounds and nurseries for the juveniles.

- Mesh size restriction of not less than 50 mm for all stationary gillnets. This restriction allows for new recruits to attain a minimum size before being exploited.

- Introduction of permanently closed areas as sanctuaries and breeding grounds for commercially important species.

- A complete ban on use of some destructive fishing methods such as forcefully driving of fish into set nets (locally known as kutumpula), using explosives, use of weirs targeting migratory fish, and beach seine nets operated in shallow waters, which incidentally destroy fish nests and foul the water by stirring up silt.

Fish Products

2. Individually quick frozen (IQF) products:

Radical changes have taken place in the freezing set up of fish and fishery products over the years. An important improvement in freezing shrimp/prawns is the shift from the conventional block frozen to the individually quick frozen products. With the advent and spread of aquaculture for shrimp/prawn, in particular, individual quick freezing has become very popular. Farmed shrimp/prawn has the advantage of facilitating harvesting during a predetermined period. This facility enables freezing them individually in the freshest possible condition. Because of this, most of the farmed shrimps/prawns are frozen whole in

IQF form. Likewise, lobster, squid, cuttlefish, different varieties of finfish are also processed in the individually quick frozen style.

IQF products fetch higher prices compared to conventional block frozen products. However, for the production of IQF products raw materials of very high quality need to be used and the processing has to be carried out under strict hygienic conditions. The products have to be packed in attractive moisture-proof containers (thermoform moulded trays have come to be accepted as containers for IQF products in western countries) and stored at around -30°C without fluctuation in storage temperature. Utmost care is needed during the transportation of IQF products, as rise in temperature may cause surface melting of the individual pieces causing them to stick together forming lumps. Desiccation leading to weight loss and surface dehydration are other serious problems met with during storage of IQF products.

Some of the IQF products in demand are shrimp/prawn, whole cooked lobster, lobster tails, lobster meat, cuttlefish fillets, squid tubes, squid rings, boiled clam meat and skinless and boneless fillets of white lean fish etc. so far as shrimp is concerned, it is particularly in demand in different forms such as whole, peeled and de-veined, cooked, headless shell-on, butterfly, fan tail and round tail-on.

3. Accelerated freeze dried products:

Accelerated freeze-drying is now being increasingly used for the preservation of high value food products. In this process the product in frozen condition is subjected to very high vacuum causing the ice crystals to sublime. The product has the advantages like absence of shrinkage, quick re-hydration up to 95%, minimum heat induced damage etc. In India this technique is now applied for processing

shrimp, squid rings etc. the possibilities for various ready-to-eat products based on fish and shellfish employing this technique are immense.

4. Heat processed products:

Far reaching developments have taken place in canning industry, especially in respect of the design and development of containers, canning equipment and nature and type of the products. Some of the containers of recent origin are retortable pouches, rigid plastic containers, aluminum cans, drawn and wall ironed (DWI) as well as drawn and redrawn (DRD) cans made of tinplate, easy-open cans with ring or pull tabs. Heat processing of retortable pouches, heat sealed plastic containers as well as easy-open cans with pull/ring tabs is carried out in over pressure autoclaves of which many models are now available. Employment of hydrostatic cooker-sterilizer for heat processing high temperature short time process etc., are other innovations in the field of equipment/machinery for heat processing seafood.

The product mix up in the heat-processed category of seafood includes several 'convenience' ready-to-serve products such as fish curry, fish-in-rice etc. these products can conveniently be processed in retort pouches using an over pressure autoclave. Because of the smaller cross sectional profile of retort pouches such products need to be maintained only for a shorter time in the retort and hence temperature induced changes on the quality parameters of the product will be minimum.

5. Coated products

The most prominent among the group of value added products is the battered and breaded products processed out of a variety of fish and shellfish. Battered and breaded products offer a 'convenient' food, valued widely by the consumer. These are products which receive a coat or two each of a batter followed by coating with bread crumbs, thus increasing the bulk and reducing the cost element. The pick-up of coating can be increased by adjusting the consistency of the batter or by repeating the coating process. By convention, such products should have a minimum fish component of 50%. The production of battered and breaded products involves several stages. The method varies with the type of product and pickup desired. In most cases the following steps are involved:

1. portioning/forming
2. pre-dusting
3. battering
4. breading
5. pre-frying
6. freezing, and
7. Packaging and cold storage.

A variety of battered and breaded products can be prepared from shrimp, squid, clams, fish fillets, minced meat from low cost fish etc. a brief profile of some important battered and breaded products is as under:-

5.1. Shrimp products

Breaded shrimp can be prepared both from wild as well as cultured shrimp in different styles. Shrimp in different forms such as peeled and deveined, butterfly, round tail-on and cooked and peeled are

coated with batter and bread crumbs and flash fried for 20 seconds at 180°C in refined vegetable oil. They are then frozen and packed in IQF form, preferably in thermoformed containers.

5.2 Squid products:

5.2.1 Squid Rings

Cleaned squid tubes are cut in the form of rings, followed by cooking in boiling brine (3%) for 1-2 minutes. They are then cooled, breaded and battered. The battered rings are flash fried at 175-180°C for 20 seconds, cooled, frozen and packed.

5.2.3 Stuffed Squid

Stuffed squid is prepared from small squid which are not generally processed for export. The cleaned tubes from such small squids are filled with a stuffing mixture prepared using cooked squid tentacles, potato, fried onion, spices etc. the stuffed squid are then battered, breaded and flash fried.

5.3 Clam and other related products

Live clams are depurated and the meat is shucked out after boiling. The meat is blanched in boiling brine, cooled and battered, breaded, flash fried for 20 seconds, frozen and packed. Other bivalves such as oyster, mussels etc., can also be converted into coated products by the same name.

5.4 Fish fillets

Skinless and boneless fillets of white lean fish are brined in dilute brine to improve the color and taste. The brined fillets are battered and breaded, flash fried for one minute, frozen and packed.

6. Fish mince and mince-based products

Minced meat is the meat separated from fish in comminuted form free of bones, skin etc. in principle, meat separation process can be applied to any species of fish, but when it is applied to low cost fishes significant value addition will accrue. Flesh can be separated from filleting waste also. Minced meat can be used as a base material for the preparation of a number of products of good demand. The properties of minced meat, to a large extent, are determined by the nature and quality of raw material. Meat-bone separators (meat picking machines) are generally used for the preparation of minced meat.

7. Minced based products

Minced fish can be used for the preparation of a number of products like fish sausage, cakes, cutlets, patties, balls, pastes, surimi, texturised products etc. the processes for the production of most of these products are available and some of them are very much suitable for starting small scale industries.

8. Surimi

Surimi is a Japanese term for mechanically deboned fish flesh that has been washed with water and mixed with cryoprotectants for imparting good frozen shelf life. Washing not only removes fat and undesirable matters such as blood, pigments and odouriferous substances but also increases the concentration of myofibrilar protein, the content of which improves the gel strength and elasticity of the

product. This property can be made use of in developing a variety of fabricated products like shellfish analogues.

9. Kneaded products

Several kneaded products like kamaboko, chikuwa, hampen, fish ham and sausage are processed using surimi and incorporating other ingredients. The ingredients used in most of these preparations are identical; however, the classification is principally based on the manufacturing process involved. The ingredients employed other than surimi include salt, monosodium glutamate, sugar, starch, egg white, polyphosphate and water. The method of processing all these products involves grinding together of the various ingredients to a fine paste and some sort of heat treatment at some stage.

10. Fibreized products

Fibreized products are the greatest in demand among the surimi based imitation shellfish products. The ingredients used in the formulation of fibreized products include, besides surimi, salt, starch, egg white, shellfish flavor, flavor enhancers and water. All the ingredients are thoroughly mixed and are ground to a paste. The paste is extruded in sheet form on the conveyor belt and is heat treated using gas and steam for partial setting. A strip cutter subdivides the cooked sheet into strings and is passed through a rope corner. The final product is formed by steam cooking of the colored and shaped material.

11. Frozen fish fillets

Skinless and skin-on fillets from lean/medium fat white meat fish have enormous market potential. Many varieties of deep sea fishes such as grouper, red snapper, reef-cod, breams and jewfish are suitable

for making fillets both for domestic market and for export to developed countries in block frozen and IQF forms. In the importing countries, these fillets are mainly used for conversion into coated products. Fish fillets can also be used for the production of ready-to-serve value added products such as fish in sauce and fish salads.

12. Chilled fish

Chilled fish is another important value added item of international trade. The most prominent among this group is sashimi grade tuna. Sashimi is a Japanese term for raw fish fillets mainly from tuna and it is a traditional delicacy in Japan. Three species, blue fin, big eye and yellow fin are mainly used for this purpose. The best quality sashimi tuna is that which is chilled at all stages from capture to final consumption. Other important products of this group are pomfret, shrimp, lobster and crabmeat.

13. Stretched shrimp (nobashi)

Increasing the length of peeled and deveined shrimp and minimizing its curling by making parallel cuttings at the bottom, and applying pressure using simple mechanical devices is a new technology adopted by the seafood processing industry in recent years. Increasing the length by about 1-2 cm depending on the size of the shrimp is possible by this method. The stretched shrimp will have better appearance compared to conventional PD shrimp and it also fetches higher unit price. The stretched shrimp, because of its increased surface area, will have more pick up of coating during battering and breading and also a good appearance.

Shrimp is washed in chilled water containing 5 ppm chlorine, beheaded, deveined, using bamboo stick and peeled keeping the last

segment and tail intact. The tail is then trimmed and the shrimp is then stretched using a metallic stretcher after making 2-3 parallel cuttings on the bottom side. Stretched shrimps are then packed in thermoformed trays under vacuum and frozen at -40°C.

14. Barbecue

Shrimp is washed in chilled water containing 5 ppm chlorine, beheaded, deveined, peeled and again washed in chilled water. Bamboo stick is then pierced into the meat from head portion to tail. It is then packed in thermoformed trays under vacuum and frozen at -40°C.

15. Sushi (cooked butterfly shrimp)

Shrimp is washed in chilled water containing 5 ppm chlorine, beheaded, deveined and again washed in chilled water. Bamboo stick is then pierced between the shell and the meat from head portion to tail and then cooked in 1% brine for 2 minutes at 100°C. The cooked shrimp is then cooled in chilled water, bamboo stick removed and then peeled completely, including the tail fans. The ventral side is then gently cut down length wise completely using a sharp scalpel. The cut surface is then gently opened up to form the butterfly shape, packed in thermo-formed trays under vacuum and frozen at -40°C.

16. Skewered shrimp

The process is similar to that of barbecue, but piercing of shrimp is carried out in such a way that 4-5 shrimps are arranged in a skewer in an inverted "U" shape. It is then packed in thermoformed trays under vacuum and frozen at -40°C.

17. Shrimp head-On (Central Peeled)

Shrimp is washed in chilled water containing 5 ppm chlorine, peeled at the center keeping the head and the last two segments intact, deveined, and the tail is trimmed. It is again washed in chilled water, packed in thermoformed trays under vacuum and frozen at -40°C.

18. Shrimp head-on cooked (Center Peeled)

Shrimp is washed in chilled water containing 5 ppm chlorine, deveined and then cooked in 1% brine for two minutes at 100°C. It is immediately cooled in chilled water and peeled keeping the head and the last two segments intact. The tail is trimmed and again washed in chilled water. It is then packed in thermoformed trays under vacuum and frozen at -40°C.

19. Squalene

Squalene is an unsaturated hydrocarbon found in the unsaponifiable fraction of fish oils, especially of certain species of sharks. Liver oil containing high proportion of Squalene is distilled in a stainless steel glass lined vessel under a vacuum of 2 mm bar. Fraction distilled between 240 and 245°C is collected. All operations are to be carried out preferably in an inert atmosphere, as Squalene is easily oxidisable. Squalene is widely used in pharmaceuticals and cosmetics.

20. Tuna eyes

Tuna eyes are an item of commerce. The high demand for them is attributed particularly to their content of polyunsaturated fatty acids like decosahexaenoic acid. This fatty acid is valued for its medicinal properties in combating atherosclerotic and thrombotic problems of chronic heart patients. Extraction and preservation of eyes of tuna and its marketing stand good prospects.

21. Fish calcium

Calcium powder processed from the backbone of tuna can be used to combat calcium deficiency in the diet of children. Calcium deficiency can lead to bone failure and spine curvature. The method of production of calcium mainly involves removing the gelatin from the crushed bones and pulverizing the remaining portion. A process recommended for processing calcium powder from the backbone of skipjack tuna involves the following steps. The bone frame is crushed and washed in clean water a number of times. A 10% solution of calcium carbonate is added to the residue and is left for an hour. After draining the solution, washing and treatment with calcium carbonate is repeated a number of times. Finally, washed bone residue is further washed and dried and pulverized to the required mesh size.

22. Shark cartilage

Shark cartilage assumes importance because of the presence of chondriotic sulphate, which is a mucopolysaccharide. Chondriotin sulphate has therapeutic uses and is effective in reducing cancer related tumours and inflammation, and pain associated with arthritis, psoriasis and enteritis. Oral intake of shark cartilage is reported to be effective in the above cases.

The bones separated from the shark are cleaned for removing the adhering meat, blood stain etc. after washing well; the bones are preserved by drying at a temperature not exceeding 70°C to a moisture level below 6%.

23. Chitin and Chitosan

The body peelings from shrimp processing plants are a major and economical source of chitin. Lobster and crab shell waste also contain sizeable quantities of chitin. The shells are deproteinised with alkali and demineralised with dilute hydrochloric acid. The fibrous portion obtained after washing is chitin. Chitin can be deacetylated with caustic soda to give chitosan. The deacetylation is achieved by treatment of chitin with (40% W/W) aqueous potassium or sodium hydroxide at about 100°C. The production obtained is dried in hot air dryer to a temperature not exceeding 60°C. Chitosan finds extensive applications in many industries such as pharmaceuticals, textile, paper, water purification etc.

24. Fish maws/Isinglass

Air bladders of hake, sturgeon and carp are the main sources of isinglass. In India it is obtained from air bladders of eel, catfish, carp etc. the dried bladders are softened by soaking in water for several hours. They are mechanically cut into small pieces and pressed between hollow iron rollers, converted into thin strips of 3-6 mm thickness and then dried. It is used mainly for clarifying beverages, as an adhesive base in confectionery products, glass pottery and leather and also as an edible luxury. Its exports are mainly confined, at present, to Hongkong, Singapore and Germany.

2.5. Shark fins/fin rays

Shark fin soup is considered as a great delicacy in Singapore and Hong Kong and hence our exports of shark fins are confined to these countries. The commercial value of the fins depends on their color, size, variety and quality. Depending on the quality and quantity of rays present in the fins they are broadly classified into two varieties,

generally known as black and white. The white fins usually fetch a better price compared to black fins. Fins are generally marketed in dried form. The preparation of shark fin does not require any elaborate treatment, but care is needed in cutting, trimming and drying operations. The dried fins are further processed, for the 'rays'. The price of fin rays depends mainly on color, length and thickness of the individual strands, quantity of connective tissue, cartilage present and physical appearance.

26. Fish Meal and Fish Oil

Fish oil is obtained as a by-product in the wet reduction process employed for fish meal production from oil sardine. Fish is boiled, oil that separates is skimmed off and the cooked fish is put in coir mat bag and pressed in country type vertical process. The mixture of oil and stick water is collected in large settling tank and allowed to settle for about 2 days when all the oil floats. The oil is then separated and heated to remove water from it.

Fish oil is of two types:-

1. Fish Liver oil.
2. Fish Body oil.

Fish liver oil is used for therapeutic purpose in the treatment of vitamin A and D deficiencies. Sources of liver oil are Cod, haddock and shark. Liver oils of halibut and tuna also are rich sources of Vit-A&D. Fish body oil is more important as an industrial product besides its limited use in human nutrition. Fish body oil has recently won much attention because of the content of polyunsaturated fatty acids, particularly n-3PUFA used in the control of heart ailments in humans.

Sources of fish body oil are oil sardine, pilchard, herring etc.

27. Fish meal

It is traditionally used as fish and livestock feed supplement. Fish meal has high quality protein containing high levels of lysine, methionine and cysteine, three of the essential amino acids. It is also a good source of B group of vitamins like cyanocobalamin (B12), choline, niacin, pantothenic acid and riboflavin.

Raw material: - High fat fishes like anchovies, sardines, herring, menhaden etc. Wastes from fish processing and filleting plants, cannery wastes, carcasses of fish like shark and other fishes wastes are also used as raw material for fish meal manufacturing.

There are two methods for processing of fish meals:-

a) Wet rendering b) Dry reduction process.

a) Wet rendering is exclusively used for processing high fat fish and fish offal where simultaneously production of fish meal and fish oil is envisaged.

b) Dry reduction is employed to process fish meal from non-oily fish and fish offal.

Yield is higher in dry reduction process because water soluble materials are retained in the meal. Oil obtained in dry process is darker and of inferior quality.

28. Fish fingers

It is very popular product made out of fish mince. Mince is mixed with 1% salt, made into rectangular slabs and frozen. Frozen mince is cut into suitable sizes and coated with batter followed by breading. Battered and breaded fish fingers are flash fried in oil maintained at 180-200ºC for 20 seconds. After cooling the fingers are frozen and stored.

29. Fish sausage

Fish sausage is made from Surimi mixed with salt, sugar, sodium glutamate, and soy protein. The above mixture is stuffed into PVC casing using automatic screw stuffer.

The casing tube is closed using metal rings and heated in hot water at 85-90°C for 40-46 minutes.After heating, it is slowly cooled to avoid shrinking of the tube and then dried.

FISHERIES PROBLEMS AND POSSIBLE SOLUTIONS

5.1 How To Determine Levels of Sustainable Fishing Using Fish Population Models

In studying trends of exploited fish stocks in stable and unstable ecological systems two types of modelling should be considered:

a. One type deals with natural history of a fish species, its growth, feeding, reproduction, genetics, physiology and behaviour - as these relate to migration, inter-and intra-specific competition, recruitment and fish yields.
b. The other type is concerned with the dynamics of exploited populations and has its foundation in watching depletion of many fish stocks as fish harvesting methods become more intense and efficient. This aspect of fishery research has developed a cohesive body of observation and theory. The

modern theory of fishing has resulted in a rather narrow class of mathematical models intended to describe and predict the response of a single species to various rates of exploitation. It should be noted that the great Lakes are more characterized by multiple species and single species situation only feature in small unstable lakes with harsh environment.

A relationship exists between fish population models and ecological models applicable to the evaluation of stocks management of fisheries. Hence, resource managers can use relationships to manipulate ecosystem for the long-range nutritional benefit of mankind and conservation of stocks, providing the food-web links are not disrupted. Most model taxonomies consider details of mathematical structure or assumptions employed versus non-linear. Attention should be focussed on abstract, qualitative features of fishery models, asking whether they fit the scheme of maximizing realism, generality and precision. The major ecological issue is whether we have an equilibrium centred view or are we concerned with the transient behaviour of lake systems that are away from equilibrium state and for which the probability of extinction of e.g. haplochromines, Schilbe and Labeo (in Lake Victoria).

Oreochromis macrochir (Lake Mweru), Citharinus or Mpoi (Lake Mobutu Sese Seko) and the indigenous tilapia of Lake Baringo (O. niloticus baringoensis). Two basic approaches have evolved to modelling the dynamic response of a fish population to harvesting regimes. They are not conceptual alternatives, but rather different ways of solving the same general model; they result from different types of data and simplifying assumptions. The general model may be constructed by expressing the relative rate of change in biomass of an exploited population as the sum of input rates (growth and recruitment) and loss rates (mortality) to the biomass.

The first approach focusses attention on the steady state, in which the fish biomass is not changing; the catch can be expressed in terms of recruitment, growth and mortality, especially fishing mortality which is somewhat under the direct control of effort. This “analytical” approach which was first developed by Baranov (1918) is frequently referred to as the Beverton-Holt Model (1957).

The other approach, which was more completely developed, and first applied to fishery management problems by Schaefer (1954), combines the elemental rates of recruitment, growth and natural mortality, and expresses the rate of population increase as a single function of population size. This could be a very comforting approach

to resources managers around Lake Victoria who appear to record ever-increasing catches of Nile perch notwithstanding a reported, somewhat stable fishing effort. If the catch and effort data collecting system is adequate and reliable around Lake Victoria and if there is no double-counting because of porous borders, then scientists with experience in the region should start testing the validity of theories on primary production, food-web links and carrying capacity.

5.2 The Role of Ecological Models

Ecological models have been used primarily to describe distribution of species assemblages in space and time. Attempts have also been made to describe mathematical diversity in biological communities and the spatial theory of bio-geography as described by MacArthur and Wilson (1967).

Fishery biology has traditionally been more ecosystem oriented than most other areas of renewable resources management, perhaps because the emphasis in commercial fisheries even in the Great Lakes is on biomass, and hence on the actual fish production process. Ecological theory has always played an important role in the development of fishery biology, but ecological models could also provide valuable input to ecosystem theory, which safeguards against manipulating the aquatic systems.

Fishing grounds alone are not very valuable data, but when a fishery is intensive and it can be assumed that fishing contributes a large proportion of total mortality (Z), then catches give reasonable notion of productivity of a lake. If we can couple landings with effort data, age or size composition, then we can use models to estimate fishing mortality and natural mortality; and if values of changing primary productivity and corresponding fish yields are known, then we can build a food web based on the main constituent historical species fished. This might be very difficult in the case of Lake Victoria where ecological stress from the Nile perch is to be enhanced by the invasion of black bass (Micropterus salmoinedes).

5.3 The Problems of Overfishing

Some exploited fish stocks of the African lakes show signs of overfishing because of increased fishing effort by the artisanal fishermen. There may be both biological and economic factors affecting overfishing.

Biological overfishing is associated with decreasing growth in size and recruitment success but other factors have also to be considered. For example, the total catch of a certain species may drop as a result of changes in target species in response to new market conditions and fishing methods. There may also be seasonal and/or non-density dependent factors affecting the behaviour of stocks, namely: changes in feeding grounds, migration patterns which prevent fish from encountering gears.

Economic overfishing occurs essentially when redundant inputs are used; leading to depletion of any rents (i.e., total revenues minus total costs) which could be produced.Economic overfishing does not necessarily imply biological overfishing. However under open-access conditions, a fishery will experience both biological and economic overfishing for as catches decline, the price of fish rises and the cost per unit of catch increases.

5.4 Causes of Overfishing

There are four main factors leading to overfishing in the African Great Lakes, viz.

- the open and generally free-access to fishing grounds, particularly in the easily accessible shallow inshore areas;
- the renewable character of exploited resources;
- the profit maximizing behaviour of artisanal and industrial fishing units operating under market conditions;
- the increasing population around the lakes, in areas with few alternative sources of employment.

Profit maximizing behaviour need not be the only driving force. In traditional or subsistence fisheries where no formal markets for fish exist, excessive effort is usually a consequence of large population size and lack of alternative sources of food and employment.

Under free and open access (or absence of ownership), severe economic and biological overfishing is likely to take place whenever cost-price ratios are very favourable (i.e., sizable rent is extracted) and usually this situation is not self-correcting. It needs control and enforcement measures which are not yet effectively implemented in East/Central/Southern Africa.

5.5 Problems of Exploited Fish Stocks and Effects of Overfishing

Excessive effort may have several important economic consequences of which the most evident is the misallocation of resources generated by the use of excessive and unnecessary effort to harvest a given amount of fish. Other important consequences are:

- forgone revenue from alternative uses of resources
- over-capitalization;
- higher risk of fluctuations and vulnerability of exploited species;
- social and economic conflicts between various fisheries; and
- Re-allocation and management costs.

Rational development and management of exploited fish stocks should be based on reliable biostatistical data, monitoring of exploited stocks and fisheries research.

5.6 Rational Use of Fishery Biostatistical Data on Lakes of Eastern/Central/Southern Africa

Promotion and improvement of fishery biostatistical systems for the lakes in Africa would require the following exercises:

a. dissemination of information on the status of exploited stocks and the rate of exploitation of various fisheries, particularly for shared lakes;
b. feasibility studies, description of existing fisheries and harmonization of data collection approaches;
c. study of fishing gear and provision of advice on suitable types and mesh sizes for various African lakes;
d. Provision of advice on development and unified management of shared fishery resources such as for Lakes Mobutu Sese Seko, Malawi and Turkana.

In addition to obtaining information from the fisheries research institutes and statistics units of Fisheries Departments, we can obtain data on the state of fisheries from the following sources:

- universities and other scientific organization dealing with fishery problems directly or indirectly:
- individual fishermen and fishing settlements chiefs;
- fishermen's groups or organizations;
- extension of agents for fishery and associated industries;
- data from fishing licences of artisanal and semi-industrial vessels;
- marketing organisation for local and export fish supply;

- Fish- processing plants.

5.7 Strengthening Fisheries Research in Eastern/Central/Southern Africa and Manpower Training for the Region

Rational development of fishery research in Eastern/Central/Southern Africa could be achieved in the following ways:

i. assess the availability of data and their suitability for stock assessment purposes and feasibility studies; determine the reliability of data and the main weaknesses;
ii. assess the need for fishery research institutes and equipment for limnological and biological studies;
iii. assess the need for fishery research vessels in the region, particularly larger Lakes Tanganyika, Malawi, Victoria;
iv. assist in setting up and supervising data collection systems for catch and effort, including data processing;
v. set up a reference collection of fish species and seek advice on the validity of species from taxonomists; and assist in preparing field guides for determination of exploited commercial species;
vi. assess the need for expertise and training in fisheries biology and related sciences like statistics, biomathematics and limnology;
vii. teach nationals various aspects of fisheries science and extension services;
viii. support the dissemination of relevant scientific papers to scientists and policy makers in the region: and
ix. Improve fisheries, libraries and fishery information systems, particularly for shared lakes.

The Threats of Overfishing: Consequences at the Commercial Level

According to marine ecologists, overfishing is the greatest threat to ocean ecosystems today. Overfishing occurs because fish are captured at a faster rate than they can reproduce. Advanced fishing technology and an increased demand for fish have led to overfishing, causing several marine species to become extinct or endangered as a result. In the long-term, overfishing can have a devastating impact on

ocean communities as it destabilizes the food chain and destroys the natural habitats of many aquatic species.

In the past, fishing was more sustainable because fishermen could not access every location and because they had a limited capacity for fish aboard their vessels. Today, however, small trawlers and fishing boats have been replaced by giant factory ships that can capture and process extremely large amounts of prey at a given time. These ships use solar/sonar instruments and global positioning systems (GPS) to rapidly locate large schools of fish. Fishing lines are deployed with thousands of large hooks that can reach areas up to 120 kilometers deep. The trawling vessels and machines can even reach depths of 170 kilometers and can store an extraordinarily large volume of fish. Each year these huge trawling ships comb an area twice the size of the United States. They use massive nets 50 meters wide with the capacity to pull the weight of a medium-sized plane. They also have several plants for processing and packing fish, large freezing systems, fishmeal processing plants, and powerful engines that can carry this enormous fishing gear around the ocean.

Because these ships have all the equipment necessary to freeze and tin fish, they only need to return to their base once they are full. Even when the ships are filled, however, the fish are often transferred to refrigerated vessels in the middle of the ocean and are processed for consumption later. As such, industrial fishing has expanded considerably and fishermen can now explore new shores and deeper waters to keep up with the increased demand for seafood. In fact, it has been reported by the United Nations Food and Agricultural Organization (FAO) that over 70 percent of the world's fisheries are either 'fully exploited', 'over exploited' or 'significantly depleted'. The annual total global catch of fish is 124 million metric tons, which is equivalent in weight to 378 Empire State Buildings.

Fishing gear is often non-selective in the fish it targets. For example, any fish that are too big to get through the mesh of a net are captured. Therefore, overfishing does not only threaten the species of fish that is targeted for food, but also many non-target species. As a result, these other species, including marine mammals and seabirds, are accidentally caught in the fishing gear and killed. For example, for every ton of prawn caught, three tons of other fish are killed and thrown away. Those in the trade refer to this practice of inadvertent catching of other species as by catch. The FAO has pointed out that about 25 percent of the world's captured fish end up thrown overboard because

they are caught unintentionally, are illegal market species, or are of inferior quality and size.

Many of the fish caught this way include endangered and over exploited species, 95 percent of which are eventually thrown away. Bycatch is not just limited to just unwanted fish, but rather affects all types of marine life, including whales, dolphins, porpoises, fur seals, albatrosses, and turtles. For example, tuna fisheries are indirectly responsible for the deaths of an estimated one million sharks annually due to bycatch. Small cetaceans, such as dolphins and porpoises, are also targets of bycatch as they are often caught in fishing nets. In fact, hundreds of dolphin corpses are washed up on the beaches of Europe every year, bringing attention to the growing scale of this problem.

Many modern fishing methods are also irreversibly destructive. For example, bottom trawling, a technique that uses extremely wide nets armed with heavy metal rollers, can crush everything in the path of the gear, destroying fragile corals, smashing rock formations, and killing several tons of fish and animals as by catch. As such, these practices can wreak havoc on delicate marine ecosystems.

Not surprisingly, it has been reported that industrial fishing takes between only 10-15 yrs to wipe out a tenth of whichever species it targets. In fact, several marine species have already been fished to commercial extinction, and this number is rapidly increasing. One of the reasons for this is that the regulation of fishing vessels and the fishing industry is universally inadequate. Roughly two-thirds of the ocean is free of laws and fishing vessels only follow the laws ratified by their country of origin. However, most fishing countries have not ratified any international convention to protect the sea or marine life. Moreover, fishing factory ships and companies are given access to fisheries before the long–term impact of their fishing practices is understood.

Today, the number of fish caught worldwide is actually shrinking as the fishing industry is in decline from many years of over fishing. The year 1988 was the first time in human history that global wild fish catches dropped and they have continued to fall ever since. In European waters, four out of every five known fish stocks are already beyond safe biological limits. Illegal and unreported fishing have also contributed a great deal to the depletion of the oceans and continues to be a serious problem.

A new study conducted by the International Union for Conservation of Nature (IUCN) found that 5 out of the 8 tuna species

are at risk of extinction. All three species of bluefin tuna, for example, are threatened with extinction and are at a population that makes their recovery practically irreversible. The IUCN has also reported that freshwater fish are among the most endangered species, with more than a third facing extinction. Not surprisingly, among those at the greatest risk are species like the Mekong giant catfish, the freshwater stingray, and the European eel, which are used to make some of the most expensive caviars. The Mekong giant catfish is the closest to extinction, with as few as 250 left. Overfishing has reduced the numbers of Mekong freshwater stingray by over 50 percent in Southeast Asia and has reduced the giant Mekong salmon carp population by over 90 percent.

As previously mentioned, shark populations have also been greatly affected by overfishing. There are already more than 135 species of shark on the IUCN's list of endangered animals and more are being added each year. For example, the number of scalloped hammerhead shark has decreased by 99% over the past 30 years. Other species recently added to the endangered list include the smooth hammerhead, shortfin mako, common thresher, big-eye thresher, silky, tiger, bull, and dusky. Besides being caught as bycatch, sharks are now also being targeted by commercial fishermen for their fins which can fetch a substantial price on the Asian food market. Sharks are particularly vulnerable to exploitation because they have long life spans, are exceptionally slow to mature (taking as long as 16 years in some cases), and are relatively unprolific breeders. Recent reports suggest that over fishing has caused a 90% decline in shark populations across the world's oceans and up to 99% along the US east coast, which are some of the best managed waters in the world. Because sharks are at the top of the food chain, a decline in their numbers has devastating consequences on marine ecosystems.

Over-fishing impacts not just the particular species that is exploited, but also damages other species of fish and disrupts local ecosystems. The stability of ecological communities depends largely on the interactions between predators and prey. Thereby, the balance of the food chain is disturbed when certain species are removed. As a result, many ocean species are disappearing and losing their habitats. The evolutionary process of marine species is also being altered, causing cycles of premature reproduction and relative decreases in the size of fish across generations. As predators diminish, the populations of smaller fish escalate because they were previously the food source of the bigger fish. In addition, the disappearance of these species affects many other species, like seabirds and sea mammals, which are vulnerable to the lack of food.

A recent study found that overfishing is also decreasing the genetic diversity of fish worldwide. Diversity is projected to be reduced further if overfishing continues at the same rate. This has serious effects on nutrient recycling in marine ecosystems because fish species vary widely in their rates of nitrogen and phosphorus excretion. As such, altering fish communities creates divergent nutrient recycling patterns and disrupts the functioning of the ecosystem. Recently conducted studies in lakes affected by overfishing show that the loss of species contributes to a decline in nutrient recycling and destabilizes the ecosystem.

While it is often overlooked for other environmental issues, overfishing has historically caused more ecological extinction than any other human influence on coastal ecosystems, including water pollution. Unfortunately, due to a lack of data, the extent of this damage has only recently been recognized.

Given that fishing is a food source for millions of people, attempting to solve the problem of overfishing not easy, especially for developing countries. Nevertheless, scientists and the UN Committee for Sustainable Development have called for a restoration of depleted fisheries and continue to stress the importance of stricter fishing regulations in oceans and inland waters. Sustainable fishing will be a necessary goal in counterbalancing depletion in fisheries and re–stabilizing coastal ecosystems.

The fishing pressure is an increasing threat to the sustainability of fishery resources in Lake Tanganyika

Interventions proposed for developing sustainable fisheries in this lake are such as reviewing and updating the national components of the Fisheries Management Frame Plan, developing and implementing fishing license process, improve the involvement of local communities in fisheries management, and promote sustainable fisheries alternative livelihoods.

The fishing pressure is an increasing threat to the sustainability of fishery resources in Lake Tanganyika, mentions M. Gaspard Ntakimazi in the “National Action Plan (NAP) for implementing the Strategic Action Programme (SAP) for protecting the biodiversity and sustainable management of natural resources in Lake Tanganyika basin”.

According to the same source, the main challenges identified in the SAP adopted by the Lake Tanganyika Authority Conference of Ministers in February, are such as an excessive fishing pressure in the pelagic area, an excessive fishing pressure in the littoral area and catches of ornamental fishes poorly controlled.

Management of fisheries and activities affecting the lake basin should be done under the regional planning frame including activities on the basin and the lake resources, as fisheries are now characterized by a free access. Interventions proposed for developing sustainable fisheries in this lake are such as reviewing and updating the national components of the Fisheries Management Frame Plan, developing and implementing fishing license process, improve the involvement of local communities in fisheries management, and promote sustainable fisheries alternative livelihoods.

Sustainable Fisheries

The ocean plays a vital role in the global economy by providing food and a source of income for millions of people. More than 50 million people work in the fishing and aquaculture sector, many in small-scale fisheries that are critical to the economies of their communities. More than three billion people, many of whom live in the poorest and least developed countries, rely on food from the ocean as a significant source of protein, highlighting the role of marine species in food security worldwide.

The Challenges

The oceans face serious challenges that threaten the sustainability of marine fisheries. Catches of many types of fish in the ocean are declining while demand continues to increase. Based on data reported in 2014 by the Food and Agriculture Organization, an estimated 29 % of the world's fish stocks for which reasonable information exists are overexploited, while another 61 % cannot support expanded harvest and require effective management and related measures to avoid decline. Individual nations manage many fisheries; in other cases groups of nations must manage fisheries collaboratively. Unfortunately, existing mechanisms for international management of fisheries have produced mixed results.

Overfishing harms the ecology of the ocean, while reducing the long-term potential of fish stocks to provide food and jobs for the

future. Harmful fishing practices have unintended impacts on species of birds, marine mammals, sea turtles and non-target fish stocks. The scientific data needed for managing certain fish stocks are often not available, due to inadequate funding or poor reporting of fisheries data. Even where good scientific information is available, management decisions do not always follow it. Illegal, unreported and unregulated fishing further undermines fisheries management worldwide, particularly in developing countries. Harmful fisheries subsidies that encourage over-fishing or contribute to excess capacity of fishing fleets also undermine the effectiveness of fisheries management regimes.

Steps Forward:

The 'Our Ocean' conference will examine the steps fishery management authorities need to take to reduce, and ultimately end, overfishing and to mitigate adverse impacts on the broader marine environment. For fisheries shared by two or more nations, conference participants can consider ways to improve the outcomes achieved through regional fisheries management organizations, including setting fisheries rules on the basis of sound science, monitoring fishing activity using all available tools, enforcing meaningful penalties on violators and building capacity for developing nations to fulfill their commitments in this field.

But improved fisheries management alone will not end threats to the sustainability of marine fisheries. Governments, the private sector, civil society, and ordinary citizens must all do their part. Building on earlier events in 2014, the Our Ocean conference is designed to spur action among all these entities, support and strengthen existing partnerships, create new collaborations, and develop new technologies to produce sustainable marine fisheries.

An active media outreach effort, including a social media "Call to Action", is raising public awareness of the need to protect the ocean and give ordinary citizens a way to contribute. Private sector and civil society participants will describe initiatives underway to safeguard the ocean's health, and build bridges that will empower future collaboration. The conference will also provide an opportunity for all stakeholders to discuss and unite behind a set of common sense understandings to protect and restore the ocean's health that can then be taken forward to the media, civil society initiatives, and diplomatic processes. With respect to sustainable fisheries, these understandings could include:

- Ending overfishing in the ocean;

- Eliminating harmful fisheries subsidies that contribute to overfishing and overcapacity of fishing fleets ;
- Preventing illegally harvested fish from entering commerce, including by bringing the Port State Measures Agreement into force promptly ;
- Using "smarter" fishing gear and techniques to radically reduce bycatch and discards of fish and the harm that certain gear and techniques cause to vulnerable marine ecosystems ;
- Establishing more marine protected areas, particularly in areas that will promote recovery of depleted fish stocks ;
- Using market incentives to promote sustainable fisheries, including efforts to enable consumers to choose seafood that has been sustainably harvested;
- Treating fish as essential components of ocean ecosystems and managing fisheries as part of those ecosystems.

Fish Farms

Fish farms or fish farming is a form of aquaculture. The act of fish farming is about raising fish commercially in tanks or enclosures for human consumption. There are different types of fish farms that utilize different agricultural methods.
The first method is the **cage system**s which use cages that are placed in lakes, ponds and oceans that contain the fish. This method is also widely referred to as off-shore cultivation. Fish are kept in the cage like structures and are "artificially fed" and harvested. The fish farming cage method has made numerous technological advances over the years, especially with reducing diseases and environmental concerns. However, the number one concern of the cage method is fish escaping and being loose among the wild fish population.

The second method is **irrigation ditch or pond systems** for raising fish. This basic requirement for this method is to have a ditch or a pond that holds water. This is a unique system because at a small level, fish are artificially fed and the waste produced from the fish is then used to fertilize farmers' fields. On a larger scale, mostly in ponds, the pond is self-sustaining as it grows plants and algae for fish food.

The third method of fish farming is called **composite fish culture** which is a type of fish farming that allows both local fish species and imported fish species to coexist in the same pond. The number of species depends, but it is sometimes upwards of six fish species in a single pond. The fish species are always carefully chosen to ensure that

species can coexist and reduce competition or food.

The fourth method of fish farming is called **integrated recycling systems** which is considered the largest scale method of "pure" fish farming. This approach uses large plastic tanks that are placed inside a greenhouse. There are hydroponic beds that are placed near the plastic tanks. The water in the plastic tanks is circulated to the hydroponic beds, where the fish feed waste goes to provide nutrients to the plant crops that are grown in the hydroponic beds. The majority of types of plants that are grown in the hydroponic beds are herbs such as parsley and basil.

The last type of fish farming method is called **classic fry farming** this method is also known as "flow through system". This is when sport fish species are raised from eggs and are put in streams and released.

There are a number of different fish species that are raised on fish farms, the most common fish spices raised are salmon, carp, tilapia, catfish and cod.

Catfish farming:-

Catfish are easy to farm in warmer climates. Catfish are predominantly farmed in fresh water ponds and fed mostly soybeans, corn and rice. Catfish are often considered one of the most sustainable fish specifies for fish farming purposes. Cultivating catfish first began in the 1900s and became commercialized in the 1950s. Catfish is populous because of its health benefits and market demand. Farm-raised catfish are usually harvested at 18 months of age whereas wild catfish usually get much bigger. There are a number of catfish species, but the three most prominent ones are blue catfish, channel catfish, and flathead catfish.

Tilapia farming:-

Tilapia is the third most popular fish used in fish farming or aquaculture, with the first two being carp and salmon. They have increased in popularity due to their high protein, large size and growth capabilities. Tilapia is a tropical fish that requires warmer water to survive. The ideal water temperature is usually between 28 to 30ºC. Tilapia fish are known to reproduce rapidly and this is a challenge for managing tilapia fish species for farming use. If not managed properly, fish will aggressively compete for food which may result in stunted growth. Therefore, males are almost used exclusively. Tilapias are resilient towards fighting off diseases and parasites. Tilapia fish

farming originated in Africa and is popular in Honduras, Papua New Guinea, Philippines and Indonesia. Tilapia fish require a cereal-based diet and don't eat other fish, but they are also considered to be one of the most invasive fish species.

Salmon farming

Salmon is one of the most popular fish species with the most commonly farmed being Atlantic salmon. There are two other varieties of Pacific salmon that are also farmed – Chinook and Coho. Farmed salmon are vaccinated to prevent disease outbreaks and only on rare occasions do they require additional medications. There are often questions about the different colours between wild and farmed salmon – farmed salmon aren't dyed, their colour comes from their food. Salmon feed is made to conserve wild fish stocks.

Tuna farming

Tuna fish are salt water fish and are important in the commercial fish farming industry. Japan is the biggest consumer of tuna and has invested a significant amount of research into studying the fish. There are different species of tuna including, bluefin, yellowfin, and albacore. Bluefin tuna populations have dropped significantly in some regions due to over fishing. Farming tuna is complex as the fish are "massive" and are very active - so simulating their natural environment is extremely difficult. Most tuna for human consumption are caught in the wild and raised in a facility to increase weight gain. Tuna are carnivorous and eat other fish. Tuna are typically farmed in net pens offshore and in some cases are farmed in recirculation systems.

Eel farming

Eel fish farming emerged in the early 1950s and it is considered one of the most profitable in terms of export value in the fishing industry. However, the profit value is largely driven by the Asian markets and is culture specific. Eels are a carnivorous and catadromous fish, which means that when they are young they live in fresh water, but as they mature they migrate to the sea for breeding –spending anywhere from 8 -30 yrs in freshwater before they migrate. The majority of eel farming takes place in Asia, with China, Japan and Taiwan leading as the biggest producers. Glass eels are preferred over elvers because they are easier to transport and wean onto artificial diets. Eel farming can take on one of two different forms – high intensity recirculating tank (indoors) or intensive pond facilities.

(Details about heating and cooling sysytems, lighting, hydroponics equipment, pluming, tasks and water treatment products are missing)

Aqua farming

Aquaculture is also known as "aqua farming" which relates to the farming of aquatic organisms such as fish. The farming aspect of aqua farming implies some aspect of intervention into the natural growing process to enhance production. According to the United Nations' Food and Agriculture Organization – aquaculture has grown three times faster compared to land-based animal agriculture.

Fish farming supplies

Fish farming supplies are needed for the aquaculture industry. The supplies can range from feed and feeders, filtration systems, hatchery supplies, heating and cooling systems, lighting, hydroponics equipment, pluming, predator control, tanks and water treatment products just to name a few.

Feed and feeders: Feed quality is important in fish farming and is vital to fish health. Depending on the feed that is given, it can help with desirable colour, growth and overall health and well-being. There are a wide variety of different feeds that are suited to different types of aqua-farming methods and species.

Water Filtration Systems Water filtration systems are important when attempting to mitigate environmental impacts. Filtration involves the removal of waste products from the water. There are a number of different types filtering systems that can be used, but it often depends on the state of the filtration process. It is important to have a staging filtration system that will ensure most optimal results.

Hatchery supplies Hatchery supplies include anything from fish graders, shipping supplies to spawning and handling containers.

Predator control Predator control tools are used in the fish's habitat, which often includes the use of physical deterrents which may include visual and audio deterrents.

Indoor fish farming

Indoor fish farming is the alternative to cultivating fish outdoors in a cage system. With the emergence of technological advances,

raising fish indoors is now possible using proper control production methods. Indoor fish farming is often very sophisticated and in some cases allow for automatic collection and processing of fish wastes into crop fertilizers. There are advantages and disadvantages in indoor fish farming:

Advantages in indoor fish farming

- Fish are protected from predators and weather changes.
- Fish are often produced faster through temperature control, water quality and feeding practices.
- Indoor fish farming is often considered more environmental friendly because it requires less water and produces less waste.
- Avoids the chance of fish escaping and getting loose amongst wild fish populations.
- Allows higher stock densities and often saved farm labour input costs.
- It often allows greater flexibility for facility locations, which can save transportation costs if facilities are located near markets.

Disadvantages in indoor fish farming

- Requires electricity input costs.
- Requires infrastructure set-up which often requires a significant amount of startup capital.
- Fish raised indoors are carnivorous, which requires the capture of large amounts of other fish for their diet.

Fish hatchery

A **fish hatchery** is a "place for artificial breeding, hatching and rearing through the early life stages of animals, finfish and shellfish in particular". Hatcheries produce larval and juvenile fish (and shellfish and crustaceans) primarily to support the aquaculture industry where they are transferred to on-growing systems i.e. fish farms to reach harvest size. Some species that are commonly raised in hatcheries include Pacific oysters, shrimp, Indian prawns, salmon, tilapia and scallops. The value of global aquaculture production is estimated to be US$98.4 billion in 2008 with China significantly dominating the market, however the value of aquaculture hatchery and nursery production has yet to be estimated. Additional hatchery production for small-scale domestic uses, which is particularly prevalent in South-East Asia or for conservation programmes, has also yet to be quantified.

There is much interest in supplementing exploited stocks of fish by releasing juveniles that may be wild caught and reared in nurseries before transplanting, or produced solely within a hatchery. Culture of finfish larvae has been utilized extensively in the United States in stock enhancement efforts to replenish natural populations. The U.S. Fish and Wildlife Service have established a National Fish Hatchery System to support the conservation of native fish species.

Purpose

Hatcheries produce larval and juvenile fish and shellfish for transfer to aquaculture facilities where they are 'on-grown' to reach harvest size. Hatchery production confers three main benefits to the industry;

1. Out of season production;

Consistent supply of fish from aquaculture facilities is an important market requirement. Broodstock conditioning can extend the natural spawning season and thus the supply of juveniles to farms. Supply can be further guaranteed by sourcing from hatcheries in the opposite hemisphere i.e. with opposite seasons.

2. Genetic improvement:

Genetic modification is conducted in some hatcheries to improve the quality and yield of farmed species. Artificial fertilisation facilitates selective breeding programs which aim to improve production characteristics such as growth rate, disease resistance, survival, colour, increased fecundity and/or lower age of maturation. Genetic improvement can be mediated by selective breeding, via hybridization, or other genetic manipulation techniques.

3. Reduce dependence on wild-caught juveniles:

In 2008 aquaculture accounted for 46% of total food fish supply, around 115 million tonnes. Although wild caught juveniles are still utilised in the industry, concerns over sustainability of extracting juveniles, and the variable timing and magnitude of natural spawning

events, make hatchery production an attractive alternative to support the growing demands of aquaculture.

Production steps

Broodstock

Broodstock conditioning is the process of bringing adults into spawning condition by promoting the development of gonads. Broodstock conditioning can also extend spawning beyond natural spawning periods, or for production of species reared outside their natural geographic range with different environmental conditions. Some hatcheries collect wild adults and then bring them in for conditioning whilst others maintain a permanent breeding stock. Conditioning is achieved by holding broodstock in flow-through tanks at optimal conditions for light, temperature, salinity, flow rate and food availability (optimal levels are specific). Another important aspect of broodstock conditioning is ensuring the production of high quality eggs to improve growth and survival of larvae by optimising the health and welfare of broodstock individuals. Egg quality is often determined by the nutritional condition of the mother. High levels of lipid reserves in particular are required to improve larval survival rates.

Spawning

Natural spawning can occur in hatcheries during the regular spawning season however where more control over spawning time is required spawning of mature animals can be induced by a variety of methods. Some of the more common methods are:
Manual stripping: For shellfish, gonads are generally removed and gametes are extracted or washed free. Fish can be manually stripped of eggs and sperm by stroking the anaesthetised fish under the pectoral fins towards the anus causing gametes to freely flow out.
Environmental manipulation: Thermal shock, where cool water is alternated with warmer water in flow-through tanks can induce spawning. Alternatively, if environmental cues that stimulate natural spawning are known, these can be mimicked in the tank e.g. changing salinity to simulate migratory behaviour. Many individuals can be induced to spawn this way, however this increases the likelihood of uncontrolled fertilisation occurring.

Chemical injection: A number of chemicals can be used to induce spawning with various hormones being the most commonly used.

Fertilisation

Prior to fertilisation, eggs can be gently washed to remove wastes and bacteria that may contaminate cultures. Promoting cross-fertilisation between a large numbers of individuals is necessary to retain genetic diversity in hatchery produced stock. Batches of eggs are kept separate, fertilised with sperm obtained from several males and allowed to stand for an hour or two before samples are analysed under a microscope to ensure high rates of fertilisation and to estimate numbers to be transferred to larval rearing tanks.

Larvae

Rearing larvae through the early life stages is conducted in nurseries which are generally closely associated with hatcheries for fish culture whilst it is common for shellfish nurseries to exist separately. Nursery culture of larvae to rear juveniles of a size suitable for transferral to on-growing facilities can be performed in a variety of different systems which may be entirely land-based, or larvae may be later transferred to sea-based rearing systems which reduce the need to supply feed. Juvenile survival is dependent on very high quality water conditions. Feeding is an important component of the rearing process. Although many species are able to grow on maternal reserves alone (lecithotrophy), most commercially produced species require feeding to optimise survival, growth, yield and juvenile quality. Nutritional requirements are specific and also vary with larval stage. Carnivorous fish are commonly fed with live prey; rotifers are usually offered to early larvae due to their small size, progressing to larger *Artemia* nauplii or zooplankton. The production of live feed on-site or buying-in is one of the biggest costs for hatchery facilities as it is a labour-intensive process. The development of artificial feeds is targeted to reduce the costs involved in live feed production and increase the consistency of nutrition, however decreased growth and survival has been found with these alternatives.

Settlement of shellfish

The hatchery production of shellfish also involves a crucial settling phase where free-swimming larvae settle out of the water onto a substrate and undergo metamorphosis if suitable conditions are found. Once metamorphosis has taken place the juveniles are generally known

as spat, it is this phase which is then transported to on-growing facilities. Settlement behaviour is governed by a range of cues including substrate type, water flow, temperature, and the presence of chemical cues indicating the presence of adults, or a food source etc.[7][17] Hatchery facilities therefore need to understand these cues to induce settlement and also be able to substitute artificial substrates to allow for easy handling and transportation with minimal mortality

Hatchery design

Hatchery designs are highly flexible and are tailored to the requirements of site, species produced, geographic location, funding and personal preferences. Many hatchery facilities are small and coupled to larger on-growing operations, whilst others may produce juveniles solely for sale. Very small-scale hatcheries are often utilized in subsistence farming to supply families or communities particularly in south-east Asia.[3] A small-scale hatchery unit consists of larval rearing tanks, filters, live food production tanks and a flow through water supply.[3] A generalized commercial scale hatchery would contain a broodstock holding and spawning area, feed culture facility, larval culture area, juvenile culture area, pump facilities, laboratory, quarantine area, and offices and bathrooms.

Expense

Labour is generally the largest cost in hatchery production making up more that 50% of total costs. Hatcheries are a business and thus economic viability and scale of production are vital considerations. The cost of production for stock-enhancement programmes is further complicated by the difficulty of assessing the benefits to wild populations from restocking activities.

Issues

Genetic:

Hatchery facilities present three main problems in the field of genetics. The first is that maintenance of a small number of broodstock can cause inbreeding and potentially lead to inbreeding depression thus affecting the success of the facility. Secondly, hatchery reared juveniles, even from a fairly large broodstock, can have greatly reduced genetic diversity compared to wild populations (the situation is comparable to the founder effect). Such fish that escape from farms or

are released for restocking purposes may adversely affect wild population genetics and viability. This is of particular concern where escaped fish have been actively bred or are otherwise genetically modified. The third key issue is that genetic modification of food items is highly undesirable for many people.

Fish farms

Other arguments that surround fish farms such as the supplementation of feed from wild caught species, the prevalence of disease, fish welfare issues and potential effects on the environment are also issues for hatchery facilities.

CONCLUSION

The analysis of the information gathered during the course of the mission from existing documentation, reports, and from the conversations with project management and ifferent persons involved in fish-farming, leads to conclude that there are good conditions for development of commercial fish-farming in Zambia. Those conditions are best when fish-farming can be combined with other farming activities which can supply feeding and/or fertilizing ingredients like chicken, duck or pig-raising at no, out-of-pocket, cost to the farmer. Fish-farming operations covering 5 HA or more could then bring financial returns of 23–33% in average performance conditions of 6 t/HA yields.

Significant differences in construction costs seem to favor large size (5000m^2, 2500m^2) production ponds over smaller (1500m^2) ponds. Increased yields can hardly offset the cost effectiveness.

The financial returns expected from fish-farming operations depend on the cost of development since fish-farming is a capital intensive operation. Therefore the financial rates of return which have been computed depend on the prices quoted by Brunelli Construction which have provided the information on construction costs. Compared to costs charged by Brunelli for actual projects, the quoted costs appear high. Thus, the financial rates of return based on those costs would probably be considerably underestimated.

In general, the costs figures on which the calculation have been based are subject to this strong variations of this Zambian economy and in particular to its external trade sector and the rate of exchange of the

Kwacha. Therefore, it would be useful to revise periodically those costs figure used, although it would take major changes to modify the general orientation of this conclusion.

The most favorable factor for the success of commercial fish-farming is the growing demand for fish and in particular for fresh fish in the urban areas of Zambia. The fact that the fish breeding is necessary at a fast pace, that urban population is expanding even fast and that capture fisheries are approaching maximum sustanable yield (75,000 t) create favourable conditions for development of commercial fish-farming, mainly in peri-urban areas.

The development of this potential requires gathering of more information and creation of a program which would provide technical support for expansion of commercial fish-farming.

In Zambia much needs to be done to reduce the high percentage of post-harvest losses. Not only is the product poor in quality but also reduced in quantity. Wastage begins from the time the fish is caught, and continues as it is processed, packaged, transported and stored.

Research in fish processing has had very little impact in improving traditional processing practices in the fishing industry. Some of these problems have already been outlined. There are few datas are available to show the reasons why improved smoking kilns which were initiated by researchers like Watanabe and Joeris have not yet been adopted by fishermen or fish traders; reasons include the following:

- The drum smoker, proposed by Watanabe and Joeris (1967) was of limited capacity, restricting the quantity of fish processed at a time.
- Fishermen preferred using the drum for brewing beer and other purposes to smoking fish.
- Artisanal fishermen are highly nomadic people going where the catches are high, hence they did not like structures such as proposed by Clucas (1976).
- Costs and other restraining factors like permanent clean water supply, has made building good smoking kilns like the one designed by Watanabe and Cabrita (1971) an unattractive venture to both fishermen and fish traders.
- Extension services are probably not adequate.
- Lastly, there are no incentives given to fishermen, traders and marketeers for improved quality of their product. The fish is sold regardless of the quality.

UNIT – III

MINING

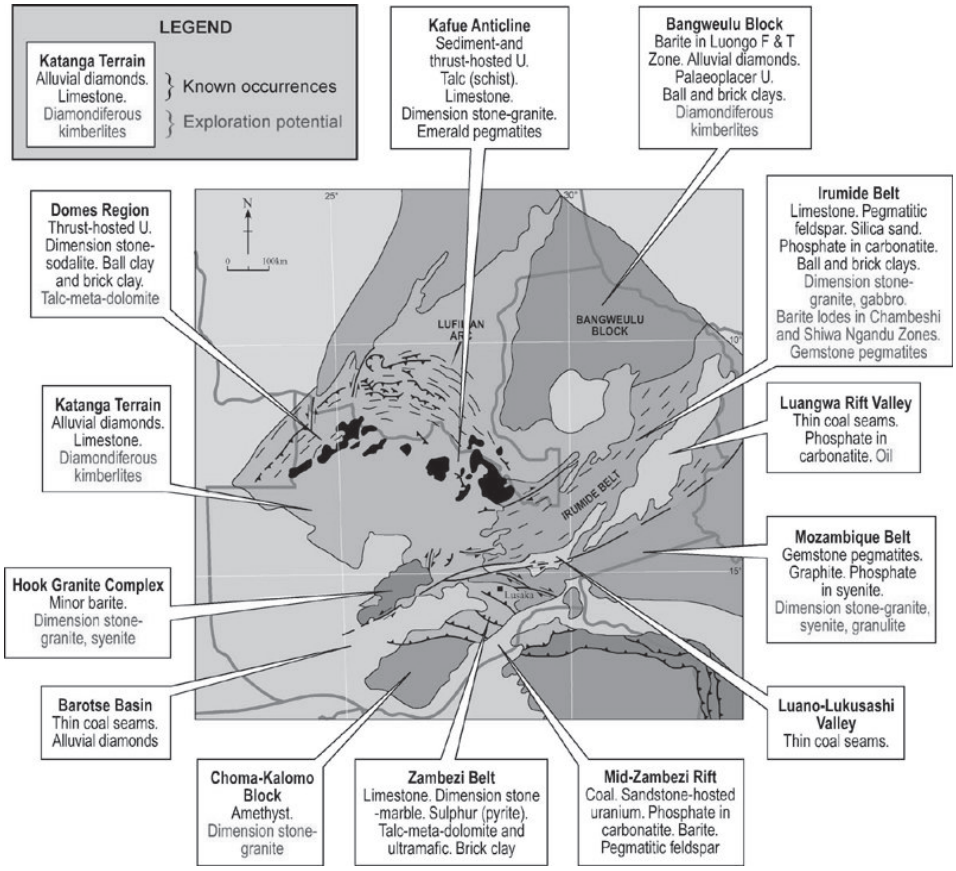


Figure.*** Zambia Industrial Minerals Map

LOCATION AND DISTRIBUTION OF MAIN MINERALS

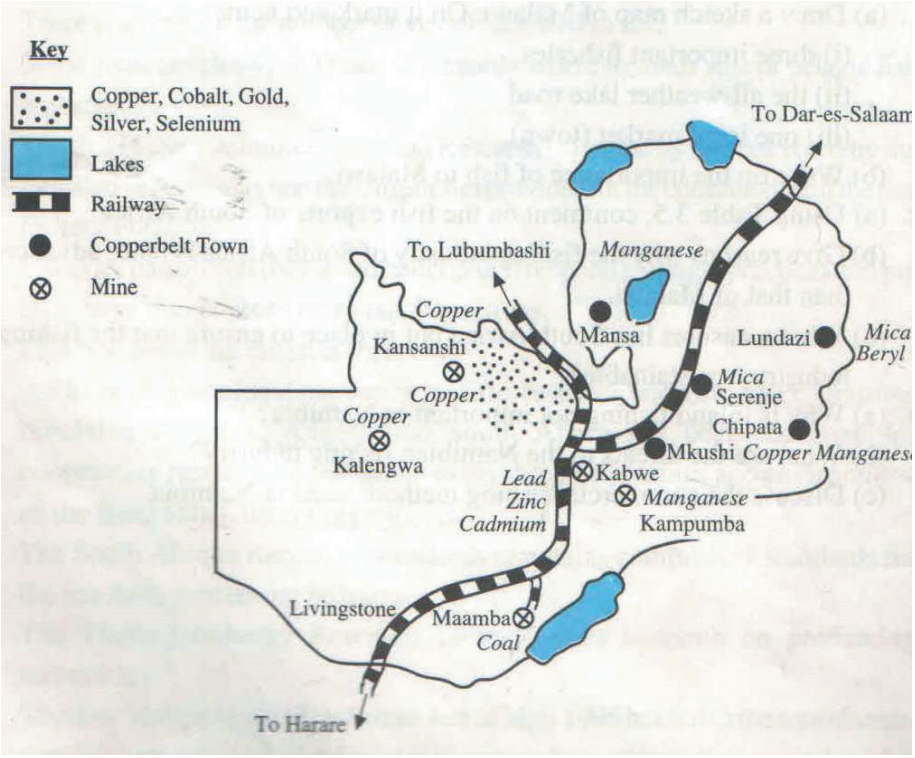
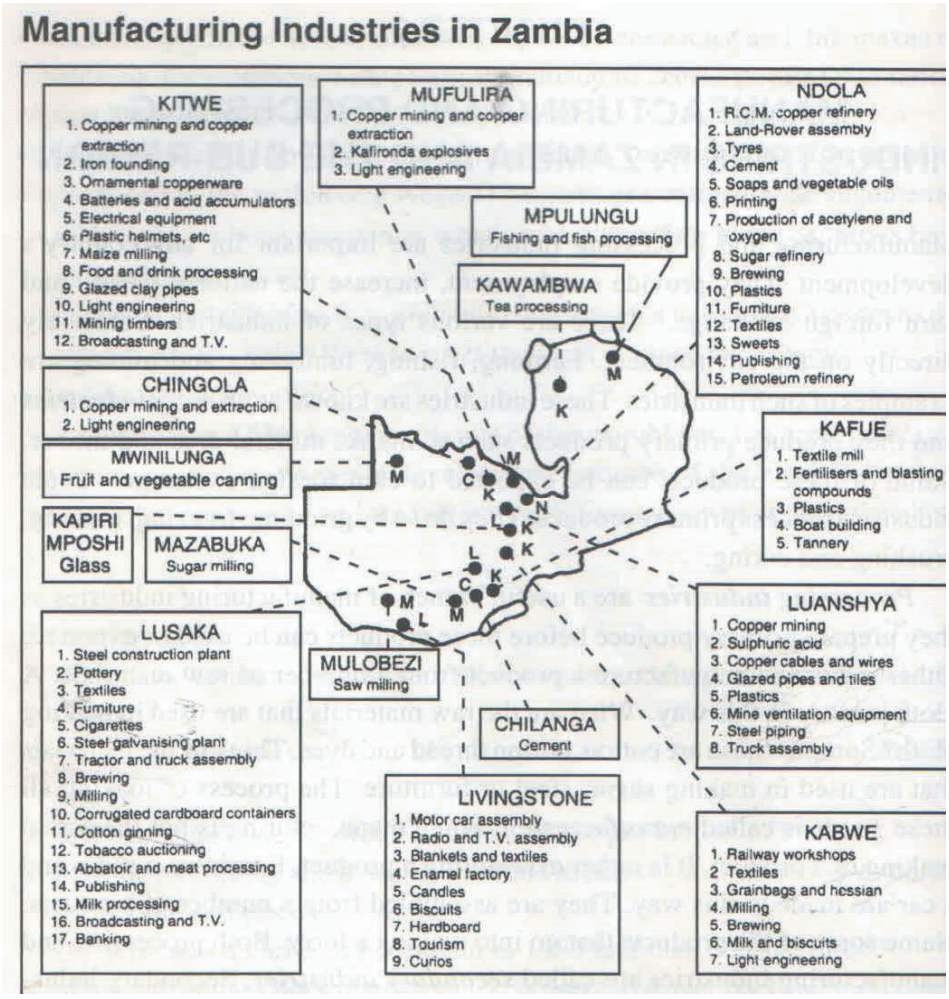


Fig.*** Mineral deposits of Zambia



- Copper – Solwezi at Kansanshi, Lumwana mines and the following Copperbelt towns: Luanshya, Kitwe, Chingola, Chililibombwe, Mufurila, Kalulushi.
- Lead and Zinc in Kabwe.
- Coal in maamba.
- Manganese in Serenje, Mansa, Lundazi, Kampumba.
- Silver in Kabwe.
- Limestone in Kabwe and Lusaka.
- Iron in Kansanshi.
- Amethyst in Maamba.
- Sulphur in Nampundwe.

- Emeralds in Kitwe, Kalulushi.
- Beryl in Lundazi.
- Selenium in Kabwe.
- Gypsum in Monze, Lochnivar around the Kafue basin.
- Talk in Lusaka at Lilayi.
- Nickel in Mazabuka

The mining industry has been the economic and social backbone of Zambia since the first major phase of exploitation of the Copperbelt's Cu-Co deposits commenced in the early 1930's. Since that time a wide spectrum of other metalliferous and non-metalliferous resources have been discovered in Zambia and, although exploitation of these has been limited, they clearly demonstrate the considerable opportunities for further exploration and mining.

Copper

Copper mineralization was first discovered at the turn of the century but large-scale production only commenced in the 1930's with the start-up of Roan Antelope (Luanshya - 1931), followed rapidly by Nkana (1932), Mufulira (1933), and then Nchanga in 1939. Copper production exceeded 400, 000 t.p.a. in the late 1950's and passed the 600, 000 t.p.a. mark in the mid-1960's before beginning a progressive decline in 1976-77 and sinking to a 1996-low of 350 ,000 t.p.a.

However, the move to privatization of Zambia Consolidated Copper Mines (ZCCM) should halt this decline and, with a total mineral resource of at least two billion tonnes on the Copperbelt alone, there is no doubt that copper and cobalt production will soon begin a dramatic upward trend.

Gold

Zambia has a history of gold mining on a relatively small scale, with the twenty larger deposits having produced slightly more than 2t of gold since modern mining began in 1902. The largest past producers are Dunrobin (990kg gold), Sasare (390kg), and Matala (225kg); Dunrobin has recently been re-opened by Reunion Mining and is scheduled to produce 500-600kg gold per annum. More than 300 gold occurrences have been reported throughout the country and some of these are currently being-re-evaluated. The other important metal production has been zinc and lead from the carbonate-hosted deposits of Kabwe which, with a total of 11Mt of ore containing 40% combined

zinc and lead, ranks as one of the highest grade Zn-Pb deposits of probable Mississippi Valley - type in the world. Similar styles of mineralization have been recognized over a wide area to the north of Kabwe.

Iron

Substantial resources of iron are known in central and western Zambia, occurring as ironstones and lesser skarn deposits but have yet to be exploited. Amongst other metalliferous occurrences reported are sedimentary and fracture-hosted manganese and orthomagmatic and shale-hosted nickel, together with tin and tungsten.

Gemstones

Alluvial diamonds have been recovered throughout Zambia, accompanied in places by indicator minerals but, despite the discovery of a number of kimberlite and lamproite intrusions, the sources of the diamonds have yet to be found. Zambia's high-quality deep green emeralds are in demand world-wide and, since 1970, have been mined continuously on the southern margin of the Copperbelt where they are hosted by pegmatite bodies. Pegmatites are also common in eastern Zambia where they have been exploited for aquamarine and tourmaline.

Industrial Minerals

A wide range of known industrial minerals in Zambia include feldspar, silica sand, talc, barite, phosphate (in carbonatite and syenite), limestone, clays (mostly ball clay and brick clay), graphite, and many varieties of possible dimension stones.

Since 1967, coal has been produced continuously by Maamba Collieries from the fault-controlled Karoo basins of southern Zambia. Production in 1997 was 164,000t but the open-pit mining operation has the potential to return to past production levels of 500,000t.p.a.

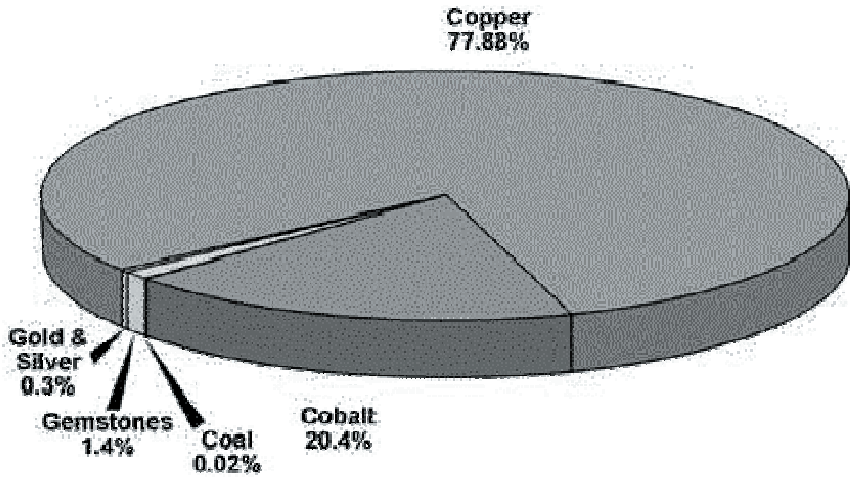
Hydrocarbons

Limited exploration for hydrocarbons till date has been unsuccessful but evaluation of existing data and re-interpretation of the sequence stratigraphy indicates significant potential in the lower and mid-Karoo sequences of the Luangwa and Mid-Zambezi graben.

Mining and the Economy

The mining sector contributed US$822 million to the total export earnings of US$1050 million in 1997 and, of this; US$798 was realized from sales of copper and cobalt. The balance of mining-sector earnings come from sales of gold, silver, and selenium, mostly byproducts of copper mining, and from emerald sales.

The vulnerability of Zambia's economy due to its reliance on copper mining has been exposed in the very recent past by the falling copper price and by falling production as a result of limited re-investment in the mining industry. However, the privatization process has already led to significant inflow of investment to the mining sector, and a reversal of fortunes is confidently predicted for the copper mining industry within the next 2-3 years. Re-inforced by future production of additional metals and minerals, there is no doubt that the mining industry will continue to provide both a sound base and a stimulus for growth in the other sectors of the economy, leading to long-term prosperity.



Value of mineral sales in Zambia

Metal Stones

Cobalt

Chemistry:Co, elementalcobalt
Class:Element
Subclass:NativeMetal
Uses: Many applications for metallic cobalt.

Cobalt has yet to be found in nature, but is being grown in laboratories and these cobalt specimens are starting to appear in rock shops. Since it has never been found in nature it is technically not a mineral although lab grown specimens can look like a natural stone.

The element cobalt has many industrial uses especially in dyes and in magnets. As a dye, cobalt produces a spectacular blue color that is used most notably in glass and ceramics. When alloyed with iron and nickel, cobalt produces a strong magnet. Cobalt has many uses in certain alloys for airplane parts and engines.

Physical Characteristics:

Colour is steel grey.
Luster is metallic.
Transparency: Specimens are opaque.
Crystal System is isometric.
Crystal Habits include only lab grown specimens.
Specific Gravity is 8.9 (very heavy for a metallic mineral).
Other Characteristics: Magnetic.
Notable Occurrences include only lab grown specimens.
Best Field Indicators are colour, magnetism and density.

Copper

Chemistry: Cu, Elemental Copper
Class: Element
Group:Gold
Uses: Minor ore of copper, ornamental stone

Native copper (copper found in a chemically uncombined state) has been
mined for centuries and now is all but depleted as an economically viable ore. Other copper minerals are far more economical to mine and purify into metallic copper that is used for wiring, electrical

components, pennies and other coins, tubing and many other applications. Native copper is still found in limited quantities in once-active mining regions. These finds are now valuable as minerological specimens and ornamental pieces. Fine specimens only rarely demonstrate crystal faces and these are prized above otherwise similar specimens.

Physical Characteristics:

Colour (Color) is copper-coloured (colored) with weathered specimens tarnished green.
Luster is metallic.
Transparency is opaque.
Crystal System is isometric; 4/m bar 3 2/m
Crystal Habits include massive, wires and arborescent or branching forms as the most common, whole individual crystals are extremely rare but when present are usually cubes and octahedrons. Occasionally, massive forms will show some recognizable crystal faces on outer surfaces.
Cleavage is absent.
Fracture is jagged.
Streak is reddish copper colour (color).
Hardness is 2.5-3
Specific Gravity is 8.9+ (above average for metallic)
Associated Minerals are silver, calcite, malachite and other secondary copper minerals.
Other Characteristics: ductile, malleable and sectile, meaning it can be pounded into other shapes, stretched into a wire and cut into slices.
Best Field Indicators are colour, ductility and
crystal habit.

Gold

Chemistry:Au, Elemental gold
Class:Element
Group:Gold
Uses: Major ore of gold and as mineral specimens.
Gold is a pleasure to own and possess, as many people have discovered throughout the ages and around the world. Gold is a very stubborn element when it comes to reacting to or combining with other elements.There are very few true gold ores, besides native gold,

because it forms a major part of only a few rare minerals, it is found as little more than a trace in a few others or it is alloyed to a small extent with other metals such as silver. Gold is almost indestructible and has been used and then reused for centuries to the extent that all gold of known existence is almost equal to all the gold that has ever been mined. Gold is a great medium metal for jewellery, as it never tarnishes. Native gold wires emerging from massive white quartz can make for a visually stunning specimen.

A few of the minerals that bear gold in their respective formulas are in a subclass of sulfides called the tellurides. The element gold seems to have an affinity for tellurium and this is one of the only elements that gold can bond with easily. In fact only a few rare tellurides are found with out gold. A few of the tellurides are nagyagite, calaverite, sylvanite and krennerite. These are all minor ores of gold but their contributions to the supply of gold pales next to native gold's own contribution. Occasionally these minerals are associated with native gold.

There are a number of minerals that are aptly named "Fool's Gold" because only a fool could believe they are gold! Actually it is easy for people who see shiny golden colored flakes sparkling at them from some rock they just picked up to believe that they have struck pay-dirt. Gold's ductility, sectility, density and softness are usually sufficient to distinguish it from the much cheaper imposters. The most famous "fool's gold" is the very common sulfide, pyrite. Chalcopyrite, marcasite and just about any golden coloured sulfide has been also proven to be worthy the "fool's gold" monicure. Weathered flakes of biotite which can sport a bright yellow colour, and a nice flash of light when viewed just right, have also been mistaken for gold.

Gold specimens are sometimes artistically stunning and a good investment as well. After all, it is gold, which never seems to lose its value. Good natural specimens though are more expensive than their actual weight value. This is to be expected as good gold crystals are somewhat scarce (most are melted down for quick profits) and you really don't want a natural specimen to be worth what a lump of previously smelted and refined gold is worth, do you?

Physical characteristics:

colour is golden "butter" yellow.
Luster is metallic.
Transparency is opaque.
Crystal System is isometric; 4/m bar 3 2/m

Crystal Habits includes massive nuggets and disseminated grains. Also wires, dendritic and arborescent crystal clusters.
Cleavage is absent.
Fracture is jagged.
Streak is golden yellow.
Hardness is 2.5 – 3
Specific Gravity is 19.3+ (extremely heavy even for metallic minerals)
Associated Minerals include quartz, nagyagite, calaverite, sylvanite, krennerite, pyrite and other sulfides.
Other Characteristics: ductile, malleable and sectile, meaning it can be pounded into other shapes, stretched into a wire and cut into slices.
Best Field Indicators are colour, density, hardness, sectility, malleability and ductility.

Silver:

Chemistry: Ag, Elemental silver
Class: Element
Group: Gold
Uses: Minor ore of silver for use in jewelry, coins and photographic films and other industrial uses.

Silver has been mined for aeons and has always been popular in jewelry and for coinage. Only in the past hundred years however, has the demand for silver been so great. The reason for this demand is the use of silver in the photography industry, which takes advantage of silver's reactivity to light. Native Silver is rare and much silver is produced from silver-bearing minerals such as prousite, pyrargyrite, galena, etc. Specimens of Native Silver usually consist of wires that are curved and intertwined together, making an inspiring mineralogical curiosity.

Physical Characteristics:

colour is silver white with exposed specimens tarnishing black.
Luster is metallic.
Transparency is opaque.
Crystal System is isometric; 4/m bar 3 2/m
Crystal Habits include massive and disseminated grains, wires and plates as the most common, whole individual crystals are extremely rare but when present are usually cubes, dodecahedrons and octahedrons. "Jack Frost" type crystal growth as shown on some specimens produces beautiful intricate structures. Wires can form coiled clusters that resemble rams horns.

Cleavage is absent.
Fracture is jagged.
Streak is silver white.
Hardness is 2.5-3.
Specific Gravity is variable according to purity 10-12 (well above average even for metallic minerals)
Associated Minerals are silver minerals such as acanthite and prousite, cobaltite, copper, zeolites and quartz.
Other Characteristics: ductile, malleable and sectile, meaning it can be pounded into other shapes, stretched into a wire and cut into slices.
Best Field Indicators are colour, tarnish, ductility and crystal habit.

Tin:

Chemistry: Sn, elemental tin
Class:NativeElement
Subclass:NativeMetals
Uses: Many applications for metallic tin.

Native tin (the latin word for tin is stannum and gives tin its chemical symbol Sn) is a rare mineral. It is so rare that in no way, can it be thought of as an ore of tin. Tin ore minerals include the oxide minerals cassiterite and rutile and a few sufides such as franckeite, cylindrite, canfieldite, stannite and teallite. By far the most tin comes from cassiterite; SnO2. The largest tin producers are China and Indonesia followed by Peru, Brazil, Bolivia and Australia. The United States which has significant resources for most industrial metals is found quite lacking in tin. Alaska has the only viable source of tin in the United States and it is insignificant compared to other world sources.

Pure tin metal has few uses and thus most tin is used in alloys. The most famous tin alloy is bronze. Roughly 5% tin smelted with 95% copper produces bronze. The development of bronze by primative humans was considered such advancement that the era was called the “Bronze Age”. Most solder is a combination of tin and lead. Another alloy of tin is pewter. Tin alloys had been used to make tin cans and tin roofs, but they are not used for those purposes too often now. Today, tin has significant use as a corrosion fighter in the protection of other metals and alloys and in use in the glass making industry as well as many other varied uses.

Native tin is found in placer deposits and in unusual igneous intrusions. Australia has the recognized type locality, but there is a report from Russia of an earlier find. Tin is too rare to be seen in typical

rock shops, but laboratory specimens are being grown and put up for sale.

Physical characteristics:

colour (color) is white to gray.
Luster is metallic.
Transparency: Specimens are opaque.
Crystal System is tetragonal (below 13.2°C(13.2 degrees C) tin converts to isometric).
Crystal Habits include grains in placer deposits and lab grown specimens.
Cleavage is indistinct.
Hardness is 1.5 – 2.
Specific Gravity is 7.3 (heavy even for a metallic mineral).
Streak: white – gray.
Other Characteristics: Sectile.
Associated Minerals include native gold, native copper, stistaite, native aluminum and other rare native metals.
Best Field Indicators are color, brittleness, hardness, locality and density.

Zinc

Chemistry: Zn, elemental zinc
Class: Native Element
Subclass: Native Metals
Uses: Many applications for the metal – zinc.

Native zinc is a rare mineral. Native zinc has been found in several locations but is never found in any abundance. It would be wrong to consider it an ore of zinc. First of all, an ore should be less valuable than its constituent metal. And since zinc is so rare in its native form, this is not true. Secondly, an ore needs to be common enough and exploitable enough to be profitable enough to mine. In other words, economical! As already stated, native zinc is a rare mineral and in addition, it does not group itself in any siginificant concentrations. Actual ores of zinc include sphalerite, smithsonite, hemimorphite, franklinite, willemite, hydrozincite and zincite. Zinc is used in a variety of special alloys that have unique industrial properties from great strength to unusual plasticity.

Native zinc's type locality is somewhat in doubt as different localities are sometimes mentioned. The Mina Dulcinea de Llampos, Copiapo, Chile locality seems to be the current type locality of

concensus; however a case has been made for the first specimens of native zinc actually coming from New Brunswick, Victoria, Australia in 1855. Native zinc is found as indistinct grains in igneous rocks with originations from a reducing environment.

As an important industrial metal, zinc has been used for aeons, even if its users did not know what it was. It was used to make the zinc/copper alloy brass in prehistoric times. A figure in the Bible, Tubal-cain, was mentioned as an instructor in brass and iron. The Bible says he was 7 genenerations from Adam. Prehistoric brass has been found in Romanian ruins. Romans made great use of brass and found it to be ornamental as well as useful. It is doubtful that the zinc metal was actually seen by its early users as it boils well below copper's melting point and thus can not be melted into the copper. More likely a technique was used that roasted the zinc ores with the copper and the resultant zinc fumes absorbed into the melting copper.

There are a few naturally occurring zinc alloys that are classified in the Elements Class with native zinc. Naturally occurring brass, Cu3Zn2, is one of them. It is being given consideration as a mineral, but is not yet officially recognized. Other zinc alloy minerals include danbaite, CuZn2 and zhanghengite, (Cu, Zn, Fe, Al, Cr).

Physical characteristics:

colour (color) is white to bright blue gray.
Luster is metallic.
Transparency: Specimens are opaque.
Crystal System is hexagonal; 6/m 2/m 2/m.
Crystal Habits include volcanic exhalations, granular (often microscopic) and lab grown specimens.
Cleavage is perfect in one direction (basal).
Hardness is 2.
Specific Gravity is 6.9 – 7.2 (heavy even for a metallic mineral).
Streak: Light gray.
Other Characteristics: Brittle at room temperatures (not malleable or ductile unless heated to 100ºC.
Associated Minerals include native gold, native copper, native aluminum and other rare native metals.
Best Field Indicators are colour, brittleness, hardness, locality and density.

Industrial Stones

Limestone

Carbonate rocks are a common component of the Katanga Supergroup and also occur within the Basement Supergroup. Limestone and dolomite are abundant in the area around Lusaka and these and other deposits in the Southern, North Western, Northern and Luapula Provinces have been identified as being suitable for agricultural use. High-purity, low-MgO limestone is currently being exploited from the lower Katanga succession near Ndola on the Copperbelt. Extensive deposits of limestone, dolomite, exist around Lusaka, in the southern part of Central Province and in isolated scattered occurrences in Eastern Province.

Silica Sand

Sands of various specifications occur throughout Zambia but the only occurrence to have been exploited is the deposit of high-quality glass sand at Kapiri Mposhi which was the basis for glass manufacture by Kapiri Glass Products Ltd., until the recent closure of the company. The sand is an unconsolidated alluvial deposit derived by the weathering of quartzites of the Muva Super group.

Phosphate

Apatite, the most important potential source of phosphate, occurs in significant concentrations in syenitic intrusions and carbonatite bodies. Significant syenite-hosted deposits include the apatite-quartz bodies of Chilembwe, near Petauke in eastern Zambia, and breccia and pegmatite bodies in syenite intrusions near the north-eastern margin of the Hook Granite Complex. Carbonatites in Zambia are mostly related to Karoo-age rifts and very substantial low-grade apatite deposits have been noted in two of these – Kaluwe in the Rufunsa-Feira area and Nkombwa Hill at the northern end of the Luangwa Rift.

Coal

Zambia possesses substantial coal resources and has been producing coal continuously since 1967. The bulk of the coal has come from the Maamba coal mine, an open-cast operation in the southern part of the country near Lake Kariba. The Maamba deposit and other known coal occurrences are confined exclusively to the lower Karoo

Gwembe Formation, within the series of fault-controlled basins that comprise the Mid-Zambezi Rift Valley. The Maamba deposit occurs within the Kazinze Basin but coal seams have also been discovered in the adjacent basins. Thin coal seams and carbonaceous shales have also been identified in the lower Karoo (Gwembe Formation) of the Luangwa and Luano-Lukusashi Valleys and in the eastern part of the Barotse Basin in western Zambia. Coal is mined at Maamba with a proven reserve of 20Mt. The coal is sub-bituminous durain-fusain with high ash content.

Feldspar

In recent years the demand for feldspar has been from local ceramic producers and also from Kapiri Glass Products Ltd., based at Kapiri Mposhi. Production has mostly come from two pegmatite deposits – a 4m thick body of alkali-feldspar-pegmatite containing minor muscovite and quartz near Siavonga and a 5m thick, partially kaolinized, pegmatite at Shipingu, near Kapiri Mposhi.

Feldspars are known to occur in several places in Zambia, mostly in pegmatites. Most of the pegmatites in the country are exploited for their gemstone potential or for tin. Only a few have been exploited for their feldspar content.

Central Province

Serenje Area

About 9000t of feldspar in an echelon of pegmatitic bodies lying 38 km southeast of Serenje was discovered

Lukusashi West Deposit

Feldspar also occurs in a 65m by 5-10m wide aggregate of microcline perthite, muscovite and quartz with occasional tourmaline and garnet. About 2,114 tonnes of reserves have been estimated.

Lukusashi South

An estimated 2,148 tonnes of *in situ* reserves of slightly weathered subhedral perthitic microcline are found.

Mita Hills Area

This deposit is located about 6 km south, south east of Mita Hills Lake. The pegmatites are predominantly microcline-perthite with a common size range between 5 to 10 cm. Sizes of up to 20cm for individual crystals are also common. The microcline-perthite is often pale yellow to pinkish or greyish in colour, but glassy varieties are present

The pegmatitic area covers is about 2-5 km and the deposit is designated deposit I and deposit II. The estimated reserves for deposit I are 20,248 tonnes and 14,632 tonnes for deposit.

NorthernProvince

Shiwang'andu Area

At Shiwang'andu, large lenses and smaller pods of feldspar set in dykes up to 20m wide and from 5 to 45m long is found. These dykes and veins together form the pegmatitic body. The reserves for this pegmatite body are 1,500 tonnes.

North-Western Province

Kifubwa Area

Albeit with minor proportions of potassium and calcium feldspars occurs in the Kifubwa river area in Solwezi district.The reserves are estimated at about 4,500 m3, with mineable reserves at 75% of this figure.

Eastern Province

Feldspar bearing pegmatites are widely spread in the Eastern Province, especially in the Lundazi and Chama districts. In Lundazi the pegmatites are exploited only for their aquamarine potential.

Southern Province

Feldspar bearing pegmatites occur in several localities of this region. Pegmatites forming the tin belt of the Southern Province have been worked mainly for cassiterite.

In the Sachenga area about 50km southeast of Mazabuka pegmatites with a high content of white feldspar have been reported. An appreciable amount of feldspar is also found in pegmatites of the Pemba area, which were formerly exploited for their mica content.

Siavonga Area

In the past, feldspar was worked by Mindeco Small Mines Limited, a then subsidiary of ZIMCO, and was supplied to Maamba Collieries and Kapiri Glass factory. The microcline was hand sorted after blasting No reserve estimations have been done.

Others

Feldspar bearing pegmatites are widely distributed in the basement formations throughout the country but their potential still remains to be assessed.

Barite

Barite has been reported in several localities in Zambia. Most are of vein type in high grade metamorphic rocks of the Basement complex, but a few are believed to be of sedimentary origin and often associated with iron and manganese deposits. Individual occurrences are as follows:

Chibote Barite

This is the largest barite deposit in Zambia. It is located 75 km north of Luwingu. Nine deposits have been mapped and sampled along a strike length of 50 km within siliceous argillites, quartzite and shales of the Chibote formation

Tabular crystals of barite form a bed 0.3 to 0.8m thick in shales dipping at 55°. Reserves to a depth of 30m are 144,000 tonnes of barite rock with 90% BaSO4.

Chasefu Barite

Chasefu barite deposit is located 45 km north-northwest of Lundazi town, about 10 km from Chasefu Mission School on the Chikwa Road. The deposit occurs in a terrain underlain by rocks of the Basement Complex which have been intruded by aplites, numerous sills of mafic composition and post-tectonic.

Pegmatite: There are two barite veins; the largest is 340 long and 1.5m wide. The barite is massive, white, off-white to light grey in colour. The two veins between them contain 80,000 tonnes of barite, calculated to a depth of 30 meters with an average grade of 95.7% BaSO4.

Chirundu Barite

This occurrence is 10 km west of Chirundu. The barite occurs together with gypsum. No reserve estimation has been made and the deposit is inactive.

Kokole Barite

This occurrence lies some 15 km east of the railway line, 20 km southeast of Kafue town. Rubble and boulders of barite were found in 3 areas along a stretch of 0.8 km. A vein 100 m long and 0.1-1 m thickness has an ore reserve of 200t-1000t.

The barite is composed of small pinkish-white crystals (1-3 cm in size), embedded in a grey brown matrix of barite, haematite, limonite and quartz. It is a fissure filling vein type cross- cutting schists and rhyolite near a granite contact.

Corundum

Rufunsa Area

Corundum occurs 9 km north of Rufunsa. The corundum in places makes up half the volume of the rock mass (Chlorite schists), occurs in crystals up to 1 cm in length and is associated with kyanite

Corundum was observed in schistose rubble in two localities 1 km apart. No further information is available, but the corundum bearing zone is thought to be narrow.

Mkwisi Area

Dark blue corundum occurs in a contact zone between gabbro and biotite schists near the headwaters of a small tributary on the eastern side of Mkwishi river, some 7 km north of Kafue river, near Chiawa.

A zone 76 m long and up to 21 m wide consist of decomposed talc and kaolin in which small blue and pink broken crystals of corundum occur, occasionally in small isolated pockets together with kyanite and sillimanite. Trial concentration of stream gravels by hand gravitation and panning produced very small amounts of corundum.

Mugoto Area

Corundum is reported to occur in pegmatites within mica schists on the west side of Nega-nega River some 4 km west of Chakela hill in the Mugoto area.

Fluorite

Sianyolo Fluorite deposit

This is the largest known fluorite deposit in Zambia. It is located at Sianyolo village in the Siavonga district of Southern province. Access is by bush tracks off the Lusaka-Chirundu road, 80 km away.

Reserve calculations were done on veins above 1 m thick, and an average thickness of 2.3m was calculated with a maximum of about 6 meters. Proven reserves stand at 1.67 million tonnes at 85% CaF2 with an average thickness of 2.8 m. Indicated reserves are 585,000 tonnes with average width of 2.5 meters and inferred reserves are 3.845 million tonnes.

Siavonga Fluorite deposit

This deposit is located at 2.4 km west of Siavonga harbour. Veins of up to 0.3m wide have been traced for over 150 m, but the reserves have not been quantified.

Mutua Fluorite

Five fluorite bearing veins are located around Shangwa hills, at some 14 km north of Siavonga. Estimated mineable reserves are 16,000 t/m depths at grades varying from 40-60% CaF2. Assuming a depth of 30 m, probable reserves are in the order of 500,000 tonnes of fluorite at about 50% grade.

Graphite

Graphite occurrences have been reported in several localities in Zambia. Of these, four areas have been examined in detail for the mineral ore.

Njoka Graphite

Njoka graphite deposit lies some 53km west of Lundazi town, 1.6 km northwards from the Lundazi-Kazembe gravel road.

The ore reserves to a depth of 5 metres are 41,460 tonnes containing 4880 tonnes with an average grade of 11.7% fixed carbon.

Kajumba Graphite

Kajumba deposit presents a small graphite deposit but of higher grade than Njoka. It lies in remote part of Chama district in a country underlain by rocks of granulite facies.Reserves to a depth of 1.5 meters are 6,000 tonnes with an average of 26.63% fixed carbon.This deposit was exploited by a SIDO company in the early 1990s for production of pencil lead.

Petauke Graphite

The Petauke graphite deposits are easily accessible via the Great East Road.

Uranium

Uranium is found in the following geological environments in Zambia:-

- Karoo age continental sandstones and grits.
- Associated with the Cu-Co mineralisation in the Copperbelt.
- Basal Kalahari sandstones in Western and North-Western Provinces.
- Mporokoso Group sediments in Northern Zambia. These rocks are similar to the Witwatersrand of South Africa and thus have very high potential for Uranium and Gold.
- In pegmatites.
- In magmatic deposits.
- In veins.
- Gneiss domes environment in North-Western Province.
- In carbonatites.

The only significant production has been 102,000kg of U_30_8 from the Mindola shaft in Kitwe in the rocks of the lower Katanga Supergroup.

Dimension Stones

Dimension Stone is a stone used for building, 'dimensioned' to size. Typical dimension stones, from smoothest to roughest, are; granite, marble, limestone, slate, and sandstone.

Evolution in building technology over the past 60 years has dramatically changed the way in which granite and marble are used in building construction. In older city buildings, the masonry walls were necessarily thick and strong enough to support the upper floors. Advances in granite processing technology, particularly developments in diamond sawing and computer control systems over the last decade or so, have reduced the relative cost of granite for use in domestic applications such as tiles and counter-tops. As a consequence granite has become an international commodity of some importance, with ~16 Mt/year being mined around the world.

Granite dimension stone have distinctive red or pink colours due to abundant minute iron oxide inclusions within the plagioclase and K-feldspar. The calcsilicate metasomatite is variable in colour, and composed of a syn- to post-metamorphic alteration mineral assemblage including pink-green albeite and microcline, actinolite, magnetite, haematite, quartz, epidote, dolomite, sphene and pyrite, with traces of chalcopyrite and apatite. Marble deposits have in the past provided ornamental and monumental stone from deposits.

Slate is a term applied to many paving stones where the natural form is thin planar slabs. Many of these should more correctly be referred to as 'flagstone', and the term 'slate' reserved for fine-grained metasedimentary rocks which split into sheets thin enough to be used as roofing shingles.

Slate stone is well suited for paving, panelling, floor tiles and for high-quality slate in architectural work. Full size, single piece billiard tabletops are a specialty.

Gemstones

Amethyst

Amethyst is simply the purple variety of quartz and is a popular gemstone. If it were not for its widespread availability, amethyst would be very expensive. Its color is unparalleled, and even other, more expensive purple gemstones are often compared to its color and beauty. Although it must always be purple to be amethyst, it can have a wide range of purple shades.

Amethyst is prevalent in most places in Zambia but major production is in the Mapatizya area in the Mwakambiko Hills and in the Mumbwa-Namwala area.

Amethyst deposits in the Mwakambiko Hills occur in a northeast trending belt. They intrude basement rocks. The amethyst belt is some 30 km long 15 km wide and appears to be related to the boundary faults separating Karoo from Basement. The deposits have been known since the 1950s and Northern Minerals started commercial production in 1956, which is now being run as Kariba Minerals Ltd.

Annual production of amethyst is about 700 tonnes. Currently the major producer is Kariba Minerals Limited, which is jointly owned by the Government and Lonrho, a private company.

In general the potential is substantial and high quality materials are becoming more and more apparent.

Aquamarine

Aquamarine is the blue, or perhaps more correctly, blue-green or aqua variety of the mineral beryl. Other gemstone colour varieties that belong to beryl include emerald, morganite, and heliodor. Other colour of beryl is simply referred to by their colour, such as red beryl.

Aquamarine is coloured by trace amounts of iron that find their way into the crystal structure. Most gem aquamarines have been heat treated to produce the popular blue-green colors from less desirable yellow or pale stones.

Aquamarine bearing pegmatites are found in the Lundazi, Mkushi and Itezhi Tezhi areas and intruded the Basement rocks during post-Katangan, pre-Karoo times.

Beryl

Beryl is often unknown to the general public, even the gemstone-buying public. However, it is one of the most important gem minerals. Beryl is colourless in pure form; it is the many different impurities that give beryl its varied colouration. Without these splendid color varieties, beryl would be a rather ordinary gemstone with only average fire and brilliance. Emerald is the green variety and Aquamarine is the blue variety of beryl.

Other colours of beryl are also used as gemstones but are not as well known.

The greenish-yellow variety is called Heliodor.
The pink variety is called Morganite.
The colorless variety is called Goshenite.
The name beryl is used for the red and golden varieties, which are simply called red beryl and golden beryl, respectively.

Emerald

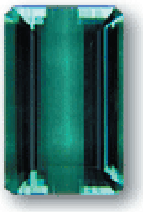
Emerald is highly prized and is one of the most valued gemstones. Its green color is peerless and all other green gemstones are compared to its intensity. Emerald specimens are often “flawed” with mineral inclusions and fractures; unlike other gems, these are considered part of the stones’ “character.” These flaws actually help determine natural from synthetically-produced stones. Uncut emerald specimens are rare on the mineral markets, probably because even low grade emeralds can carry a high price when cut as gems. Especially hard to find are true “in-matrix” specimens. Fakes are often produced with natural crystals glued into a “host” rock and then sold as an in-matrix specimen with a highly inflated price.

Emerald is the green variety of the mineral beryl. Other gemstone color varieties that belong to beryl include aquamarine, morganite, and heliodor. Other colors of beryl are simply referred to by their color, such as red beryl.

The wonderful green color of emerald is unparalleled in the gem kingdom. Emerald’s precious green color is caused by small amounts of chromium and enhanced by traces of iron. Unlike other beryls, emeralds often contain inclusions and other flaws. These flaws are not looked on as negative aspects for emerald like they would be for other gemstones. Indeed, these flaws are considered part of the character of the stone and are used to assure the purchaser of a natural stone.

Emeralds are found in the Miku-Kafubu area. They were emplaced in the pre-Katangan time in the Muva sediments.

Tourmaline



Most people consider tourmaline to be a single mineral, but in fact it is a group named for several different, but closely related minerals. Members of the Tourmaline Group are favorites among mineral collectors. Their rich and varied colors can captivate the eye. Even the black opaque tourmalines can shine nicely and produce sharp crystal forms. Tourmalines are cut as precious gems, carved into figurines, cut as cabochons, sliced into cross-sections and natural specimens are enthusiastically added to many a rock hound's collection.

There are many unique properties of tourmalines. First, they are piezoelectric which means that when a crystal is heated or compressed (or vibrated) a different electrical charge will form at opposite ends of the crystal (an electrical potential). Conversely if an electrical potential is applied to the crystal, it will vibrate. Secondly they are pleochroic which means that the crystal will look darker in color when viewed down the long axis of the crystal than when viewed from the side. This property goes beyond the idea that the crystal is just thicker in that direction. Even equally dimensioned crystals will demonstrate this trait. This property can be used as an advantage by gem cutters who may wish to enhance a crystal's pale color or weaken a strongly colored crystal.

The four most common and well-known tourmalines are distinguished by their colour and transparencies. Elbaite is the gemstone tourmaline and comes in many varied and beautiful colours. It is transparent to translucent and is highly prized as minerals specimens and as gemstones. Elbaite is easily the most colourful of all the gemstones.

The iron-rich schorl is the most abundant tourmaline and is black and opaque. It is a common accessory mineral in igneous and metamorphic rocks and can form nice crystals. Although too opaque to be used as a gemstone, schorl is used as an ornamental stone when found as inclusions in quartz, when a stone is called "tourmalinated quartz". Usually when someone refers to tourmaline they are referring to either elbaite or schorl.

The two other more common tourmalines; dravite and uvite are much less common than elbaite or schorl, but they are getting noticed for their beautiful specimens. Some of dravite's crystals are nicely formed, translucent brown and they can reach a rather large size. Uvite is a green translucent to opaque tourmaline that is growing in popularity and is being cut as a gemstone.

The Tourmaline Group has a general formula of AX3Y6(BO3)3 Si6O18(O, OH, F)4. The A can be either calcium or sodium. The X can be aluminum, iron, lithium or magnesium. The Y is usually aluminum, but can also be chromium or iron. Some potassium can be in the A position, some manganese can be in the X position and some vanadium can be found in the Y position, but these elements are usually not represented in the formulas of the tourmaline members.

Garnet

Garnets are a ubiquitous component of metamorphic rocks throughout Zambia. Gem garnets found in Zambia include: red garnets (generally mixtures of pyrope and almandine), rhodolite (a pale violet type of pyrope) and spessartite (an orange to red-brown variety). The most productive garnet deposits are a group of mines centred around Sangu and Doost mines northwest of Lundazi.

Other Gemstones

Other gemstones that have been found in Zambia include **topaz, opal and agates, citrine.** Agates occur in vesicles in the Karoo basalts found in Livingstone and elsewhere in Zambia.

The **diamond** potential of Zambia is an area that requires serious attention in future. De Beers carried out extensive work over a period of 30 years and they managed to identify over 100 kimberlite pipes. De Beers reported many occurrences of small diamonds and indicator minerals but no economic or commercial deposits were found. The kimberlite and lamproite pipes found in Zambia can be divided into the following domains; Tanzania-Mweru, Luangwa, Mid-Zambezi, Mulobezi-Kafue and Kabompo. The failure by De Beers to find an economic deposit in Zambia while some of the world's most prolific and richest deposits are being, or have been mined, in the adjoining countries of Botswana, Angola, Democratic Republic of Congo and Tanzania. It is apparent that more research and exploration is required in this particular area.

Mining's contribution to Zambia's national and local economy

The Zambian economy has historically been based on the copper-mining industry. The discovery of copper is owed partly to Frederick Russell Burnham, the famous American scout who worked for Cecil Rhodes. By 1998, however, output of copper had fallen to a low of 228,000 t, continuing a 30-year decline in output due to lack of investment, and until recently, low copper prices and uncertainty over privatization. In 2001, the first full year of a privatized industry, Zambia recorded its first year of increased productivity since 1973. The future of the copper industry in Zambia was thrown into doubt in January 2002, when investors in Zambia's largest copper mine announced their intention to withdraw their investment. However, surging copper prices from 2004 to the present day rapidly rekindled international interest in Zambia's copper sector with a new buyer found for KCCM and massive investments in expanding capacity launched. China has become a major investor in the Zambian copper industry, and in February 2007, the two countries announced the creation of a Chinese-Zambian economic partnership zone around the Chambishi copper mine.

Today copper mining is central to the economic prospects for Zambia and covers 85% of all the country's exports, but concerns remain that the economy is not diversified enough to cope with a collapse in international copper prices.

In January 2013, the Zambia Environmental Management Agency (ZEMA) approved 27 mining and exploration licences, with more rumoured to be confirmed.

The International Council on Mining and Metals (ICMM) was established in 2001 to act as a catalyst for performance improvement in the mining and metals industry.

ICMM brings together 21 mining and metals companies as well as 34 national and regional mining associations and global commodity associations to maximize the contribution of mining, minerals and metals to sustainable development.

ICMM hosted a multi-stakeholder workshop in Lusaka, Zambia on 7 November to discuss the first ever independent study of the

mining industry's contribution to the national and local economy of Zambia.

The study uses ICMM's Mining: Partnerships for Development Toolkit – a methodology that has been used in ten other mineral-driven economies. This work aims to provide a factual evidence base to inform discussion on how mining can better contribute to broad-based social and economic development.

The findings of the study suggest that mining's contribution to development in Zambia could be further enhanced by stronger collaboration between companies, government, local communities, civil society and development agencies – particularly at the local level.

The workshop was opened by the Minister of Mines, Energy and Water Development, Honourable Christopher Yaluma who introduced the guest of honour and keynote speaker, Zambia's Vice President Honourable Dr. Guy Scott. They were joined by ICMM's Deputy President, Mr. Aidan Davy and Mr. Emmanuel Mutati, President of the Chamber of Mines.

In closing, commitments were made by the Honourable Christopher Yaluma on behalf of the Government, by Mr. Emmanuel Mutati on behalf of the Chamber of Mines and its members, by Pius Maambo leader of the Zambia Revenue Authority (ZRA) Minerals Value Chain Monitoring Project, and Mr Aidan Davy from ICMM, to move forward productively and in partnership to ensure that mining plays its full part in the Zambian economy and society.

The analysis that was presented at the workshop was prepared by a specialist team from Oxford Policy Management (OPM), supported by a number of local Zambian researchers. The study has had support from the Chamber of Mines of Zambia but has been developed independently.

Work began in March 2013 and will be completed in the early 2014 when the final version of the report – redrafted in light of comments from the workshop and following a fact checking review by government – will be prepared.

Some of the main findings of the draft study are as follows:

- Zambia still has an exceptionally high level of macro-economic dependence on mining than most Countries in the World

- Since the late 1990s, total new **investment** in all sectors of the economy has risen from circa $500 million to well over $3 billion annually.

- Cumulative new **investment in mining** since 2000 has been approximately US$10 billion. These investments followed several years of almost zero new investment in mining through the late 1990s.

- The data from the study suggests that **production could rise further in the future to well over 1 million tonnes by 2016** if the known company plans for further investment go ahead.

- At 80% of dependence on mining, this is now the highest of all the world's mining economies alongside Botswana. It is a **source of considerable vulnerability** in the event of a down-turn in commodity prices.

- These factors combined have been important contributors to both the sustained high **GDP growth rates** that Zambia has achieved between 2000 and 2012 (the only time since independence when growth has been positive in five or more consecutive years) and to Zambia's ability to build a strong **foreign reserves** position (to over three months of imports).

- Mining **employment** levels have risen on the back of the gains in investment and production. **But the sector's contribution to direct employment, still accounts for less than 2% of the total labour force and about 8% of total formal sector jobs.**

- Previous studies have shown that the various multiplier effects greatly increases this employment contribution – by a factor or 4 or 5 times. In particular, mining is an especially dominant source of both **formal sector** jobs (direct and indirect jobs) and **informal** jobs in local areas and increasingly so in North Western province.

- In relation to **government revenue** the study finds that, by 2011 and 2012, mining taxes plus royalties had come to account for over 30% of total government tax revenue from only 8% in 2006. This more recent level of mining's tax contribution surpasses that expected at the time when the short-lived windfall tax was introduced in 2008 and in 2012 was the equivalent of 5.9% of GDP.

- This strong **government revenue** contribution of mining is of recent origin and is explained by a combination of the tax reforms introduced in 2008, the on -going increasesn production and the expiry of the capital allowances applicable to the first wave of new private investments after 1998.

- It is clear that prior to 2008 the tax revenue contribution from mining was much lower and was much criticized. But now the Zambian tax take (as a percentage of both total taxes and of GDP) is among the highest in the world.

- The official data on mining's **contribution to GDP** is extremely confusing – probably due to the out-dated base year (1994) for the national accounts data (which the CSO is in the process of updating). For 2012 the official data shows a mining sector contribution of only about 3% of GDP (in current prices). The true figure is estimated in the report to be almost five times higher than this at 14% of GDP.

- This exemplifies a more general challenge of **data weaknesses and data availability** in Zambia. The study suggests that this is a major source of many of the damaging and highly publicized conclusions about mining's contributions to the economy. The Government and the Chamber of Mines have committed to resolving this issue.

- The **forward-looking analysis** included in the report shows the prospect of further significant rises in investment, production levels and government tax payments from mining in the next few years. But this prospect is contingent on the domestic policy

The study suggests that there are three main **challenges** to address if mining is to sustain its present central role in Zambia's macro-economic performance.

- While most international observers agree that the demand for copper might still increase at high rates from a historical perspective, the high prices of recent years were the result of a conjuncture of several factors that are very unlikely to be repeated. There will, therefore, be periods when the copper price stays well below current levels, possibly for prolonged periods. **Zambia's extremely high reliance on mining makes it extremely vulnerable to a price down-turn. This very real**

possibility should be an increasingly important factor in policy considerations.

- The recent but very large increase in government revenues from the mining sector provides opportunities – not seen in any previous era – to develop coherent plans to build greater sustainability into the macro-economic trends that the mining sector makes possible. There are two main ideas here – (i) to more actively decentralize a larger proportion of the mineral revenues to local areas, including to non-mining districts, to help catalyze and spread the broader benefits of mining; and (ii) to begin to assign some part of those revenues for a futures investment (or stabilization) fund to help deal with a less favourable commodity price future.

- Mining companies have invested huge amounts in Zambia and continue to invest in capital equipment that will raise productivity and ensure the mines survive over the longer term. This is necessary because **copper mines in Zambia have high costs in an international perspective**: (**but this means people losing jobs)** the old mines in the Copperbelt are among the world's most expensive to operate; the new mines in North West province have operating costs that are a little above the world average.
- In addition to new capital investment, mining companies are **investing considerable sums in training in order to raise productivity**. This will result in higher qualifications and better wages for employees, but it will not in itself create new jobs.The mining industry has made a **major contribution to employment and living standards** in the regions where it is active. Total employment generated by four of the largest mines in Zambia is estimated at just under 100,000 jobs in the Copperbelt and 40,000 in the North West province. About half of this is the result of the stimulus to local economies from spending by mine workers. Induced employment has led to broad-based increases in income – this provides an opportunity to diversify the economy.
- Incomes are higher and have increased more rapidly in the two main mining provinces than in the non-mining ones. **People in the regions affected by mining consider themselves less poor** than those in non-mining regions and poverty has declined faster.

2. ENVIRONMENTAL IMPACTS OF LARGE SCALE MINING IN ZAMBIA

There are many environmental impacts resulting from mining activities. In this study, a choice has been made to focus on impacts with mostly local and sometimes regional effects. This means that environmental issues with impacts on a global scale, such as emission of greenhouse gases, are not considered.

Impacts' resulting from mining is focused on the following topics;

- o air pollution,
- o soil contamination,
- o water pollution and siltation,
- o geotechnical issues, and
- o land degradation.

Due to Zambia's long history as a mining nation there are many historical legacy sites that cause environmental problems. In many historical mining areas, there are now new operations which make it hard to distinguish between historical and current impacts of mining. Here an attempt has been made to describe the environmental impacts divided geographically by provinces and, where possible, into historical, ongoing and future operations.

2.1 Copperbelt province

The copper industry has dominated the mining scene in Zambia for more than eight decades since the first commercial mine was opened 1928. The copper industry was gradually nationalized from 1969, and the mining operations were after that run by the state through Zambia Consolidated Copper Mines Limited (ZCCM). Copper production in Zambia peaked in the early 1970´s and during a short period the country saw an exceptional investment in the construction of new schools, hospitals and roads using surpluses from copper revenues. After 1975 the copper production declined, and the industry faced a number of challenges due to the lack of investment, over-staffing, poor technology and falling copper prices. In the year 2000, the mines were privatized and ZCCMs assets were divided and sold to various investors. Zambia´s government kept shares in some operations during the privatization and today still owns a minority stake in many of the mines through a holding company called ZCCM-Investment Holdings

(ZCCM-IH). During the privatization process, the government made a deal with the new owners that none of the historic environmental legacies and the impacts resulting from them would fall under the responsibility of the new owners. Instead it was decided that the state through ZCCM-IH should take care of remediation actions and monitoring of the historical sites.

2.1.1 Environmental legacies from historic mining

Environmental problems directly linked to historical mining operations in the Copperbelt are largely related to geotechnical integrity of waste dumps. There are at least 21 waste rock dumps covering more than 388 hectares, 9 slag dumps covering 279 hectares and finally more than 45 tailing dams covering an area of around 9125 hectares.In total, more than 10 000 hectares in the Copperbelt is covered with mineral waste and thus represent a "loss of opportunity" for the local population in terms of other land use such as agriculture, forestry, housing, ranching etc. In addition to the geotechnical risks associated with waste dumps, the use of tailing ponds for water supply and fishing, as well as growing crops on the tailing surface has the potential to cause health impacts.

Mine wastage containing sulphide minerals is a potential source for acid mine drainage (AMD) if they are exposed to oxygen and water. Acid forms when sulphide minerals weather by oxidation, and if the neutralizing capacity of the surrounding rock is too low to buffer the generated acid, the result will be low pH waters with high metal content. Generally the geology in the Copperbelt area is enriched with carbonates which act as a buffer against acidification. Because of that, acid mine drainage water is a rare feature in the Copperbelt. The only major exception is a 2 hectares large former ore stockpile in Chibuluma west of Kitwe. Drainage water from the area holds a pH of 2-3 and high content of primarily copper and cobalt. No people reside within the contaminated area or in the immediate surroundings to the north following the contaminated watercourse.

Besides the acid mine drainage in Chibuluma and the land degradation issues described above all the historical mine sites naturally give rise to other environmental impacts such as dust fallout and discharge of suspended solids to surface waters. However, an extensive study states that the contributions from old mining legacy sites are only minor compared to current mining operations.

2.1.2 Environmental impacts of active mining:

Since 2001, most of the previously state-owned and unprofitable copper mines have been revived through extensive investments by new owners. As the mining operations are scaling up production to make profits on the invested capital, the concern for the environment is prone to be overlooked. A number of serious environmental impacts are directly linked to operating copper mines, and the most important ones are described here.

Air pollution:

In Zambia, the mining industry (mostly the copper smelters) contributes to over 98 percent of the country's SO_2 emissions. In the early 2000´s, the total SO_2 emission was 346, 700 t/yr. Recent investments in mining activities are expected to yield increased SO_2 emissions because of several new copper smelters. High SO_2 concentrations will directly affect the health of both humans and biota. Oxides of sulphur (SO_x) can irritate respiratory passages and aggravate asthma, emphysema and bronchitis.[3] Due to normal weather conditions (i.e. wind speed and direction) areas northwest and west of the large Nkana and Mufulira smelters are severely affected by poor air quality. Measurements taken in those areas have shown concentrations between 500-1000 $\mu g/m^3$ which clearly exceeds the Zambian guideline of $50\mu g/m^3$.[5] Most residential areas in both the city of Mufulira and Kitwe lie directly within the affected vicinity of the smelters and the inhabitants there are daily exposed to concentrations exceeding maximum daily average guidelines for SO_2.

Particulate matter less than 10 µm in size (PM10) originates both from smelters and from dusting of tailing dams and unpaved roads. The largest contribution comes from smelters, and the same geographical scenario as described for the SO_2 emissions prevails also for PM10. Children exposed to high concentrations of PM10 are likely to have an increase in lower respiratory symptoms and reduced lung functions.

Soil contamination:

Accumulation of metals in soil is a result from wind-borne dust particles (from dry tailing dams) and particle fall-out from smelters. The main soil contaminants that occur in concentrations high enough to constitute a significant hazard to human health, are copper

(particularly) and cobalt (less severe). Large areas within the mining region are contaminated compared to natural background values and a variety of elements occur in elevated concentrations in addition to copper and cobalt. A broad study on soil contamination has been made in the Copperbelt. The study showed that the highest concentrations for many elements were geographically directly associated with the districts of Kitwe, Mufulira and Chingola, and also to a lesser extent with Kalulushi, Chililabombwe and Chambishi. A summary of the study is presented in table 1.

	Kitwe	Mufulira	Chingola	Kalulushi	Chililabombwe	Chambishi
Population[7]	522 000	161 000	210 000	96 000	90 000	11 000
Mining operations	Nkana & Mindolo	Mufulira	Nchanga & Chingola	Chibuluma	Konkola	Chambishi
As (mg/kg)	>5	>5	3	1	0,5	0,5
Co (mg/kg)	**>60**	**>60**	**>60**	**35**	9	19
Cr (mg/kg)	36	36	36	16	25	16
Cu (mg/kg)	**>2200**	**>2200**	**>2200**	**1800**	**600**	**300**
Hg(mg/kg)	>0,06	>0,06	0,035	0,02	0,02	0,02
Ni (mg/kg)	12	22	7	5	7	5
Pb (mg/kg)	*>60*	*>60*	*>60*	5	5	5
Zn (mg/kg)	>60	>60	>60	20	40	10

Table 1: Average element concentrations presented per city together with information of population and active mines. Concentrations marked in brown (bold) are higher than international guideline values for soil suitable for residential and agricultural purposes, and concentrations marked in blue (italic) are likely to also be higher.

It is difficult to estimate how many of the Copperbelts residents who are directly living upon or using contaminated soils for agriculture. It should be pointed out that soils in mineral rich areas often are naturally enriched in metals. Soil samples from the subsurface (70-90 cm) show that Cr and Ni in quite many places actually are higher below the surface soil layer. In the case for copper, subsurface samples show that the surface soil layer contains at least

10 times, and quite often more than 50 times, higher concentrations in more or less the whole Copperbelt.

Surface water pollution and siltation in the Upper Kafue River:

The mining operations in the Copperbelt lay within the catchment area of the Kafue River. Kafue's watershed is the most developed in the country and the river is coming under increasing threat from pollution as well as competition in water utilization. The major cities in the Copperbelt region receive their domestic water supply from the Upper Kafue, and concern for potentially contaminating mining activities is always present. The Kafue River and its branches are also used for irrigation as well as for providing local communities with fish.

Several studies have shown that concentrations of many dissolved elements (i.e. ions) are clearly elevated in the Kafue and its tributaries within the Copperbelt. Metal discharges can negatively affect biodiversity and alter species composition in streams. In general the aquatic biota is more sensitive to contamination than higher animals or plants and, therefore, water quality standard with the aim to protect aquatic life are often considerably stricter than standards for drinking water. The dissolved copper content have shown to be considerably higher than standards for protecting aquatic life in more or less all monitoring stations within the Copperbelt region. The most significant contributors to metal pollution are the Nchanga, Nkana and Konkola mining operations.

Downstream the mining operations, the concentrations of mining-related contaminants are quickly lowered mainly due to the formation of secondary particles that rapidly settles on the river bed. Since the severe pollution from mines mainly is concentrated to hotspots the water companies around the Copperbelt manages quite well with producing potable water. However, there are exceptions and especially the Mulonga and Nkana water and sewerage companies often struggle with water quality.

Additionally accidents do happen from time to time. In media there have been reports of complete water supply failure in Chingola 2006 due to a spill from Konkola´s leaching plant, and in 2008, at least 13 people in Mufulira were admitted to hospital after a similar spill from Mufulira´s leaching plant. Even though high concentrations from the mining areas are mostly local, elevated concentrations of dissolved sulfur can be traced all the way down to the confluence with the

Zambezi River. When the water discharge in Kafue is increased during the rainy season, secondary particles are re-suspended and transported downstream in the river system.

Mining activities in the Copperbelt also severely affects the waterways through extensive siltation. Concentrations of suspended elements (i.e. small particles) are naturally very low in the Kafue River but because of pollution from the mining industry suspended concentrations of copper and cobalt can be seen down to the junction with the Zambezi River. The siltation problem is partially a result of erosion from existing tailing dams and waste dumps (contribution of 9000 t/yr, but the really large impact comes from ongoing mining operations. For example, dewatering of Konkola mine contributes with 15 000 t/yr, and the Nchanga mining area alone contributes with 91 000 t/yr for example discharging tailings directly to the river. Due to extensive siltation caused by mining activities there is a continuous build up in the river channel and the bed sediment in many places is totally dominated by tailing material with high metal concentration.

Accumulation of metals in vegetables, fruit and fish:

Metals can both accumulate in and adhere to crops via contaminated water, soil or air. Since vegetables and fruit constitute a significant part of the local diet, the ingestion of it is a pathway for human exposure of potentially toxic metals. Traces of metal uptake in the agricultural plants cassava, sweet potato and maize, have been studied in the Copperbelt at several occasions. In the case of cassava and sweet potato it has been shown that in less contaminated areas, only the plant leaves contains elevated metal concentrations. For cassava and sweet potato grown on heavily contaminated soils, the metal concentrations were seen in the roots.

A correlation of down-wind distance from the Nkana and Mufulira smelters and copper-arsenic content in both cassava and sweet potato leaves exists. Compared with cassava and sweet potato, maize grains are less affected by industrial contamination. The result of one study concludes that it is recommended to reduce growing and consumption of cassava and sweet potato in areas where contents of arsenic exceeds 5 mg/kg, copper 200 mg/kg and lead 4 mg/kg. In the same areas, growing of maize should be encouraged and promoted as it was shown not to be affected.

In Zambia many people are directly or indirectly dependent

upon resources provided by aquatic ecosystems, mainly through fishing. In addition to the Kafue River, tailing dams in the Copperbelt are an important source of fish for the local communities. Several fish samples from the Kafue and various tailing dams have shown elevated concentrations of particularly copper and cobalt compared to fish from unaffected waters upstream the mining operations. A research experiment with caged fish (threespot tilapia) showed bioaccumulation of many trace elements already after only two weeks' exposure downstream a mining operation. From an ecotoxicological aspect, the pollution of metals in the Kafue is severe and affects aquatic animal health. However, when assessing metal concentrations in fish compared to guidelines values for oral intake it is clear that no immediate health risk is associated with consumption of fish from the Copperbelt.

2.2 Other provinces

Historically mining in Zambia has to a large extent been focused to the Copperbelt region. There are, however, exceptions and one major environmental legacy site can be found in the Central province. Since privatization, the government has been looking to diversify its copper-dominated mining industry by encouraging investments in exploration and mine developments of other minerals, such as zinc, manganese, uranium, coal and precious metals. This has led to advanced plans for mine developments as well as new mining operations in regions previously unaffected by large scale mining.

In the following sections, a simple review is given on both existing environmental impacts from mining legacies and mining operations, as well as future possible impacts from promising exploration projects in the Central, the North Western, the Southern and the Luapula province

2.2.1 The legacy of Broken Hill in Central province

The capital of the Central province, Kabwe, was founded in the early 1900´s when the Broken Hill lead and zinc deposits were discovered. The Broken Hill Mine was for a long time the largest one in the country until it was overtaken by larger copper mines in the early 1930´s. Apart from lead and zinc the mine also produced smaller amounts of silver and cadmium. The mine has been closed for almost

two decades and the legacy site which occupies 250 hectares is located 1 km south-west of the centre town centre.

The major environmental problem lingering from the historical mining activities is serious contamination of soils as a result of smelting and dust emissions from waste dumps. The content of lead in soils can reach as high as 26, 000 mg/kg in the most polluted areas and thus a high content are also to be found in agricultural products.[16] Land up to 4 km away from Kabwe in all directions, and at least as far away as 14 km to the west is unsuitable for agricultural purposes.

High concentration of lead in soils, consumption of contaminated vegetables, inhalation of lead rich dust and usage of lead polluted water has led to higher concentrations in the blood of citizens living in Kabwe. Normal blood levels are less than 10 µg/dl, and levels above are considered unhealthy according to the WHO (World Health Organization). In Kabwe as high concentrations as 300 µg/dl has been recorded in children, and investigations show average blood levels of children between 60-120µg/dl. Children are particularly vulnerable to toxic effects of lead and can suffer severe and permanent health effects which influence the development of the brain and nervous system.

A number of mitigation measures were undertaken in Kabwe between 2003 and 2011. Nonetheless, Green Cross Switzerland and The Blacksmith Institute has 2013 yet again listed Kabwe as one of the 10 worst polluted places in the world.

2.2.2 The new Copperbelt in North Western province

The North Western province is sometimes also referred to as the new Copperbelt for its abundant and relatively newly found copper resources. Since privatization two large scale open pit copper operations (Kansanshi and Lumwana) have started up nearby the town Solwezi, and at least one more project (Trident) has been approved and is about to start up. In addition to copper, the Lumwana mine also extracts uranium. Unlike the ones in the Copperbelt area, the environmental impacts from mines in the North Western region are not well documented, but a few observations are still made here.

Regarding air pollution, the emissions of both SO_2 and PM10 from new smelters are expected to be lower than in the Copperbelt due to new technology. The dust fall-out from dry tailings is likely to be the same as described for the Copperbelt, and the long term potential

for soil contamination is unsecure. Regarding pollution of surface water in the North Western province there are, however, serious concerns for two reasons; 1) the potential for acid mine drainage formation is more likely to occur due to less favorable geological conditions, and 2) the bedrock naturally contains rather high concentrations of uranium. The run-off from the relatively new mining areas is towards tributaries of both the Upper Kafue and the Upper Zambezi River, where the latter one is less supervised.

2.2.3 Abundant coal and uranium resources in Southern province

In the Southern province, several coal mines, and at least one nickel mine (Munali) are in operation. In addition, one uranium project has so far been approved by the environmental authority - and more are bound to follow. The approved uranium project has not yet started production due to low commodity prices.

The present and future mines of the Southern region are very different from the copper operations. Because of this they also imply new and previously unknown challenges for the environmental regulators in Zambia. Especially uranium mining is associated with severe risks for both the environment and the workforce. There is a concern that high risk projects are being approved without the correct conditions under which the project should operate.

2.2.4 A future manganese mining district in Luapula province

Luapula province has potential to become a new mining district due to its promising resources of manganese, mainly occurring as high-grade (40-65 %) pyrolusite ores. Currently a lot of small scale mining of manganese is taking place in the region, but there are plans for large scale operations as well. One thing hindering large scale production is a secure supply of energy for the operations.

Manganese mining operations are different from the copper mines. Particular concern needs to be taken regarding smelters as exposure to manganese dust and fumes can be highly toxic even for short exposure times. A recent study from Mexico showed that people living close to manganese mines and processing plants often suffer from incipient motor deficit. In addition, waterborne manganese has a high bioavailability and a study from Canada suggest that exposure to manganese rich drinking water is associated with intellectual impairment in children.

2.3 Indirect impacts of mining

Apart from the described environmental impacts above, mine operations in developing nations often indirectly lead to other social and environmental challenges. One crucial challenge for the new mining districts is the large increase in population. The number of people living in the new mining town Solwezi has almost doubled in less than a decade. Such rapid inward migration causes extreme pressure on civic functions like provision of drinking water and treatment of wastewater. In the Copperbelt, where migration also has been huge, the water treatment plants still struggle to produce potable drinking water from the river to the population living in urbanized areas. Today the biggest threat to drinking water quality in the Copperbelt is not from metal pollution by the mines but from inadequate handling of waste sewage. There are many places around the Copperbelt where sewage is flowing directly into the environment which apart from polluting water with faecal bacteria, also have a negative effect on aquatic life due to depletion of oxygen. It might be hard to claim that the mining sector should take responsibility for all the indirect effects of their existence; nevertheless they should not be forgotten even though they are not given much attention in this study.

3. LEGAL FRAMEWORK FOR THE ENVIRONMENT

In Zambia, the general framework for environment issues is in many ways quite similar to the situation in most developed countries. There is, however, a lack of coordination between institutions and the implementation of existing laws and regulations is unfortunately not satisfactory.

3.1 Governmental institutions and authorities:

Environmental issues cut across a variety of sectors in Zambia, and a number of government institutions are involved in environmental management issues. The most important responsibilities regarding environmental impacts of mines are dispersed between two ministries (figure 2).

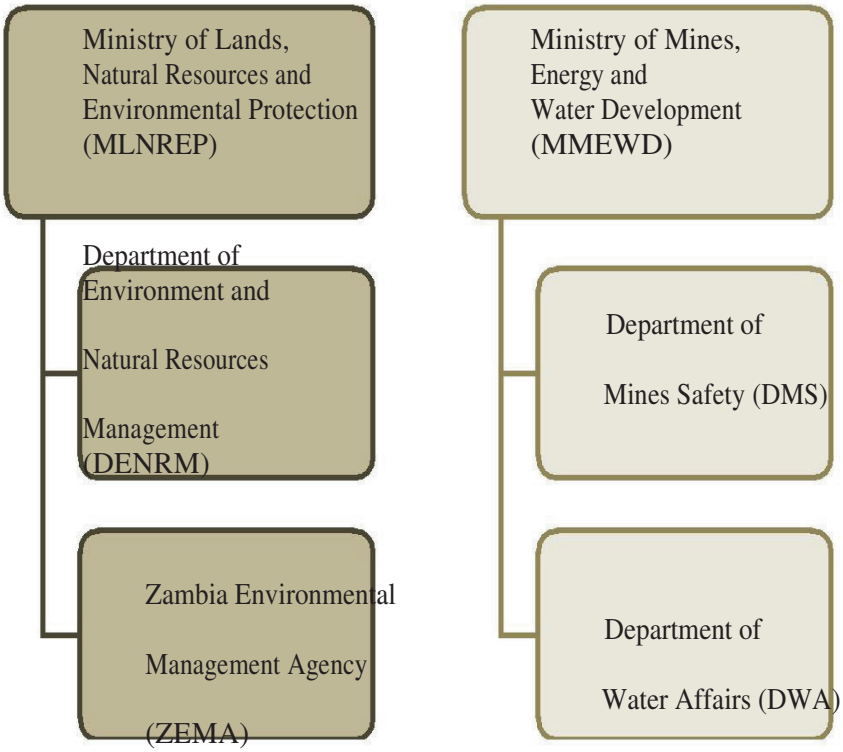


Figure 2: Main governmental institutions with responsibility for environmental impacts of mining.

The Ministry of Lands, Natural Resources and Environmental Protection is the former Ministry of Tourism, Environment and Natural Resources (MTENR). Under the Ministry, it is the Department of Environment and Natural Resources Management that is responsible for the overall policy formulation on environment, natural resources

and pollution control and thus is the focal point for all environmental management issues in the country. The department also co-ordinates, monitors and evaluates the operations of the executive agencies (statutory bodies) that have been created to implement policies on behalf of the government. One such statutory body is Zambia Environmental Management Agency (ZEMA) which was originally established in 1992 under the former name Environmental Council of Zambia. ZEMA is the major environmental institution in Zambia and the lead agency with a mandate by law to; "*do all things necessary to ensure the sustainable management of natural resources andprotection of the environment and the prevention and control of pollution*".

ZEMA´s functions include;

- Advising the government on policy work,
- coordinating the implementation of environmental management in all ministries,
- develop and enforce measures to prevent and control pollution,
- develop guidelines and standards related to environmental quality,
- promoting research and studies,
- controlling the Environmental Impact Assessment process,
- authorize or inhibit industrial projects,
- issuing permits and licenses,
- audit and monitor the compliance of operating industries, and
- Publicizing information regarding environmental management and pollution control.

ZEMA is autonomous and run by a board comprising members drawn from a wide range of ministries, business and non-governmental organizations. On paper, ZEMA has a lot of power and is continuously being strengthened as the legislation keeps improving. However, the agency is heavily understaffed and can only manage a few of its responsibilities in a satisfactory way. A special concern is raised for the severe lack of supervision towards the industry after projects have been authorized and pertained all its licenses and permits.

The Ministry of Mines, Energy and Water Development has been formed by merging the former Ministry of Mines and Mineral

Development (MMMD) with the Ministry of Energy and Water Development (MEWD). Under the Ministry, the Department of Mines Safety is a sector specific institution that formulates, monitor and maintain legislation regarding safe and sustainable exploitation of mineral resources. The main focus of the department lies on working environment issues, and they supervise the industries implementation of job safety regulations. The department also has an environment section with the responsibility to;

- Provide submission of comment to ZEMA in all mining related environmental applications,
- monitor and where needed remediate environmental legacies from the small-scale mining and exploration sectors, and
- administrate an Environmental Protection Fund (EPF).

3.3 Environmental acts and national policies

The body of environmental legislation in Zambia is largely fragmented. It is spread over more than 30 sets of legislation with dispersed responsibility across several line ministries. In 2009, the government developed a National Policy on the Environment (NPE) which is supposed to address the scattered policy and legal framework and instead try to harmonize and rationalize it. The NPE has so far not lead to much practical action mainly because it has not been backed by financial resources.

The principal legislation governing environmental management in Zambia is the Environmental Management Act (No. 12 of 2011). The Act is an umbrella law which stands over all other environmental legislation in Zambia. Through the Act, the Environmental Council of Zambia was renamed to ZEMA which now is mandated to ensure the sustainable management of natural resources and protection of the environment. The Act is based on many modern principles;

- The environment is the common heritage of both present and future generations,
- adverse effects shall be prevented and minimized,
- the people shall be involved in the development of policies, plans and programmes for environmental management,
- community participation and involvement in natural resource management shall be promoted and facilitated,
- the

precaut
ionary
princip
le,

- the generation of waste should be minimized wherever practical, and otherwise in order of priority, be reused, recycled, recovered and disposed safely, and
- non-renewable natural resources shall be used prudently, taking into account the needs of the present and future generations.

The new Act is considerably stronger than its predecessor the Environmental Protection and Pollution Control Act (No 12 of 1990 and No 12 of 1999), but even though the new Act repeals the old one, part of the old regulations are still being enforced. Relevant regulations which are still in use are

- The Waste Management Regulations (SI 71 of 1993)
- The Water Pollution Control Regulations (SI 72 of 1993)
- The Pesticides and Toxic Substances Regulations (1994)
- The Air Pollution Control Regulations (SI 142 of 1996)
- The Environmental Impact Assessment Regulations (SI 28 of 1997)
- The Hazardous Waste Management Regulations (SI of 2001)

Legislation to provide equitable and sustainable use of water in Zambia is incorporated by the Water Resources Management Act (No 21 of 2011). The new act provides for the ownership, control and use of water. It delegates management of water resources through Catchment Councils consisting of the water users of the catchment. The Act also clearly states that anyone wishing to discharge any effluent into a water resource shall do so in accordance with the Environmental Management Act.

For the purpose of enhancing wildlife ecosystems, the Zambia Wildlife Act (No 12 of 1998) gives Zambia Wildlife Authority the mandate to control and manage national parks, game management areas and bird sanctuaries. Exploration of mineral resources is not forbidden in national parks. Exploitation of mineral resources is not allowed if it will cause large environmental impacts.

Regulations specifically related to mines and minerals can be found

in the Mines and Minerals Development Act (No 7 of 2008). The Act mainly regulates the rights for exploration, exploitation and processing of mineral resources. There are two statutory instruments under the Act which are related to pollution from mining activities. The first is the Mines and Minerals Environmental Regulations (SI 29 of 1997) which provides the framework for conducting and reviewing environmental impact assessments for the mining sector as well as regulations for auditing project implementation. The second is the Mines and Minerals Environmental Protection Fund Regulations (SI 102 of 1998) which provides the mechanism of setting up and operating an Environmental Protection Fund. The objectives of the Fund are to:

- Provide assurance to the Director of Mines Safety Department that the developer shall execute environmental and social impact statements, and
- provide protection to the government against the risk of having the obligation to undertake rehabilitation of a mining area where the holder of the mining license fails to do so.

The contribution by the developer shall be calculated depending on performance and the last year's total contributions[30] can be seen in table 2.

Year	Million USD
2008	1,83
2009	2,29
2010	2,98

Table 2: Annual contribution from developers.

The Environmental Protection Fund may also receive income from other sources such as government funding, donor contributions etc. Funds from additional sources shall be put into a dedicated account and the money should be used to primarily address the governments environmental obligations from orphaned mine sites around the country.

In addition to the written authorization from ZEMA, the developer also needs to obtain a number of permits and licenses before undertaking operation. At the moment, up to 30 permits and licenses might be required. This is about to change since ZEMA is

working on implementing integrated permits and licenses to make it more perspicuous and easily managed. The most important permits needed for a mine developer are:

- Air Pollution Monitoring Permits,
- Water Effluent Dishcarge Licenses,
- Water Abstraction Licenses,
- Pesticides and Toxic Substances Licenses,
- Waste Management Licenses,
- Building Permits.

The important permits and licenses for air pollution and water discharge contain site specific emission standards. The standards generally follow the Zambian Effluent Statutory Limits which is given in table 3:

Air emission (mg/Nm^3)		Water effluent discharge (mg/l)	
Sulphur dioxide	1 000	Suspended solids	100
Arsenic	0,5	Arsenic, total	0,5
Cadmium	0,05	Cadmium, total	0,5
Copper	1	Copper, total	1,5
Lead	0,2	Lead, total	0,5
Mercury	0,05	Mercury, total	0,002
PM10 Smelters	50	Iron, total	2
PM10 Other	50	pH	6-9 units

Table 3: Zambia´s National Effluent Statutory Limits.

The developer is by law obliged to hand in quarterly reports to ZEMA on air pollution monitoring, and biannual reports on quantity and quality effluents to water. ZEMA has the possibility to send an inspector to the premises of any mining project at any time to undertake investigations and audit that the developer undertakes all measurements stated in the EIA report and follow the standards given in the permits and licenses. In practice, this is rarely effectuated and to execute this mandate properly ZEMA need to substantially increase its capacity.

5.2 Improved control and management of operating and future mines

The work to clean up the active mining industry is a real challenge and actions are needed on many levels. Despite progress in recent years, environmental issues are still not integrated adequately or systematically in Zambia´s national development process. As long as environmental protection is viewed upon as a threat to development, there is a chance that limited initiatives in this field will not achieve much. Several suggestions, apart from the obvious one of mainstreaming environmental issues on a national level, are made here.

Better implementation of existing environmental legislation:

The responsibility of environmental legislation is carried out by almost ten line ministries which naturally pose a major implementation challenge. The situation is changing for the better and through the relatively new Environmental Management Act (2011) ZEMA has a comprehensive environmental management mandate. However, ZEMA suffers from inadequate resourcing to fulfill its mandate and has insufficient staff to adequately pursue compliance monitoring and auditing. The lack of effective control of the mines environmental performance leaves the existing legal framework to a large extent unimplemented. For better implementation of the legislation, surveillance of the industry is much needed.

A suggestion to support ZEMA´s monitoring work, without directly contributing to the staff body, is to install automatic monitoring stations that measure water quality downstream of point sources. Such stations can be run by solar panels and be equipped with for instance sensors measuring pH, conductivity and turbidity. Measurements can be done every hour and the results can directly be seen online. The system can also be programmed to set alarms when water quality parameters exceeds set limits, and thus the nearest drinking water plants can be warned in case of large spills and authorities can put pressure on the mine operators.

Improved quality of Environmental Impact Statements and Management Plans:

The EIA performance is improving, but the quality of the reports

remain rather low. A checklist of required topics is frequently deemed sufficient, and the EIA´s are routine procedure rather than well-advised individual applications. This is a severe concern since mining operations can differ substantially in their environmental impacts depending on geology and other factors. At least the following should be done to help ZEMA and the Mines Safety Department to put higher demands on quality of impact statements and the attached management plans;

- The sector specific guidelines for mining projects prepared by ZEMA should be overlooked according to international standards and preferably together with the Mines Safety Department.
- Technical guidelines on waste characterization must be compiled. The need for better knowledge on how to characterize and thereby proper handling of mine waste is crucial, especially when mining projects are being considered in places with different geology than in the Copperbelt.
- Technical guidelines on best practices of mine water management are desirable. Identify options and initiatives early for water conservation and management is very important, especially for mining in regions where water resources are scarce.

The authorities in Zambia would also benefit from comparing technically best practice methods with advanced mining countries. For instance, advanced techniques for flue gas purification and dust prevention are not commonly used by the Zambian mining sector.

Technical and geoscientific capacity building:

The Environmental team at the Mines Safety Department is in need of increased technical and geoscientific knowledge to adequately execute its sector authority when reviewing mining EIA´s. The department has existed for a long time; under which most of it's environmental management was not considered an issue. Since the authority now has an enhanced mandate for environmental management and the responsibility to keep growing along with the mineral sector, the need for re-orienting the staff is obvious. As a suggestion technical and geoscientific training should first be provided on chosen topics, and secondly the knowledge should be followed up and implemented by

assistance in real reviewing cases.

There is also a need for broader capacity building on radiation risks related to uranium mining. Workshops with ZEMA, Mines Safety Department, as NGO´s and other interested parties have suggested. From interviews with the representatives from ZEMA, environmental consultants and NGO´s, it is concluded that the concern for risks of uranium mining is real and the knowledge about it is poor.

5.3 Good water governance

Good water governance is a key issue for sustainable development in most countries, and Zambia is no exception. A large World Bank funded project is just starting up in Zambia to support the implementation of an integrated framework for the development and management of water resources. One component within the project is to strengthen the institutional capacity for water resources management and development, which is much needed. When it comes to water issues the responsibilities between different government institutions is today unclear. ZEMA is responsible for monitoring the water effluents from mines, Mines Safety Department has the sector specific responsibility for the mines environmental performance and the Department of Water Affairs has the overall responsibility for national water quality except for certain water bodies where the Zambezi River Authority is responsible. The coordination, and more importantly, the cooperation between the different organizations need to be improved.

The Department of Water Affairs is the state institution who should take on a leading role in all water related issues. The department has until recently mainly focused on water quantity and not quality, and therefore the work load of water monitoring has ended up on other institutions. Since the department is aiming to improve their water quality performance, capacity building is essential. Technical assistance can be provided to the department in the following ways:

- Technical training including basics of water geochemistry, the coupling of background values to

regional geology, sampling and measuring techniques. Preferably this is done by implementing a monitoring project such as setting up a baseline survey in the manganese province Luapula.

- Creating a GIS database for water quality. Extensive water quality data already exist for example the Kafue River, but nearly all of that data collected through different development projects is spread out and not easily accessible. For example all the data sampled within the Copperbelt project is found in a database belonging to ZCCM-Investment Holdings, a newly formed Consultant Company. A major contribution to the water sector would be to compile all the data and make it publicly available.

These suggestions can probably be made parallel to the World Bank initiative without interfering as they will most likely focus on management practices rather than technical training. Coordination with the large project is however needed before taking action.

UNIT IV

ENERGY AND POWER

Zambia's energy sources include; electricity, petroleum, coal, biomass, and renewable energy. It is only petroleum which is wholly imported in the country, while the country is basically self-sufficient in all the other energy resources, as it has substantial unexploited reserves of these forms of energy. The country's economy has been growing at an average of 5 percent per annum over the past 10 years and demand for energy has also been rising.

Energy and Power Concepts

Energy

Energy is referred to as the ability to do work. Energy is measured in units called **joules, J**, or in ***watt hours*** as shown below. One ***kilojoule***, **kJ** is equal to a thousand joules, and one ***megajoule*****, MJ**, is equal to a million joules.

Watt hours (Wh), are a convenient way of measuring electrical energy. One **watt hour** is equal to a constant one watt supply of power supplied over one hour (3600 seconds). If a bulb is rated at 40watts, in one hour it will use 40 Wh, and in 8 hours it will use 320 Wh of energy. Electric power companies measure the amount of energy supplied to costumers in ***kilo***

watt hours, Wh (or thousands of watt-hours, kWh). Note that one kilowatt hour (1kWh) is equal to 3.6 megajoules.

Power

Power is the rate at which energy is supplied (or energy per unit time). Power is measured in ***watts*****.** One watt is equal to one joule supplied per sec.

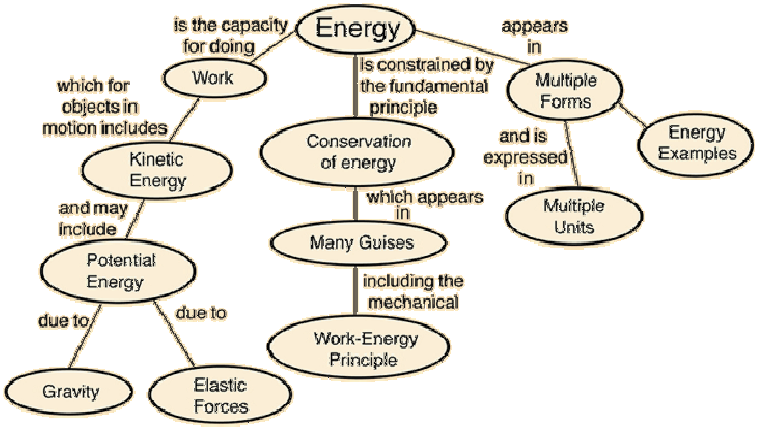
What is Energy?

It comes from many sources and in many forms. The forms of energy are classified in two general categories: potential and kinetic.

Potential energy is the energy stored in an object. Chemical, mechanical, nuclear, gravitational, and electrical are all stored energy. Kinetic energy does the work. Light, heat, motion, and sound are examples of kinetic energy.

Here's a simple example. Stretching a rubber band gives it the potential to fly. The tension created from the stretching is potential mechanical energy. When the rubber band is released, it flies through the air using motion (kinetic energy). The process of changing energy from one form into another is called energy transformation. The rubber band is transformed from potential energy into kinetic energy.

Systems convert energy at various rates of efficiency. Water turbines, for example, are very efficient, while combustion engines are not. Engineers and physicists constantly work to develop systems with high energy-conversion efficiency.



What is Power?

Electrical power is usually measured in watt (W), kilowatt (kW), megawatt (MW), etc. Power is energy transferred per unit of time.

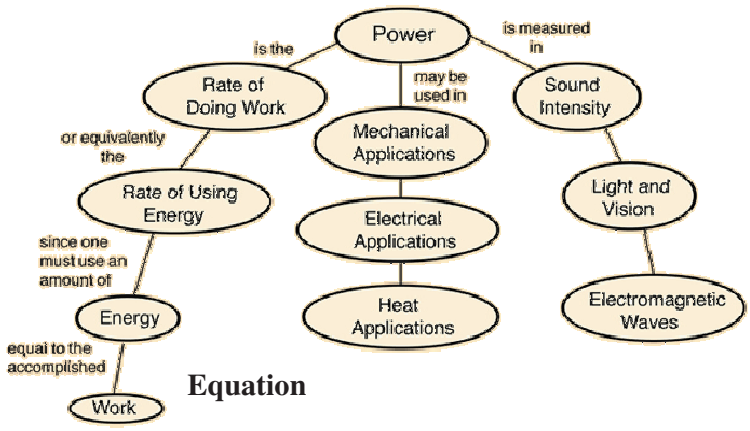
Power may be measured at any point of time, whereas energy has to be measured during a certain period, e.g. a second, an hour, or a year. (Read the section on energy, if you have not done so yet).

If a wind turbine has a rated power or nameplate power of 1000 kW, that tells you that the wind turbine will produce 1000 kilowatt hours (kWh) of energy per hour of operation, when running at its maximum performance (i.e. at high winds above, say, 15 metres per second (m/s)).

The power of automobile engines are often rated in horsepower (HP) rather than kilowatt (kW). The word "horsepower" may give you an intuitive idea that power defines how much "muscle" a generator or motor has, whereas energy tells you how much "work" a generator or motor performs during a certain period of time.

Power Units

1 kW = 1.359 HP



Equation

Power is energy per unit of time. As a rate of change of work done or the energy of a subsystem, power is:

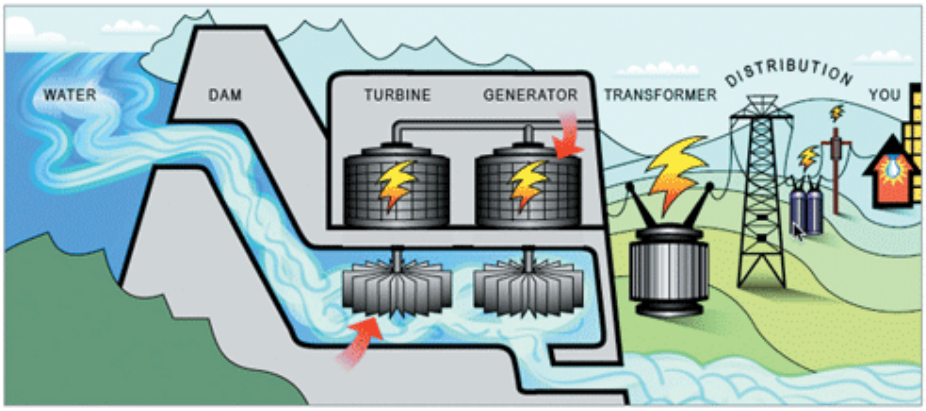
$$P = \frac{W}{t}$$ Where P is power, W is work and t is time.

Hydro Power

How hydro power works

Hydroelectric generation begins with a forceful, rushing river or with a dam that holds back a river and diverts flow. Falling water flows through propeller-like turbines and causes them to rotate. The rotation of these turbines spins generators to produce electricity. The amount of electricity generated from each unit is determined largely by volume of water flow and "head," or the height from the water surface at the dam reservoir to the water surface downstream.

While the fuel is free and hydroelectric power produces no air emissions or waste, its use is limited because of the natural hydrological conditions it requires. There also can be ecological concerns, such as the impact on fish and other wildlife. We manage our dam operations to protect the aquatic environment, and at some facilities, improve recreational opportunities.



Hydroelectric power, electricity produced from generators driven by water turbines that convert the potential energy in falling or fast-flowing water into (to) mechanical energy.

In the generation of hydroelectric power, water is collected or stored at a higher elevation and led downward through large pipes or tunnels (penstocks) to a lower elevation; the difference in these two elevations is known as the head. At the end of its passage down the pipes, the falling water causes turbines to rotate. The turbines in turn drive generators, which convert the turbines' mechanical energy into electricity. Transformers are then used to convert the alternating voltage suitable for the generators to a higher voltage suitable for long-distance transmission. The structure that houses the turbines and generators, and into which the pipes or penstocks feed, is called the powerhouse.

Hydroelectric power plants are usually located in dams that impound rivers, thereby raising the level of the water behind the dam and creating as high a head as is feasible. The potential power that can be derived from a volume of water is directly proportional to the working head, so that a high-head installation requires a smaller volume of water than a low-head installation to produce an equal amount of power. In some dams, the powerhouse is constructed on one flank of the dam, part of the dam being used as a spillway over which excess water is discharged in times of flood. Where the river flows in a narrow steep gorge, the powerhouse may be located within the dam itself.

In most communities, electric-power demand varies considerably at different times of the day. To even the load on the generators, pumped-storage hydroelectric stations are occasionally built. During off-peak periods, some of the extra power available is supplied to the generator operating as a motor, driving the turbine to pump water into an elevated reservoir. Then, during periods of peak demand, the water is allowed to flow down again through the turbine to generate electrical energy. Pumped-storage systems are efficient and provide an economical way to meet peak loads.

In certain coastal areas, such as the Rance River estuary in Brittany, France, hydroelectric power plants have been constructed to take advantage of the rise and fall of tides. When

the tide comes in, water is impounded in one or more reservoirs. At low tide, the water in these reservoirs is released to drive hydraulic turbines and their coupled electric generators (*see*tidal power).

Falling water is one of the three principal sources of energy used to generate electric power, the other two being fossil fuels and nuclear fuels. Hydroelectric power has certain advantages over these other sources: it is continually renewable owing to the recurring nature of the hydrologic cycle and produces neither atmospheric nor thermal pollution. Hydroelectric power is a preferred energy source in areas with heavy rainfall and with hilly or mountainous regions that are in reasonably close proximity to the main load centres. Some large hydro sites that are remote from load centres may be sufficiently attractive to justify the long high-voltage transmission lines. Small local hydro sites may also be economical, particularly if they combine storage of water during light loads with electricity production during peaks.

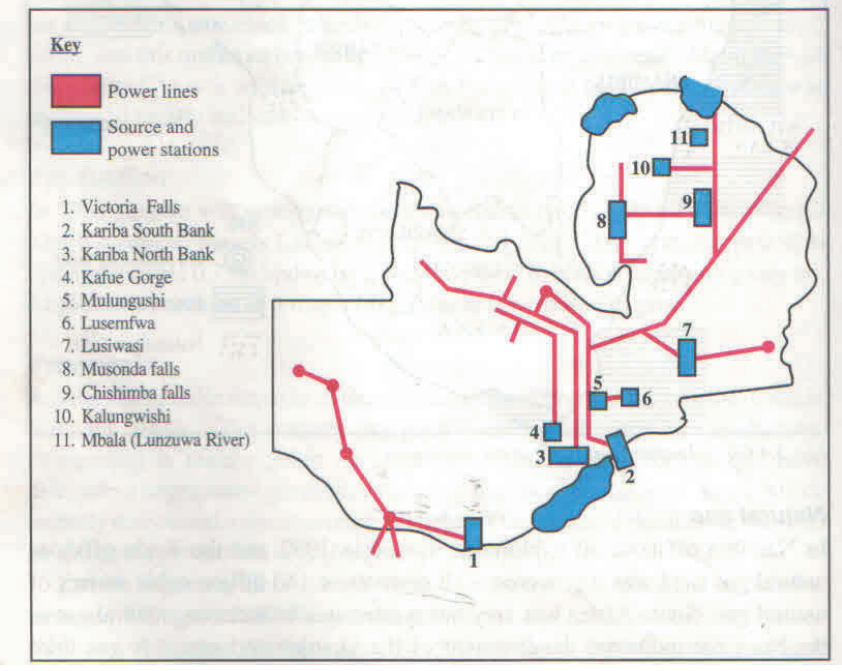


Figure.** Zambia`s Hydro-Electric Power Stations Location**

Region/Basic	HEP sites	Capacity (in mega watts)
Zambezi River Basin	• Mpata Gorge • Devil's Gorge • Batoka Gorge • Kabompo Gorge • Kariba North and South Bank • Chavuma Falls	640 to1,200 1600 1600 30 300 20
Kafue River Basin	• Kafue Gorge • Itezhi-tezhi	450 to 600 5 to 80
Luapula River Basin	• Mumbotuta Gorge • Mambilima Falls • Chipoma Falls on Lwela river	425 to 594 425 to 594 Not yet determined
Kalungwishi River Basin	• Kabwelume Falls • Lumangwe Falls	54 - 60
Luangwa River Basin	• Lusiwasi Extention • Manyamadzi River and its tributaries	40 Not yet determined
Chambeshi River Basin	• Lubu River • Lukulu River	Not yet determined Not yet determined
Lake Tanganyika Basin	• Lufubu River which flows into Lake Tanganyika	Not yet determined
Mwinilunga Bridge	• West Lunga River • Kabompo River at Chikata Rapids	1.2 1.2
Total estimated potential		**5,701 to 6,000**

Table.** Zambia`s Hydro-Electric Power Potential**

Station	Community	Coordinates	Capacity (MW)	Status
Itezhi-Tezhi Dam	Itezhi-Tezhi	15.765278° S 26.018056°E	120	constraction
Kafue Gorge Dam			990	Operational
Kariba Dam	Kariba	16.521667° S 28.761389°E	1,320	Operational
Victoria Falls			108	
Mulungushi			28.5	
Chishimba Falls			6	
Lusiwasi			18	
Lunsemfwa			12	
Musonda Falls			5	
Lunzua			1	

ZESCO'S Current Generation Capacity/Expected Capacity By 2015

POWER STATION	GENERATION CAPACITY (MW)	AVAILABLE CAPACITY (MW)	CAPACITY AFTER UPRATING (MW)	PROJECTED CAPACITY BY 2015(MW)
Kafue Gorge	990	990	990	990
Kariba North Bank	720	690	720	720
Victoria Falls	108	108	108	108
KNBE	-	-	-	360
Kafue Gorge Lower	-	-	-	750
ITT	-	-	-	120
Lunzua	0.75	0.75	15	15
Lusiwasi	12	12	-	27*
Chishimba	6	6	15	15
Musonda	5	5	10	10
Shiwang'andu	-	-	-	1
	1841.75	**1811.75**	**1858**	**3116**

Thermal power station

A **thermal power station** is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle. The greatest variation in the design of thermal power stations is due to the different fossil fuel resources generally used to heat the water. Some prefer to use the term *energy center* because such facilities convert forms of heatenergy into electrical energy. Certain thermal power plants also are designed to produce heat energy for industrial purposes of district heating, or desalination of water, in addition to generating electrical power. Globally, fossil fueled thermal power plants produce a large part of man-made CO_2 emissions to the

atmosphere, and efforts to reduce these are varied and widespread.

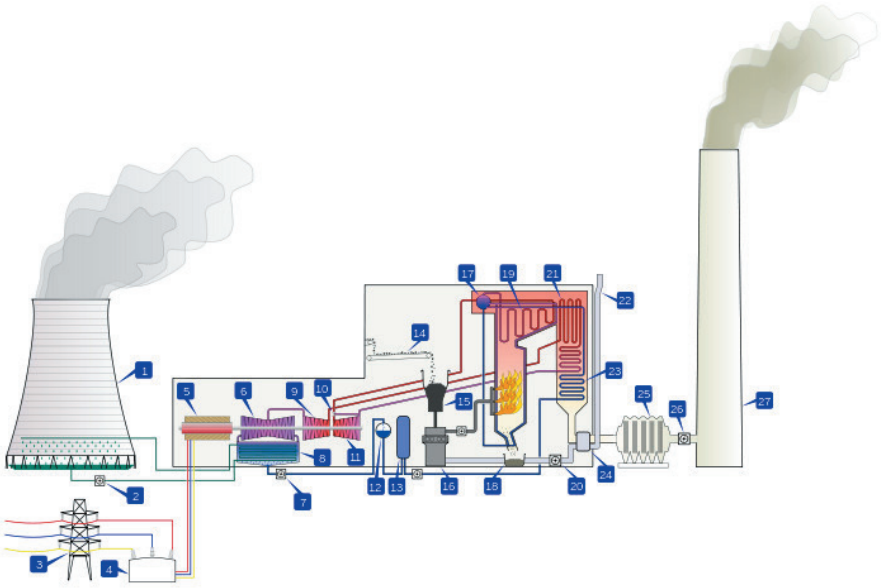
Types of thermal power station

Almost all coal, nuclear, geothermal, solar thermal electric, and waste incineration plants, as well as many natural gas power plants are thermal. Natural gas is frequently combusted in gas turbines as well as boilers. The waste heat from a gas turbine can be used to raise steam, in a combined cycle plant that improves overall efficiency. Power plants burning coal, fuel oil, or natural gas are often called *fossil-fuel power plants*. Some biomass-fueled thermal power plants have appeared also. Non-nuclear thermal power plants, particularly fossil-fueled plants, which do not use co-generation, are sometimes referred to as *conventional power plants*.

Commercial electric utility power stations are usually constructed on a large scale and designed for continuous operation. Electric power plants typically use three-phaseelectrical generators to produce alternating current (AC) electric power at a frequency of 50-60 Hz. Large companies or institutions may have their own power plants to supply heating or electricity to their facilities, especially if steam is created anyway for other purposes. Steam-driven power plants have been used in various large ships, but are now usually used in large naval ships. Shipboard power plants usually directly couple the turbine to the ship's propellers through gearboxes. Power plants in such ships also provide steam to smaller turbines driving electric generators to supply electricity. Shipboard steam power plants can be either fossil fuel or nuclear. Nuclear marine propulsion is, with few exceptions, used only in naval vessels. There have been perhaps about a dozen turbo-electric ships in which a steam-driven turbine drives an electric generator which powers an electric motor for propulsion.

Combined heat and power plants (CH&P plants), often called *co-generation plants*, produce both electric power and heat for process heat or space heating. Steam and hot water lose energy when piped over substantial distance, so carrying heat energy by steam or hot water is often only worthwhile within a local area, such as a ship, industrial plant, or district heating of nearby buildings.

Typical coal thermal power station



Typical diagram of a coal-fired thermal power station

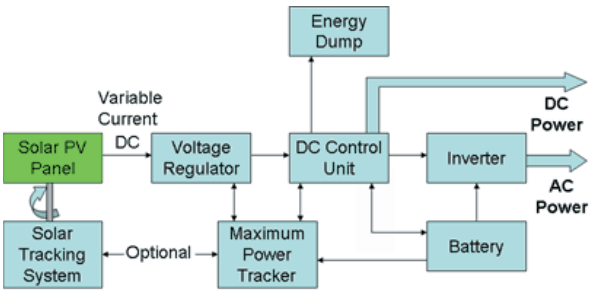
1. Cooling tower	10. Steam Control valve	19. Superheater
2. Cooling water pump	11. High pressure steam turbine	20. Forced draught (draft) fan
3. transmission line (3-phase)	12. Deaerator	21. Reheater
4. Step-up transformer (3-phase)	13. Feedwater heater	22. Combustion air intake
5. Electrical generator (3-phase)	14. Coal-conveyor	23. Economiser
6. Low pressure steam turbine	15. Coal hopper	24. Air preheater

7. Condensate pump	16. Coal pulverizer	25. Precipitator
8. Surface condenser	17. Boiler steam drum	26. Induced draught (draft) fan
9. Intermediate pressure steam turbine	18. Bottom ash hopper	27. Flue gas stack

For units over about 200 MW capacity, redundancy of key components is provided by installing duplicates of the forced and induced draft fans, air preheaters, and fly ash collectors. On some units of about 60 MW, two boilers per unit may instead be provided.

Photovoltaic Power Plant (Solar Power Plant)

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic , or indirectly using concentrated solar power. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic convert light into electric current using the photoelectric effect.



Photovoltaic Electric Power Generation

Zambia is located just south of the equator and has ample sunshine to produce power bythe use of photovoltaic (PV). The annual solar radiation in Zambian is amongst the highest in the world. The radiation is fairly uniform across the country, varying in the range of 6,600-7,700 MJ/m^2 (5.27-6.09kWh/m^2)

Zambia however has plenty of sources of energy that can contribute to the social and economic emancipation in rural communities. One such source is solar energy. Solar energy or Solar power, refers to the conversion of sunlight into electricity by photovoltaic (PV) solar cells. Simply said, photovoltaic is a technology that converts natural sunshine into electricity. The country has abundant sunshine which gives the country great potential to develop this renewable resource and provide affordable energy to rural communities. Like other forms of energy, solar power has many benefits including improved literacy through access to lighting and modern information technology, increased economic activities arising from access to electricity, and improved provision of health services resulting from provision of electric powered equipment and machinery. Solar energy also contributes to the reduction in carbon emissions as well as enhancing leisure and entertainment prospects.

Due to the abundance of free solar energy resource in all the COMESA Member States and the demand electricity supply in remote areas, photovoltaic applications are on the increase. Solar PV systems are used for rural domestic and public institutions (clinics, schools) electrification, powering remote telecommunication equipment as well as for pumping water. Solar thermal is dominated by solar water heaters mostly used to heat water in remote public institutions (hospitals, government buildings) and hotels.

The main market for PV systems consists of:

1. Rural domestic electricity
2. Telecommunication
3. Water pumping in rural areas
4. Rural schools and public institutions
5. Rural clinics
6. Other: robots, navigational buoys, parking ticket

dispensers, solar powered hearing aids, etc.

Solar water heaters are mostly used for hot water supply to households, clinics, hotels and remote government buildings. Local manufacturing capacity for these technologies has been developed in Egypt and Zimbabwe. These countries, together with imported units from Europe, Asia and South Africa supply most of the COMESA demand. SWH is the renewable energy with the potential for local manufacturing or sourcing from within the COMESA trading block. There is considerable potential for market growth for SWH, their price is gradually declining whereas electricity prices are increasing rapidly due to the requirement for new (and expensive) generation capacity. The growth is highly dependent on the energy policy of each COMESA Member State – market forces are yet able to stimulate or sustain growth because SHW still require some form of incentives to compete with conventional electricity.

One of the tasks of the Rural Electrification Authority (REA) is to promote the utilization of appropriate alternative rural electrification technologies in order to enhance economic activities in rural areas. This is against the background that the availability of abundant sunshine as well as alternative viable technologies that can utilize this resource to generate power has opened the opportunity to increase access to energy in rural areas. These are areas where the population is dispersed and the load is relatively small and unsuitable for grid inter-connection. Other factors such as measures taken by the Minister of Finance and National Planning in March 2008 to suspend Duty and Value Added Tax on solar photovoltaic panels, batteries, and related accessories have made the solar systems much more affordable to rural populations.

REA commenced the Solar Energy Programme as part of its rural

electrification strategy in 2007. The programme aims at putting solar photovoltaic installations at various public and social institutions. The REA recognizes the fact that access to electricity is not only critical for community services such as health, education and communication services, but also for traditional institutions of authority.

Wind power

Wind power is the conversion of windenergy into a useful form of energy, such as using wind turbines to produce electrical power, windmills for mechanical power, windpumps for water pumping or drainage, or sails to propel ships.

Large wind farms consist of hundreds of individual wind turbines which are connected to the electric power transmission network. For new constructions, onshore wind is an inexpensive source of electricity, competitive with or in many places cheaper than fossil fuel plants. Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electricity to isolated off-grid locations.

Wind power, as an alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation and uses little land. The effects on the environment are generally less problematic than those from other power sources. Wind power is very consistent from year to year but has significant variation over shorter time scales. As the proportion of windpower in a region increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur. Power management techniques such as

having excess capacity storage, geographically distributed turbines, dispatchable backing sources, storage such as pumped-storage hydroelectricity, exporting and importing power to neighboring areas or reducing demand when wind production is low, can greatly mitigate these problems. In addition, weather forecasting permits the electricity network to be readied for the predictable variations in production that occur. Wind power can be considered a topic in applied eolics.

Wind farms

A wind farm is a group of wind turbines in the same location used for production of electricity. A large wind farm may consist of several hundred individual wind turbines distributed over an extended area, but the land between the turbines may be used for agricultural or other purposes. A wind farm may also be located offshore.

Almost all large wind turbines have the same design — a horizontal axis wind turbine having an upwind rotor with three blades, attached to a nacelle on top of a tall tubular tower.

In a wind farm, individual turbines are interconnected with a medium voltage (often 34.5 kV), power collection system and communications network. At a substation, this medium-voltage electric current is increased in voltage with a transformer for connection to the high voltage electric power transmission system.

Feeding into grid

Induction generators, often used for wind power, require reactive power for excitation so substations used in wind-power collection systems include substantial capacitor banks for power factor correction. Different types of wind turbine generators behave differently during transmission grid disturbances, so extensive modelling of the dynamic electromechanical characteristics of a new wind farm is required by transmission system operators to ensure predictable stable behaviour during system faults (see: Low voltage ride through). In particular, induction generators cannot support the system voltage during faults, unlike steam or hydro turbine-driven synchronous generators. Doubly fed machines generally have more desirable properties for grid interconnection.Transmission systems operators will supply a wind farm developer with a *grid code* to specify the requirements for interconnection to the transmission grid. This will include power factor, constancy of frequency and dynamic behavior of the wind farm turbines during a system fault.

Offshore wind power

Offshore wind power refers to the construction of wind farms in large bodies of water to generate electricity. These installations can utilise the more frequent and powerful winds that are available in these locations and have less aesthetic impact on the landscape than land based projects. However, the construction and the maintenance costs are considerably higher.

Wind Energy Growth and Feasibility

Since 1980, there has been significant growth in the output of global wind power by 10 percent or more every year apart from two. There does not appear to be any signs that the growth is going to slow down.

In 2007, there was enough wind power to provide power to approximately 70 million homes. In Denmark, over 19 percent of electric power comes from wind generators.

However the rest of the world is yet to catch up; for example, in the United States less than 1 percent of total electric power was provided by wind.

Financial Incentives

A major obstacle in the development of renewable energy projects is their high initial investment cost.

Fossil fuel power plants have lower investment or start-up costs but high operation costs due to the fuel consumed and constant labor. Wind energy has high start-up costs but low ongoing costs.

The introduction of governmental subsidies and tax cuts as well as policies such as Feed in Tariffs and Green Energy Certificates have enabled wind energy development companies to meet the financial requirements for wind power-generation.

Banks have also been influential in the take up of wind power, providing large long-term loans for the development of wind farms.

Wind Resource Assessment Technology

The most important aspect of wind farm development is the availability and nature of the resource.

Without a clear picture of how much power you can get out of the wind, no project is feasible. There have been major advancements in both the methodology and equipment used for wind resource assessment in order to reduce or mitigate risk on investment.

The incorporation of computational fluid dynamics and mesoscale numerical weather prediction (NWP) models enables wind analysts to simulate the wind characteristics over the previous 10-40 yrs which help wind farm developers to predict the wind resource over the lifespan of their project.

This assists with project planning and investment risk as wind farm output calculations will be more accurate and reliable.

Environmental Impact of Wind Energy

There are many benefits of wind energy, just some of which are financial savings, increased job opportunities, and a way to help revive depressed rural areas.

In this time of high unemployment rates, with jobs not as readily available, the transition to using wind energy is invaluable to the economy.

The United State department of energy reports, "According to the American Wind Energy Association, employment in the wind industry's manufacturing sector has increased from 2,500 jobs in 2004 to 20,000 in 2010, with an estimated additional 14,000 manufacturing jobs planned."

This fact alone means that the creation of jobs would be substantial, leading to a lessening of unemployment. Between the savings on energy costs for consumers that can be realized by the use of wind energy, and the increased number of employed individuals, the benefit to the economy could be substantial.

One of the most important factors in using wind energy is that it does not have the negative environmental impact that fossil fuels do. Wind energy, unlike fossil fuels, does not produce greenhouse gases, the discharge of particles and other pollutants into the atmosphere, or cause liquid or solid wastes to be discharged into water and/or soil.

Environmental Impacts of Wind Energy

One of the major concerns with regards to wind turbines and wind farms is its impact on the inhabitants, both human and animal, that live in close proximity to wind farms.

The wildlife most likely to be adversely affected by wind farms are birds and bats, who are susceptible to things such as disturbance, habitat loss and collisions.

There have been a number of high profile wind farms that have been delayed and/or cancelled due to environmental concerns, including:

- Washington, USA –Massachusetts, USA
- Otago, New Zealand – Project Hayes

According to the Royal Society for the Protection of Birds, "if wind farms are located away from major migration routes and important feeding, breeding, and roosting areas of at-risk bird species, it is likely that they will have minimal impacts".

In order to minimize these risks it is essential that a thorough study of the area, including an environmental impact assessment, is conducted before planning the building of wind farms.

Impact of Wind Turbines on People

Another concern is the effects that wind farms and wind turbines have on people living in proximity to the sites.
The most common complaint is that wind farms are an eye-sore, and a blight on the natural landscape and scenery.

Residents living near wind farms also have both psychological and physiological complaints.

Some complain of not being able to sleep due to turbine noise, and psychological issues due to the low decibel sound and vibration that the turbines produce.

The Canadian and American wind energy associations requested an expert panel to review the situation and investigate. The resulting document, Wind Turbine Sound and Health Effects determined the following:

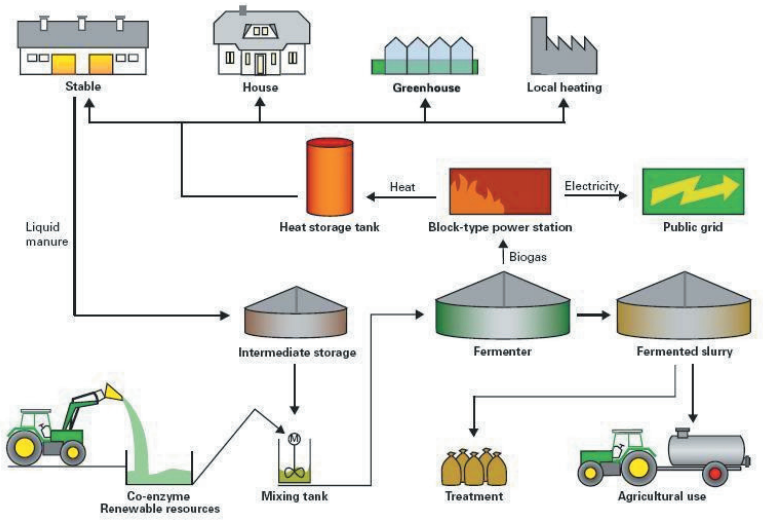
- There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects.
- The ground-borne vibrations from wind turbines are too weak to be detected by, or to affect, humans.
- The sounds emitted by wind turbines are not unique. There is no reason to believe, based on the levels and frequencies of the sounds, and the panel's experience with sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences."

In order to alleviate some of these issues the best plan should be to educate the residents about the impact of the wind farm.

When undertaking the development of a wind farm, planners should also take into consideration the number of residents in the area, and should consider finding areas that are less densely populated to construct wind farms.

In addition, new technological developments, and methods to reduce wildlife mortality should be prioritized, to make this clean, green energy source that much greener.

Biogas Power Plant



Biogas typically refers to a mixture of gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from regionally available raw materials such as recycled waste. It is a renewable energy source and in many cases exerts a very small carbon footprint.

Biogas is produced by anaerobic digestion with anaerobic bacteria or fermentation of biodegradable materials such as manure, sewage, municipal waste, green waste, plant material, and crops. It is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes.

The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat.

Biogas can be compressed, the same way natural gas is compressed to CNG, and used to power motor vehicles. In the UK, for example, biogas is estimated to have the potential to replace around 17% of vehicle fuel. It qualifies for renewable

energy subsidies in some parts of the world. Biogas can be cleaned and upgraded to natural gas standards when it becomes bio methane.

Production

Biogas is practically produced as landfill gas (LFG) or digested gas. A *biogas plant* is the name often given to an anaerobic digester that treats farm wastes or energy crops. It can be produced using anaerobic digesters. These plants can be fed with energy crops such as maize silage or biodegradable wastes including sewage sludge and food waste. During the process, an air-tight tank transforms biomass waste into methane, producing renewable energy that can be used for heating, electricity, and many other operations that use a reciprocating internal combustion engine, such as GE Jenbacher or Caterpillar gas engines. Other internal combustion engines such as gas turbines are suitable for the conversion of biogas into both electricity and heat.

There are two key processes: mesophilic and thermophilic digestion which is dependent on temperature. In experimental work at University of Alaska Fairbanks, a 1000-litre digester using psychrophiles harvested from "mud from a frozen lake in Alaska" has produced 200–300 liters of methane per day, about 20%–30% of the output from digesters in warmer climates.

Landfill gas

Landfill gas is produced by wet organic waste decomposing under anaerobic conditions in a landfill.

The waste is covered and mechanically compressed by the weight of the material that is deposited above. This material prevents oxygen exposure thus allowing anaerobic microbes to thrive. This gas builds up and is slowly released into the atmosphere if the site has not been engineered to capture the gas. Landfill gas released in an uncontrolled way can be hazardous since it can becomes explosive when it escapes from the landfill and mixes with oxygen. The lower explosive limit is 5% methane and the upper is 15% methane.

The methane in biogas is 20 times more potent a greenhouse gas than carbon dioxide. Therefore, uncontained landfill gas, which escapes into the atmosphere may significantly contribute to the effects of global warming. In addition, volatile organic compounds (VOCs) in landfill gas contribute to the formation of photochemical smog.

Technical

Biochemical oxygen demand (BOD) is a measure of the amount of O2 (oxygen) required by aerobic micro-organisms to decompose the organic matter in a sample of water. Knowing the energy density of the material being used in the biodigester as well as the BOD for the liquid discharge allows for the calculation of the daily energy output from a biodigester.

Another term related to biodigesters is effluent dirtiness, which tells how much organic material there is per unit of biogas source. Typical units for this measure are in mg BOD/litre. As an example, effluent dirtiness can range between 800–1200 mg BOD/litre in Panama.

Composition

The composition of biogas varies depending upon the origin of the anaerobic digestion process. Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55–75% methane, which for reactors with free liquids can be increased to 80-90% methane using in-situ gas purification techniques. As produced, biogas contains water vapor. The fractional volume of water vapor is a function of biogas temperature; correction of measured gas volume for water vapor content and thermal expansion is easily done via simple mathematics which yields the standardized volume of dry biogas.

In some cases, biogas contains siloxanes. They are formed from the anaerobic decomposition of materials commonly found in soaps and detergents. During combustion of biogas containing siloxanes, silicon is released and can combine with free oxygen or other elements in the combustion gas. Deposits are formed

containing mostly silica (SiO_2) or silicates (Si_xO_y) and can contain calcium, sulfur, zinc, phosphorus. Such white mineral deposits accumulate to a surface thickness of several millimeters and must be removed by chemical or mechanical means.

Practical and cost-effective technologies to remove siloxanes and other biogas contaminants are available.

For 1000 kg (wet weight) of input to a typical biodigester, total solids may be 30% of the wet weight while volatile suspended solids may be 90% of the total solids. Protein would be 20% of the volatile solids, carbohydrates would be 70% of the volatile solids, and finally fats would be 10% of the volatile solids.

Benefits

Use of biogas would generate enough electricity to meet up to 3% of the continent's electricity expenditure. In addition, biogas could potentially help reduce global climate change. High levels of methane are produced when manure is stored under anaerobic conditions. During storage and when manure has been applied to the land, nitrous oxide is also produced as a byproduct of the denitrification process. Nitrous oxide (N2O) is 320 times more aggressive than carbon dioxide and methane 21 times more than carbon dioxide.

By converting cow manure into methane biogas via anaerobic digestion, the millions of cattle in the United States would be able to produce 100 (approximately) billion kilowatt hours of electricity, enough to power millions of homes. In fact, one cow can produce enough manure in one day to generate 3 kw (kilowatt) hours of electricity; only 2.4 kilowatt hours of electricity are needed to power a single 100-watt light bulb for one day. Furthermore, by converting cattle manure into methane biogas instead of letting it decompose, global warming gases could be reduced by 99 million metric tons or 4%.

Applications

Biogas can be used for electricity production on sewage works, in a CHPgas engine, where the waste heat from the engine is conveniently used for heating the digester; cooking; space

heating; water heating; and process heating. If compressed, it can replace compressed natural gas for use in vehicles, where it can fuel an internal combustion engine or fuel cells and is a much more effective displacer of carbon dioxide than the normal use in on-site CHP plants.

Biogas upgrading

Raw biogas produced from digestion is roughly 60% methane and 29% CO_2 with trace elements of H_2S; it is not of high enough quality to be used as fuel gas for machinery. The corrosive nature of H_2S alone is enough to destroy the internals of a plant.

Methane in biogas can be concentrated via a biogas upgrader to the same standards as fossil natural gas, which itself has had to go through a cleaning process, and becomes *biomethane*. If the local gas network allows, the producer of the biogas may use their distribution networks. Gas must be very clean to reach pipeline quality and must be of the correct composition for the distribution network to accept. Carbon dioxide, water, hydrogen sulfide, and particulates must be removed if present.

There are four main methods of upgrading:

a) water washing,

b) pressure swing adsorption,

c) selexol adsorption, and

d) amine gas treating.

The most prevalent method is water washing where high pressure gas flows into a column where the carbon dioxide and other trace elements are scrubbed by cascading water running counter-flow to the gas. This arrangement could deliver 98% methane with manufacturers guaranteeing maximum 2% methane loss in the system. It takes roughly between 3% and 6% of the total energy output in gas to run a biogas upgrading system.

Biogas gas-grid injection

Gas-grid injection is the injection of biogas into the methane grid (natural gas grid). Injections includes biogas until the breakthrough of micro combined heat and power two-thirds of all the energy produced by biogas power plants was lost (the heat), using the grid to transport the gas to customers, the electricity and the heat can be used for on-site generation resulting in a reduction of losses in the transportation of energy. Typical energy losses in natural gas transmission systems range from 1% to 2%. The current energy losses on a large electrical system range from 5% to 8%.

Biogas in transport

If concentrated and compressed, it can be used in vehicle transportation. Compressed biogas is becoming widely used in Sweden, Switzerland, and Germany. A biogas-powered train, named Biogaståget Amanda (The Biogas Train Amanda), has been in service in Sweden since 2005. Biogas powers automobiles. In 1974, a British documentary film titled *Sweet as a Nut* detailed the biogas production process from pig manure and showed how it fueled a custom-adapted combustion engine. In 2007, an estimated 12,000 vehicles were being fueled with upgraded biogas worldwide, mostly in Europe.

Measuring in biogas environments

Biogas is part of the wet gas and condensing gas (or air) category that includes mist or fog in the gas stream. The mist or fog is predominately water vapor that condenses on the sides of pipes or stacks throughout the gas flow. Biogas environments include wastewater digesters, landfills, and animal feeding operations (covered livestock lagoons).

Ultrasonic flow meters are one of the few devices capable of measuring in a biogas atmosphere. Most thermal flow meters are unable to provide reliable data because the moisture causes steady high flow readings and continuous flow spiking, although

there are single-point insertion thermal mass flow meters capable of accurately monitoring biogas flows with minimal pressure drop. They can handle moisture variations that occur in the flow stream because of daily and seasonal temperature fluctuations, and account for the moisture in the flow stream to produce a dry gas value.

Environmental Impacts of Biomass for Electricity

Biomass power plants share some similarities with fossil fuel power plants: both involve the combustion of a feedstock to generate electricity. Thus, biomass plants raise similar, but not identical, concerns about air emissions and water use as fossil fuel plants. However, the feedstock of biomass plants can be sustainable produced, while fossil fuels are non-renewable.

Sources of biomass resources for producing electricity are diverse, including energy crops (like switchgrass), agricultural waste, manure, forest products and waste, and urban waste. Both the type of feedstock and the manner in which it is developed and harvested significantly affect land use and life-cycle global warming emissions impacts of producing power from biomass.

Water Use

Biomass power plants require approximately the same amount of water for cooling as coal power plants, but actual water withdrawals and consumption depends on the facility's cooling technology. For biomass plants with once-through cooling systems—which take water from nearby sources, circulate it through the plants cooling system, and then discharge it—water withdrawals range between 20,000 and 50,000 gallons per megawatt-hour with consumption of 300 gal/mwhrs(300 gallons per megawatt-hour). Biomass facilities that use wet-recirculating cooling systems—which reuse cooling water in a second cycle rather than immediately discharging it—withdraw between 500 and 900 gallons per megawatt-hour and consume approximately 480 gallons per megawatt-hour.

Approximately 75% of existing biomass plants that require cooling uses wet-recirculating technology, while 25% of plants use once-through cooling technology. In either case, when withdrawn cooling water is returned to its source, it is much warmer than when it was withdrawn, which often has a negative impact on plant and animal life. As in all thermal plants, this impact must be closely monitored. Dry-cooling systems do not withdraw or consume any water, but the tradeoffs to these water savings are higher costs and lower efficiencies—meaning more fuel is needed per unit of electricity.

Water is also needed to produce some biomass feedstocks. While some feedstock sources—such as agricultural, forest, and urban waste—require no additional water, others—such as energy crops—can be very water intensive. Different energy crops vary in terms of how much water they require. Miscanthus, one type of perennial grass, requires a large amount of water, while switchgrass, another perennial grass, generally requires much less. Water use efficiency of a given crop depends on a number of factors, including soil quality and temperature.

In regions with sufficient rainfall where irrigation is not required, water use for producing energy crops may be less of a concern. However, even in water-rich areas, the increased cultivation of energy crops may harm regional water quality as a result of soil tillage and nutrient runoff. Such water quality impacts can be managed through proper harvesting techniques. Many of these same issues arise in the cultivation of energy crops for biofuels.

Air Emissions

Burning biomass to produce electricity can impact air quality. The level of air emissions associated with biomass power plants varies depending on the feedstock, combustion technology, and types of installed pollution controls, but the most common pollutants include nitrogen oxides (NOx), sulfur dioxide (SO2), carbon monoxide, and particulate matter. The table below compares air emissions from different types of biomass, coal, and natural gas power facilities with pollution control equipment. In

general, biomass facilities emit less SO2 and mercury (a neurotoxin) than coal.

Nitrogen oxides from biomass are lower than those from coal but higher than natural gas. NOx emissions causes ground-level ozone, or smog, which can burn lung tissue and can make people more susceptible to asthma, bronchitis, and other chronic respiratory diseases. Like SO2, NOx also contributes to acid rain and the formations of harmful particulate matter. Biomass power plants also emit high levels of particulates (soot and ash) and carbon monoxide. Readily available technologies, such as fluidized bed or gasification systems, and electrostatic precipitators, can help reduce NOx, CO, and particulate emissions associated with biomass power.

Table 6.1 Direct Air Emissions from Wood Residue Facilities by Boiler Type

	SO_X	NO_X	CO	PM-10[1]	Comments
Biomass Technology					
Stoker Boiler, Wood Residues (1,4)	0.08	2.1 (biomass type not specified)	12.2 (biomass type not specified)	0.50 (total particulates) (biomass type not specified)	Based on 23 California grate boilers, except for SO_2 (uncontrolled)
Fluidized Bed, Biomass (4)	0.08 (biomass type not specified)	0.9 (biomass type not specified)	0.17 (biomass type not specified)	0.3 (total particulates) (biomass type not specified)	11 FBC boilers in California
Energy Crops (Poplar) Gasification (a,b)	0.05 (**suggested** value based on SOx numbers for Stoker and FBC, adjusted by a factor of 9,180/13,800 to account for heat rate improvement)	1.10 to 2.2 (0.66 to 1.32 w/SNCR, 0.22 to 0.44 with SCR)	0.23	0.01 (total particulates)	Combustor flue gas goes through cyclone and baghouse. Syngas goes through scrubber and baghouse before gas turbine. No controls on gas turbine.
Coal Technology					
Bituminous Coal, Stoker Boiler (f)	20.2 1 wt% S coal	5.8	2.7	0.62	PM Control only (baghouse)
Pulverized Coal Boiler (d)	14.3	6.89	0.35	0.32 (total particulates)	Average US PC boiler (typically :baghouse, limestone FGC)
Cofiring 15% Biomass (d2)	12.2	6.17	0.35	0.32 (total particulates)	?
Fluidized Bed, Coal (f)	3.7 (1 wt% S coal Ca/S = 2.5)	2.7	9.6	0.30	Baghouse for PM Control, Ca sorbents used for SO_x
Natural Gas Technology					
4-Stroke NG Reciprocating Engine (g)	0.006	7.96-38.3 (depends on load and air:fuel ratio)	2.98-35.0 (depends on load and air:fuel ratio)	0.09-0.18 (depends on load and air:fuel ratio)	No control except PCC at high-end of PM-10 range
Natural Gas Turbine (e)	0.009 (0.0007 wt% S)	1.72	0.4	.09 (total particulates)	Water-steam injection only
Natural Gas Combined Cycle (c,e)	0.004	0.91 (0.21 w/ SCR)	0.06	0.14 (total particulates)	Water-steam injection only

Direct Air Emissions from Biomass, Coal and Natural Gas Power Plants, by Boiler Type.

Note: UCS does not consider waste-to-energy plants that burn raw municipal waste to be a sustainable form of biomass. Waste-to-energy plants emit high levels of air pollution, including toxic metals, chlorinated compounds, and plastics.

Land Use

Land use impacts from biomass power production are driven primarily by the type of feedstock: either a waste stream or an energy crop that is grown specifically for generating electricity. Because waste streams are only secondarily available as a result of another activity that would have otherwise occurred—such as logging or farming—there is no marginal increase in land use. However, if not collected properly, using agriculture and forest waste streams for biomass power could lead to land or habitat degradation.

Important safeguards and best practices for removal are needed to ensure that sufficient crop residues are left behind to improve soil carbon storage, maintain nutrient levels, and prevent erosion. Similarly, harvesting of forest waste products can be done sustainably, but proper forest management practices need to be followed to ensure that wildlife habitat is not destroyed and the forest remains healthy.

Impacts associated with the use of energy crops depends greatly on whether the planting leads to land use change or displaced food production. If energy crops are planted on a large scale and displace food production, then new lands may need to be cleared to maintain food supplies. As a result, this could potentially change U.S. or global land use patterns and lead to habitat destruction or increases in food prices. However, it is possible to sustainably increase agricultural efficiency and reduce the land required for food production while also improving soil health, erosion, and eutrophication. Doing so could free up land for energy crops while minimizing food displacement and other land use changes.

Energy crops present many of the same environmental challenges as food crops, and therefore the same principles of sustainable agriculture apply: crop rotation, integrated pest management, and proper soil husbandry to prevent soil erosion. Many energy crops use less fertilizer and pesticides than typical food crops, and perennial grasses do not require annual tilling and planting. These crops can even be advantageous for some farmers; alternating the planting of food and energy crops can help stabilize the soil and provide supplemental farm income.

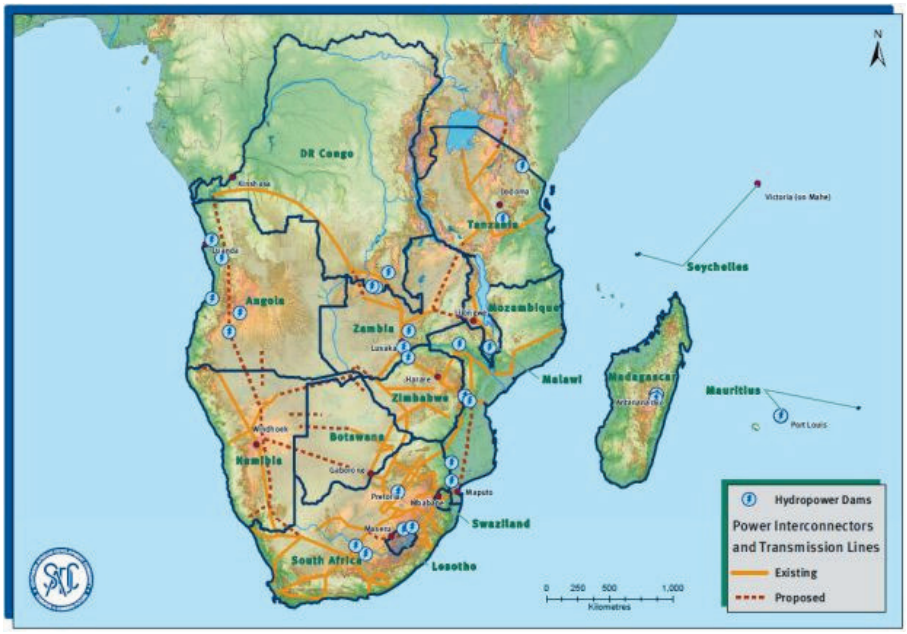
Generation and Trade in Energy in Zambia and Power within the Region - SADC

As it develops, Southern Africa relies on electricity for infrastructure projects that improve the economy and for social development in the region. While most Member States of SADC have abundant energy resources, they sometimes lack the technical capacity to put them to use. As a result, energy production and consumption varies widely throughout the region. With industrial productivity steadily increasing in the region, the World Bank anticipates the demand for electricity to increase by 40% over the next 10 years.

In order to keep pace with demand and benefit its Member States, SADC promotes stronger Regional Integration of its Member States' electricity sectors. Integration takes advantage of economies of scale, reducing the cost of electricity infrastructure development – especially in smaller countries – and saving the region $1.1 billion a year in energy costs.

To better facilitate this integration, SADC passed its Protocol on Energy in 1996. This Protocol acts as a policy framework for effective use and development of energy in the region, including the electricity sector.

Distribution of energy infrastructure in SADC.



The Protocol on Energy

The Protocol on Energyadvises SADC Member States to cooperate on electricity usage and development. Specifically, Member States should strive to:

- promote power pooling and trade in electricity, as described in the Southern African Power Pool Intergovernmental Memorandum of Understanding;
- promote integrated resource planning as it pertains to electricity, taking advantage of economies to scale to optimise investment and benefits;
- coordinate a Regional Electricity Master Plan;
- promote regional standards, rules, and procedures that relate to electricity generation, transmission, and distribution;
- develop and use electricity in an environmentally sound manner, with projects following basic environmental standards;

- emphasise universal access to electricity for all citizens of SADC Member States; and
- encourage agreements, both inside and outside the region, on regional electricity development and trade.

Toward these ends, the SADC Committee of Ministers should appoint a subcommittee that oversees development and progress in these areas.

The Southern African Power Pool

The Southern African Power Pool is a key achievement of both Regional Integration and increased access to electricity. At present, nine SADC Member States have connected together their power grids, creating a rudimentary but competitive energy market. In doing so, the Southern African Power Pool has expanded trade in electricity, reduced costs, and improved energy stability throughout the region. Witnessing the benefits to participating Member States, SADC's Regional Energy Sector Programme aims to incorporate the other outlying SADC Member States into the Southern African Power Pool, extending grid connections to encompass the whole region and furthering the benefits of a regional energy market.

Infrastructure Development

In order to capitalise on the region's potential for electricity generation, SADC encourages investment in the region's electricity infrastructure, especially in electricity plants, transmission lines, coal depots, and nuclear demonstration plants.

At present, most electricity in Southern Africa is produced through burning coal. However, SADC aims to develop the region's renewable energy resources, with plans for hydropower plants underway in Mozambique, the Democratic Republic of Congo, Lesotho, and along the Zambezi River. As well, two transmission lines – the North-South Power Transmission Corridor and the Central African Interconnection – are under development.

This new infrastructure, however, requires new training and capacity building. In order to make real gains in the energy sector, locals must be capable of operating and maintaining these

infrastructure projects once they are constructed and must be available to do so.

Access to Energy

Along with industrial productivity, electricity generation can assist in SADC's mandate of poverty eradication across Southern Africa. At present, only 5% of rural areas in Southern Africa have access to electricity, which inhibits their ability to control sanitation, clean water, and food. In 2010, SADC passed the **Regional Energy Access Strategy and Action Plan**, which aims to combine regional energy resources as a means of ensuring the entire SADC region has access to affordable, sustainable electricity. The plan's goal is to within ten years reduce by half the number of people in the region without access to energy, and then halving it again every five years until the region has universal access.

Generation and Trade in Energy in Zambia and Power within the Region - COMESA

The Common Market for Eastern and Southern Africa (COMESA) is a regional economic grouping comprising 19 member States which have agreed to promote regional integration through trade development and to develop their natural and human resources for the mutual benefit of all their people. The member states are Burundi, Comoros, Congo DR, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Sudan, Swaziland, Uganda, Zambia and Zimbabwe. COMESA has a total land area of about 12 million square kilometres, spanning Northern, Eastern and Southern Africa and has a population of over 389 million. Moreover, the region is endowed with diverse natural resources which include arable land, minerals, petroleum, water, etc, and it is also a big market.

Trade and investment are the primary instruments for promoting and deepening economic integration in COMESA. In order to facilitate trade and investment, the development of appropriate physical infrastructure and facilitation in energy, transport and communications are key issues.

The COMESA Free Trade Area (FTA) was launched in October, 2000 when nine of the member States eliminated their tariffs on COMESA originating products. Currently there are fourteenmember states participating in the FTA namely Burundi, Comoros, Djibouti, Egypt, Kenya, Libya, Madagascar, Malawi, Mauritius Rwanda, Seychelles Sudan, Zambia and Zimbabwe.

The COMESA Customs Union, which by definition incorporates a Free Trade Area, waslaunched in June 2009. The intra-COMESA trade reached a US$ 17 billion mark in 2010.
Energy plays a critical role in the development process, as a domestic necessity but also as a factor of production whose cost directly affects prices of other goods andservices and the competitiveness of enterprises. Moreover, as the region's economy and trade continue to grow, energy will be critical element to support and sustain the achieved growth.

Energy also plays an important role in reducing the cost of doing business and COMESA has recognized energy infrastructure development as a priority and strategic focus area that requires special attention. The strategic objective, to be pursued, is to effectively address constraints related to the improvement of energy infrastructure in the region in order to foster physical regional energy connectivity and integration as well as enhance competitiveness.

The removal of supply-side constraints related to energy is an essential pillar/component necessary for improved market access and enhanced productive capacity. It is also critical factor in reducing the cost of doing business and in enhancing the competiveness of COMESA in national, regional and international markets.

Transport

Transport or **transportation** is the movement of people, animals and goods from one location to another. Modes of transport include air, rail, road, water, cable, pipeline and space. The field can be divided into infrastructure, vehicles and operations.

Transport is important because it enables trade between people, which is essential for the development of civilizations.

Transport infrastructure consists of the fixed installations including roads, railways, airways, waterways, canals and pipelines and terminals such as airports, railway stations, bus stations, warehouses, trucking terminals, refueling depots (including fueling docks and fuel stations) and seaports. Terminals may be used both for interchange of passengers and cargo and for maintenance.

Vehicles traveling on these networks may include automobiles, bicycles, buses, trains, trucks, people, helicopters, watercraft, spacecraft and aircraft. Operations deal with the way the vehicles are operated, and the procedures set for this purpose including financing, legalities and policies. In the transport industry, operations and ownership of infrastructure can be either public or private, depending on the country and mode.

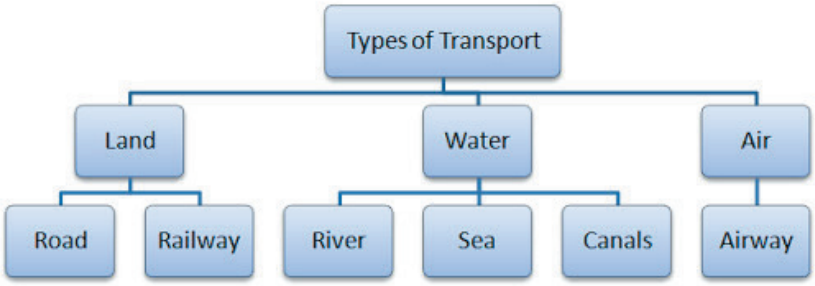
Passenger transport may be public, where operators provide scheduled services, or private. Freight transport has become focused on containerization, although bulk transport is used for large volumes of durable items. Transport plays an important part in economic growth and globalization, but most types cause air pollution and use large amounts of land. While it is heavily subsidized by governments, good planning of transport is essential to make traffic flow and restrain urban sprawl.

Mode of transport

Mode of transport (or **means of transport** or **transport mode** or **transport modality** or **form of transport**) is a term used to distinguish substantially different ways to perform transport. The most dominant modes of transport are aviation and land transport, which includes rail, road and off-road transport, and ship transport. Other modes also exist, including pipelines, cable transport, and space transport. Human-powered transport and animal-powered transport are sometimes regarded as their own mode, but these normally also fall into the other categories.

Each mode of transport has a fundamentally different technological solution, and some require a separate environment.

Each mode has its own infrastructure, vehicles, and operations, and often has unique regulations. Each mode also has separate subsystems. A subsystem is a group of many parts that make up one part. All modes of transportation have 6 subsystems. They are: Propulsion, Suspension, Control, Guidance, Structural, and Support. Transport using more than one mode is described as intermodal. Transportation that carries around many people and can be used by the public is known as Mass Transportation.



Air

A fixed-wing aircraft, typically airplane, is a heavier-than-air flight vehicle, in which the special geometry of the wing generates lift. A gyroplane is both a fixed-wing and rotary-wing. Fixed-wing aircraft range from small trainers and recreational aircraft to large airliners and military cargo aircraft.

The angle of the wing (or blade) relative to the direction of flight (or rotation in a rotary-wing) deflects air downward, generating lift. Wings (or blades) are shaped in a complex fashion to help reduce friction and drag on the aircraft, which rob fuel efficiency and can create turbulence or noise. (See more at angle of attack.)

Air transport is the second fastest method of transport, after space travel. Commercial jets can reach speeds of up to 955 kilometres per hour (593 mph), (note that an aircraft's groundspeed can sometimes reach over 1,000 kilometres per hour (620 mph), depending on the tailwind on a given altitude) while single-engine piston aircraft may reach up to 555 kilometres per hour (345 mph). Aviation is able to quickly transport people and

limited amounts of cargo over longer distances, but incur high costs and energy use; for short distances or in inaccessible places, helicopters can be used.[1] WHO estimates that up to 500,000 people are on planes at any time.

Land

Rail

Rail transport is a means of conveyance of passengers and goods by way of wheeled vehicles running on rail track, known as a railway or railroad. The rails are anchored perpendicular to railroad train consists of one or more connected vehicles that run on the rails. Propulsion is commonly provided by a locomotive, that hauls a series of unpowered cars, that can carry passengers or freight. The locomotive can be powered by steam, diesel or by electricity supplied by trackside systems. Alternatively, some or all the cars can be powered, known as a multiple unit. Also, a train can be powered by horses, cables, gravity, pneumatics and gas turbines. Railed vehicles move with much less friction than rubber tires on paved roads, making trains more energy efficient, though not as efficient as ships.

Intercity trains are long-haul services connecting cities; modern high-speed rail is capable of speeds up to 350 km/h (220 mph), but this requires specially built track. Regional and commuter trains feed cities from suburbs and surrounding areas, while intra-urban transport is performed by high-capacity tramways and rapid transits, often making up the backbone of a city's public transport. Freight trains traditionally used box cars, requiring manual loading and unloading of the cargo. Since the 1960s, container trains have become the dominant solution for general freight, while large quantities of bulk are transported by dedicated trains.

Road

A road is an identifiable route of travel, usually surfaced with gravel, asphalt or concrete, and supporting land passage by foot or by a number of vehicles.

The most common road vehicle is the automobile, a wheeled passenger vehicle that carries its own motor. As of 2002, there were 590 million automobiles worldwide. Other users of roads include buses, trucks, motorcycles, bicycles and pedestrians.

Automobiles offer high flexibility, but are deemed with high energy and area use, and the main source of noise and air pollution in cities; buses allow for more efficient travel at the cost of reduced flexibility. Road transport by truck is often the initial and final stage of freight transport.

Water

Water transport is the process of transport that a watercraft, such as a barge, boat, ship or sailboat, makes over a body of water, such as a sea, ocean, lake, canal or river. If a boat or other vessel can successfully pass through a waterway it is known as a navigable waterway. The need for buoyancy unites watercraft, and makes the hull a dominant aspect of its construction, maintenance and appearance. When a boat is floating on the water the hull of the boat is pushing aside water where the hull now is, this is known as displacement.

In the 1800s, the first steamboats were developed, using a steam engine to drive a paddle wheel or propeller to move the ship. The steam was produced using wood or coal. Now, most ships have an engine using a slightly refined type of petroleum called bunker fuel. Some ships, such as submarines, use nuclear power to produce the steam. Recreational or educational craft still use wind power, while some smaller craft use internal combustion engines to drive one or more propellers, or in the case of jet boats, an inboard water jet. In shallow draft areas, hovercraft are propelled by large pusher-prop fans.

Although slow, modern sea transport is a highly effective method of transporting large quantities of non-perishable goods. Commercial vessels, nearly 35,000 in number, carried 7.4 billion tons of cargo in 2007.[5] Transport by water is significantly less costly than air transport for transcontinental shipping;[6]short sea shipping and ferries remain viable in coastal areas.

Other modes

Pipeline transport sends goods through a pipe, most commonly liquid and gases are sent, but pneumatic tubes can also send solid capsules using compressed air. For liquids/gases, any chemically stable liquid or gas can be sent through a pipeline. Short-distance systems exist for sewage, slurry, water and beer, while long-distance networks are used for petroleum and natural gas.

Cable transport is a broad mode where vehicles are pulled by cables instead of an internal power source. It is most commonly used at steep gradient. Typical solutions include aerial tramway, elevators, escalator and ski lifts; some of these are also categorized as conveyor transport.

Space transport is transport out of Earth's atmosphere into outer space by means of a spacecraft. While large amounts of research have gone into technology, it is rarely used except to put satellites into orbit, and conduct scientific experiments. However, man has landed on the moon, and probes have been sent to all the planets of the Solar System.

Unmanned aerial vehicle transport, (or drone transport), is currently being tested by Amazon.com and other transportation companies. This method will allow short-range small-parcel delivery in a short time frame.

Transport and Poverty Reduction

Transport is critical to poverty reduction but if inappropriately designed, transport strategies and programs result in networks and services that heighten the conditions of the poor, harm the environment, ignore the changing needs of users, and exceed the capacity of public finances. Transport is capable of generating growth by facilitating trade both nationally and internationally, and by increasing access to social services like health and education.

At the macroeconomic level, investment in transport raises growth by increasing the social return to private

investment. Similarly, at the microeconomic level, improvements in transport often lower agricultural input prices and hence the costs of 56oduction. In addition access to markets generally improves and hence facilitates the development of the non-agricultural rural economy and tourism. In urban areas, the quality of transport service influences the location of firms and individuals. The cost of labour and the efficiency of the labour market are also determined by transport.

Without an efficient transport system, it is harder and costly to move goods, resulting in loss of market competitiveness and lower economic growth. Further, Zambia can benefit from her central location by serving as a hub of economic development in the region as a transit route. In the rural areas where poverty is more extensive, a cause of poverty is inadequate transport, which leads to restricted access to markets.

PRSP Interventions in Transport

The primary goal for the PRSP interventions on transport are first and foremost to support the economy to grow, thereby enabling more resources to be generated for more public interventions in all areas, including transport. For sustainable national development there is need for a national transport policy that requires the development of a comprehensive transport programme which is divided into three priority categories. -

1. Preserving investment already made in Infrastructure roads through maintenance.
2. Establishing infrastructure, which aid economic recovery and poverty reduction.
3. Establishing infrastructure which bring environmental and social benefits, and
4. Instituting effective management systems.

These issues will now be discussed within each transport mode.

Railways

As the mining industry slowly recovers followed by the related sectors the volume of business for railway will also recover, provided they can match the competition from road transport. A well functioning railway system is important for

enhancing export competitiveness, economic growth and poverty reduction since railway haulage tends to be cheaper than other modes where speed is not a major consideration.

Government shall therefore focus on the following issues:-

1. Ensuring the rehabilitation and preservation of investment and the continuous improvement of the rail infrastructure
2. Improving railway efficiency through concessioning to the private sector.
3. Make arrangements for new railway connection to areas that will come into new economic production especially large-scale mining.
4. Level the playing field between roads and rail so that it is not economic for very heavy cargo to be transported by roads in order to reduce pressure on roads.
5. Expand and strengthen government capacity to develop supportive regulatory and investor-friendly legislation, monitor compliance with policies and legislation;
6. Standardising practices and procedures in line with SADC member states to provide seamless and predictable service throughout the region;
7. Provide a competitive, cost- effective, commercial, efficient and market-driven railway transport system.
8. Foster inter-modal co-operation between road and rail, especially for the movement of international freight and passengers;
9. Promote co-operation with regional railways to ensure undisrupted movement of cargo at interchange points.
10. Promote collaboration between Zambia Railways Limited and TAZARA.
11. Evaluate and implement extension of the railway network like Chipata-Mchinji rail link and the Kasama-Mpulungu rail link as part of railway network development strategy;

Although all the above objectives are important, the first five take priority.

Road Transport
Road Infrastructure:

Being a large but poor country, Zambia will continue to depend on road transport. There are two major challenges associated with this, however. Firstly, her extensive road infrastructure is in need of rehabilitation and maintenance. A stagnant economy, heavy debt burden and wrong priorities have all contributed to road deterioration. The second challenge is linking this important transport mode with increased overall productivity for the economy.

Over the next three years, Zambia intends to continue putting greatest priority on rehabilitating and maintaining all her road network from feeder to trunk roads. This is important for the following reasons:

1. Delay in maintenance and rehabilitation increases costs eventually.
2. Economic growth and poverty reduction require that the roads and other transport systems are efficient and cost effective and this is not possible with poor roads.
3. Efficient delivery of services including emergency relief requires good roads.
4. Road rehabilitation creates jobs and business opportunities, often at the lower end of the labour market and this has direct impact on reducing income poverty.

Zambia has been undertaking road repair under Road Sector Investment Program (ROADSIP), which is a partnership between road users, the government and donors to promote development through roads. The first phase was launched in 1998. ROADSIP's objective has been to bring a core network of the road to maintainable condition and already positive impact has been registered with the percentage of paved roads in good condition having risen from 20 in 1995 to 44 in 1999 and the paved roads in poor conditions falling from 51 percent in 1995 to 29 percent in 1999. Over the first PRSP period, ROADSIP II will be launched and it will continue with the objectives set out in phase I.

For the size of her economy and the population parameters,

Zambia's paved road network is quite extensive, exceeding that of the average for Sub Saharan Africa and even that for Zimbabwe and South Africa. This partly explains the difficulty in keeping abreast with maintenance and rehabilitation. The implication is that Zambia will minimise construction of new paved roads and pay more attention to looking after what she already has including rural feeder roads. Further, economic and social rates of return will be applied for trunk, main and urban roads in the selection of roads for improvements.

Many of Zambia's paved and other roads were not necessarily constructed as part of an organised package to enhance national productivity or capitalise on her central location for trade. With the emphasis now being placed on growth, the roads must be integrated into the overall plan to make this happen. This will be done as follows:

1. Rehabilitation and maintenance of all roads to enhance efficiency.
2. Where new mining areas are to be opened up as anticipated in the Lumwana area in the North-Western Province, appropriate road connections will be done to complement the railway connection
3. In agriculture new farming blocks will be established in rural Zambia to take advantage of the land and water resources to produce high value products. Farm blocks must be near existing roads but where this is not feasible new roads, not necessarily paved, will be constructed.
4. A similar approach will be taken for tourism. In all tourist zones, the minimum intervention will be to ensure continued accessibility through good roads.

Rural Travel and Transport: -

Poverty is said to be highest in most of the Zambian rural areas because of the lack of access to market for agricultural produce as well as productive inputs. This has been worsened by the poor transport systems that exist in rural areas. Therefore, if the poverty situation in rural areas has to be addressed the issue of transport has to be of paramount importance .In order to improve the rural travel and transport, the following measures have been proposed:

(i) Establish an institutional framework for the development and management of rural transport and travel in the country;

(ii) Improve the planning, management and financing of rural road transport as well as upgrading the road infrastructure such as community roads, paths, tracks, trails and footbridges through community participation;

(iii) Facilitate the rural communities with establishment of sustainable approaches to the construction and maintenance of rural transport infrastructure;

(iv) Facilitate the introduction and promotion of appropriate motorised and non-motorised means of transport aimed at improved mobility in rural areas;

(v) Encourage the development of industries for the design, manufacture, repair and maintenance of intermediate motorised and non- motorised means of transport for rural areas, and

(vi) Ensure that gender issues are considered in rural travel and transport.

Institutional and Management Issues in Roads

For the goals outlined above to be realised, the government is aware that a number of institutional and management issues will need to be dealt with. The key issues are as follows:

a The multiplicity of authorities in the management of roads causes difficulties.

b Within a rationalised authority for roads, Government's role will primarily be to plan, facilitate, co-ordinate, implement, regulate and monitor developments in the infrastructure and industry. The private sector will do the rest.

c Create a more credible and sustainable domestic system for financing and managing the road network to gradually reduce dependence on external financing.

d Institutional reform and human resources development will be undertaken;

e Promote the road transport growth in the region, by levelling the playing field with other countries and improved traffic handling at border points.

Road Safety

Zambia loses an average of 1,000 lives through road accidents and it is estimated that road accidents in Zambia cost the country about 2.3% of the Gross Domestic Product (GDP) annually. Costs include direct costs such as damage to vehicles, policing and administration costs, medical expenses and insurance costs. In order to reverse this trend, Government will focus on the development of appropriate legislation to ensure satisfactory safety levels, and the Implementation of efficient and effective law enforcement procedures in line with regional norms.

These issues would be tackled through pursuance of the goal of protecting the lives of road users and property through the introduction of appropriate road safety measures and enforcement of regulations.
In achieving this goal government will put in place the following policy objectives

(i) Make road safety engineering aspects compulsory in the construction, rehabilitation and maintenance of roads;

(ii) Improve the awareness of the need for better road safety behavior among the road users through publicity and training; and

(iii) Improve the enforcement of traffic laws and regulations.

Based on the policy objectives Government shall: -

a Institute safety engineering within the present and future institutional arrangements in the road sector;

b Collaborate with relevant agencies in a national road transport authority for motor vehicle examination and testing in accordance with regionally accepted standards;

c Integrate the National Road Safety Council into a national road transport authority for efficient management of the road safety;

d Improve the reporting and analysis of road accident data in order to better target actions towards priority road safety measures;

e Ensure that the lives of all road users are protected through the introduction of appropriate road safety measures with strict enforcement of road traffic laws and regulations;

f Improve the co-ordination between institutions involved in road safety activities at national and regional level.

g Institute arrangements for a more efficient and effective enforcement of traffic regulations.

h Introduce an insurance safety levy to finance road safety programmes.

Civil Aviation

Liberalising of air transport since 1991 has resulted in the formation of private local airlines. The reasons behind a slow growth in the industry can be attributed to factors such as unattractiveness of the Zambian market caused by small passenger loads, and lack of properly managed tourist destinations.

Currently, there are 144 airports/aerodromes in the country of which National Airports Corporation manages the four major airports. Government or private individuals and organisations manage the rest. National Airports Corporation is providing air Navigation Services throughout the country.

Expansion in the mining and tourism industries will revive air transport demand. Government shall ensure safe and efficient air navigation services in accordance with international civil aviation standards. She will also create a competitive environment so that private companies continue to provide transport services. Further, Zambia will ensure those airports that are critical for commerce and tourism; i.e. the Lusaka, Ndola, Livingstone and Mfuwe are always in good serviceable condition.

In the effort of achieving this, the government shall ensure that the following issues are addressed

a Pursuing legal and institutional reforms aimed at revamping the industry to meet the challenges of a liberalised environment;

b Promoting civil aviation in accordance with the Convention on International Civil Aviation;

c Ensuring compliance with regional and international agreements;

d Educating, training and professional development of human resources in the aviation industry, and

e Attracting international carriers to stimulate tourism and trade.

Maritime and Inland Waterways

Inland waterways are needed especially in areas that are inaccessible by other modes of transport and are accessible by water transport. It has inherent advantage that the services can be operated wherever navigable waters are available without requiring huge investments. Sustainable investments would be required for the improvement and maintenance of navigable rivers, canals and channels and development of terminal facilities at harbours. The Government shall also ensure that water transport operators adhere to communications regulations on lakes and rivers.

In order to achieve the above stated goal, Government shall: -

1. Improve the safety and efficiency of inland water transport system and shipping including promotion of regional co-operation;
2. Promote a safe and clean marine and inland waterways environment.
3. Prepare a comprehensive plan for ensuring proper navigability on all designated waterways in the country including canals;
4. Encourage private sector participation in the operation of water transport services;
5. Develop and improve the infrastructure at the existing ports

to the standards of regional ports;

Communication

Communication, whether in organizations, personal relationships, politics or public information campaigns, is one of the most complex and strategic activities of human beings. It may have limited effectiveness for two interacting reasons.

Types of Communication

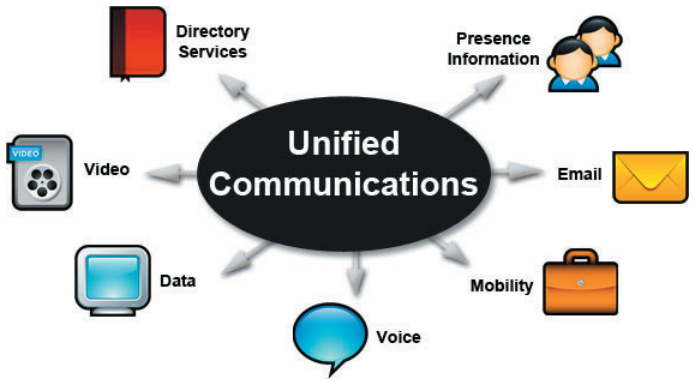
Face-to-face, video, audio and text-based are all different modes of communication. These are the basic umbrella forms of communication, but they can be broken down into more specific styles.

Face-to-face communication is the most common. This includes casual conversation between two or more people and business meetings. Face-to-face is a very easy communication style that everyone has experienced. It requires no extra materials, making this the cheapest option for communication. It is also instant, and you get the benefit of visual cues from the person or people to whom you are communicating.

Video communication is achieved by using Web cameras to connect two or more parties. This is the next-best communication option after face-to-face, as you get most of the same benefits. However, there is always the possibility of bad connections or other technical issues that hinder the communication.

Audio is a voice-only form of communication, such as a conversation on a telephone. This is a good instant communication tool if you catch the person instead of getting an answering machine or voice mail, but it does not have the benefit of allowing you to see the other person. It is also more difficult to include more than two parties.

Text communication includes Internet communication, such as email, instant messaging and forums, text messaging and printed papers. Text communication does not have the benefits of audio and video, but it is much easier to distribute information to a large group of people and save records of the communication.



EDUCATION, RESEARCH AND DEVELOPMENT

It has to be recognized that for developing countries like Zambia, to make major progress in social and economic development, there is need to invest significant effort and resources in the education system. Zambia's education system in rural areas is currently under resourced, with a substantial section of the population without access to high school and tertiary level education as well as professional training. Therefore, a significant percentage of the population is education attainment required for meaningful contribution to national development.

Against this background, there is great need to integrate ICT in the education system and develop the nation's research and development (R&D) capacity to support, facilitate and contribute to the development of key sectors of the national economy.

At local levels in rural areas, teachers spend a lot of time and money travelling to their district headquarters for either administrative programs or to get their salaries. Such is needed due to lack of proper communications due to lack of ICT facilities or services. They usually come back without meeting their supervisors or without collecting salaries.

There is great need to have Internet at every school to improve on teacher's output and expose pupils to internet at the early stages of their education. This will enhance the research component as it will cover wider and deeper areas of our rural communities and

researchers will see the challenges of introducing ICT at grass roots level.

CULTURE AND HERITAGE

Access to information through Internet forms the basis for creating an information society. Therefore the availability of 'internet access points' to the members of the communities is as important as the information itself. Development and exploitation of ICT supports rural development, community based initiatives and projects.

Information on our Cultural Heritage is passed from one generation to another by oral means. This means over a period of time, the information could either be misrepresented or misinterpreted or indeed diluted. There is therefore great need to introduce and promote ICT in rural areas to safeguard African Cultural Heritage , also through the Internet. This was discussed during the Lwiindi Ceremony. Apart from safeguarding our Cultural Heritage, the use of internet in rural areas will enhance our ability to communicate this heritage to the internal communities for their benefit and the social and economic advancement of our country.

The emphasis should be to promote wide spread public access to information through appropriate traditional and new technology solutions based on relevant local content while promoting cultural heritage.

HEALTH CARE DELIVERY

The performance of the health care delivery system over the years has been affected by communication problems. This is mainly due to distances between health delivery points and administrative centre, just like in the education sectors. This draw back has affected the delivery of drugs, messages and date collection/dissemination. Most specialist like doctors, nurses and teachers are confined to the line of rail leaving rural areas to cope with very inadequate staff levels.

It is important to note that the introduction of internet in rural areas will play a vital and effective role in the organization and delivery of heath care health services. The emphasis here will be to improve access to quality health care

as close to the family as possible through the development and exploitation of internet and other modern technologies since the existing of communications between health centres and administrative centres are inadequate.

AGRICULTURE AND DEVELOPMENT

Agriculture is Zambia's economic backbone as it plays an important role in the social and economic development in many Zambian communities. There is need to integrate ICT in the agricultural sector through the use of internet in the planning, implementation, monitoring and the information delivery process.

TOURISM, ENVIRONMENT AND NATURE RESOURCE MANGEMENT

The tourism sector constitutes one of the economic pillars of Zambia's economy, this includes both wildlife and no-wildlife tourism.

Over the recent past, Zambia has positioned herself well in the tourism market. By its very nature, the tourism sector is well suited for integration and application of ICT which potentially enhances marketing of tourism products and services, will increase efficiency and effectiveness of transactions, and service delivery. It is, therefore, necessary to introduce internet in rural areas for the development of the tourism industry and facilitate the conservation of our natural resources and Cultural Heritage as well as to protect the environment.

MAINSTREAMING YOUTH AND WOMEN ISSUES

The successful penetration of internet with existing social and economic structures depends on its people. Usually in most of our communities youths and women are heavily marginalised. However, in most activities they constitute a very important segment of society. They are actually the majority in all communities. Therefore, there is need to address youths and women as special groups in society that positively contribute to the growth of ICT as as well as the use of Internet as empowerment tools in their daily activities. It is becoming very clear that we have to use Internet as an instrument to mainstream youths and women issues in most activities of the rural economy

and society and to empower youths and women through opportunities created by implementation of ICT projects and programs in the rural areas.

TELECOMMUNICATIONS AND SUPPORTING INFRUSTRUCTURE

It is commonly understood that ICT infrastructure encompasses telecommunication networks, radio and TV transmission systems, the internet and other multimedia delivery platforms. It should be generally acknowledged that transmission networks for radio, telephone, TV and internet are the basis for mass media development. This is further enhanced by associated physical infrastructure such as roads, electricity and general utilities. With respect to ICT, lack of reliable, widely distributed and and high capacity date network for data, sound and video has contributed to the low availability and penetration of ICT services as well as cost effective deployment of basic services especially in rural areas.

All this has resulted in inadequate or complete lack of telephone and internet services, high start-up costs and long bureaucratic procedures for radio, especially community radio and TV broadcasting. The major emphasis here is to increase access and promote widespread deployment of ICT services through the expansion of the nation's telecommunication back bone infrastructure covering the remotest part of Zambia.

The opening of Vision Community Radio Macha and internet services offered by LinkNet are efforts which need to be supported by all stakeholders and promoted to enable them expand their catchment areas from Chief Macha, into other chiefdoms such as Chikanta, Muchila, Hachitema, Mapanza, Shezongo, Singani, Nalubamba, and Moonze. The new catchment area would house more than 65 basic schools and slightly more than 13 Rural Health Centres and 15 palaces.
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IMPORTANCE OF TRANSPORT AND COMMUNICATION IN ECONOMIC DEVELOPMENT

- Creation of employment opportunities.
- It has boosted trade links both local and international markets thereby earning income.
- Transport has promoted international understanding and relations which encourage sharing of ideas and borrowing of funds and international aid.
- It has boosted the tourism industry which is one of the main income earner for any country.
- Has facilitated exchange of technology which is important for industralisation.
- It is the avenue for economic development since all other income sources rely on it.

UNIT V

PROCESSING AND MANUFACTURING INDUSTRIES

Difference between Processing and Manufacturing Industries

Production is the process of converting inputs into outputs through various operations. All the operations that demands consumption of resources together is known as manufacturing. Both the terms are used interchangeably yet both are different axioms.

The difference is in the raw material.

In production, the raw material is not procured from outside, the company owns it and after processing, makes the final product.

But in Manufacturing, the company procures the raw material from outside, and then makes the final product.

Manufacturing is a process of converting raw material in to finished product by using various processes, machines and energy.it is a narrow term.

Production is a process of converting inputs in to outputs.it is a broder term.

Every type of manufacturing can be production, but every production is not a manufacturing.

Exa- making of a turbine by various processes is manufacturing

Assemble the various parts to make an engine is production not manufacturing.

Manufacturing is producing the product; it includes other stages such as design, sales, management and marketing.

Factors Influencing the Location of Industries: Geographical and Non-Geographical Factors!

Many important geographical factors involved in the location of individual industries are of relative significance, e.g., availability of raw materials, power resources, water, labour, markets and the transport facilities.

But besides such purely geographical factors influencing industrial location, there are factors of historical, human, political and economic nature which are now tending to surpass the force of geographical advantages. Consequently, the factors influencing the location of industry can be divided into two broad categories i.e.

(I) Geographical factors, and

(II) Non-geographical factors.

I. Geographical Factors:

Following are the important geographical factors influencing the location of industries.

1. Raw Materials:

The significance of raw materials in manufacturing industry is so fundamental that it needs no emphasising. Indeed, the location of industrial enterprises is sometimes determined simply by location of the raw materials. Modem industry is so complex that a wide range of raw materials is necessary for its growth.

Further we should bear in mind that finished product of one industry may well be the raw material of another. For example, pig iron, produced by smelting industry, serves as the raw material for steel making industry. Industries which use heavy and bulky raw materials in their primary stage in large quantities are usually located near the supply of the raw materials.

It is true in the case of raw materials which lose weight in the process of manufacture or which cannot bear high transport cost or cannot be transported over long distances because of their perishable nature. This has been recognised since 1909 when Alfred Weber published his theory of location of industry.

Some of the industries, like watch and electronics industries use very wide range of light raw materials and the attractive influence of each separate material diminishes. The result is that such industries are often located with no reference to raw materials and are sometimes referred to as 'footloose industries' because a wide range of locations is possible within an area of sufficient population density.

2. Power:

Regular supply of power is a pre-requisite for the localisation of industries. Coal, mineral oil and hydro-electricity are the three important conventional sources of power. Most of the industries tend to concentrate at the source of power.

The iron and steel industry which mainly depends on large quantities of coking coal as source of power are frequently tied to coal fields. Others like the electro-metallurgical and electro-chemical industries, which are great users of cheap hydro-electric power, are generally found in the areas of hydro-power production, for instance, aluminium industry.

As petroleum can be easily piped and electricity can be transmitted over long distances by wires, it is possible to disperse the industry over a larger area. Industries moved to southern states only when hydro-power could be developed in these coal-deficient areas.

Thus, more than all other factors affecting the location of large and heavy industries, quite often they are established at a point which has the best economic advantage in obtaining power and raw materials.

3. Labour:

No one can deny that the prior existence of a labour force is attractive to industry unless there are strong reasons to the contrary. Labour supply is important in two respects (a) workers in large numbers are often required; (b) people with skill or technical expertise are needed. Estall and Buchanan showed in 1961 that labour costs can vary between 62 per cent in clothing and related industries to 29 per cent in the chemical industry; in the fabricated metal products industries they work out at 43 per cent.

In our country, modem industry still requires a large number of workers in spite of increasing mechanisation. There is no problem in securing unskilled labour by locating such industries in large urban centres. Although, the location of any industrial unit is determined after a careful balancing of all relevant factors, yet the light consumer goods and agro-based industries generally require a plentiful of labour supply.

4. Transport:

Transport by land or water is necessary for the assembly of raw materials and for the marketing of the finished products. As industrial development also furthers the improvement of transport facilities, it is difficult to estimate how much a particular industry owes to original transport facilities available in a particular area.

2. Government Policies:

Government activity in planning the future distribution of industries, for reducing regional disparities, elimination of pollution of air and water and for avoiding their heavy clustering in big cities, has become no less an important locational factor.

There is an increasing trend to set up all types of industries in an area, where they derive common advantage of water and power and supply to each other the products they turn out. The latest example in our country is the establishment of a large number of industrial estates all over India even in the small-scale industrial sector.

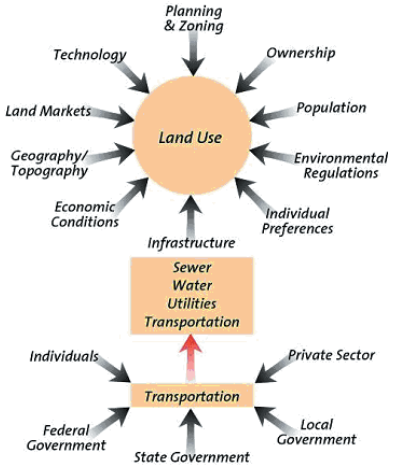

*Figure.**** Factors Influencing Land Use and Development*

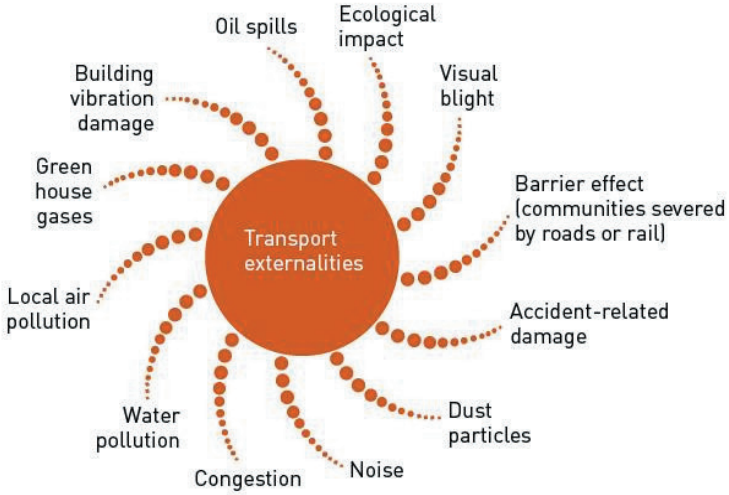

*Figure.**** Factors Influencing Transport Externalities*

Factors Influencing Industrial Location

Generally, location of industries is influenced by economic considerations though certain non-economic considerations also might influence the location of some industries. Maximisation of profit which also implies cost minimization is the most important goal in their choice of particular places for the location of industries. There are several factors which pull the industry to a particular place. Some of the major factors influencing location are discussed below:

1. Availability of raw materials: In determining the location of an industry, nearness to sources of raw material is of vital importance. Nearness to the sources of raw materials would reduce the cost of production of the industry. For most of the major industries, the cost of raw materials form the bulk of the total cost. Therefore, most of the agro-based and forest-based industries are located in the vicinity of the sources of raw material supply.

2. Availability of Labour: Adequate supply of cheap and skilled labour is necessary for and industry. The attraction of an industry towards

labour centres depends on the ratio of labour cost to the total cost of production which Weber calls 'Labour cost of Index'. The availability of skilled workers in the interior parts of Bombay region was one of the factors responsible for the initial concentration of cotton textile industry in the region.

3. Transport Facilities: Transport facilities, generally, influence the location of industry. The transportation with its three modes, i.e., water, road, and rail collectively plays an important role. So the junction points of water-ways, roadways and railways become humming centres of industrial activity. Further, the modes and rates of transport and transport policy of Government considerably affect the location of industrial units. The heavy concentration of cotton textile industry in Bombay has been due to the cheap and excellent transportation network both in regard to raw materials and markets.

4. Power: Another factor influencing the location of an industry is the availability of cheap power. Water, wind, coal, gas, oil and electricity are the chief sources of power. Both water and wind power was widely sought at sources of power supply before the invention of steam engine. During the nineteenth century, nearness to coal-fields became the principal locating influence on the setting up of new industries, particularly, for heavy industries. With the introduction of other sources of power like electricity, gas, oil, etc. the power factor became more flexible leading to dispersal and decentralization of industries.

Power: Initially, industry had to locate right beside its power source. Water power was used at first, and then the burning of coal produced steam power. Both sources of energy restricted where industries could locate, as they had to be beside a suitable river or near the coal field. Now, industries can gain their power from the National Grid and so power does not really influence location a great deal.

Raw Materials: Old, heavy industry required large amounts of bulky raw materials, which were very costly to transport, and so the industry located close to them. Newer industries are described as being **footloose**, as they are not tied by being near raw materials, which are smaller and easier to transport.

Government policy: Governments can greatly influence the location of industry, by giving tax incentives, cheap rent and other benefits to companies locating in certain areas of the country. Often these are places, which the government wants to develop economically.

Government policy also leads to the closure of many of the heavy industries in the United Kingdom, such as numerous coal mines and ship building yards.

Labour Supply: Very important to old, labour-intensive industries. This is why many of them located in the inner cities, so that there was a huge pool of potential workers close by. With the growth in car ownership, and industries becoming more mechanised labour supply is not such an important factor for most industries. However, some industries rely on it.

The Impact of Privatisation on the Zambian economy

From 1975 Zambia's economy underwent a world record breaking decline. Between the periods 1970-1975, 1976-1990 and 1991-1999, per capita GDP fell by -0.8, -3.1 and -7.2% respectively. A large share of the blame for this disaster can be put at the feet of the collapse of the world price of copper. Mining's contribution to national GDP fell from 16.5% in 1994 to 11.8% in 1997, the year privatisation started. In the next five years it fell further, to just 7.9% in 2002. This figure was at least rebounding a little, and though more up to date figures are not available, we can assume that the rebound has continued, on the basis that production and profits have done.

Mines privatisation was claimed to hold the key to turning the economy around in the medium term. Firstly, it was said, taking responsibility for what had become a loss-making industry out of Government hands would reduce the burden on the Zambian state. Secondly, if reinvestment could make the industry profitable again, it was hoped that new taxes would flow into state coffers,that the companies would train the Zambian workforce up to international standards, and new linkages would be made to local firms.

However, it was always possible that new companies would 'revive' the profitability of the copper industry without reviving the national economy. If the companies made themselvesprofitable principally by cutting back the workforce, reducing wages and stripping the assetsof the mines, before leaving the country with their profits, without re-investing, Zambiawould benefit not at all. Something similar had already occurred in the Zambian steel andtextile industries, in which most privatisations had involved asset stripping and then companiesquickly selling up and leaving. The Development

Agreements for the copper mines weretherefore designed in part to counter this risk. They committed the companies to makinginvestments in the first few years of their ownership.

However, one of the first problems with Zambian privatisation to show up was the absenceof constraints on companies to encourage them to adopt a longer-term perspective ratherthan making a quick buck and getting out. Anglo-American and Binani pulled out completely,early in the process, without suffering any significant regulatory penalties. Nonetheless, aswe have already seen, overall the privatisation did bring in new investments

Foreign ownership

The clearest impact of privatisation is that it places ownership of the copper mines in privatehands, rather than being in the control of Government, and in Zambia's case, becausethere are few if any Zambian companies with enough wealth to buy a copper mine, it placesownership in the hands of foreign firms rather than Zambian nationals. This makes it likelythat profits from mining leave the country without having any positive impact on the Zambian economy, and, rather than being re-invested in building up the national economy, will beplaced in banks or re-invested in companies outside the country. As the Permanent Secretary notes, "Today the public is saying that these large-scale mines are now with foreigners.Mining is the backbone of the Zambian economy, so the backbone is in foreign hands.What about us nationals - can't we participate in ownership? Government should have putin place measures to allow Zambian private individuals to participate in the ownership of these mines."

There is one obvious problem. There are not very many individual Zambian nationals or nationally-based companies with sufficient capital to make a go of taking over and investing in the rehabilitation of a major mining company. The original privatisation model did attempt to provide some wider 'participation' of Zambians in the process. The idea was that ZCCMInvestment Holdings (ZCCM-IH), would be set up as a state-equity company, holding minority interests in each company. The company would therefore make some money for the state as the mines became profitable. At a later date, the aim was somehow to widen the shareowning base of ZCCM-IH. This has not yet happened, and asked how to increase local participation in the mining sector, the Permanent Secretary recognised that ideas about how to proceed are thin on the ground. "It's a challenge. How can one do it?

Provide loan facilities or do what? Well the feelings of the population at large is that they would wish they had participated and that Government should have come up with measures to make that possible. Of course they don't explain how Government would have done it. They just want the Government to have thought of something. I think it's possible to use ZCCM-IH as a vehicle for individual Zambians to own shares in those mines. So something creative could have been worked out. There are opportunities. It's not impossible to come up with measures to let nationals participate in large scale mines. It just takes some exercise of the mind."

The tax takes from Zambian mining

Placing the mines in private hands means that any income to the state is not directly from sales and profits from the mines, but rather from any taxes that can be levied on the companies – in the form of income tax for employees, VAT paid on services purchased by the mines, border taxes paid on imports and exports, corporate taxes on profits, and mineral royalties on sales of copper. However, as we have seen, in their Development Agreements, the mining companies managed to negotiate exemptions from paying most of these taxes.

The World Bank argues that "The main feature of the mining sector is that most of theincentives are negotiated on a case-by-case basis by companies which have purchasedprivatized entities from ZCCM. This feature makes it difficult to analyse the sector as a whole.However, in general, mining contributions to total tax revenues are extremely small." Nonetheless, the Bank calculates an aggregate figure, called the 'Marginal Effective TaxRate' (METR) to describe how much each industrial sector is taxed and concludes that,"Because of the relatively low tax rates and significant incentives, the mining sector enjoysan METR of around 0%. In particular, the expensing of many equipment purchases andmoderately accelerated depreciation deductions for the rest, the METR on machinery reflectsthe largest subsidy (-18.3 percent) received in any sector for any asset." Mining is themost favoured sector in the Zambian economy, a source of significant resentment as theGovernment is thus favouring international investors over local business owners.

Fig. 2: Comparative Marginal Effective Tax Rates for different industrial sectors in Zambia

Mining 0%

Tourism 0-10%

Manufacturing 0-10%

Small Businesses 20-25%

Financial 25-35%

Even the Chamber of Mines own statistics, presented to make thecase that tax on the mines should not be increased, demonstrate that, while the revenuegenerated for Government from mining has increased since ZCCM's nadir in the secondhalf of the 1990s, the 2005 contribution, of around $75 million, is less than one third ofthe contribution made to the national treasury by ZCCM in 1991.

The mining industry does contribute to government revenue through the taxes paid by its employees in form of income tax. However, in their Development Agreements, companies negotiated to pay lower corporate tax rates than apply to other industries. Because they are also able to roll losses from previous years forward and to write off profits that would have been taxable, the mining sector barely contributes at all. As shown in Appendix 8, mining contributes less corporation tax than smaller sectors such as the financial services and telecoms sector. The mining sector also claims back from the Zambian Government all of the VAT that it pays on goods that it buys locally. Since the company from which these good were initially bought will have paid the VAT aspect of the price charged to the Government, and the Government then pays that back to the purchaser, VAT contributions show up as a minus figure – a subsidy from Government to the mines.

In 2006, one company, First Quantum, which is still well within the period of the tax holiday provided by its development agreement, decided that the situation was embarrassing and decided to start paying tax, contributing $19million to the Zambia Revenue Authority. The companies also argue that, although the tax income so far has been very low, their ability to write off investments against profits will soon come to an end, and the Zambian state will benefit more. They also point out that there are a number of other ways in which the Zambian state benefits. Written into the Development Agreements are 'price participation' clauses, under which, as the world price increases beyond a certain point, a larger share of income is paid to the state. Finally, through their minority interest in the companies, held by ZCCM-IH, the Zambian state has a stake in the companies. As and when the companies

start to reap major profits, dividends will also be paid to ZCCM-IH. The Chief Financial Officer at Mopani argues, “GRZ are going to benefit substantially from the various investments that the mining houses have made, and particularly Mopani. They are not going to benefit from it now in 2006, but 2008 onwards they are going to see significant benefit. That's when the capital allowances have been used for tax purposes, so then the tax is 25% and that is a significant amount of money to any regime...You're going to see a dramatic jump in 2-3 years time.

Bwana Mkubwa is already paying tax. I think they are forcecasting about US$150million next year and Mopani will join suit 2007 - 2008 so we've got to be very careful that GRZ aren't rushing to strangle the goose again before it lays its golden egg... The GRZ through the ZCCM-IH have had a free carry for the last five year. They've invested no capital but their 10% holding in the various companies has gone up. So when the dividends do get paid, which will be happening in the next year to two years, and they'll be reaping benefits far outweighing any attempt at a 2.5% royalty they're looking at. Now that doesn't happen anywhere else in the world."

Training of the local workforce

Mining companies can contribute to the Zambian economy by providing experience and training for their own management and workforce. However these benefits will only occur if the companies develop good human resources and training programmes and commit to building up the skills of Zambians, rather than employing expatriate workers in all of the senior and technical roles. As the CEO at Luanshya Mining argues, for many companies it may seem easier to bring in expatriate workers. He suggests however," There has got to be a conscience that says, those skills we accept - those ones no. And that I don't think is happening very effectively at the moment. There definitely is an inclination to employ expats where you actually have the skills in Zambia."

Foreign investors tended to bring in entirely new management teams at the moment of their purchase of the mines. They seem to have been able to do so because Zambian labour laws are antiquated. While the IMF suggests that Zambia simply doesn’t have a labour market law, one ex-miner noted, “The labour laws date from the 1960s. We have had two new Republican Constitutions since then. How can we not have changed the labour law?” The IMF goes on, “The current labour laws are also weak on the engagement of expatriate staff by new investors

and the differences between their incomes and those of local staff. Many new investors take advantage of the situation by recruiting their managers in management positions and paying them heftily, compared to local experts of similar qualifications and experience."

This situation has created significant resentment, as much of the most educated and skilled workforce from ZCCM was laid off. Many of those Zambians have left the country and taken their skills and knowledge with them. As already noted this is still the situation at firms such as NFCA that employ just one Zambian manager and even bring in shift bosses from China. However, other companies clearly are making an effort to redress the situation. Vedanta brought in Indian management wholesale after they bought KCM. However, they are now altering the balance, and have identified 40-50 Zambian 'young business leaders' who they are fast-tracking on a management training scheme.

KCM claims to be the only company that has taken Zambian staff out of the country to work on its other international programmes, to gain international experience. KCM has also re-established something similar to the old ZCCM training scheme for the main workforce, recruiting 1,200 school-leavers from all around the country to be trained and to work at KCM. Many of the company executives interviewed expressed similar views on the issue – arguing that total numbers of expats were low and dropping, blaming a lack of trained Zambian workers on the country's educational and training systems, and arguing that they have no desire to hire from outside Zambia. As the resident Director at KCM put it, "I have absolutely no interest in bringing in Chinese labour if it's not necessary. The contractor has absolutely no interest in bringing in expensive expat labour if a local could do it."

Linkages from the mines to other industries

There are a range of wider expected impacts of privatisation to the Zambian economy other than the tax paid to Government. Firstly, if new investment revitalises the mining industry, the mines should need to buy more goods and services from local firms. This should multiply the effects on employment and wages. Secondly, by lowering costs of production and introducing new technologies, the new companies might be able to make new linkages to manufacturing industries, set up around the mines to process the copper into basic electrical goods.

One of the reasons that the collapse of employment in ZCCM had such a devastating impact on the Copperbelt region, with many of the main urban centres becoming ghost towns, is that the mines sit at the centre of trading networks with a huge number of other local businesses. The mines themselves buy in food, cleaning, security, building materials, petrol etc. from outside suppliers.

There is a widespread belief amongst local firms on the Copperbelt that the management of the new companies distributes contracts on a less-than transparent basis to companies in which they themselves already have an interest. It was not possible to confirm this theory and a range of alternative explanations also present themselves:
- Problems of supply and stock-holding for local companies make it difficult to meet the short notice demand of multinational companies. The situation is cyclical. Once local companies lose confidence that they might be approached for a particular good, they will stop stocking it. As a result, as the Chairman of the local Chamber of Business notes, “they will come to you, and say we want this, like yesterday, and when you fail to supply, they will say you are not efficient.”
- Finally, once a machine has been purchased from a foreign company, servicing and repairs will also typically come from the same source, at least for the first five years where a guarantee is in place.

There have been some efforts to resolve these problems. For example, there is now a mining liaison committee in the Chamber of Commerce and the group is running an exercise with KCM to try and match KCM’s needs to local manufacturers of goods such as foundry, fabrication and machinery products which have been produced locally for many years. However, there is a huge lack of trust between even the Chamber of Business and the mine owners. This results on the part of the owners in part from corrupt practices that emerged in the chaos of deregulation and the rush by a huge number of ‘briefcase businessman’ that competed in the early years of privatisation for contracts from the mines.

As the Chairman of the Chamber of Mines notes, “In the past we had a system where every year, all the registered companies were given a questionnaire and were registered here and that questionnaire would ask you what you supplied and many other things. They would ask you for your address and bankers and they could counter-check that information. But now they have destroyed that system and lots of crooks have come on board."

While much of the focus in national debates has been on suppliers to the mines, it is also useful to think about the 'forward linkages that the copper mining industry could be developing in order to build up the Zambian economy. The most basic tasks of processing copper ore do mostly take place in the country. The rock is crushed and concentrated next to the mines. It is also usually smelted into flat sheets of copper, called cathodes, which are convenient for transporting and exporting copper. As new ore bodies are discovered and mined, both in Zambia and in the DRC, Zambia is trying to position itself as the place to smelt these ores and to manufacture them. However, this is not true of all the mines. For example, Chambishi Mines do not have a smelter, and having encountered difficulty getting other local smelters to process their concentrates, are exporting the concentrates to Namibia. As NFCA management recognise, they are literally exporting jobs. As an MUZ representative noted, "despite our proximity to the ore body, our tax structure and the treatment charges appear not to have been very competitive."

Wildlife & Tourism

If you were of the opinion that cultivated plants and domesticated animals is what wildlife consists of, you are mistaken. Wildlife, in fact, comprises of the innumerous varieties of wild plants, animals, fungi and microorganisms that exist on our planet earth, rather than just cultivated plants and domesticated animals.

Knowingly or unknowingly, we largely depend on this wildlife for every elementary requirement in our life. The food we eat, the clothes we wear, the medicines we consume, a variety of building materials used for construction, numerous chemicals used for manufacturing our necessities, all are extracted from the wildlife existing around us. A study by the American Association for the Advancement of Science indicates that as many as 40,000 species of plants, animals, fungi and microscopic animals benefit us in some way or the other. To know the various benefits that this wildlife provides us, read on further.

The **wildlife of Zambia** refers to the natural flora and fauna of Zambia. This article provides an overview, and outline of the main wildlife areas or regions, and compact lists of animals focussing on prevalence and distribution in the country rather than on taxonomy. More specialised articles on particular groups are linked from here.

What is the importance of Forests and Wildlife?

Forest has been of great importance to mankind since prehistoric days. Sixty percent (60%) of the earth once covered with forest. With the development of civilization, large areas have been cleared to make way for farms, mines, towns and roads. Today about 30% of earth is still forested.

The economic value of forests, supply many products like wood from trees as lumber, plywood and fuel wood or charcoal. Timber is used in furniture making, building houses, ships and railway sleepers. Pulp and paper are made from the cellulose of trees. Processed wood products include cellophane, plastics, synthetic fibers like rayon and nylon. Latex from trees such as the rubber tree goes to make tyres, tunes and a wide range of rubber goods.

Other uses; fruits, nuts (balls) and spices are gathered from the forest. Many medicinal plants such as camphor, cinchona, coca (from which the drug cocaine is extracted) also come from the forests. Cork from the thick bark of the cork oak is stripped for making bottling cork.

Forests help to conserve soil by preventing rapid runoff of water after heavy rain and minimizing flooding. Trees take in carbon dioxide and release oxygen into air, which is a great benefit to mankind. Forests influence local and global climate. The forest is also vital as a watershed. Because of the thick humus layer, loose soil, and soil-retaining powers of the trees' long roots, forests are vitally important for preserving adequate water supplies.

The wild animals and other beings get enough protection from the solar heat, temperature and the leaf cover formed on the earth gives cooling effect to the earth. Since trees absorb heat, we shouldn't cut them down. Natural wildlife is important because it is part of the natural circle of life. If bears start to die, as it would be too hot without trees/forests} than the trout are going to become overpopulated and other scavengers that rely on bears will begin to starve. Without eagles and other birds of prey, rodents' population will increase which will cause more rodents in the cities and towns.

Forests offer privacy, reduce light reflection, offer a sound barrier and help guide wind direction and speed.

• Forest help in giving the direction of wind and its speed.

• Forest helps in keeping environment healthy and beautiful.

• Forests also minimize noise pollution. They help in the occurence of rainfall,reduces soil erosion

Zambia wildlife sector policy: situation analysis, policy recommendations

Zambia is endowed with an abundance of natural resources that include, water, forests and wildlife. The country's wildlife resources are managed through government-supported National Parks and Game Management Areas (GMAs) and private sector game ranches. The main objective of this wildlife sector policy review is to consolidate the findings collected from an extensive bibliography published during the life of the current policy, and the analysis of key sector practitioners. The second objective is to analyze these findings with a view to formulating broad recommendations to inform the design of the new vision and new policy of the sector.

This document aims to identify policy issues that would provide a basis for the creation of an enabling environment for the development of the wildlife sector as a growth sector according to the Sixth National Development Plan (SNDP) and the vision 2030.

It contains five provisional priority recommendations that offer practical solutions and six strategic options which constitute policy objectives.

In conclusion, an improvement of the policy framework could have a large impact on how people and wildlife relate and coexist in Zambia.

This policy review confirmed that, while important policy measures are necessary, particularly for shared growth, the adoption of a forward looking wildlife policy and act will not be sufficient if it is not accompanied by unequivocal willingness on the part of Government to reorganize and strengthen Zambia Wildlife Authority's (ZAWA's) capacity and provide financing commensurate to its need.

- **Strategic options**

The foregoing recommendations are supported by a series of strategic options for the future Wildlife Policy and legislation that the

Zambian policy makers may wish to take into consideration. Key options are discussed below.

1. Financing of conservation – Given thatlack of financing is identified as one of the main causes for ineffectiveness of the current Wildlife Policy, the new policy could have a provision that unequivocally apportions to Government the main responsibility for financing the difference between an agreed realistic recurrent cost ceiling for managing the public wildlife estate and revenues generated from competitive statutory and other charges within it. The new Wildlife Policy could also articulate the respective roles of the Government, the Ministry, ZAWA, civil society and the private sector, in raising funds for the development and management of the public, community and private wildlife estate.

2. Citizen empowerment - The new Wildlife Policy should address the need for deliberately encouraging and training Zambians and Zambian businesses to get involved in the tourism industry including its wildlife sub-sector, the management of protected areas and in game farming. Regarding investment, it would be preferable that such encouragement could take the form of tax breaks, reduced licence fees, or scholarships in order to maintain a degree of competition.

3. ZAWA's role - With the emergence of 'business centres' to run the affairs of national parks, and following the recommendations for protected area reclassification, developing various forms of partnership and modification of GMA governance, the policy should recognise that ZAWA's role will evolve. In some cases, it will remain a *managing institution* (for the parks that remain managed by ZAWA), in others an *associate* (for the parks managed in partnerships), and in yet others a *regulator* (for the GMAs, forest reserves, game farms, game ranches, forest reserves and wildlife in the common areas). These roles should be clearly defined to avoid misunderstanding or potential conflicts of interest.

4. Incentive and market based mechanism - The new Wildlife Policy could provide for incentive and market based mechanisms for sustainable land management such as conservation easements, payment for ecosystem services, trade of carbon sequestration and purchase of development rights, where land holders agree to maintain their areas in a natural state while those benefiting from this maintenance agree to pay for this service. The policy could also recognise the respective wildlife land managers namely ZAWA in National Parks, Forest

Department in various forest reserves, communities in GMAs, private companies in game farms who are the land holders and resource owners as producers of ecosystem services. Such recognition would entail providing them with facilities to access compensation mechanisms in a variety of private or public deals under existing and emerging multilateral environmental initiatives such as the BioCarbon Fund, the Forest Carbon Partnership Facility, the REDD+ initiative and other climate change and environmental rehabilitation financing initiatives.

5. Community land trust, easements, and conservancies - The new Wildlife Policy should consider a variety of options for managing wildlife on land outside the wildlife domain but under customary tenure. On land that they allocate to a form of wildlife-based land use, communities could either (a) engage directly in CBNRM, (b) join forces with a private investor through a joint venture or a Community Private Partnership (CPP) or (c) delegate management to a professional private operator for a fee. In any such case, an option would be to secure the land in community land trusts. Another option would be to establish a conservation easement that does not affect tenure but legally prevents land transformation. The selected land can then be managed as a game farm, game ranch or wildlife reserve depending on the development objective and the commercial purpose. Conservancies are an option. They require land use and resource management planning on a substantial scale and delegation of resources ownership, tree and wildlife, to the conservancy itself.

6. Local Government - In line with the Decentralisation Policy, the new Wildlife Policy could have provisions for entrusting district councils with regulating hunting of wildlife in open areas that are not part of the public or private wildlife domain. The current Decentralisation Policy provides for the devolution of natural resource management and associated capacity to the district level. As the planning authorities and the secretariat of district development coordinating committees, district councils could play a key role in mainstreaming natural resource management in district development plans and budgets.

7. Other public entities- In line with the draft Forest Policy, the new Wildlife Policy could have provisions for entrusting the Forest Department with stimulating community and private sector involvement in forest management, including wildlife, as well as regulating hunting of wildlife and/or non-consumptive tourism in Forest Reserves. Other potential public partner entities would be the National Heritage

Commission, the Department of Fisheries, and the Department of Water Affairs - all of which could be encouraged to become involved in managing wildlife on the land or water that they administer.

8. Special Licences – To improve transparency in the allocation of public wildlife quota, the new Wildlife Policy should restrict, or even cancel altogether, the 'Special Licence' (a discretionary hunting licence delivered by the MFAT and not ZAWA). The need for game meat for special occasions such as traditional ceremonies could be planned by ZAWA within the official public quotas and, with the emergence of game ranching, game meat for special occasions should be procured from private sources either directly or through prior arrangements between wildlife producers and communities. Where communities enterprises are in joint ventures with the private sector in game ranching as it is envisaged, communities will themselves gradually become suppliers of game meat.

9. Role of Non-Governmental Organisations – In complement to Government efforts, Non- Government Organisations (NGOs), especially international NGOs, have contributed significantly to conservation in Zambia. Their role would benefit in being encouraged and facilitated. The new Wildlife Policy should provide guidelines for effective engagement with NGOs based on identified areas of need, capacity and opportunity. This engagement should be on the basis of negotiated agreements with clear problem definition, interventions and realistic performance targets.

In conclusion, an improvement of the policy framework could have a large impact on how people and wildlife relate and coexist in Zambia. Most certainly, the wildlife estate already is a significant contributor to livelihood, economic growth and employment. Yet, the potential of the wildlife sector to contribute to economic growth may be at risk. This policy review confirmed that, while important policy measures are necessary, particularly for shared growth, the adoption of a forward looking Wildlife Policy and Act will not be sufficient if it is not accompanied by unequivocal willingness on the part of Government to reorganise and strengthen ZAWA's capacity and provide financing commensurate to its need.

Location of Major Tourism Attractions in Zambia

National Parks in Zambia

About 30 % of Zambia's 752,614 square kilometers is reserved for wildlife. There are 20 national parks and 34 game management areas in the country. South Luangwa, Kafue and Lower Zambezi rank among the finest game parks in the world.

Luambe, and Lukusuzi Liuwa Plain, West Lunga, Sioma Ngwezi, and Nyika Plateau have substantial wildlife but are still undeveloped. Mosi-oa-Tunya, near Victoria Falls, is regarded as a Zoological park as it has a well managed population of antelope, elephants, giraffe and rhino, but does not have any predators.

Isangano, Lavushi Manda, Lusenga Plain, and Mweru Wantipa have never had management or facilities and have little wildlife but are still worth a visit by intrepid explorers and birdlovers. The newest Park to be proclaimed is Lusaka National Park, just outside the capital. It is currently being developed and will be open in 2014.

In approximate order of importance in terms of wildlife resources, the 9 main functioning parks, all with access and accommodation are:

Popular Parks (alphabetically)

- Kafue National Park
- Kasanka National Park
- Lochinvar National Park
- Lower Zambezi National Park
- Liuwa Plains National Park
- Mosi-oa-Tunya National Park
- North Luangwa National Park
- Nsumbu National Park
- Sioma Ngwezi National Park
- South Luangwa National Park

Smaller parks (alphabetically)

- Blue Lagoon National Park
- Lavushi Manda National Park
- Luambe National Park
- Lukusuzi National Park
- Lusenga Plains National Park
- Mweru Wantipa National Park
- Nyika National Park
- West Lunga National Park

The national parks are administered by ZAWA, the Zambia Wildlife Authority,

Spectacular Waterfalls

Zambia is one of the most water-rich countries in Africa and her many rivers cascade into fabulous displays of falling water as they wind over the undulating landscape. The most spectacular is of course the not-to-be-missed Victoria Falls, but there are 17 other beautiful falls dotted around the country. Waterfall Tours are becoming a popular trip providing access to these out of the way delights as well as opportunities to see rural village life in Zambia.

Northern Waterfalls

The northern provinces of Zambia are very remote and uncommercialised. A two or three-week self-drive circuit from Lusaka is the only practical way to explore these off the beaten track areas of the country. The northern waterfalls are like finding the treasure chest from a secret map. Many of them have no tarred roads leading to them so it is quite an adventure locating them. The local villagers are always helpful and will tell you what they know about the traditional lore behind each waterfall, all of which are viewed as sacred places. Several operators offer tours around these areas and include visits to local villages to get a feel of authentic rural life in the beautiful unspoiled Zambian countryside.

Major Waterfalls (alphabetically)

- Kalambo Falls
- Kundalila Falls
- Lumangwe Falls
- Ngonye Falls
- Victoria Falls

Smaller Waterfalls (alphabetically)

- Chipembe Falls
- Chipoma Falls
- Chisimba Falls

- Kabweluma Falls
- Kundabwika Falls
- Mumbuluma Falls
- Mutumuna Falls
- Ntumbachushi Falls
- Nyambwezi Falls

Vast Lakes in Zambia

Despite being landlocked, there can be few places in the world as blessed as Zambia when it comes to water resources. And the nation's vast and beautiful lakes are as breathtaking as the mighty

Zambezi River and Victoria Falls. Lake Tanganyika is the longest lake in the world, while Lake Kariba is Africa's largest man made dam and rapidly becoming Zambia's very own French Riviera. For the more intrepid traveller, the tropical and wild Lake Mweru offers a fascinating glimpse of village lif that lines the shores of this vast lake in th far north…overall, they are well worth a visit.

Lakes

- Lake Bangweulu
- Lake Kariba
- Lake Mweru
- Lake Tanganyika

Rich Rivers

Blessed with 3 major rivers, several substantial tributaries, and many smaller rivers, as well as vast natural lakes and the enormous Kariba dam, Zambia is one of the most water rich countries in Africa. The source of the Zambezi is in northwest Zambia and runs through the Barotse Floodplains until it forms the border with Zimbabwe. After providing power from Kariba Dam, it is joined by the Kafue River and later the Luangwa before heading out to the Indian Ocean. The Kafue and Luangwa Rivers are the life blood of the Kafue and Luangwa National Parks, teeming with hippos, crocodiles, water birds and plains game coming to drink. Many other rivers traverse the country with an abundance of delightful waterfalls.

- Kafue River
- Luangwa
- Zambezi River

Major Towns

Zambia is one of Africa's most urbanised countries, with over 44% of the population living in its towns and cities. And as Zambia's economy continues to grow (at one of the fastest rates in the developing world), it seems this trend will increase in years to come, with more and more poor rural dwellers moving to urban areas, many of which have already seen substantial development since the 1990s.

The capital Lusaka is at the core of this movement and has become one of Africa's fastest growing cities. The steady increase of tourism throughout the country as a whole has brought further development and better tourist infrastructure to once small provincial towns like Livingstone and Chingola, as well as to commercial and industrial centres like Ndola and Kitwe.

With all this in mind, in many of Zambia's towns and cities there is a sense of restlessness and perpetual motion, complimented by an increasingly cosmopolitan mix of people, cultures and commodities from all over the country and far beyond its borders too. To overlook Zambia's urban centres is to overlook the people of Zambia.

Some towns and cities in Zambia (alphabetically)

- Chingola
- Kitwe
- Livingstone
- Lusaka
- Ndola
- The Copperbelt

Tourism Policies

Local and regional authorities were asked if they had knowledge of the Zambia Tourism Policy. There is no statutory requirement for a Tourism Policy, the publication of one indicates a strong community interest and local government commitment to tourism, the survey revealed that 26 tourism institutions under at the three levels of planning and implementation level have knowledge of the tourism policies and other strategies.

The survey respondent's percentage outcome based on proximity to the study site revealed a lower understanding of the Tourism Policy. The respondents' percentage figure trends shows 33% of CBNRM respondents had knowledge of the policy and the trend rise in the knowledge of Tourism Policy and strategies by a significant rise at the main government ministry of tourism and government department agency ZAWA. This would appear to indicate that the effect of the national tourism strategy better understood at the core ministry and department and less appreciated or limited knowledge at local

community level to develop and adopt strategies. Respondents with no knowledge of the Tourism Policy stated that all tourism matters delegated to the MTENR or ZAWA. Findings suggest that despite major tourism activities taking place in Livingstone and its surrounding areas, the local population have never come across the earmarked Livingstone greater area plan for sustainable development, but could be encouraged if they had one. This could explain the reason for low response from at local community level, and indicates a lack of interest in tourism development issues at this level, where tourism planning and policy issues were delegated to other bodies at ZAWA and MTENR.

Environmental Impacts

To fulfill the environmental requirements of sustainability, hunting tourism must be of value to conservation through the preservation of habitats and the protection of wildlife. Although protected areas afford this, they are not large enough to contain or maintain wide-ranging, viable animal populations. Alternatively, game reserves encompass a far greater area (highlighted in the earlier table), which could provide a greater network of protected areas for game species, facilitating an increase in population size and genetic variation between populations.

The economic success of hunting tourism hinges on the quality of the game species harvested, which in turn relies on the quality of the habitat to provide their environmental needs. Therefore, it is in the best interests of hunting operators to maintain pristine habitats for game species. Agricultural expansion is a major cause for concern among conservationists, as it leads to habitat fragmentation and ecological degradation. Game reserves play a pivotal role in protecting wildlife habitats, as they attach economic significance to land areas that would normally be utilized for agriculture. There is much evidence to suggest that hunting is less destructive than other nonconsumptive forms of ecotourism, such as photographic tourism. Hunters have less impact on the environment than photographic tourists as they require fewer local amenities and infrastructure, therefore reducing habitat degradation. The income generated from the hunting industry far exceeds that generated from other forms of ecotourism and is derived from fewer tourists, reducing their ecological impact while providing increased revenue for conservation initiatives. In fenced reserves the controlled hunting of overpopulated herds is an important aspect of habitat management, as this keeps animal populations below carrying capacity,

preventing ecological degradation. However, fenced reserves have received much criticism as they block migratory routes.

Although hunting opposition members argue that hunting by tourists will result in the widespread extinction of greater numbers of animal species, this is not necessarily the case.[15] Bontebok (*Damaliscus pygargus dorcas*), black wildebeest (*Connochaetes gnou*) and cape mountain zebra (*Equus zebra zebra*) have all been successfully reintroduced in South Africa as a result of financial assistance provided by hunting tourism. Similar success has been achieved with the southern white rhinoceros (*Ceratotherium simum simum*), and from 1968 to 1994 populations increased from 1,800 to over 6,370 on privately owned game ranches.

However, concerns have been raised about the evolutionary consequences of hunting, as the most sought-after trophy animals are usually those with the best physical characteristics. By removing animals with superior genes from a population the genetic integrity of that population is compromised, casting doubt over the long-term sustainability of hunting tourism.

Misconduct by game ranch owners threatens the hunting tourism industry's viability as an effective tool of conservation. Some game

ranch owners cross-breed closely related species to create unique trophy animals that would prove more desirable to hunters; examples of such hybrids include the red wildebeest and the white springbok. Such genetic manipulation that alters coloration can compromise an animal's ability to evade predation. To diversify the range of species available to hunters, outfitters have introduced exotic species to game ranches, which can facilitate habitat degradation and loss of biodiversity. Other forms of misconduct include hunting practices from which the trophy animal has little or no chance of escape, such as canned or put-and-take hunting.

The hunting industry is often considered self-regulating, as modest offtake is required to ensure trophy quality remains high over subsequent years. Nevertheless, this kind of exploitation carries the risk of reducing population size to a point where hunting is no longer profitable and in extreme cases leaves the species vulnerable to extinction. To avoid overexploitation, quotas are established to ensure hunting remains sustainable. However, due to a lack of resources, population estimates that determine quotas are often infrequent and the result of educated guesswork, relying on anecdotal evidence from professional hunters and wildlife officers.[31]

Quotas have also been criticized for their failure to acknowledge how animal breeding systems may affect the ability of a species to respond to hunting pressure. Caro et al. analyzed the affect of paternal care and infanticide on the sustainability of current hunting quotas and found both decrease the sustainable offtake. The detrimental effect of hunting on species that practice infanticide has been well documented in lions (*Panthera leo*), which are particularly susceptible to male offtake as the removal of pride-holding males increases juvenile mortality.

Due to the legal repercussions of the killing of game as a preventative measure for crop damage and livestock predation, it is difficult to ascertain how many animals are killed in these circumstances. In turn, this makes it equally as difficult to consider this when establishing quotas. In a review of the Selous game reserve, Caro et al. found that although most species were being hunted at sustainable levels, quotas for eland (*Taurotragus oryx*), hartebeest (*Alcelaphus buselaphus*), lion, reedbuck (*Redunca arundinum*), sable antelope (*Hippotragus niger*), warthog (*Phacochoerus africanus*), and waterbuck (*Kobus ellipsiprymnus*) were set at unsustainable levels. However, the author admitted that although retaliatory killings and illegal offtake are prevalent, these weren't taken into account due to the aforementioned

difficulties in estimating the number of animals killed. This suggests that the hunting pressures on game species perceived as problem animals may be greater than originally considered; therefore, quotas for such species should be reviewed to prevent conservation initiatives being impeded.

Corruption also plays a role in destabilizing hunting quotas, as corrupt officials are thought to provide wealthy hunters special permits which authorize quota exempt offtake. Furthermore, in Tanzania, quotas established by the Wildlife Department have been increased by government officials without adequate scientific justification.

Until more scientific measures are put in place to produce more accurate population estimates, the true toll that illegal offtake is taking may never be known and what is considered to be sustainable offtake may be nothing more than unsustainable exploitation.

Potential Threats to Tourism in Zambia

•Competition from well-developedneighbouring destinations [Mauritius and Seychelles]
•No formal climate change policy
•Over-exploitation of the coastal areas
•Lack of qualified and skilled labour
•Lack of funds for developing tourism products, tourism marketing
•Poor investment climate
•Visa requirement for Mayotte citizens makes it expensive to visit the other Islands

Tourism driven impacts on natural World Heritage

Tourism is often praised for its ability to reconcile conservation and development goals in or near protected areas (Ashworth & van der Aa, 2006; Figgis & Bushell, 2007). From a conservation perspective, tourism can raise funds for protecting natural areas, enhance local and tourist awareness of biodiversity and conservation issues as well as discourage local people from unsustainable livelihoods. From a development perspective, tourism revenue may reduce poverty by stimulating business development and job creation that is in principle compatible with biodiversity conservation as well as enhancing local services, and through improved education empower local people to advocate for the protection of the natural environment. However, if

tourism is badly planned and not managed responsibly, it can on the contrary lead to biodiversity loss, ecosystem degradation and negative impacts to local communities. It is therefore essential for tourism that takes place in protected areas to be managed correctly and uphold the principles of sustainable development. Furthermore, it should not be forgotten that the overall goal of a protected area is conservation and in the case of World Heritage Sites there is a particular emphasis on the protection, conservation and presentation of the features that are of OUV.

A recent IUCN study on developing biodiversity businesses explored to some extent the relationship between tourism and protected areas (IUCN, 2009). The study focused on IUCN NGO members that have set up small businesses to solve conservation problems and the majority of the businesses were tourism businesses. One of the key recommendations of the study which relates well to this discussion on impacts was the constant need to keep present the conservation objective behind tourism development. This needs to be clear when establishing the vision for the business and should be integrated in all components of tourism development. This is also vital in developing, managing and monitoring tourism in and around World Heritage Sites.
A study commissioned by the UK Lake District World Heritage Project (Redbanks Consulting & TBR, 2009) compared economic and social benefits of World Heritage inscription on a number of international sites. While it was confirmed as a positive catalyst for change, they found few benefits occur across all sites as a generic outcome of inscription. More effective conservation, partnerships, civic pride, social capital and investment gains seem to follow inscription but tourism advantage is not a given. If a site is already an established destination the effect can be negligible. They also note that averaging findings from studies tends to mask quite large differentials in motivation, actions and performance. And, that these are the more important determinants than inscription, on increases in tourism.

Overall, the research demonstrated that there is a mixed picture of tourism development in Natural World Heritage Sites. It was found that in some cases tourism development is well-planned and occurs in a sustainable manner, whereas in others development occurs rapidly and often without planning or appropriate regulatory control. As expected, an upward trend in visitor numbers which frequently accompanies nomination can be problematic if the correct site protection mechanisms are not in place. In the sites with tourism-related problems, the key negative impacts observed were visitor pressures from unsustainable

growth in numbers, invasive/destructive infrastructure development, pollution and social impacts deriving from unrealised expectations. On the other hand, when tourism was well-planned some positive impacts of tourism were achieved including, infrastructure and other developments that enhanced the OUV of the site, as well as conservation and community development goals being supported. Table 2 gives an overview of the tourism-driven impacts of the 12 sites selected and Appendix III provides a more detailed account of these.

3.1 Negative impacts (Threats)

In regards to negative impacts of tourism development, some common trends were reported. Increased visitor pressure is seen as one of the key issues associated with World Heritage Site status and can have severe consequences for the integrity particularly when the increases are either unplanned or very rapid, outstripping the capacity of site infrastructure and management systems to cope. A rapid increase in tourism numbers, particularly when this is not accounted for by the management of the property often threatens the values for which the property was inscribed in the list in the first place. Associated to an increase in visitor numbers are other issues reported in the survey including congestion, heavy traffic, infrastructure development, air, noise and /or water pollution and severe effects to the diversity of the area through physical changes provoked by the presence of large numbers of tourists (e.g. through trampling, disturbance, vandalism etc). A number of indirect effects of high numbers of visitors to an area, such as the introduction of invasive species were also reported.

The Galapagos Islands are a good example of the knock-on effect provoked by increased visitor pressure. Tourism to the islands has grown considerably in recent years leading to a multitude of issues threatening the OUV of the property. First, a high number of entry points with an availability of several transport modes, especially air transport, has facilitated the rapid increase in visitors to the islands.. Second, the increase in numbers and numbers of operators and tour options and activities available has meant that visitors now access areas of the islands that were previously off limits. Other effects of the increases in tourist numbers have included a growth in hotel construction to service tourism, and other operators servicing the area. Third, tourism growth has triggered significant migration from mainland Ecuador for jobs bringing about a very dramatic and unplanned urbanisation pressure to the islands, together with a range of

social issues. Collectively, these changes have resulted in many threats to the local flora and fauna of such fragile ecosystems due to the introduction of invasive species, increased and poor waste management, pollution and changes to many of the intangible attributes of the remote site. The Galapagos Islands, among the first inscribed natural World Heritage sites in 1978, were included in the List of World Heritage in Danger (2007), substantially because of the direct and indirect impacts of tourism. Box 1 below gives a more detailed example of another property with high visitor numbers.

Another common problem of tourism growth reported in the study is unplanned and invasive infrastructure development. For instance, in places like Iguazu/Iguaçu National Park, Mosi-oa-Tunya/Victoria Falls and the Ngorongoro Crater, tourism concessions have not been well planned leading to a proliferation of developments that devalue the sites. One extreme example of infrastructure development threatening the OUV of a site has been occurring in the Belize Barrier Reef System (BBRS). Despite strong concerns from the World Heritage Committee, the lease and development of land within this property for tourism and real estate has reached unsustainable levels. Mangrove cutting and coral dredging are amongst the most immediate effects of such developments. This uncontrolled tourism-related development led to the inclusion of BBRS on the List of World Heritage in Danger in 2009.

Pollution and waste also rank highly on the list of tourism-driven impacts to natural World Heritage Sites. These tend to be related to increased visitor numbers and infrastructure development but also to recreational activities that take place in the site. Sites such as Ha Long Bay in Vietnam have seen pollution and waste become a considerable problem over time. The tourism offer is currently limited to boat trips around the bay and there are more than 400 boats in operation which contribute to pollution and decrease in water quality. In addition, most boats do not have adequate methods for waste disposal and/or management. Another issue exacerbating the pollution problem is infrastructure development outside the site boundaries, namely construction of hotels and ports.

The issue of unrealised expectations is another issue often associated with tourism development (Pedersen, 2002). This research showed that local communities are sometimes convinced by site management and the tourism industry that World Heritage nomination will bring about an increase in visitors to the area and with it, positive

change. This can lead to a variety of negative consequences for the site, particularly related to local communities who may become antagonistic toward the management authority and even actively threaten the site's integrity. Of the sites studied, East Rennell in the Pacific is a good example of unrealised expectations. The experts interviewed about this site reported that the local people envisaged that nomination would bring about a major development boost, not just in terms of tourism, but also regarding the building of new hospitals, improving infrastructure and transport within and to the island. The fact that this has not happened has led to local people becoming despondent and could in the future lead to conflicts and threats to the site.

3.2 Positive impacts (Opportunities)

The findings of the study also suggest that tourism development in natural World Heritage sites can be beneficial when planned and managed in a sustainable way. Social, economic and environmental benefits are all achieved when appropriate site protection mechanisms are in place and tourism planning is integrated with site management planning. For instance, economic benefits from tourism development are often vital for managing the site and used for conservation and monitoring activities. In Jiuzhaigou, tourism generated revenue not only supports site management activities and creates jobs, but also benefits local communities and the local government. Whereas in Australia, a study measuring the economic contribution of World Heritage Areas to the state demonstrated that these contribute 16.1 million AUD in annual direct and indirect national output or business turnover (as well as 83,349 direct and indirect national jobs), 95 percent of which derives from visitor expenditure in these sites (Gillespie Economics & BDA group, 2008). A study of the Dorset & East Devon World Heritage site (ERA, 2009) found that World Heritage inscription had "stimulated the creation of a new identity" and this had revitalised the economy in several ways. This included increased investment, increased national and international media coverage, stimulated new infrastructure, services, businesses and products and hence new employment and educational opportunities.

Through tourism and by using appropriate interpretation tools it is also possible to raise awareness of both locals and visitors to the value of a site and the importance of protecting it. In Wadi-Al-Hitan in Egypt, much work has been done to develop the site for tourism with appropriate infrastructure being built, as well as focus being placed on interpretation and capacity building for all staff and surrounding communities. This work began prior to the inscription of the site and as part of a project for the improved management of several Egyptian

protected areas. However, once inscribed, focus was placed on this property in order to make it a benchmark for other protected areas in the country.

Community development can be another positive outcome of tourism being developed in World Heritage Sites and has been reported in many sites. Again in Wadi Al-Hitan, tourism development has occurred mainly at small scale and through local communities who offer most of the services available to the visitors. The site management has worked with the local communities to build their capacity in regards to the site but also with regards to building their skills for offering these services to the tourists. Economic development of local communities has been another outcome of well-planned tourism at Wadi Al Hitan. In many of the Australian sites, community involvement has been a priority and not only as regards tourism development but also in managing the sites. Such involvement has been accompanied by capacity building which in turn empowers communities to participate in decision-making. Other sites such as Canaima National Park in Venezuela and Shiretoko in Japan also demonstrate good mechanisms for community involvement and collaboration and ultimately development.

Although some common impacts of tourism development in natural World Heritage Sites were identified throughout the sites, the reasons for these vary considerably and not surprisingly, cannot be easily categorised to a specific cause. The impacts reflect a multitude of relational factors which range from understanding the socio-political context of the site to analysing its management to other issues related to stakeholder participation and communication. In trying to find common threads among sites, the contrasts between them become apparent and their diversity striking. Natural World Heritage Sites represent a wide and diverse range of protected areas and should be analysed as such if a framework for sustainable tourism development in these sites is to be reached.

Attaining sustainable tourism

Although there are many parallels between natural World Heritage Sites there are also many differences. These begin with the nomination criteria that in themselves allow for very different natural characteristics to be inscribed and continue on to differences in area, management regime, traits, species, habitats, and ecosystems as well as the diverse social, political, cultural and economic characteristics. It may therefore be relatively straightforward to identify common impacts amongst them, but it is much more complex to attempt identifying the causes or indicators for these impacts. In fact, comparing these sites in

an effort to identify commonalities and extrapolate a set of rules for sustainable tourism development would be over simplistic and lead to quite contrary results. Instead, it may be worth digging deeper and examining the underlying conditions that are required for tourism to be managed sustainably.

It is also important to examine the relationship between the site, buffer zone, surrounding area and destination. In the World Heritage Sites examined, this relationship was often deemed inexistent or at the very least undeveloped. In fact, the authority of site management stops at the boundaries of the sites and there is little that can be done by the site management to control what happens immediately outside it.

Based on the research carried out, some common denominators were identified for sustainable tourism development. These are explained in detail below but generally illustrate that approaches to tourism development and management need to be tailored to the specific conditions of each site. The need for effective and responsible tourism development and management is also apparent.

4.1 Understanding the context

In order to predict how a site will evolve in terms of tourism development, it is important to analyse the context of the site including the social, environmental, economic (market context), political, geographical, and ecological characteristics of the wider area. The Lake District World Heritage Project (2009) confirmed that worldwide there are very significant differentials in motivation, actions and performance following inscription. These of course are themselves a reflection of a range of existing socio-economic and political factors which are inherently site specific. It is also very important to remember that natural areas are dynamic and conditions change, so it is necessary to build a factor of change into this contextual analysis.

A good analysis of the site's characteristics as well as of its relationship with the wider destination (including the market, other heritage attractions and national tourism authorities, etc) will allow for context-dependent solutions to be reached and make for much more sustainable planning of tourism. The lack of influence beyond site boundaries requires that site managers need to establish strong relationships with local authorities and tourism operators in order to influence development in buffer zones and surrounding areas. Understanding the full complexity of a site and the existing relationships needs to precede any tourism planning exercise and should also be built into monitoring plans and occur at regular intervals.

4.2 Planning for tourism

Tourism planning is extremely important if the negative impacts of tourism development are to be avoided. Without a concrete plan of

what will be done to encourage tourism on the one hand, and on the other, to limit it, there is also the danger that the expectations of local communities, operators and tourists will be unrealistic. Both the tourism and public use plan need to be consistent with the site's plan of management to ensure conflicting activities do not occur. These plans should also be accompanied by a sound business plan.

The World Heritage Committee in its decisions often alludes to the need for newly inscribed properties to develop and submit management and public use plans. This request is often reiterated at regular intervals in committee decisions but little in terms of support and incentives are offered to the properties to ensure that this occurs. The nomination process would be good occasion to advise the States Parties on the complexity and possible consequences of inscription in a more proactive way encouraging solutions at an early stage. Also, the minimum standards for consideration of tourism in nomination processes deserve to be discussed as there may be room for clarification and improvement, including in the nomination form. Meanwhile, rapid growth of tourism could take place leading to a number of the aforementioned negative impacts and ultimately threats to the OUV of the site. On the other hand, sites with a proactive attitude to tourism planning reap the benefits of tourism development without suffering the costs..

Another important consideration related to tourism planning is whether site plans for tourism support the destination's approach to tourism and on the flipside, if the overall destination promotes a type of tourism that is in line with the OUV of the World Heritage Sites. This does not seem to be the case on several of the World Heritage properties with unsustainable tourism development taking place outside the site's boundaries. In places such as Ha Long Bay and Jiuzhaigou for example some of the biggest tourism-related concerns are occurring immediately outside the site due to different government authorities being responsible for overseeing tourism development. The proposed Principles for Sustainable Tourism at World Heritage sites (Appendix III) recommends as noted above, the need to establish strong relationships between site management, local authorities and tourism operators in order to influence a productive tourism development/conservation dynamic.

4.3 Governance of tourism

This relates to the overall political context of the site but more specifically to the relationships between government institutions involved in managing the site or site resources as well as their interaction with those institutions responsible for tourism management in the destination. Good governance and a good working relationship

between these institutions often results in sound tourism development and management whereas in places where there is lack of trust between these institutions and lack of transparency overall the opposite occurs. Although rules and regulations are also important, these should not replace open and transparent governance and open communication, they should instead serve as a framework for it. At a forum of World Heritage site managers at the 2008 World Conservation Congress, open, regular, two-way communication with tourism operators was cited repeatedly as one of the most important and productive strategies.

In both the Galapagos Islands and the Belize Barrier Reef governance related issues have created issues in relation to tourism development in these World Heritage Sites. With regards to the Galapagos, political instability at the national level and an incongruence of local and national policies have exacerbated tourism and other management issues in the property. Local authorities would like to see the number of permits to work on the Islands heavily restricted, and rather to train up existing local community, but national authorities keen to support tourism as a key contributor to the national economy have allowed unsustainable and unplanned migration to continue. National government representatives rarely stay in office for more than 12 months whereas local authorities are more stable serving regular terms, this tends to affects their priorities (Mission report, 2006). In Belize, the overriding issues are a combination of real estate pressures with a lack of strong protective legislation supported by effective institutions. However, lack of coordination between government agencies and a proliferation of agencies being responsible for different elements within the site (e.g. the forestry department is responsible for the mangrove areas and the fisheries department for the surrounding marine environments) exacerbate the problem making the overall management of the site difficult and loopholes for unsustainable tourism development easy to find.

4.4 Stakeholder involvement in site governance and management

The present research identified stakeholder involvement and participation as extremely important elements for ensuring that tourism development is sustainable. Moreover, this engagement needs to be regular and not just part of a mandatory process. By making sure that all stakeholders are involved from the beginning and throughout, more holistic decision-making can be achieved and enhanced ownership from all parties is possible. Both local communities and the private sector are important players in supporting tourism development and should invariably be afforded a seat at the table.

Collaboration with local communities and their involvement in site management and tourism planning is considered extremely

important. However, this adds a lot to the complexity as it is not always easy to determine who in the community needs to be involved and at what level of involvement. Consultation exercises are also often perceived as costly and time-consuming despite the fact that this will not be the case when they are made integral part of the management approach.

4.5 The role of the private sector

The findings of this research indicate that links between the tourism industry and the management authority of World Heritage properties are often weak. The private sector is almost always a player in these sites, having a vested interest in ensuring that the expectations of tourists to the site are met. However, given the nature of the tourism industry, private sector involvement is often disorganised with a multitude of companies competing for the tourist dollar. Presence of industry players is most marked outside site boundaries in the form of tourism infrastructure (hotels, restaurants, bars, retail outlets etc.). Within the site, industry presence is regulated through concessions, going from operating tours, cafes, accommodation, through to providing more alternative tourist experiences such as helicopter, hot air balloon and boat rides. The management authority is responsible for the public use of the sites, managing the concessions within the site but has no control or formal influence over how tourism is managed immediately outside site boundaries.

A more coordinated and collaborative approach between site management and industry players would be beneficial in many of the sites studied to ensure sustainable tourism development and management. At present, site management authorities see tourism management almost exclusively as public use of the site and there is limited interaction with private sector players and tourism authorities in the area. Promoting collaboration between these entities would enable a more holistic approach to tourism in the wider area that the site is part of.

The research shows that in sites where collaboration occurs between the management authority and the private sector, tourism concessions are better planned and the industry is more amenable to requests from the management. This is particularly important for ensuring that visitor pressure is minimised and invasive infrastructure avoided. In the aforementioned case of Iguazu national park, the Argentinean management authority worked with the private sector to plan tourism concessions and infrastructure, therefore minimising impacts to the site (Box 2).

It is also important to recognise that there are many other benefits from collaboration such as resource and expertise sharing, mutual capacity and knowledge building, enhanced visitor experience, and conflict management. The role of the private sector extends beyond minimising impacts to the site. Collaboration and partnerships with the industry are also important in awareness raising and capacity building for tourism development as is shown in the Lindblad Expeditions case study below (Box 3). In Canaima National Park in Venezuela, a partnership between UNESCO, The Nature Conservancy and the industry has been formed to provide planning and business skills to site management, train local communities as entrepreneurs and help find creative approaches for financing the park through sustainable tourism development.

Furthermore, as was demonstrated by a recent IUCN study, "The Time for Biodiversity Business" (IUCN, 2009), private sector has a vital role to play in building capacity for site management on tourism-related issues as well as building the capacities of other local stakeholders in running tourism businesses. The industry has expertise in a multitude of business skills that would support site managers in managing their sites more effectively for tourism, including, monitoring of tourism numbers, product design as well as marketing and promotion. The industry also has the ability to help identify indicators of tourism sustainability that could be used both in World Heritage nomination documents and for monitoring missions.

4.6 Making use of effective communication tools to add value to a site

In sites where innovative interpretation has been implemented there is clear evidence of visitors engaging with the conservation values and issues of the site. In the Galapagos Islands the partnership between the National Park, the Charles Darwin Research Station and private operators allows visitors to see and hear first hand the alarming facts about the impacts of human activity on the flora and fauna of the site throughout its interesting history, including inappropriate human behaviours on the island today.

The employment of research scientists as guides around the research station provides visitors with privileged insights. In return visitors leave happily knowing their tourist tax is going to a good cause, many purchase souvenirs from the research station which is an important source of revenue, and many of the souvenirs are DVDs and books providing detailed information about the islands natural and

social history. The visit to the research station also greatly supports the effort of tour operators like Lindblads to encourage traveller philanthropy.

The use of appropriate communication tools can serve the purpose of both protecting and promoting a site's values. The power of such tools should not be underestimated in achieving sustainable tourism at World Heritage Sites. Communicating World Heritage and conservation values to local communities, the tourism industry and tourists through a variety of mechanisms raises public awareness and promotes the site and its OUV. Well-designed and effective interpretation which can include access to materials and information before, during and after a visit, not only contributes to the visitor experience, it also provides explanations of why the site is precious and should be preserved for future generations, thus meeting the obligations of the World Heritage Convention. Through exciting and innovative interpretation, site managers can foster strong attachment to the site in individuals regardless of the age or background of the visitor.

Appropriate marketing serves a similar purpose to interpretation for tourists who are yet to visit the site. Selective and evocative marketing can target and encourage particular types of visitors to the site. The iconic value of the World Heritage 'brand' is well understood by the tourism industry, and serves as an important aspect of the value adding of the site to the destination as a whole, and as a very significant point of leverage in gaining the cooperation and support from the industry and local authorities.

Overall, the interpretation of sites, the explanation of World Heritage as a concept and use of the World Heritage emblem is not well done in many natural World Heritage Sites. The educational and emotional value of visitation is underestimated. There is need for focus to be placed on reinforcing the use of these tools for both promotion and protection of natural sites**.**

New Forms of Tourism

1. Slow Travel: appearance, features and benefits

1.1. Appearance

Slow Travel is an offshoot of the slow food movement, which began in Italy in the1980's as a protest against the opening of a McDonald's in Rome. Slow Travel is not so much a particular mode of transportation as it is a mindset. Rather than attemptingto squeeze as many sights or cities as possible into each trip, the slow traveler takesthe time to explore each destination thoroughly and to experience the local culture.Slow Travelers assume that they do not have to see everything on one trip, that therewill be other trips." In other words, it's more important to get to know one small areawell than it is to see only a little bit of many different areas -- that way you'll havesomething left to see on the next trip.

Slow Movement was initially an expression as an alternative to the impact we haveon the environment the journey by plane or by car. Against the high environmentalimpact prefigured alternatives such as walking pilgrimages, canoeing, leisurelycycling, place based experience that value nature and cultural traditions. (Fullagar,Markwell, Wilson, 2012, 4).In these conditions was born Slow Travel as a distinct form of leisure vacation or leisure of the people.

. 1 . 2 . F e a t u r e s

Slow Travel begins to be more and more appreciated by tourists from all over theworld. Is a type of tourism hard measurable in terms of the number of tourists thatpractice it. The same thing goes for the returns made by economic agents from thistype of tourism.Inside this form of tourism can harmonize the phenomenon of Downshifting (Nelson,Paek, Rademacher, 2007): which can be defined as a social behavior or trend inwhich individuals lead a simple life in order to escape materialism and obsession toreduce the level of stress that can accompany this obsession.Reducing the pace of life and spending time with a specific purpose without spendingunnecessary money are fundamental principles of downshifting. Another direction of the downshifter’s gardening is spending time in the company of other people,especially loved ones.So-called downshifters seek more meaningful lives by decreasing the amount of timethey devote to work, leaving more time for the valuable goods of friendship, familyand

personal development. The main motivation is winning a downshifting leisure, toescape the cycle of work-for hire, as well as the waiver unnecessary things that areassociated with a high living life as being a high level of production (Levy, 2005).In practice downshifting implies behavior and lifestyles changes. Most of thesechanges are voluntary choices, but may be caused by natural events, or events inthe life of each individual, such as the loss of employment or the birth of a child cancause practicing downshifting. Downshifting may be temporally or permanently (Houston, Stanford, Taylor, 2001).

.1.3.Benefits of Slow Travel

Traveling more slowly allows as forming a stronger connection to the place we'revisiting, and we'll feel much less rushed. With a "slow" itinerary, we won't experiencethe stress of attempting to knock out every site in our guidebook. Instead, we will stayin one place long enough to recognize our neighbors, shop in the local markets andpick a favorite coffeehouse. Few societies move as quickly as Americans do, soslowing down in other countries not only allows as to escape stressful day-to-day lifebut also to slip naturally into the pace of another culture. Another less obvious advantage of slow travel is that it's generally much easier onthe environment than other types of travel. While airplanes have recently beenpinpointed asmajor contributors to global warming, trains are a much more eco- friendly alternative -- as are bikes and, of course, your own two feet! And eventraveling by car becomes less damaging to the environment when we're only drivingshort distances.Slow Travel is often kinder to our budget as well. Staying in one place for a week or more at a time reduces our transportation costs, and vacation rentals are often morecost-efficient than hotels since they allow as to cook our own food instead of eating out for every meal

Visits of the Prince Charles in the Transylvanian villages, as well as many traditional products fairs organized in various towns and villages throughout the country major.Sense of identity, belonging, are the two most important feeling that we, romanians,have deeply in our soul, was remark of Prince Charles to the inhabitants of Transylvania. "What are awesome in this relationship are unique relationship between

man and the environment", he said. People crave some sense of belonging, identityand value.On the level of the General Secretariat of Government; there is a technicalsecretariat which coordinates a tourism development strategy for CarpathianMountains. There were discussions, which results in a strategy on governmentallevel. Minister Hellvig said that the partnership is primarily the achievement of acoherent strategy for promoting Carpathians, on the one hand, and on the other hand, initiation of specific projects such as: gourmet festival, promoting tourismregions from rural areas and provide funding on tourism infrastructure.

3. Slow Food: a new form of superior valorification of responsible tourism

We got used to do it all in high speed. We eat on the run and if there's anything fromfast food, sure it's something ordered in the Office, that is no longer going out even half an hour.The old saying latin Festina lente (make hurry slowly) is in actuality. We are nowadvised to journey, look around leisurely, unhurried, in order to know better thosewhom we meet and to have more care for environment. "The democratization of travel and open up new horizons for tourism has provoked frenetic reactions – noticethe co-founder Maximilien Nardi at Swiss travel agency Synopsis. The fact many urged the tourists to visit the world in record time. "But – Le Temps newspaper conscientiously objects, too many travelers kill the journey".Here starts the felling the urge to less travel, for doing better. The principle of "SlowTravel" ("Slow Trip") is analogous to that which opposes his Fast Food (eatingleisurely), who opposed "mcdonaldiezed" the planet and aims of rehabilitation andlocal cuisines (Dickinson, Lumsdon, Derek, 2010).

Over the last couple of years the phrase "Sustainable and Responsible Tourism" hasgained currency. But they are not the same thing, there is a broad agenda of sustainability issues, with the latest example being the long lists are constructed bythe European Union with its draft "European Charter for Sustainable and ResponsibleTourism".Responsible Tourism is about taking action, it is about identifying the economic, social and environmental issues which matter locally and tackling them, bringing the stake holders together to

exercise responsibility. We need to do much more if the challenge of sustainability is to be met; over the twenty years since Rio not enough has been done. There has been too much talk of sustainability and too little taking of responsibility. All forms of tourism can be more or less responsible.

Responsibility is free, and you can take as much of it you can handle. But others can undermine the efforts of a few, and there is a role for government and regulation to control the free riders. It cannot be right that the efforts of those businesses whichtake responsibility and try to operate sustainably should be undermined by those whocarry on over exploiting our environments and the public realm.It is time to move on from talking about sustainability and making lists, that was the agenda 20-30 yrs ago – now it is time to take responsibility, act and make adifference

.3.1.Slow Food: what it means?

Slow Food is an international movement that is campaigning for the satisfaction of food pleasure, but to protect biodiversity, spreading education, taste, ask about"green" producers with consumers and find it touching the food, agriculture and environmental policy.Slow Food is a non-profit eco gastronomic organization that was founded as a counterpart of the fast-food, contemporary life, consumed in the disappearance of local food traditions and people's interest for food drop.

What kind of products can be promoted to such events? Of course, authentic products. There are a multitude of products that should be promoted. In addition, theproduct must be in the back and an interesting history. By promoting the product, infact is promoted the local community and the well-being of people. All these emergewith some principles: food does not must be consumed in a hurry; every meal mustbe made only from natural products without preservatives other than salt; everyonehas the right to be gourmet; children must learn that there is a discipline for tasting; banquets are occasions to be happy on eating time; lifestyle fast food seriously harm the health.

3.2. Slow Food vs. Fast Food: advantages and disadvantages

The concept of Fast Food exist for a long time ago, itinerant traders selling cooked food or beverages. This concept is closely connected to urban development. The emergence and development of the Fast Food industry is closely linked to two disheson the menu of every restaurant Fast Food. Each of these two products is the story of that, probably for most of us are unknown. In the next two tables are presentedadvantages and disadvantages of Slow Food and Fast Food

A healthy eating do well to our soul and mood, in other words, this depends on how we feel day by day, how much energy we have, and how we look at things from that perspective, how bright or how we are emotionally balanced. It has a positive effect upon digestion and our well being.